NOT MEASUREMENT SENSITIVE

MIL-STD-881C
3 October 2011

SUPERSEDING
MIL-HDBK-881A
30 July 2005
MIL-STD-881B
25 March 1993

DEPARTMENT OF DEFENSE STANDARD PRACTICE

WORK BREAKDOWN STRUCTURES FOR DEFENSE MATERIEL ITEMS

Reinstated after 3 October 2011 and may be used for new and existing designs and acquisitions.

AMSC 9213 **AREA MISC**

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FOREWORD

1. This Standard is approved for use by all Departments and Agencies of the Department of Defense (DoD). It is for direction and should be included as a contract requirement.

2. This Standard addresses mandatory procedures for all programs subject to DoD Instruction 5000.02.

3. This military standard is applicable to all defense materiel items (or major modifications) (a) established as an integral program element of the Future Years Defense Program (FYDP), or (b) otherwise designated by the DoD Component or the Under Secretary of Defense (Acquisition). This Standard is mandatory for all Acquisition Category (ACAT) I, II, and III programs.

4. A Work Breakdown Structure (WBS) provides a consistent and visible framework for defense materiel items and contracts within a program. This Standard offers uniformity in definition and consistency of approach for developing all levels of the WBS. Generating and applying uniform work breakdown structures improves communication in the acquisition process. It also provides direction to industry in extending contract work breakdown structures.

5. This Standard supersedes MIL-HDBK-881A, dated 30 July 2005 and MIL-STD-881B, dated 25 March 1993 entitled Work Breakdown Structures for Defense Materiel Items. MIL-STD-881C is based on the cooperative efforts of the military services with assistance from industrial associations. Changes to the Standard specifically address advances in technology and modifications of the acquisition process, and incorporates new materiel items, developmental concepts, and approaches.

6. Comments (such as recommendations, additions, or deletions) and any pertinent information, which may be useful in improving this document, should be addressed to the Office of the Assistant Secretary of Defense for Acquisition, Performance Assessments and Root Cause Analysis (OASD(A))/PARCA, 3620 Defense Pentagon, RM 5A 1082, Washington DC 20301-3620. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.daps.dla.mil.

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1. GENERAL INFORMATION

1.1 Standard Purpose and Structure. This Standard presents direction for effectively preparing, understanding, and presenting a Work Breakdown Structure (WBS). It provides the framework for Department of Defense (DoD) Program Managers to define their program's WBS and also to defense contractors in their application and extension of the contract's WBS. Section 1 defines and describes the WBS. Section 2 provides instructions on how the WBS is applied as well as how to develop a Program WBS in the pre-award timeframe. Section 3 provides direction for developing and implementing a Contract WBS and Section 4 examines the role of the WBS in the post-award timeframe. This Standard also provides WBS definitions for specific defense materiel commodity systems in Appendices A through K. Appendix L addresses WBS elements that are common to all systems.

The primary objective of this Standard is to achieve a consistent application of the WBS for all programmatic needs (including performance, cost, schedule, risk, budget, and contractual). Discussion and direction was compiled based on many years of lessons learned in employing WBSs on defense programs.

1.2 Support Documentation. The foundation for a WBS is contained in DoD Directive 5000.01 and DoD Instruction 5000.02. These documents identify responsibilities in the acquisition process from the Office of the Secretary of Defense to the DoD component field activities. Preparing a WBS is generally discussed in the context of planning and monitoring a defense system program.

DoD Directive 5000.01 "The Defense Acquisition System" requires a disciplined approach in establishing program goals over its life cycle with streamlined and effective management that "is accountable for credible cost, schedule, and performance reporting." The WBS is a critical tool in ensuring all portions of the program are covered. The WBS will also facilitate the required collaboration within the Integrated Product Team (IPT) structure by providing a tie between performance, cost, schedule, and risk information. The WBS can also facilitate the required technical rigor and integrated test and evaluation throughout the defense acquisition process.

DoD Instruction 5000.02 "Operation of the Defense Acquisition System" further outlines the required framework and provides impetus for use of a WBS. The evolution of the system through incremental development further drives the requirement to breakdown the system in a structure that clarifies which capabilities will be satisfied in a specific increment of the system development. The instruction sets the requirements for Integrated Master Schedules (IMS), Earned Value Management (EVM) and other statutory, regulatory, and contract reporting information and milestone requirements in which the WBS is a critical element.

The WBS is also a critical link to the Systems Engineering Plan (SEP), which is required to be developed prior to all milestone decisions for all Acquisition Category (ACAT) programs. Guidelines for the SEP are included in the SEP Annotated Outline (current version).

In addition, the purpose of the Chairman of the Joint Chief of Staff Instruction (CJCSI) 3170.01 (current version) (in concert with the Manual for the Operation of the Joint Capabilities Integration and Development System (JCIDS) (current version) is to establish the policies and procedures of the JCIDS, which directly supports the DoD acquisition process and hence has WBS implications.

The Program WBS and Contract WBS aid in documenting the work effort necessary to produce and maintain architectural products in a system life cycle. The DoD Architecture Framework (DoDAF) (current version) defines a common approach for DoD architecture description development, presentation, and integration for warfighting operations and business operations and processes.

The Defense Acquisition Guidebook (DAG) is a source of best practices and includes numerous references to the use of a WBS.

1.3 What Does a WBS Accomplish? The following three sub-paragraphs will discuss Applications, Benefits and Challenges with regard to the WBS.

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1.3.1 Applications. This Standard addresses two fundamental and interrelated WBS structures: (1) the Program WBS and (2) the Contract WBS (including flow-down reporting requirements).

The Program WBS provides a framework for specifying program objectives. Each WBS element provides logical summary levels for assessing technical accomplishments, for supporting the required event-based technical reviews, and for measuring cost and schedule performance. The WBS defines the program in terms of hierarchically-related, product-oriented elements and includes "other Government" elements (for example, Program Office Operations, Manpower, Government Furnished Equipment (GFE), and Government Testing). It represents the entire program from the Government Program Manager's responsibility.

The contract WBS is the Government approved WBS for program reporting purposes and includes all program elements (for example, hardware, software, services, data, or facilities), which are the contractor's responsibility. It includes the contractor's discretionary extension to lower levels, in accordance with Government direction and the contract Statement of Work (SOW).

The WBS is defined, developed, and maintained throughout the system life cycle based on a disciplined application of the systems engineering process. The goal is to develop a WBS that defines the logical relationship among all program elements to a specific level (typically Level 3 or 4) of indenture that does not constrain the contractor's ability to define or manage the program and resources. However, if the Government considers some program elements to be high-cost or high-risk, the system may be defined to a lower level of the WBS; this is reasonable if the product-oriented logical extension is maintained. The contractor should extend all other elements to the level and form based on the way the system is developed, produced, or managed. A secondary, but still important goal, is to provide a systematic and standardized method for gathering cost data across all programs. Having actual historical data to support cost estimates of similar defense materiel items is a valuable resource. However, the primary purpose of the WBS is to define the program's structure, and the need for data should not distort or hinder the program definition.

Further, the WBS serves as a coordinating medium. Through the Program WBS and the Contract WBS, work progress is documented as resources are allocated and expended. Performance, cost, schedule, and technical data are routinely generated for reporting purposes. The WBS is the infrastructure to summarize data for successive levels of management and provide appropriate information on projected, actual, and current status of the individual elements. When appropriately structured and used in conjunction with systems engineering principles, cost estimating, EVM, integrated scheduling, and risk management, the WBS allows for program status to be continuously visible so the program manager and the contractor can identify, coordinate, and implement changes necessary for desired results.

The WBS applies to the specific categories of defense materiel items listed below. These are further discussed in 1.5 and complete definitions of each are included as Appendices A through L.

a. Aircraft Systems

b. Electronic Systems

c. Missile Systems

d. Ordnance Systems

e. Sea Systems

f. Space Systems

g. Surface Vehicle Systems

h. Unmanned Air Vehicle Systems

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i. Unmanned Maritime Systems

j. Launch Vehicle Systems

k. Automated Information Systems

l. Common Elements

1.3.2 Benefits. The WBS assists in several ways during the program life cycle:

a. Segregates a defense materiel item into its component parts, clarifying the relationship among the parts, and the relationship of the tasks to be completed both to each other and to the end product.

b. Facilitates effective planning and assignment of management and technical responsibilities.

c. Aids status tracking of technical efforts, risks, resource allocations, expenditures, and cost/schedule/technical performance.

d. Helps ensure that contractors are not unnecessarily constrained in meeting item requirements.

e. Provides a common thread for the Earned Value Management System (EVMS), the Integrated Master Plan (IMP) and the IMS, allowing consistency in understanding program cost and schedule performance. The contract WBS includes the breakdown of work into small enough entities that can be analyzed and assessed. As part of EVMS, the contract WBS elements provide a structure for collecting costs and assessing performance. The IMP is the contractor's event-driven plan that documents the significant accomplishments necessary to complete the work and ties each accomplishment to a key program event. The IMS is tied to the IMP and serves as a tool for time phasing work and assessing technical performance. Schedule activities in the IMS are traceable to the IMP and contract WBS elements used in EVMS, allowing commonality for integrated program assessment of cost, schedule, technical performance, and associated risks.

1.3.3 Challenges. The primary challenge is to develop a WBS that defines the logical relationship between all program elements without constraining work necessary to achieve program objectives and meets all program reporting requirements. A WBS should be sufficient to provide necessary program insights for effective status reporting and risk mitigation, facilitating the contractor's ability to effectively execute the program.

A secondary challenge is to balance the program definition aspects of the WBS with its data-generating aspects. Using available data to build historic files to aid in the future development of similar defense materiel items is a very valuable resource. However, the primary purpose of the WBS is to define the program's structure, and the need for data should not distort or hinder the program definition.

1.4 How is the WBS Related to Other Contract Requirements? The WBS provides a basis for effective communication throughout the acquisition process. It is a common link, which integrates planning, scheduling, cost estimating, budgeting, contracting, configuration management, and performance reporting disciplines. It permits the Government and Industry managers to continually evaluate progress in terms of contract performance.

The WBS forms the basis of reporting structures used for contracts requiring compliance with ANSI/EIA 748 EVMS Guidelines and reports placed on contract such as Cost and Software Data Reporting (CSDR), Contract Performance Reports (CPR), and Contract Funds Status Reports (CFSR).

1.5 Definitions. The following definitions are intended to improve continuity and support a common understanding of program expectations.

1.5.1 Program Element (PE). The program element is the basic building block of the Future Years Defense Program (FYDP). The PE describes the program mission and identifies the organization responsible for

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performing the mission. A PE may consist of forces, manpower, materiel (both real and personal property), services and associated costs, as applicable.

1.5.2 Defense Materiel Item. This term refers to equipment, apparatus, and supplies of a military force or other organization. It identifies a system or item usually established as an integral PE or identified as a project within an aggregated PE.

1.5.3 Work Breakdown Structure (WBS). This term is defined as:

a. A product-oriented family tree composed of hardware, software, services, data, and facilities. The family tree results from systems engineering efforts during the acquisition of a defense materiel item.

b. A WBS displays and defines the product, or products, to be developed and/or produced. It relates the elements of work to be accomplished to each other and to the end product. In other words, the WBS is an organized method to breakdown a product into sub-products at lower levels of detail.

c. A WBS can be expressed to any level of detail. While the top three levels are the minimum required for reporting purposes on any program or contract, effective management of complex programs requires WBS definition at considerably lower levels. This is particularly true of items identified as high-cost, high-risk, or high technical interest. Under these circumstances, it is critical to define the product at a lower level of WBS detail. In this case, managers should distinguish between WBS definition and WBS reporting. The WBS should be defined at the level necessary to identify work progress and enable effective management, regardless of the WBS level reported to program oversight.

1.5.4 Common Elements. The term “Common Elements” refers to the elements listed below that are applicable to all major systems and subsystems as required:

a. Integration, assembly, test, and checkout

b. Systems engineering

c. Program management

d. System test and evaluation

e. Training

f. Data

g. Peculiar support equipment

h. Common support equipment

i. Operational and site activation

j. Industrial facilities

k. Initial spares and repair parts

These common elements are described in further detail in Appendix L. Appendix L also contains sections for unique application for the following:

a. Common Elements L.4 – Space Systems

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b. Common Elements L.5 – Launch Vehicle Systems

c. Common Elements L.6 – Automated Information System

In addition to these common elements, each defense system has a unique combination of hardware and software, which defines the capability or end product of that system.

a. **Aircraft System** – Applies to fixed or movable wing, rotary wing, or compound wing manned air vehicles designed for powered or unpowered (for example, a glider) guided flight

b. **Electronic System** – Applies to electronic system capability (for example, processor, radio, electronic warfare, radar, etc.).

c. **Missile System** – Applies to a missile in an operational environment, which produces a destructive effect on selected targets.

d. **Ordnance System** – Applies to all munitions (nuclear, biological, chemical, psychological, and pyrotechnic) and the means of launching or firing them.

e. **Sea System** – Applies to surface and submersible ship platforms, systems, weapons, and equipment required for performing naval tasks at sea.

f. **Space System** – Applies to developing, delivering, and maintaining space vehicles in specific orbit placement, operation, and to recovering unmanned space systems.

   NOTE: Appendix F, Space Systems is specifically written to cover unmanned earth orbiting satellites. For manned, recoverable, and interplanetary systems, additional elements are required.

g. **Surface Vehicle System** – Applies to tracked, wheeled and amphibious vehicles that navigate over the surface and water.

h. **Unmanned Air Vehicle System** – Applies to fixed or movable wing, rotary wing, or compound wing unmanned air vehicles designed for powered or unpowered (glider) guided flight.

i. **Unmanned Maritime System** – Applies to unmanned surface and submersible ship platforms, systems, weapons, and equipment required to perform naval tasks at sea.

j. **Launch Vehicle System** – Applies to developing, delivering, and maintaining launch vehicles.

k. **Automated Information System** – Applies to developing, delivering and maintaining an assembly of computer hardware, software, firmware, or any combination of these, configured to accomplish specific information-handling operations, such as communication, processing, and storage of information. Included is Enterprise Resource Planning systems (ERPs), Management Information Systems (MIS), networks, or other electronic information handling systems, and associated equipment.

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1.5.5 Level Identification. At least the top three levels are specified in each WBS. Some appendices specify a fourth or fifth level.

a. Level 1 is the entire system and/or program, a program element, project or subprogram, for example, an electronic system. An "electronic system" might be a command and control system, a radar system, a communications system, a sensor system, navigation or guidance system, or electronic warfare system.

b. Level 2 elements are the major elements subordinate to the Level 1 major elements, for example, an air vehicle of a missile or aircraft system. These major elements are prime mission products, which include all hardware and software elements. Level 2 elements also include aggregations of system-level services (for example, systems engineering, system test and system test and evaluation, or program management) and data.

c. Level 3 elements are elements subordinate to Level 2 major elements and include hardware, software, and services. For example, the radar data processor of the fire control radar, or the Developmental Test and Evaluation (DT&E) subordinate element of System Test and Evaluation, or the technical publications element of Technical Data.

d. Level 4 elements follow the same process of breakdown and are elements subordinate to Level 3 and represent a further definition of the hardware, software and services. For example, major subsystems of the radar data processor. Lower level elements follow the same process.

1.5.6 Program WBS. The Program WBS encompasses an entire program, including the Contract WBS and "other Government" elements (for example, Program Office Operations, Manpower, Government Furnished Equipment (GFE), Government Testing). It defines at a high level what is to be procured and consists of at least three program levels with associated definitions. The Program WBS is used by the Government program manager and contractor to develop and extend a contract WBS. It contains uniform terminology, definitions, and placement in the product-oriented family tree structure.

1.5.7 Contract WBS. The Contract WBS is the complete WBS as included in the DoD-approved Program WBS extended to the agreed-to contract reporting level and any discretionary extensions to lower levels for reporting, which are considered high-cost, high-risk or high technical interest. It defines these lower level components as to what is to be procured and includes all the product elements (hardware, software, services, data or facilities), which are defined by the contractor and are their responsibility. This comprehensive Contract WBS forms the framework for the contractor's management control system.

1.5.8 Subcontract WBS. The subcontract WBS is the complete WBS as included in the DoD approved subcontract plan and WBS extended to the agreed to contract reporting level and any discretionary extension to lower levels for reporting which are considered high-cost, high-risk or high technical interest. It defines these lower level components as to what is to be subcontracted and includes all the WBS elements which are defined by the subcontractor and are their responsibility. This comprehensive Subcontract WBS forms the framework for the subcontractor's management control system. The elements in the Subcontract WBS should not be duplicated in the Contract WBS. Only the Level 1 of the Subcontract WBS should be included in the Contract WBS. The prime contractor should report the subcontract costs in summary on the remaining WBS elements.

1.6 WBS Evolution. Throughout any system's life cycle, systems engineering leads the system development process. This function includes developing system specifications, functional specifications, or a set of configuration items through requirements analysis, functional analysis and allocation, synthesis and systems analysis, and controls. The important factor is satisfying total systems cost, schedule, and performance requirements at an acceptable level of risk.

As the system is defined and developed, the DoD program manager can better understand and identify the WBS structure that is appropriate for the program. Figure 1 below provides an illustration of the system life cycle.

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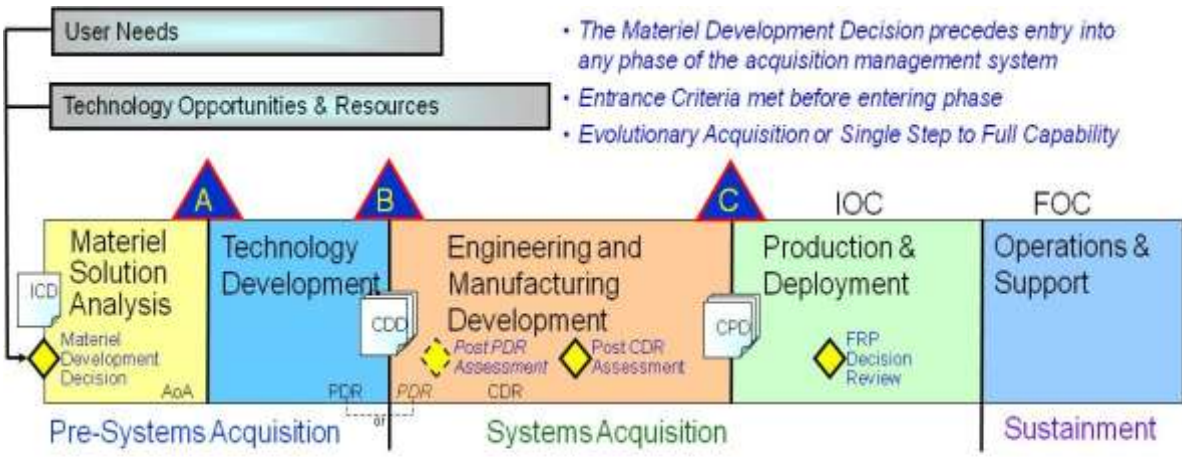

FIGURE 1. The Defense Acquisition Management Framework

The Materiel Development Decision (MDD) is the formal entry into the Materiel Solution Analysis phase and the acquisition process, and is mandatory for all programs. The purpose of this phase is to pursue a materiel solution to an identified capability gap that meets an established capability need (such as an Information Technology system, incremental improvement to an existing capability, or an entirely new "breakout" or other transformational capability). The Initial Capabilities Document (ICD) establishes conditions for the scope of alternatives to be considered in an Analysis of Alternatives (AoA). The AoA process plays a key role in the selection of a preferred system solution that satisfies the capability need documented in the approved ICD. Throughout the AoA process, a WBS is the key communication tool to establish life cycle cost estimates, the potential solution structure, and the baseline for measuring cost, schedule, and performance criteria.

Throughout the Materiel Solution Analysis phase into the Technology Development (TD) phase, the program WBS provides the basis for the system to be broken into its component parts and support the definition of a the contract WBS. The purpose of the TD phase is to reduce technology risk, determine the appropriate set of technologies to be integrated into a full system, demonstrate critical technologies on representative prototypes, and in many cases to initiate traceable requirements flow down to complete a preliminary design for the full requirement/full system. These activities form the more detailed development of the WBS.

Program offices planning a Preliminary Design Review (PDR) in the TD phase should have a well-documented and defined WBS and associated development schedules. This means that the program WBS needs to be defined with its associated contract WBS prior to Milestone B. It is essential that both the Government and the contractor can agree on a fully defined WBS at PDR and future Engineering and Manufacturing Development (EMD) activities.

By the end of the EMD phase, the establishment of the product baseline for all configuration items requires that production-representative articles be demonstrated in their intended environment and that manufacturing processes have been effectively demonstrated prior to Milestone C. Hence, by the end of EMD, the WBS is defined at its lowest levels, which best represents the entire system.

Just as the system is defined and developed throughout its life cycle, so is the WBS. The WBS will be developed and maintained based on the systems engineering efforts throughout the system's life cycle. After the Program WBS has been approved (through the CSDR process), the contractor and the Government will then agree to an extension of the Contract WBS to appropriate lower levels, to better define the complete contract scope. When integrated with the Program WBS, the extended Contract WBS forms a complete WBS, which will be used throughout the program's life cycle. Figure 2 below displays this process.

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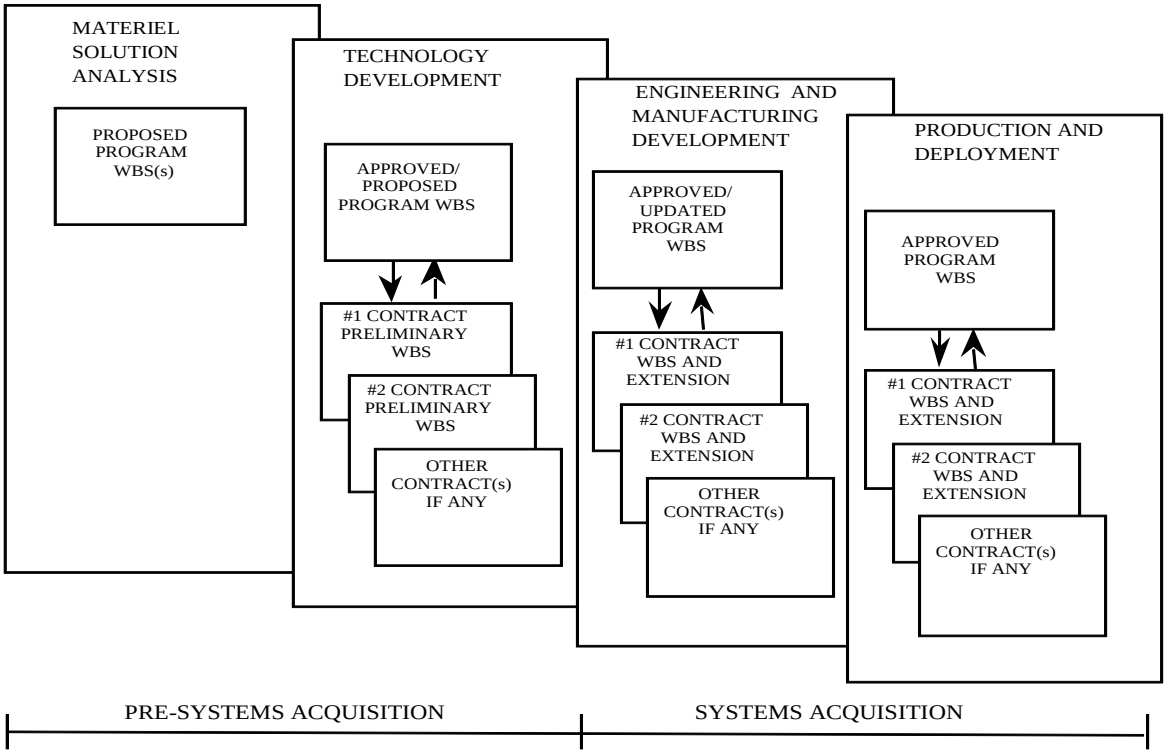

FIGURE 2. WBS Evolution

2. GOVERNMENT PROGRAM MANAGEMENT INSTRUCTIONS

2.1 Program WBS Attributes. The Program WBS is intended to structurally illustrate a clear understanding of the technical objectives and the end item(s) or end product(s) of the work to be performed by both Government and contract entities.

In order to use the Program WBS as a valuable framework for communicating the technical objectives, it must be product oriented. Its elements must represent identifiable work products, whether they are equipment, data, or related service products. A WBS is a product structure—not an organizational structure—which provides the complete definition of the work to be performed by all participants and the required interfaces between them.

2.2 Preparing a Program WBS.

2.2.1 Developing and Documenting a Program WBS. The government program manager is responsible for maintaining the Program WBS as it develops through systems engineering and management planning processes. The WBS may span one or more of the categories or elements defined in Appendices A-K. While these elements normally provide a basis for the Program or Contract WBS, tailoring may occur when a unique requirement exists. As a result, most appendices contain WBS elements designated as “Other” at the subsystem, element (product) levels that are restricted for unique requirements (products) that have not been envisioned or do not exist within the defined WBS elements in the Appendices. When a unique requirement exists, the WBS element designated as “Other” should be used. If it is determined that the “other” element is needed, the element must be specified and defined and the word “Other” replaced by the newly defined WBS element. The newly defined element must be approved by the Government Program Manager and their representative contracting officer. If it is determined that the “other” WBS element is not needed, this element should be deleted and not used in the WBS. In addition, although each appendix relates to a specific category of defense items, any item from any appendix which is applicable to the program may be used, as long as the integrity of the level of placement is maintained.

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The Program and Contract WBS should always represent the system that is being developed and/or procured. Hence the WBS should include only those WBS elements which are part of the logical decomposition of the system. Therefore, the WBS should not be expanded to include all elements identified in an appendix but should only include only those that truly represent the system being developed and/or procured.

The Program WBS will guide development early in the program's life cycle. It will evolve through iterative analysis of the program objective, functional design criteria, program scope, technical performance requirements, and other technical documentation. The documentation will describe the entire plan to build, field, and support the system through fielding.

Ultimately, the Program WBS is approved through the CSDR plan, in accordance with DOD 5000.04-M-1 CSDR Manual. The CSDR plan describes the Program WBS to be used and defines the approach the Government activity plans to use for collecting cost data.

2.2.2 Selecting Program WBS Elements. The WBS provides a framework for specifying the program objectives by first defining the program in terms of hierarchically related, product-oriented elements and the work processes required for their completion. Each element of the WBS provides logical summary points for assessing technical accomplishments and for measuring the cost and schedule performance accomplished in attaining the specified technical performance.

2.2.3 Determining Levels of Program WBS. The levels of the Program WBS must be related to the system requirements and conform to the product-oriented family tree. The detailed technical objectives are defined, and the scope of work is determined for each WBS element. Then, tasks are assigned to each WBS element. Resources, materials, and processes required for attaining the objectives are added incrementally. This relationship allows all items to be traced to the same WBS elements. Thus, the linkage between the requirements specification, the WBS, the Statement of Work (SOW), the Integrated Master Schedule (IMS), and the Integrated Master Plan (IMP) provides specific insights into the relationship between cost, schedule, and performance.

By following the Acquisition Management Framework (see Figure 1), when developing a Program WBS, systems engineers define the description of the system and its related levels. Early in the Materiel Solution Analysis phase, systems engineering efforts transform operational needs to system performance parameters and configurations. For example, suppose the established need is to "Kill a Tank." The objective is clear and achievable through numerous capabilities. Systems engineers perform tradeoffs, which ultimately define the preliminary system-level capabilities. In this case, the systems that will "Kill Tank" must be able to detect, maneuver, and shoot (see Figure 3). The Program WBS is not formed around these functional capabilities, but is developed out of the products that are expected to satisfy these requirements.

MATERIEL SOLUTION ANALYSIS

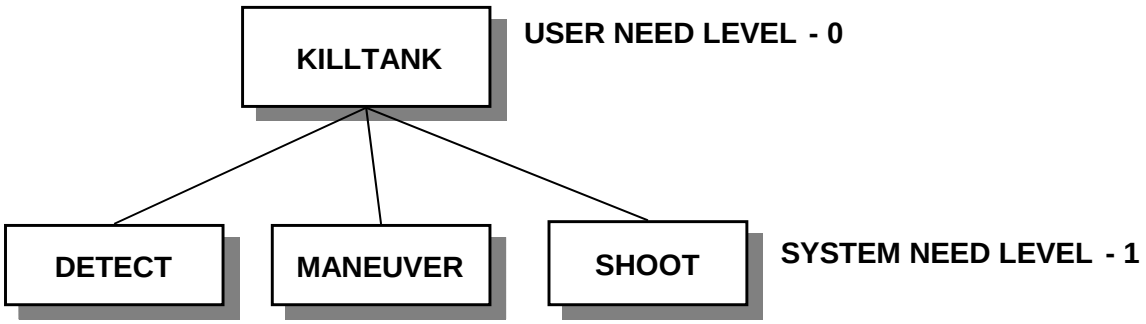

FIGURE 3. Capability Requirements in the Materiel Solution Analysis Phase

When the TD phase is initiated, the systems engineering development efforts will focus on technology requirements to meet system-level capabilities. Functional requirements are assigned under a system, all meeting the mission need of "Kill Tank." If Government laboratories or in-house engineering support is accomplishing this

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work, a statement of work (SOW) may be prepared for a request for support in the TD phase. Otherwise, this may have already been accomplished at the end of Materiel Solution Analysis phase to obtain contractual support for the TD phase.

The TD phase should describe the system and the configuration items that make up the system. Once the system concept is determined, then major subsystems and configuration items can be identified and lower level functions defined, so that lower level system elements can be created. Again, these are not WBS elements since they do not reflect a product. As an example, using the AoA process determined that a fire control system of an aircraft would be the best solution to meet the user need. The fire control system is functionally able to detect, aim, track, and fire (see Figure 4).

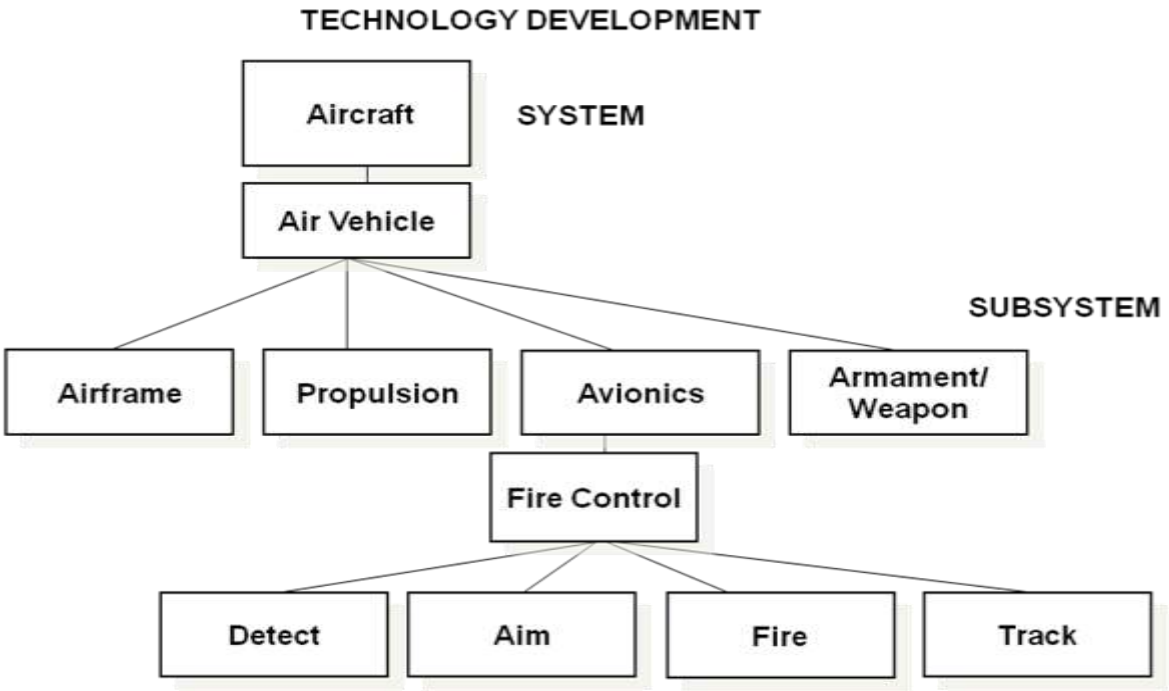

FIGURE 4. Identification of Major Subsystems and Functional Requirements

The relationship of the functions shown in this example can now be translated into products that will meet the user's requirement. The resulting Program WBS should be defined in accordance with Appendix A, Aircraft Systems WBS and Definitions.

The WBS now defines the solution to the problem in terms of a product. Figure 5 shows a simplified representation of the hierarchical relationship of the Aircraft System to the Fire Control Subsystem and to other elements. In practice, this WBS will be developed on the most refined technical representation of the end system available.

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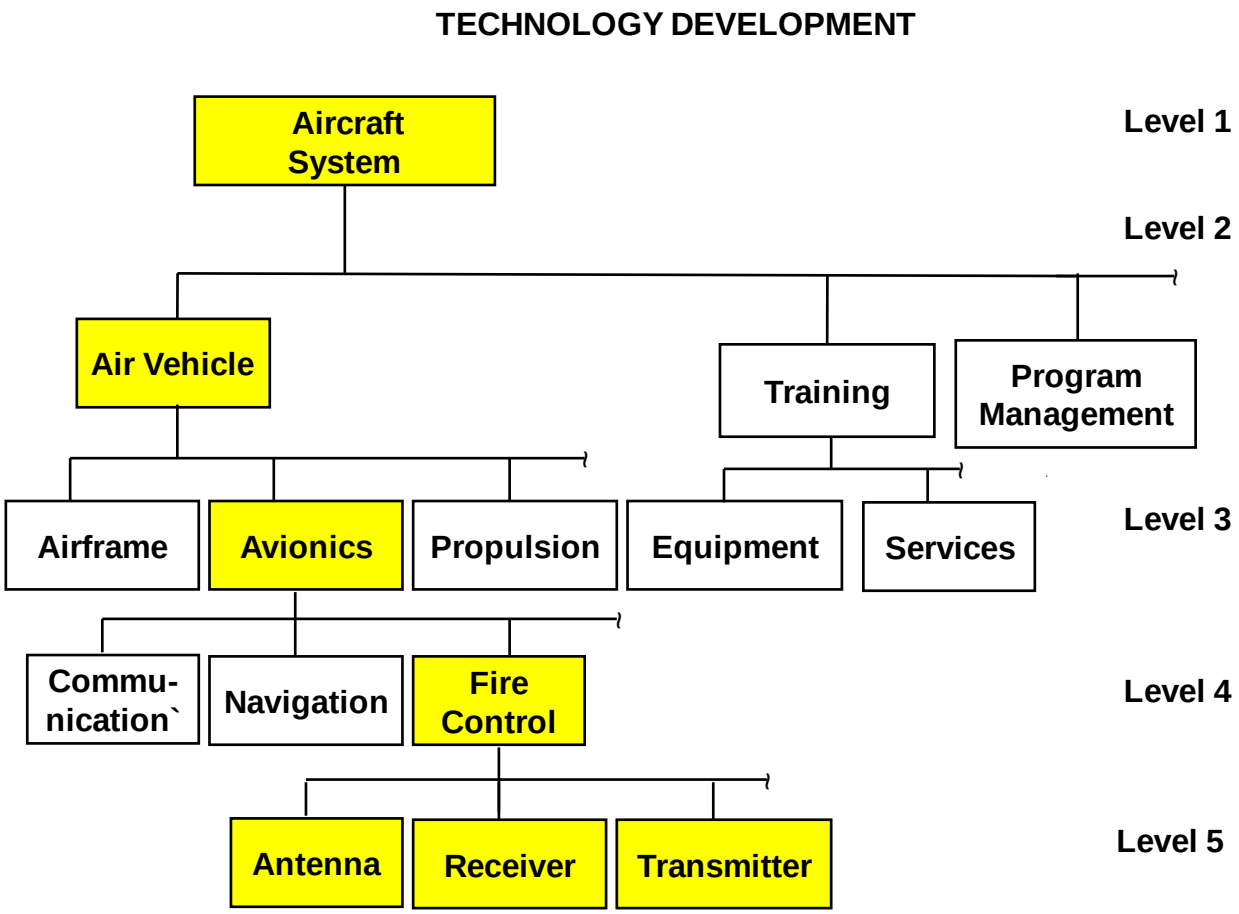

FIGURE 5. Program WBS Description

Since competitive prototyping is required to be accomplished in the TD phase, the TD units being developed and produced can be represented in the Program WBS. For ACAT I programs, the WBS should be approved by submitting a CSDR plan (as required by DoD Instruction 5000.02). The plan describes the Program WBS being used and defines the approach the Government activity plans to use for collecting cost data. After the Program WBS is approved by the Deputy Director, Cost Assessment within the Office of the Secretary of Defense (OSD) Cost Assessment and Performance Evaluation (CAPE), a request for proposals will be released with a proposed Contract WBS to each contractor developing prototypes. For all other ACAT programs, the designated Milestone Decision Authority will be the approving official.

Government and industry will work together during the TD phase to create an evolutionary acquisition strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in militarily useful increments, recognizing, up front, the need for future capability improvements. This means that programs using an evolutionary acquisition strategy need to establish the approved program's objective and threshold boundaries, and link among the cost, schedule, and performance parameters. The program manager (PM) manages the program within that trade space and the WBS is the key communication tool to support these requirements. The PM will use this information to develop an optimal product within the available trade space for each increment in the evolutionary process. As the TD phase ends and activities move into EMD, the best product that meets the cost, schedule, and performance parameters is defined to the level possible within the Government's approved Program WBS. A contract is awarded to the contractor whose solution best meets user needs and cost, schedule, and performance criteria. The Contract WBS is extended to the desired level, reflecting those items considered high-cost, high-risk and/or high technical interest as well as how the program is planned and will be managed.

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Entering EMD, two major efforts are accomplished: (1) an Integrated System Design (ISD) and (2) Post-CDR Assessment (see Figure 6). The ISD effort is intended to define system functionality and interfaces, complete hardware and software detailed design, and reduce system-level risk. It also includes the establishment of the product baseline for all configuration items. Therefore, the configuration of the entire system has been defined, the relationship between the Program WBS and the Contract WBS is developed at its lowest level, and management of the program is accomplished. Figure 7depicts a format suitable for documenting the subdivision of a program's work breakdown structure into contract work breakdown structures for each contractor/source. In the example below, the program work breakdown structure Level 4 element, Fire Control becomes Level 1 of the contract work breakdown structure, and all other Level 2 common program work breakdown structure elements (reference Appendix L) are included at Level 2 of the contract work breakdown structure. A separate contract for a Level 4 program work breakdown structure element, such as Aircrew Training Device, also follows the same procedure. The same contract work breakdown structure drawn from the program work breakdown structure will be used for each phase (development and production) of a program. At this point, the WBS is linked to major products and systems and fully integrated with the contractor's systems engineering, program management and financial functions. Figure 8 provides an example of a resulting system configuration, which reflects the Contract WBS to be delivered.

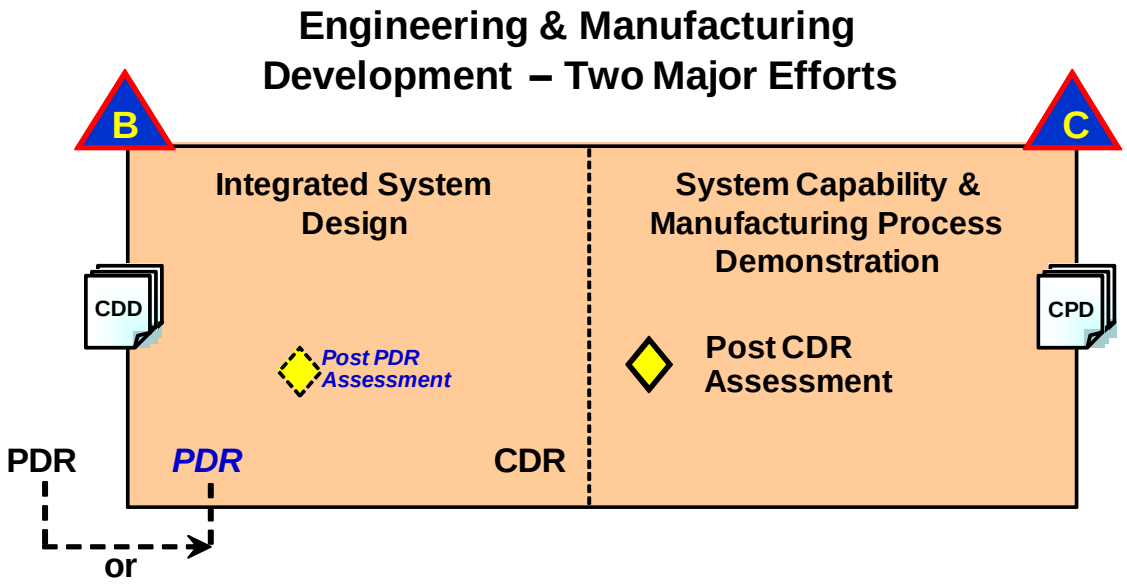

FIGURE 6. EMD Requirements

The Post-CDR Assessment effort is intended to demonstrate the system's ability to operate, while still consistent with the approved Key Performance Parameters (KPPs), and that system production can be supported by demonstrated manufacturing processes. Effort ends when: (1) the system meets approved requirements and is demonstrated in its intended environment using the selected production-representative article, (2) manufacturing processes have been effectively demonstrated, (3) industrial capabilities are reasonably available, and (4) the system meets or exceeds exit criteria and Milestone C entrance requirements.

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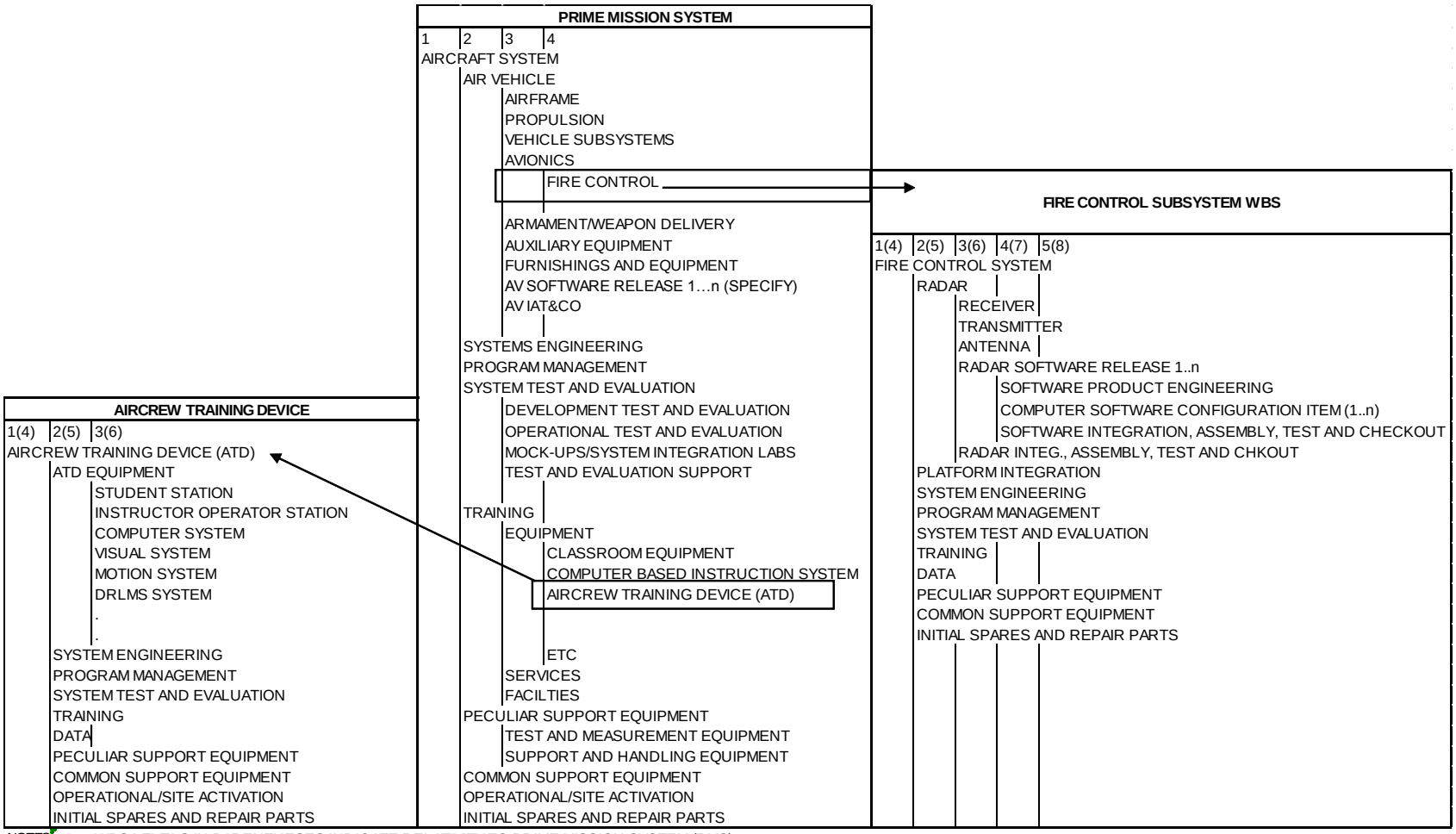

NOTES:
1. WBS LEVELS IN PARENTHESES INDICATE RELATIVITY TO PRIME MISSION SYSTEM (PMS).
2. LEVEL 2 ELEMENTS (SYSTEM ENGINEERING/PROGRAM MANAGEMENT, SYSTEM TEST AND EVALUATION, ETC.) FOR SUBSYSTEMS OF THE PMS ARE CONTAINED IN (I.E., ARE SUBELEMENTS OF THE SUBSYSTEM ELEMENT NOT THE PMS LEVEL 2 ELEMENT
3. PLACEMENT OF THE SUBSYSTEM IN THE PROGRAM WORK BREAKDOWN STRUCTURE IS RELATIVE TO ITS WBS BREAKOUT FOR CONTRACT APPLICATION

FIGURE 7. Work Breakdown Structure Matrix (Contract WBS)

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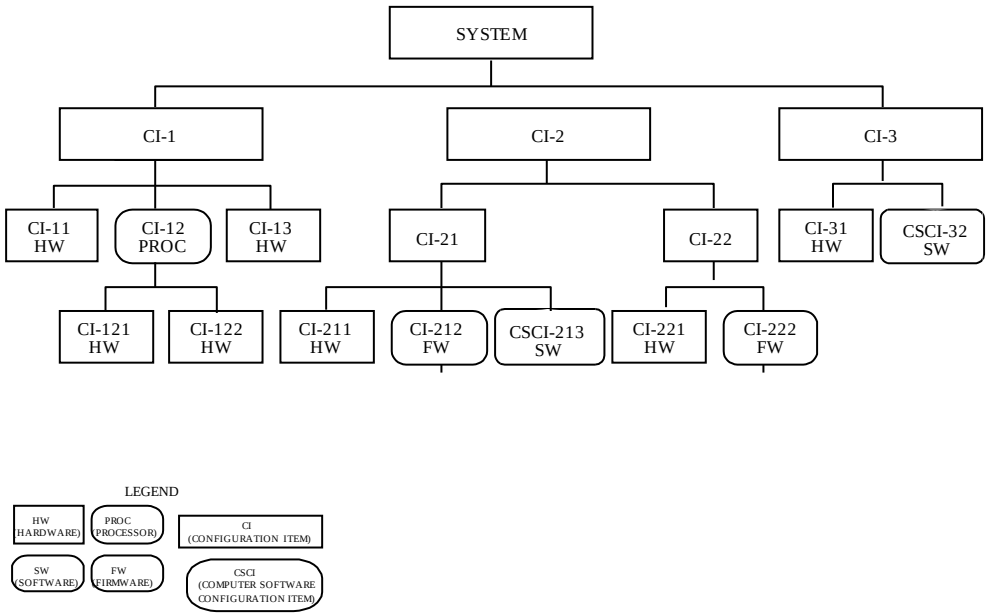

FIGURE 8. Example of System Configuration Documentation

During the Production and Deployment phase, the system is produced as defined in previous phases. The system's engineering efforts are actively involved in maintaining control over the system configuration as it is produced. The WBS is defined to the level appropriate for contract management and maintenance. When major modifications occur, the same WBS can be tailored or, if the changes are substantial, a new WBS can be developed according to the same rules.

2.2.4 Creating the WBS Dictionary. As part of developing a Program WBS, the program manager will also develop a WBS dictionary. The dictionary lists and defines the WBS elements. Although initially prepared by the Government program manager, the contractor expands the dictionary as the Contract WBS is developed. The WBS dictionary will be developed starting with the generic definitions in this Standard, and made program-specific to define the products being acquired to support effective Program Management by the contractor and to meet essential Request for Proposal (RFP) requirements.

The dictionary shows the hierarchical relationship of the elements and describes each WBS element and the resources and processes required to produce it. It also provides basic technical characteristics for the WBS elements and provides a link to the detailed technical definition documents. The WBS dictionary is routinely revised to incorporate changes and must reflect the current status of the program throughout the program's life.

2.2.5 Avoiding Pitfalls in Constructing a WBS. An effective WBS clearly describes what the program manager intends to acquire. It has a logical structure and is tailored to a particular defense materiel item. It serves as a common thread among the specifications, SOW, Contract Line Item Number (CLIN) structure, IMS, IMP, EVMS and Risk Management. Remember, the WBS is product-oriented; addressing the products required, not the functions or costs associated with those products.

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2.2.5.1 Requirement for WBS Element Exclusions.

Only include elements that are products (hardware, software, services, data, and facilities). A signal processor, for example, is a product, as are mock-ups and Computer Software Configuration Items (CSCIs) or Software Configuration Items (SCIs). On the other hand, items like design engineering, requirements analysis, test engineering, aluminum stock, and direct costs are not products. Design engineering, test engineering, and requirements analysis are all engineering functional efforts; aluminum is a material resource and direct cost is an accounting classification. Thus, none of these elements are appropriate WBS elements.

Program acquisition phases (for example, EMD, Production and Deployment) and types of funds used in various phases (for example, Research, Development, Test and Evaluation) **are inappropriate WBS elements**.

Rework, retesting and refurbishing are not separate WBS elements. They should be treated as part of the appropriate WBS element affected.

Nonrecurring and recurring classifications are not WBS elements. The reporting requirements of the Contractor Cost Data Report (CCDR) will segregate each element into its recurring and nonrecurring parts. These efforts should be included in the cost of the item they affect, not captured separately.

Cost saving efforts, such as total quality management initiatives, acquisition reform initiatives, and warranty, etc. are not part of the WBS. These efforts should be included in the cost of the item they affect, not captured separately.

Do not use the organizational structure of the program office or the contractor's organization as the basis of a WBS.

Generic terms are inappropriate in a WBS. The WBS elements must clearly indicate the actual system names and nomenclature of the product to avoid semantic confusion. For example, if the Level 1 system is Fire Control, then the Level 2 item (prime mission product) is Fire Control Radar.

Recurring units of the same end item. This is captured by a unit cost report, learning curve report or CLIN if required.

Tooling is not a WBS element. Tooling (e.g., special test equipment, automatic test equipment, and factory support equipment like assembly tools, dies, jigs, fixtures, master forms, and handling equipment) must be included in the functional cost, if possible, of the equipment being produced. If tooling is used for more than one component/subassembly, the percentage usage will be apportioned to the component/subassembly as appropriate. Programming costs for production automatic test equipment (ATE) must be included here. If the tooling cannot be assigned to an identified subsystem or component, it will be included in the cost of integration, assembly, test, and checkout.

2.2.5.2 Additional Considerations. Include software costs in the cost of the equipment. For example, when a software development facility is created to support the development of software, the effort associated with this element is considered part of the CSCI it supports or, if more than one CSCI is involved, the software effort should be included under integration, assembly, test, and checkout. Software developed to reside on specific equipment must be identified as a subset of that equipment.

Integration, assembly, test, and checkout includes production acceptance testing (including first article test) of Research and Development (R&D) and production units but excludes all systems engineering/program management and system test and evaluation that are associated with the overall system.

This Standard does not identify Level 3 elements for the systems engineering or program management WBS elements. This grants the program manager and contractor the flexibility to identify efforts that are important to the specific program. The definitions in Appendix L illustrate typical systems engineering and program management efforts.

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System test and evaluation must always separately identify tests performed in the development of a system (e.g., Developmental Test and evaluation), and tests performed by the operational user (e.g., operational test and evaluation).

2.3 Solicitation and Proposal. The WBS used for a solicitation must be structured by selecting appropriate elements from the approved Program WBS. The CLINs, configuration items, contract SOW tasks, contract specifications, and contractor responses will be expressed in terms of the WBS to enhance its effectiveness in satisfying the objectives of the acquisition. The relationship of the Contract WBS elements to the SOW and the CLINs must be clearly traceable. A one-to-one relationship might not exist, nor is it required.

2.3.1 Contractor Management Control System. The Contract WBS will serve as the framework for the contractor's management control system. That system will provide auditable and traceable summaries of internal data generated by its performance measurement procedures.

2.3.2 Acquisition Logistics. The acquisition logistics elements will be accommodated in the WBS that they support. These areas are included as part of other WBS elements and reflect the work that needs to be accomplished. For example, acquisition logistics management can be identified as part of the program management, and contractor logistics support would support site activation. Areas for consideration include: (1) acquisition logistics management and reporting, (2) contractor logistics support, (3) peculiar support equipment, (4) initial spares, support data, and training, and (5) transition to sustainment (Operations and Support (O&S) phase).

2.3.3 Planning, Programming, Budgeting, and Execution (PPBE) System. The Program WBS will be the basis for program element data to support the PPBE submittals.

2.3.4 Life-Cycle Cost. Life-cycle cost (LCC) is the total cost for the weapons or support for defense acquisition system research and development (R&D), investment, operation and support (O&S), and disposal. LCC commences at program initiation and ends with retirement or demilitarization and disposition of the system. The established WBS requirements in this standard are associated with those acquisition LCC phases of R&D and investment that are applicable to all contracted efforts.

2.3.5 Procurement. The following will be relatable to elements of the program work breakdown structure:

a. Structure of work statements
b. Contract work breakdown structures
c. Contract line items
d. Configuration items
e. Technical and management reports
f. Government-furnished items

2.3.6 Reporting. All program status reporting requirements will be consistent with the Program WBS.

2.4 Contract Statement of Work (SOW). A standardized WBS is an effective template for constructing the SOW for a system acquisition; it helps to streamline the process. The WBS structure provides a framework for defining program technical objectives. Together with the contract SOW, the WBS aids in establishing an indentured data listing (specification tree), defining configuration items, and planning support tasks. The SOW is the document that describes, in clear and understandable terms, what products are to be delivered or what services are to be performed by the contractor. Preparation of an effective SOW requires a thorough understanding of the products and services needed to satisfy a particular requirement. An explicitly written SOW facilitates effective contractor evaluation. After contract award, if the SOW is absorbed into the IMP, and if the associated tasks and schedule are absorbed into the IMS, the IMS and EVMS become better measures of contractor performance. The WBS also provides a logical arrangement of SOW elements, serving as a convenient checklist to ensure the contractor addresses all necessary program elements and meets specific contract reporting needs.

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2.5 Request for Proposals (RFP).

2.5.1 Preparing a Preliminary Contract WBS. The DoD program manager will select the individual WBS elements from the Program WBS that apply to the contract to include in the RFP as described in Section 2.3. This is the first opportunity for open dialogue between the Government and potential contractors. Acquisition approaches (e.g., a Performance Based Acquisition strategy) need to be outlined in the RFP and be inclusive to how the Government will measure technical performance. Technical measures of performance can be allocated to WBS elements. Innovative ideas or promising alternative solutions should be considered for inclusion in the RFP. The RFP will include a Contract WBS and the initial WBS dictionary. The RFP will instruct potential contractors to extend the selected Contract WBS elements to define the complete contract scope, consistent with the contractor's proposed approach for executing the program.

2.5.2 RFP Solicitation Requirements. CLINs, configuration items, contract work statement tasks, contract specifications, and contractor responses should relate to the WBS so as to enhance its effectiveness in fully describing acquisition objectives. It is important to coordinate the development of the Program WBS and the CSDR plan with the development of the SOW to ensure consistency in document structure. When aggregated with the Program WBS, the extended Contract WBS will form a complete Program WBS, thus providing a logical work flow throughout the acquisition cycle.

2.5.3 Extended Contract WBS. Contractors are expected to extend the Contract WBS to the appropriate lower level that satisfies critical visibility requirements and does not overburden the management control system. A preliminary government approved contract WBS should be included in the RFP and the contractor should provide comments on the adequacy of the CSDR contract plan WBS and submit revised WBS with their proposal if necessary. The proposal will be based on the WBS in the RFP, although contractors should be encouraged to suggest changes needed to meet an essential RFP requirement or to enhance the effectiveness of the Contract WBS in satisfying program objectives.

2.6 Integrated Cost, Schedule, and Technical Performance and Risk Management. Planning tasks by WBS elements serves as the basis for mapping the technical baseline, estimating and scheduling resource requirements, and mitigating risks. By breaking the system into successively smaller entities, program managers can ensure all required products and system components are identified in terms of cost, schedule, and performance goals in order to reduce risk.

Time phasing performance budgets, assigning them to work segments, and identifying responsible units produces a plan against which actual performance can be measured. Corrective action can be taken to resolve deviations from the plan. This integrated approach to work planning also simplifies identifying the potential cost and schedule impacts of proposed technical changes.

3. CONTRACTOR INSTRUCTIONS

3.1 Developing the Contract WBS. The Contract WBS provides the framework for the contractor's management control system. It must be tailored to the program so that it does not unnecessarily constrain the contractor in meeting defined contract requirements.

3.1.1 Relationship of Program WBS to Contract WBS. The Program WBS captures all efforts of a program to include contract and government efforts. Program WBS elements that will be contracted are reflected in the Contract WBS. The contracted system therefore will be identified at Level 1 of the Contract WBS with all applicable Level 2 Common WBS elements included. Figure 9 depicts the development and relationship of the Program WBS with the Contract WBS. In this example, the Government activity is responsible for the FX Aircraft System reflected by the Program WBS. The Government activity has determined that it will award a contract for the Fire Control System, as reflected by the Contract WBS. Figure 9 identifies the propulsion system as GFE and therefore is captured in the Program WBS. Other Government efforts supporting the program as a whole, such as support from the Air Force Operational Test and Evaluation Center would also be captured in the Program WBS within the Operational Test and Evaluation efforts. Only contract efforts will be captured within the Contract WBS, while both the Government efforts and contract efforts will always be captured in the Program WBS.

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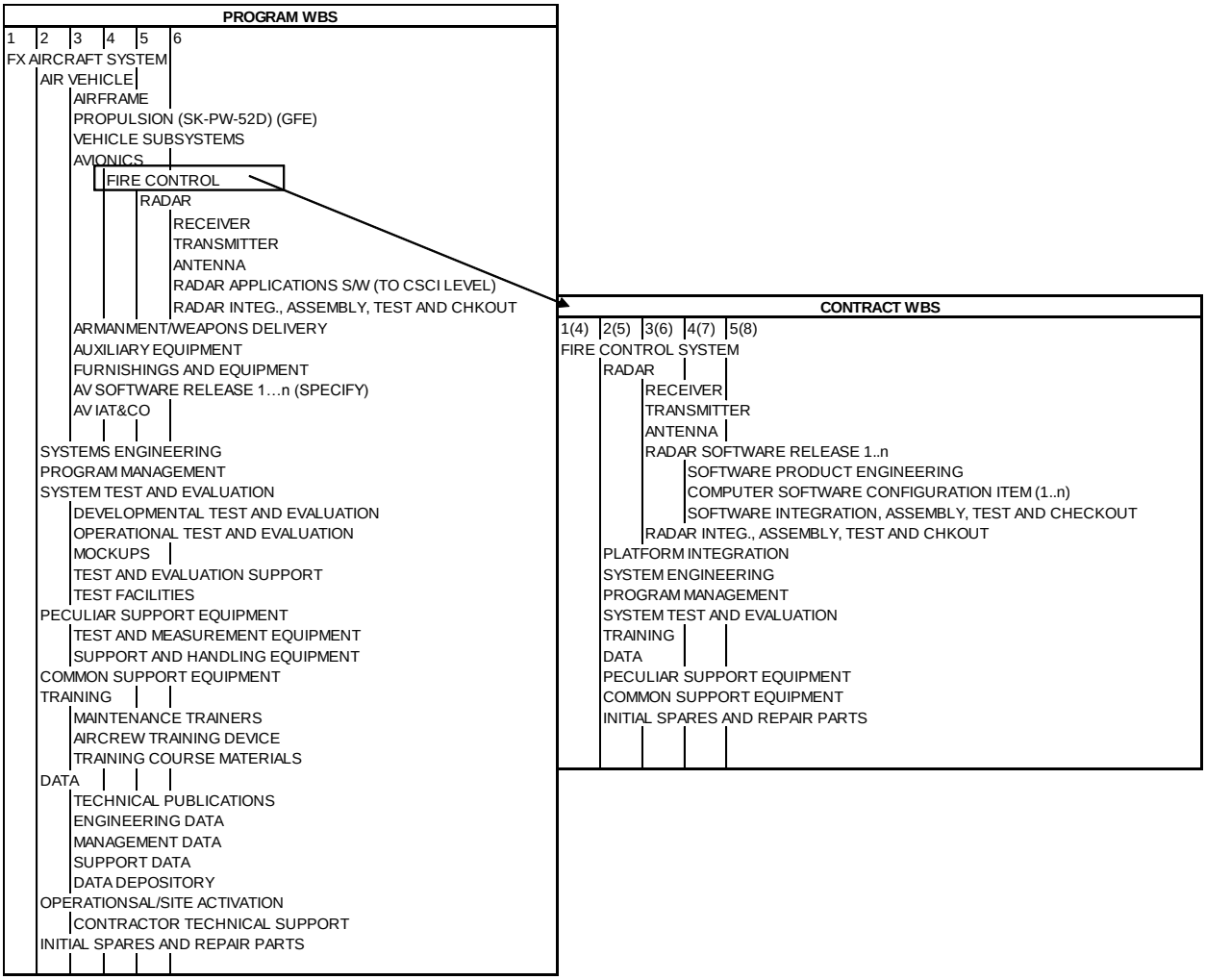

FIGURE 9. Relationship of Program WBS to Contract WBS

3.1.2 Subcontractors. When a contract is awarded to a Prime contractor, the Prime will require subcontractors that meet reporting threshold requirements to use the WBS to fulfill contractual requirements and control the subcontracted effort. The Prime or associate contractor is responsible for incorporating WBS requirements into the subcontract. Using the example in Figure 9, the Fire Control System was awarded to a Prime contractor. The Prime has further determined that it requires the Antenna System to be subcontracted. Figure 10 shows how the Prime contractor further defined the Antenna System and created a subcontract WBS for the sub work to be managed. To summarize, the FX Aircraft System is represented by the "Program" WBS, which is used by the Government to manage the FX Aircraft System Program. The Government contracts with the Prime contractor for the Fire Control System and that effort is the Contract WBS for the Prime contractor (Figure 9). The Prime contractor then subcontracts the antenna of the Fire Control System and a WBS is created to support the Antenna System subcontracted efforts (Figure 10).

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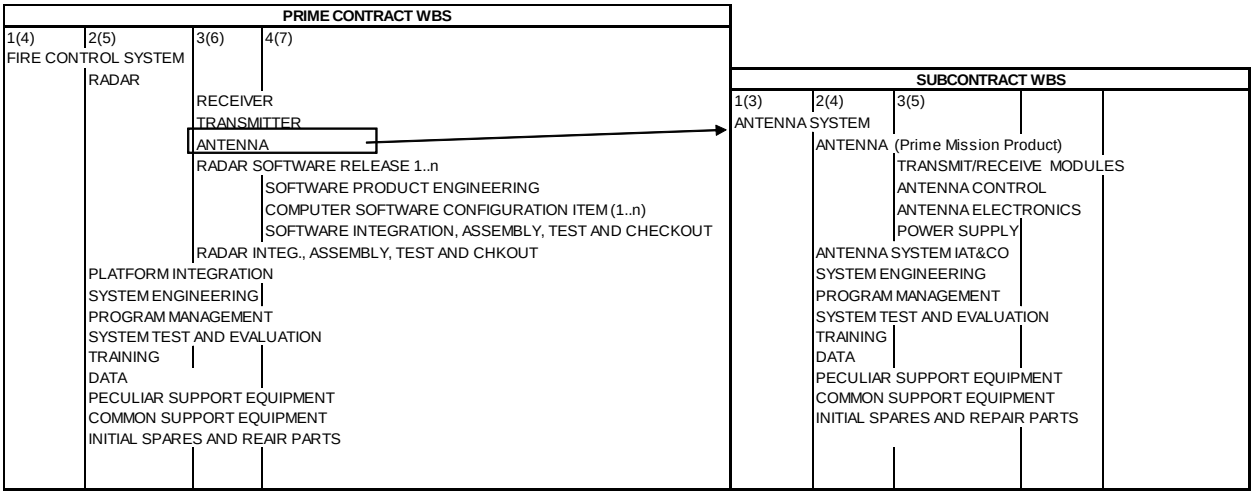

FIGURE 10. Relationship of Contract WBS to Subcontract WBS

3.1.3 Contractor's Organizational Structure. A WBS must not be influenced by a contractor's program organization. The contractor can organize according to corporate standards and still effectively use a valid, product-oriented WBS.

3.1.4 Control Account Level. To provide the responsible contract manager with technical, schedule, and other needed resource information, the management control system must be keyed to the same WBS element and organizational unit. The WBS level at which the management control system is established is primarily a function of the magnitude of the program and the type of product required by the contract. The responsible organizational level is a function of the company's management span of control and upper management's desire to delegate the responsibility for WBS elements to lower management levels. In identifying control accounts, the contractor is expected to establish organizational responsibilities at meaningful and appropriate levels. Otherwise, the contractor's existing management control system and responsibility assignments may be affected adversely.

Virtually all aspects of the contractor's management control system (i.e., technical definition, budgets, estimates, schedules, risk management, work assignments, accounting, progress assessment, problem identification, and corrective actions) come together at the control account level. Performance visibility is directly relatable to this level of detail.

As the end product is subdivided into smaller sub-products at lower WBS levels, the work effort required by each element should be identified and assigned to functional organizational units. The contractor will assign management responsibility for technical, schedule, and other performance criteria at lower levels within the WBS. The management control system will keep the lower levels of the WBS visible as it intersects with the organizational structure. At the juncture of the WBS element and organization unit, control accounts and work packages are established and performance is planned, measured, recorded, and controlled. To this end, the technical requirements for the work and work product must be specified; the work scheduled, budgeted, and performed; and attainment of specified technical requirements verified.

As Figure 11 illustrates, at some level in a contractor's organization there is a point at which a control account is managed. Likewise, in any WBS the same point exists. Therefore, every part of a WBS is visible or accessible regardless of the contractor's organization.

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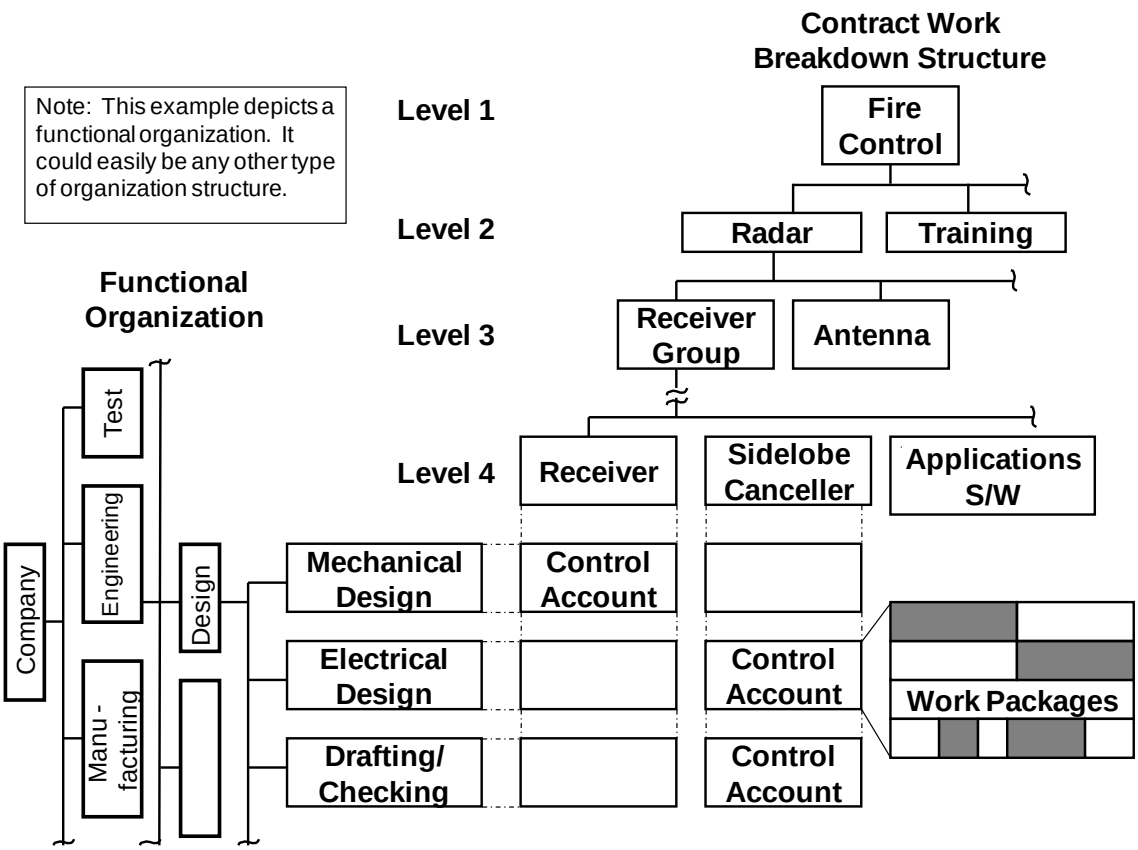

FIGURE 11. Translation from Function to Product

For example, the management information needed by the Government to manage the development of a radar receiver is available from the control accounts that are part of that effort's WBS. The information the contractor needs to manage the development is available from the same control accounts, which in this example are a part of the contractor's Electrical Design Department.

Figure 12 illustrates the same example but uses an Integrated Product Team (IPT)-structured organization and its interface with the Contract WBS.

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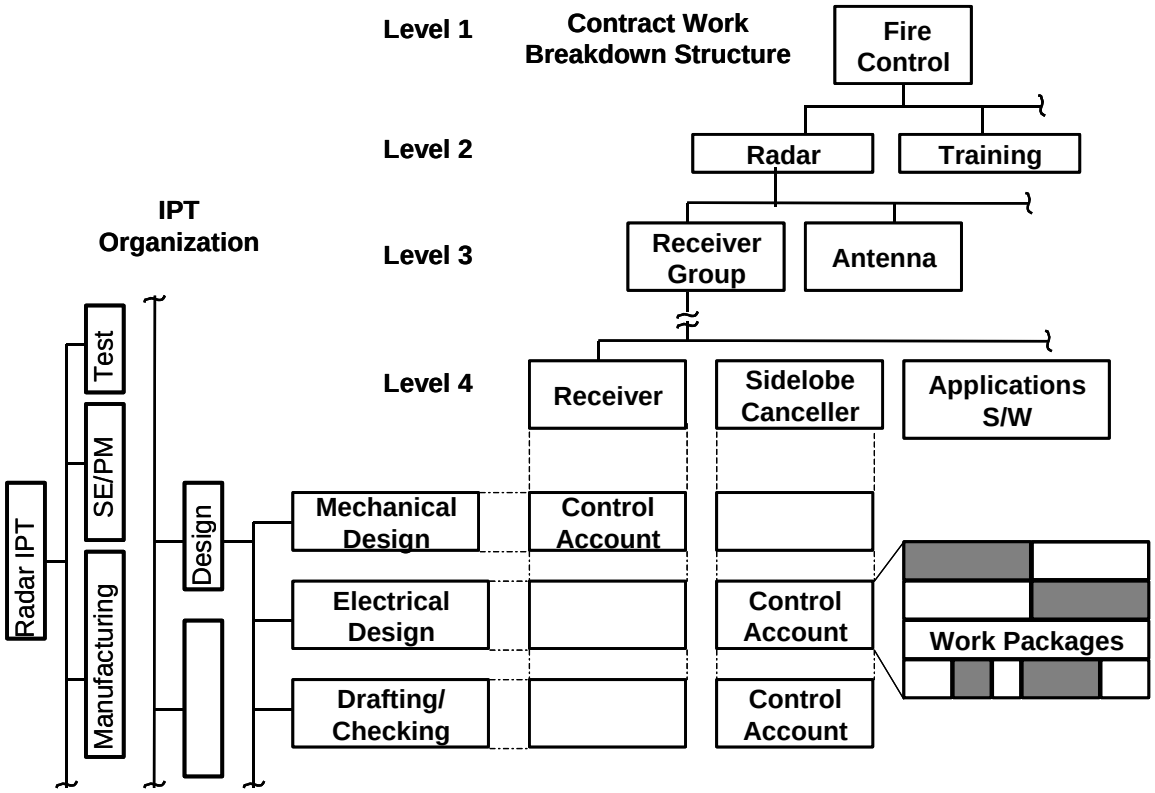

FIGURE 12. IPT Intersection with Contract WBS

3.2 Programmatic Issues in WBS Development.

3.2.1 System of Systems (SoS). A program can either have stand-alone systems or have interfaces with other systems, such as a fighter aircraft that has interfaces with the ordnance it carries. The aircraft and ordnance programs, traditionally separate, will each have a separate Program WBS. In a SoS program, such as the Missile Defense Program or the Cheyenne Mountain Complex, the program is actually a collection of systems and thus the Program WBS at the first tier will consist of the various systems that make up the SoS structure. A SoS Program will require the development of multiple system WBS definitions, found in Appendices A through L. SoS should be treated and managed as a system in their own right, and should therefore be subject to the same systems engineering processes and best practices as applied to individual systems. In this manner, the WBS requirements of a system also apply to a SoS.

Understanding the parent-child type relationship of various related programs and contracts and their impact on the WBS is important in the ever-increasing integrated and joint program environment. Often, individually baselined programs and their various prime or GFE elements are actually part of a SoS approach. The overall parent program, the SoS or joint program, needs to be associated with the various child programs. Each child program would develop a stand-alone WBS structure. The various child WBS elements then would be identified at Level 2 or 3, as appropriate, in the overall parent program. In some cases, common systems will be a child program to different parent programs and may actually enter the parent WBS as a different level. In any case, the parent-child relationship should be thought through and understood by the parent program and the various child programs. The parent-child challenge will repeat itself in the Contract WBS as the Prime contractor decides to subcontract various portions of the system. Each substantial subcontract will in essence create a program for the subcontract and thus create a parent-child relationship between the Prime and the subcontractor.

3.2.2 Family of Systems. A family of systems is a grouping of systems having some common characteristic(s). For example, each system in a family of systems may belong to a domain or product line (e.g., a family of missiles, surface vehicles, aircraft, or situation awareness systems), each having a level of commonality

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and unique variants. In general, a family of systems is not considered to be a system per se because it does not necessarily create capability beyond the additive sum of the individual capabilities of its member systems. A family of systems lacks the synergy of a SoS. The family of systems does not acquire qualitatively new properties as a result of the grouping. In fact, the member systems may not be connected into a whole.

Developing a WBS for a program that has multiple variants and varying levels of commonality can result in a WBS that is very long. This result is realized when the WBS for a particular defense materiel item (e.g., aircraft, missile, surface vehicle, etc.) is replicated for each unique variant and the degree of commonality between each unique variant.

3.2.3 Intelligence Requirements and Related Costs. Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing component cost estimating processes.

3.2.4 Software and Software Intensive Systems. It is important to recognize the fundamental distinction between two types of software acquisition: 1) software embedded on a weapon system and 2) Automated Information Systems. Both of these are an increasingly important part of DoD acquisition, but affect the process in different ways and should therefore be treated differently from a WBS perspective.

3.2.4.1 Automated Information Systems (AIS). For AIS, the software is itself the end-item. Further, AIS are typically not production items. Rather, Milestone C reflects the point at which the developed system is deployed rather than produced. This results in a WBS that is of a much different nature for post-Milestone C effort than pre-Milestone C. An AIS will not likely be deployed according to the same WBS by which it was developed. For AISs such as business systems, Enterprise Resource Planning (ERP), and Service Oriented Architecture (SOA) use Appendix K.

3.2.4.2 Software Operating on Specific Equipment. Multi-function software will be identified as a subset of the equipment WBS element, which either includes the software in the element specification or exercises the most critical performance constraint. In cases where a conflict exists between selecting either the element specification or that which exercises the most critical performance constraint, selecting the specification relationship will take precedence. For example, an aircraft's electronic equipment typically has software included in each of the subsystem elements. Software that resides and interfaces with more than one piece of equipment (for example, applications software and overall system software, which facilitates the Operations and Maintenance (O&M) of the computer systems and associated programs), will be called out at the appropriate work breakdown level. For example, elements of software development often are high technical risk and high cost. Since all critical system software should be identified, it may be appropriate to collect lower level information.

All integral software should be included in a Program or Contract WBS in conjunction with the hardware it supports. This allows for effective performance measurement and management control. When needed, a contractor's management system can use an identifier for each software element to produce summaries for software management purposes.

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3.2.4.3 Visibility into Software Development Processes. Because the WBS has a product-oriented hierarchy, its progressive subdivision will result in common management or functional tasks (for example, development processes, etc.) occurring in many WBS elements. Software may be widespread throughout the WBS and represent high risk in the contract. In such cases, the program manager should require specific visibility into software performance, but care must be taken to not overly complicate the Contract WBS and the contractor's management system. Appropriate reporting requirements should be specified in the SOW.

As Figure 13 shows, the contractor's management system and the WBS will provide critical detail and visibility of key software development processes (for example, requirements analysis, design, code and test, etc.) without extending the WBS to excessively low levels or developing a separate WBS for software. The required information can be aggregated for reporting as needed using the contractor's management system.

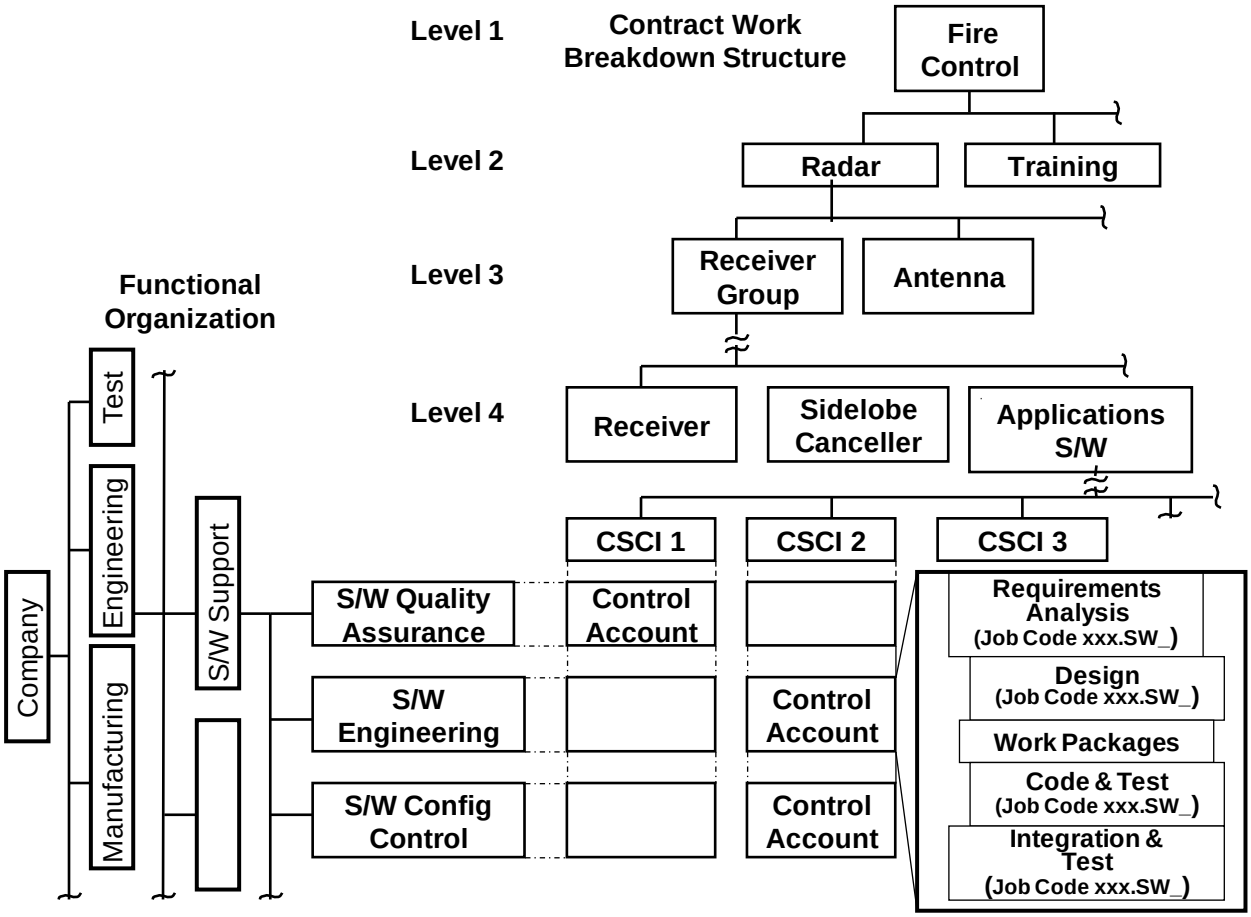

FIGURE 13. Linkage Between Contractor WBS and Contractor Management Systems

3.2.5 Integrated Master Plan and Integrated Master Schedule (IMP/IMS)

3.2.5.1 Integrated Master Plan (IMP). The IMP is an event-based plan consisting of a hierarchy of program events, with each event being supported by specific accomplishments and each accomplishment associated with specific criteria to be satisfied for its completion. The IMP should provide sufficient definition to allow for the tracking of the completion of required accomplishments for each event and to demonstrate satisfaction of the completion criteria for each accomplishment. In addition, the IMP demonstrates the maturation of the design/development of the product as it progresses through a disciplined systems engineering process. IMP events are not tied to calendar dates; each event is completed when its supporting accomplishments are completed and when this is evidenced by the satisfaction of the criteria supporting each of those accomplishments. The IMP is

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placed on contract and becomes the baseline execution plan for the program/project. The IMP is a relatively top-level document in comparison to the IMS.

3.2.5.2 Integrated Master Schedule (IMS). The IMS flows directly from the IMP and supplements it with additional levels of detail. It incorporates all of the IMP's events, accomplishments, and criteria; to these activities it adds the detailed tasks necessary to support the IMP criteria along with each task's duration and its relationships with other tasks. The IMS supports multiple views (for example, event-based, WBS-based) to support the user's needs. This network of integrated tasks, when tied to the start date (for example, contract award), creates the task- and calendar-based schedule that is the IMS. The IMS should be defined to the level of detail necessary for daily execution of the program/project.

3.2.5.3 IMP/IMS Linkage. The IMS is directly traceable back to the IMP and, where applicable, should also be traceable to the program's Contract WBS, SOW, EVMS, and risk management system. Both the IMP and the IMS should be consistent with the contractor's management and scheduling system structure and format. In general, the IMP can be thought of as the top-down planning tool and the IMS as the bottom-up execution tool for those plans. However, it should be noted that the primary purpose of the IMS is as a scheduling tool. It serves as a forecasting tool used to track technical performance and time phase the budget. Figure 14 illustrates these interrelationships.

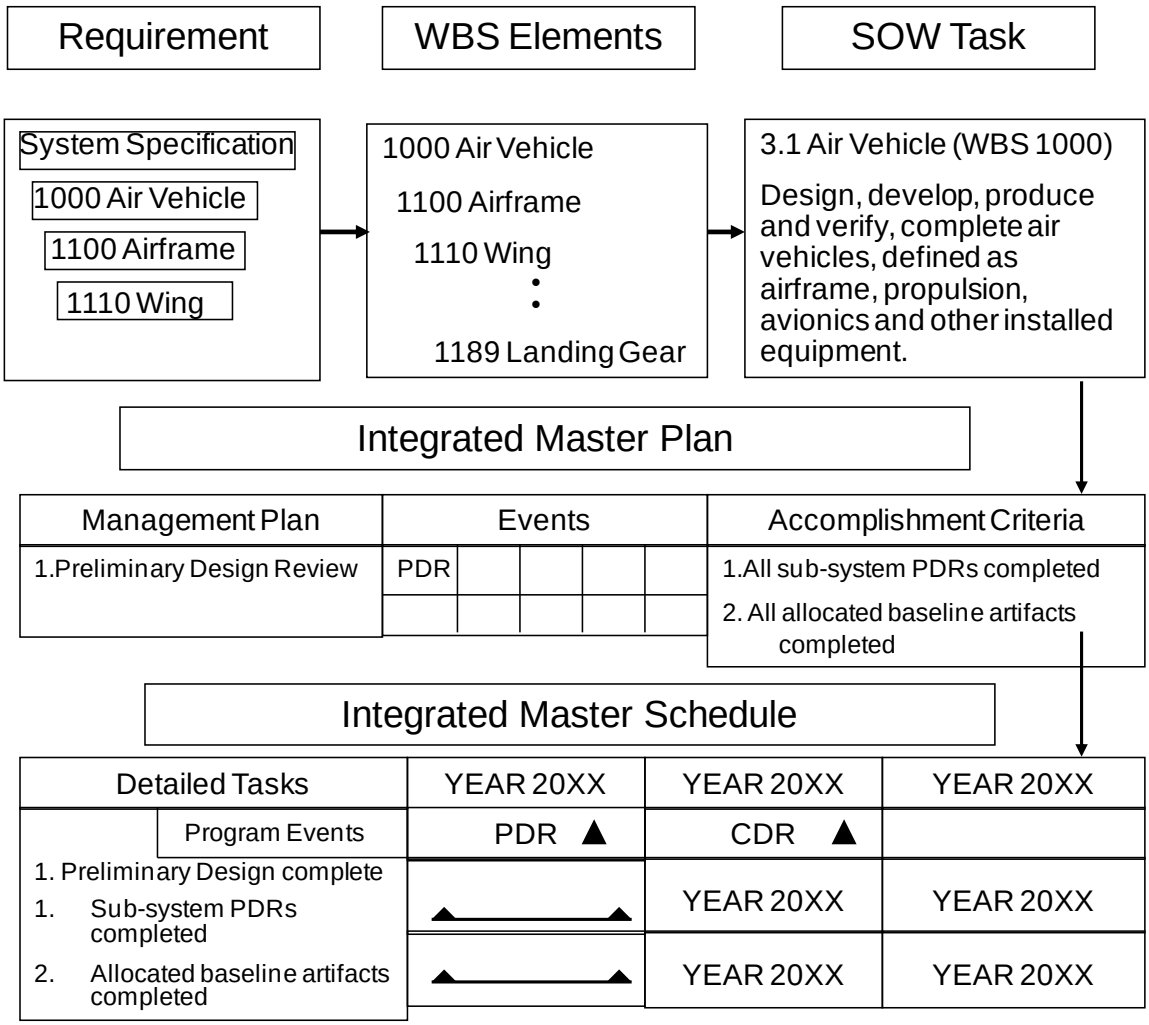

FIGURE 14. Relationship of IMP/IMS to WBS

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3.2.6 Use of Common Elements. Common WBS elements (for example, Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data (see Appendix L)) will be applied to the appropriate levels within the WBS they support. In other words, if systems engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports. For example, in Surface Vehicles common elements found at Level 2 of the WBS capture efforts associated with the "System" level as a total system (for example, training for the entire surface vehicle system). However, if training was required to support the Navigation and Remote Piloting System (Level 3 WBS element), the Training common element will also be associated with the element it supports (Navigation and Remote Piloting System) at Level 4 of the WBS. The training element should not be rolled into the "System" level training WBS element.

The intent is to understand the total effort associated with designing, developing, and producing a WBS element. Combining them into the "System" level misrepresents the true effort of delivering a complete Navigation and Remote Piloting System.

4. IMPLEMENTATION OF CONTRACT WORK BREAKDOWN STRUCTURE

The Contract Work Breakdown Structure (CWBS) included in a successful proposal serves as the basis for negotiating a Government-approved Contract WBS. The contractor may have proposed alternate approaches to accomplish the contract objectives. If the Government program manager accepts the alternatives, the Program WBS will require revision to reflect those changes. If changes are significant and broad in scope, the changes made should be evaluated at an Integrated Baseline Review (IBR).

4.1 Contract Award and Contract WBS Approval. The requirement for providing the WBS dictionary using Data Item Description DI-MGMT-81334 (current version), "Contract WBS" identified in the Contract Data Requirements List (CDRL) is included in the contract development process. Additional WBS revisions may result from program changes. Additional contract elements will become the basis for contractor extension of the Contract WBS. The extension of the Contractor WBS should be negotiated by the contractor and Government at a CSDR conference according to the CSDR Manual (DOD 5000.04-M-1). Although there is no limit on the number of additional elements, each should be justified in terms of its contribution to effective program management. All extensions should be incorporated into the Contract WBS reporting level in the contract.

Users of this Standard should understand that the sequence described in the preceding paragraphs may be repeated as the program evolves, contracts are awarded, and the work effort progresses through major program phases. Revisions to the WBS are an essential component of this process. Whenever the WBS is revised, traceability to the previous WBS needs to be maintained. Once work begins, WBS changes should be controlled to preserve the cost baseline. The Contract WBS requires a contract modification before approved changes can be incorporated.

4.2 Reporting Relationships. The contractor maintains the Contract WBS, including change traceability. In accordance with the contract terms, only changes approved by the contracting officer may be incorporated. The contract will indicate levels of the Contract WBS at which costs will be reported to the Government. The contractor should determine those extended Contract WBS levels that are used to trace the cost accumulations for cost control purposes. In the extensions, consideration should be given to the specific contractual, technical, and managerial requirements of the defense materiel item. The contractor has complete flexibility to extend the Contract WBS below the reporting requirement to reflect how work is to be accomplished, assuming the additional elements are meaningful product or management-oriented indentures of a higher level element. For reporting purposes, the WBS is required to be the same for CCDR, CPR, IMP, and IMS related reporting. While reporting levels may be different for each report, the WBS should be the same at the level for which it is reported. For example, when the WBS is reported at Level 4 for a CPR and IMP, and Level 5 or below for the CCDR and IMS, the WBS should be the same for the CPR, IMP, IMS, and CCDR through Level 4. Level 5 and below as reported on the CCDR and IMS should maintain a product-oriented logical decomposition of those Level 4 WBS elements that are extended.

4.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is

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numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

4.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

4.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

4.4 Support for Management Activities. Within the scope of the WBS, the contractor has flexibility to use the work breakdown elements to support ongoing financial management activities. These may include EVM, cost estimating, and managing contract funds (see Figure 15).

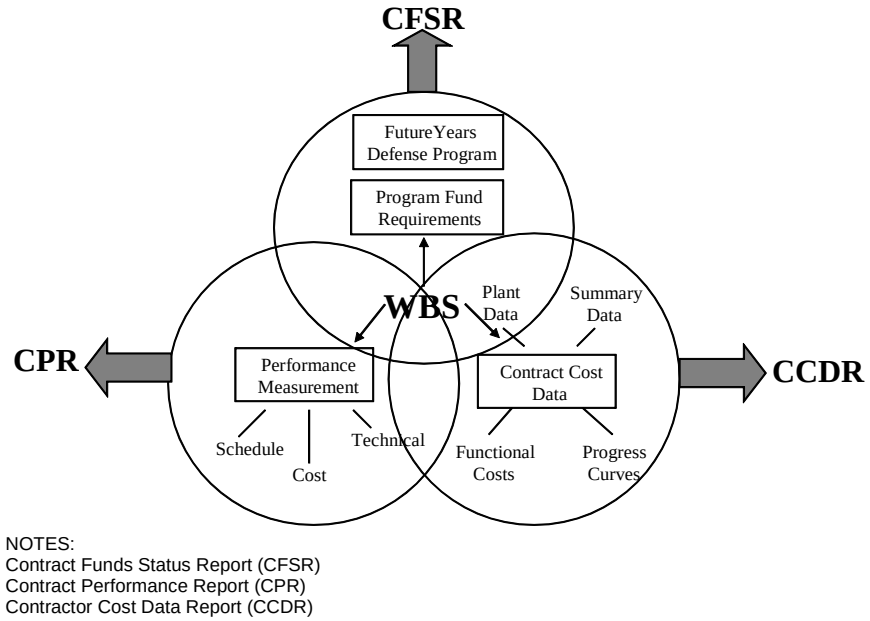

FIGURE 15. The WBS is the Basis for DoD Reporting Requirements

4.4.1 Earned Value Management (EVM). Cost performance measurement involves periodic comparison of actual costs with time-phased budgets, analysis of performance variances, and follow-up corrective action. When

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planned tasks are captured in a WBS element structure and time-phased as they are expected to be accomplished, the budgets associated with those tasks become the performance measurement baseline for EVM. EVM is a key integrated program management process in the management and oversight of Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS) Programs.

EVM data is reported using the Contract Performance Report (CPR). The CPR provides contract cost and schedule performance data that is used to identify problems early in the contract and forecast future contract performance. The CPR is the primary means of documenting the ongoing communication between the contractor and the program manager to report cost and schedule trends to date and to permit assessment of their effect on future performance. This report consists of the following five formats: (1) WBS, (2) Organizational Categories, (3) Baseline, (4) Staffing, and (5) Explanation and Problem Analyses. Format 1 provides data to measure cost and schedule performance by product-oriented Contract WBS elements for the hardware, software, data, and services the Government purchases.

4.4.2 Cost Estimating. Use of the WBS for cost estimating facilitates program and contract management aids the program office in planning, coordinating, controlling, and estimating the various program activities. It provides a common framework for tracking the estimated and actual costs during the performance of each contract. The data from the various program contracts support the DoD program manager in evaluating contractor performance, preparing budgets, and preparing program life-cycle costs.

The WBS also provides critical structure for cost reporting. The DOD 5000.04-M-1, CSDR Manual, relies upon the WBS to enable effective reporting of cost and software data on MDAPs. The requirements for cost reporting provided in this Standard are mandatory for all contracts within ACAT I programs regardless of contract type. Consequently, the guidelines for WBS construction specified in this Standard become directive in nature. This Standard also provides guidance for mandatory software reporting on ACAT I programs with significant software development content. Detailed guidelines for the Contract WBS are provided in Data Item Description DI-MGMT-81334C. This data item is invoked in the CDRL of the RFP and contract.

Cost estimating data is reported through the CCDR. The purpose of the CCDR is to collect historical program cost data in a joint service environment and use that data to estimate the cost of ongoing and future Government programs. The WBS, as the cornerstone of the cost estimating process, provides a logical breakdown of tasking necessary to accomplish program objectives. The WBS for ACAT I programs is approved using the CSDR Plan and data reporting uses the following CCDR reports based on the WBS: Cost Data Summary Report, Functional Cost-Hour Report, and Progress Curve Report, and a Software Resource Data Report.

4.4.3 Contract Funds Status. The purpose of the Contract Funds Status Report (CFSR) is to supply funding data by Line Item/WBS to the DoD program manager and the Contracting Officer's Technical Representative (COTR) for: 1) updating and forecasting contract funding requirements, 2) planning and decision making on funding changes in contracts, 3) developing funding requirements and budget estimates in support of approved contracts, 4) determining funds in excess of contract needs and available for deobligations, and 5) obtaining rough estimates of termination costs.

4.5 Summary. After contract award, at each point in the acquisition cycle, the Contract WBS continues to provide the framework for delineating the areas of responsibility and defining task requirements of the contract. The need for consistent program data must be satisfied in any further decomposition of the product-oriented Contract WBS developed by the contractor and should meet DoD needs for reasonably consistent program data. The Contract WBS format should be used as a starting point for continued tailoring. However, the same WBS will be utilized for the IMP, IMS, CPR, and CCDR as applicable.

5. NOTES SECTION

5.1 Intended Use. This Standard is directed primarily at preparing a WBS for a defense system program. This includes all systems, materiel items, or major modifications established as an integral program element of the Future Years Defense Program or otherwise designated by the DoD component or the Under Secretary of Defense (AT&L).

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The Standard is appropriate for use with any WBS developed for the Pre-Systems Acquisition (Materiel Solution Analysis, Technology Development) and Systems Acquisition (engineering and Manufacturing Development, Production and Deployment) life cycle phases. The Sustainment Phase (Operations and Support) is addressed only as it is included during the Systems Acquisition Phase. The Standard focuses on identifying how a WBS is developed and maintained throughout the Pre-Systems Acquisition and Systems Acquisition phases.

This Standard clearly delineates the overlapping responsibilities of DoD program managers and contractors relative to the execution of WBSs.

5.2 Associated Data Item Description

DID NUMBER	DID TITLE
DI-MGMT-81334 (Current Version)	Contract Work Breakdown Structure

5.3 Supersession Data. This Standard supersedes MIL-HDBK-881A dated 30 July 2005 and MIL-STD-881B dated 25 March 1993.

5.4 Subject Term (keyword) Listing.

Aircraft Systems
Automated Information Systems (AIS)
Contract Funds Status Report (CFSR)
Contract Work Breakdown Structure (WBS)
Contractor Cost and Software Data Reporting (CSDR)
Contract Performance Report (CPR)
Control Accounts
Cost Estimating Reporting
Earned Value Management (EVM)
Electronic Systems
Engineering Data
Integrated Master Plan (IMP)
Integrated Master Schedule (IMS)
Launch Vehicle Systems
Life Cycle Cost
Missile Systems
Ordnance Systems
Planning, Programming, Budgeting, and Execution (PPBE) System
Program Management
Program WBS
Request for Proposals (RFP)
Risk Management
Schedule
Sea Systems
Software
Space Systems
Surface Vehicle Systems

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Systems Engineering

System of Systems (SoS)

Unmanned Air Vehicle (UAV) Systems

Unmanned Maritime System (UMS)

Work Package

5.5 Changes from Previous Issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

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APPENDIX A: AIRCRAFT SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

A.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for aircraft systems. Definitions for WBS elements common to all defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

A.2 APPLICABLE DOCUMENTS

A.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

ANSI Standards can be found online at:
http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-1331
www.ieee.org

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A.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Aircraft System			
1.1		Air Vehicle		
1.1.1			Airframe	
1.1.1.1				Airframe Integration, Assembly, Test and Checkout
1.1.1.2				Fuselage
1.1.1.3				Wing
1.1.1.4				Empennage
1.1.1.5				Nacelle
1.1.1.6				Other Airframe Components 1..n (Specify)
1.1.2			Propulsion	
1.1.3			Vehicle Subsystems	
1.1.3.1				Vehicle Subsystem Integration, Assembly, Test, and Checkout
1.1.3.2				Flight Control Subsystem
1.1.3.3				Auxiliary Power Subsystem
1.1.3.4				Hydraulic Subsystem
1.1.3.5				Electrical Subsystem
1.1.3.6				Crew Station Subsystem
1.1.3.7				Environmental Control Subsystem
1.1.3.8				Fuel Subsystem
1.1.3.9				Landing Gear
1.1.3.10				Rotor Group
1.1.3.11				Drive Group
1.1.3.12				Vehicle Subsystem Software
1.1.3.13				Other Subsystems 1…n (Specify)
1.1.4			Avionics	
1.1.4.1				Avionics Integration, Assembly, Test, and Checkout
1.1.4.2				Communication/Identification
1.1.4.3				Navigation/Guidance
1.1.4.4				Mission Computer/Processing
1.1.4.5				Fire Control
1.1.4.6				Data Display and Controls
1.1.4.7				Survivability
1.1.4.8				Reconnaissance
1.1.4.9				Automatic Flight Control
1.1.4.10				Health Monitoring System
1.1.4.11				Stores Management
1.1.4.12				Avionics Software Release 1…n

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1.1.4.13		Other Avionics Subsystems 1…n (Specify)
1.1.5		Armament/Weapons Delivery
1.1.6		Auxiliary Equipment
1.1.7		Furnishings and Equipment
1.1.8		Air Vehicle Software Release 1…n
1.1.9		Air Vehicle Integration, Assembly, Test, and Checkout
1.2	System Engineering	
1.3	Program Management	
1.4	System Test and Evaluation	
1.4.1		Development Test and Evaluation
1.4.2		Operational Test and Evaluation
1.4.3		Mock-ups / System Integration Labs (SILs)
1.4.4		Test and Evaluation Support
1.4.5		Test Facilities
1.5	Training	
1.5.1		Equipment
1.5.2		Services
1.5.3		Facilities
1.6	Data	
1.6.1		Technical Publications
1.6.2		Engineering Data
1.6.3		Management Data
1.6.4		Support Data
1.6.5		Data Depository
1.7	Peculiar Support Equipment	
1.7.1		Test and Measurement Equipment
1.7.2		Support and Handling Equipment
1.8	Common Support Equipment	
1.8.1		Test and Measurement Equipment
1.8.2		Support and Handling Equipment
1.9	Operational/Site Activation	
1.9.1		System Assembly, Installation and Checkout on Site
1.9.2		Contractor Technical Support
1.9.3		Site Construction
1.9.4		Site/Ship/Vehicle Conversion
1.9.5		Sustainment/Interim Contractor Support
1.10	Industrial Facilities	
1.10.1		Construction/Conversion/Expansion
1.10.2		Equipment Acquisition or Modernization
1.10.3		Maintenance (Industrial Facilities)
1.11	Initial Spares and Repair Parts	

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A.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

A.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

A.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

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A.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

A.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

A.4 DEFINITIONS

A.4.1 Aircraft System. The complex of equipment (hardware/software), data, services, and facilities required to develop, produce, and support air vehicles.

Includes, for example:
a. Those employing manned fixed, movable, rotary, or compound wing

This excludes unmanned aircraft systems found in Appendix H.

A.4.2 Air Vehicle. The complete flying aircraft. It also includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use).

Includes, for example:
a. Airframe, propulsion, vehicles subsystems, avionics systems and all other installed equipment

A.4.2.1 Airframe. The assembled structural and aerodynamic components of the air vehicle that support subsystems essential to designated mission requirements.

Includes, for example:
a. Basic structure: fuselage, wing, empennage, fuselage, and nacelle
b. All administrative and technical engineering labor to perform integration of level 4 air frame elements; development of engineering layouts; determination of overall design characteristics, and determination of requirements of design review

Excludes, for example:
a. All effort associated with vehicle subsystems, avionics, and other Level 3 elements, and their integration into the airframe

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A.4.2.1.1 Airframe Integration, Assembly, Test and Checkout. The integration, assembly, test and checkout element includes all efforts as identified in Appendix L: Common Elements, Work Breakdown Structure and Definitions, to provide a complete airframe, less other Level 3 elements.

Included in this element are the efforts required to provide the integration, assembly, test and checkout of the major airframe structures (fuselage, wing, empennage, nacelle, and other airframe). Included in this effort is all administrative and technical engineering labor to perform integration of Level 4 airframe elements.

Includes, for example:

a. Overall airframe design and producibility engineering
b. Detailed production design; acoustic and noise analysis
c. Loads analysis; stress analysis on interfacing airframe elements and all subsystems
d. Design maintenance effort and development of functional test procedures
e. Coordination of engineering master drawings and consultation with test and manufacturing groups
f. Tooling planning, design, and fabrication of basic and rate tools and functional test equipments, as well as the maintenance of such equipment
g. Production scheduling and expediting
h. Joining or installation of structures such as racks, mounts, etc.
i. Installation of wiring ducting, engines, and miscellaneous equipment and painting
j. Set up, conduct, and review of testing assembled components or subsystems prior to installation

Excludes, for example:

a. All Integration, Assembly, Test, and Checkout activities associated with non-airframe Level 3 elements

A.4.2.1.2 Fuselage. The structural airframe encompassing the forward, center and aft fuselage sections of the aircraft.

Includes, for example:

a. Structural fuselage section for the forward, center and aft fuselage sections to include the main and secondary structures
b. Efforts required to splice the forward, center and aft sections
c. Windshield/canopy assembly
d. Radome
e. Access doors
f. Mounting provisions for mission peculiar avionics, armament/weapons delivery systems

A.4.2.1.3 Wing. The structure used to produce lift for flight through the air.

Includes, for example:

a. Wing torque box, inner and outer wing panels, leading edge extension wing tip, movable control surfaces to include ailerons and leading and trailing edge flaps, attach fittings for pylons, wing fold mechanism, installation of airframe related subsystems, and installation of flight test instrumentation
b. Fitting for store stations
c. Material for sealing the integral fuel tanks
d. Provisions for the electrical, hydraulic, fuel, flight controls, etc.

Excludes, for example:

a. Efforts for the structural splicing of the wing to the fuselage as provided by the Airframe Integration, Assembly, Test and Checkout.

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A.4.2.1.4 Empennage. The structural tail group encompassing the fin, stabilator and rudder as well as provisions for electrical wiring, plumbing, control linkages, antennae, and associated equipments.

Includes, for example:
a. Structural stabilators, vertical tails, rudders, installation of airframe related subsystems, and installation of flight test instrumentation
b. Tail boom for rotary wing

A.4.2.1.5 Nacelle. The streamlined enclosure separate from the fuselage used for sheltering the crew, cargo or housing an engine.

A.4.2.1.6 Other Airframe Components 1…n (Specify). This element should be replaced with other product-oriented airframe components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

A.4.2.2 Propulsion. That portion of the air vehicle that pertains to installed equipment (propulsion unit and other propulsion) to provide power/thrust to propel the aircraft through all phases of powered flight.

Includes, for example:
a. The engine as a propulsion unit within itself (e.g., reciprocating, turbo with or without afterburner, or other type propulsion) suitable for integration with the airframe
b. Thrust reversers, thrust vector devices, nozzles, transmissions, gear boxes, and engine control units, if furnished as integral to the propulsion unit
c. Other propulsion equipment required in addition to the engine but not furnished as an integral part of the engine, such as booster units
d. The design, development, production, and assembly efforts to provide the propulsion unit as an entity

Excludes, for example:
a. All effort directly associated with the integration, assembly, test, and checkout of these elements into the air vehicle
b. All ancillary equipments that are not an integral part of the engine required to provide an operational primary power source—air inlets, instruments, controls, etc.

NOTE: For lower level information, use the structure and definitions in Appendix B, Electronic Systems.

A.4.2.3 Vehicle Subsystems. The collection of core non-avionics subsystems.

A.4.2.3.1 Vehicle Subsystems Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the vehicle subsystem parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

A.4.2.3.2 Flight Control Subsystem. Primary and secondary mechanical devices and automatic equipment installed in the air vehicle when used with control surfaces, to control the flight path of the air vehicle as well as to provide additional lift, drag and trim effect.

Includes, for example:
a. Primary and secondary mechanical controls, linkage, and control surface actuators for ailerons, rudders, stabilators, leading edge flaps, trailing edge flaps, and speed brakes, which are used to control the flight path of the air vehicle and provide additional lift, drag and trim effect

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Excludes, for example:

a. Structural control surfaces, ailerons, rudder, stabilizer, etc. included in airframe as well as the installation of flight control subsystems into the appropriate basis structures element

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.3 Auxiliary Power Subsystem. The equipment that performs engine start up on the ground, emergency starting during flight, ground checkout operations of aircraft accessories, and power takeoff for hydraulic pumps and electrical generator system and fuel motive flow pumps.

Includes, for example:

a. Power takeoff shafts and oil cooling lines
b. Auxiliary power unit (APU)
c. Airframe mounted accessory drive (AMAD)
d. Air turbine starter
e. Secondary power, furnishings—cargo, etc.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.4 Hydraulic Subsystem. This system provides hydraulic power for the actuation of landing/launching gear subsystems, in-flight re-fueling probe, gun drive and flight control surfaces.

Includes, for example:

a. Pumps, reservoirs, accumulators, valves, regulators and associated plumbing distribution systems to provide hydraulic power
b. Hydraulic tubing, check valves, etc., which interconnect the hydraulic equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.5 Electrical Subsystem. Equipment installed to provide electrical power function, the AC and DC distribution of this power supply and the provision for exterior lighting.

Includes, for example:

a. Wire bundles and miscellaneous electrical parts, which provide the electrical power function, the AC and DC distribution of this power supply and exterior lighting in the center fuselage, aft fuselage and vertical tail
b. Generator system, battery system, a transformer rectifier unit and power contactors
c. Power relays, circuit breakers and distribution systems between electronic mission equipments

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.6 Crew Station Subsystem. The provisions and space allocated to the human component of the weapon system that allow performance of specific functions to ensure mission success. Aircraft system human interfaces and components that sustain and protect the human operators, troops, and passengers.

Includes, for example:

a. Life support systems; flight clothing, head protection, noise attenuation systems, communication systems, anti-exposure systems, cooling systems, gravity onset protective systems, laser threat protection, chemical/biological protection, physiological monitoring systems, body armor, oxygen systems, survival equipment, personal flotation devices, flotation platforms, survival radios/beacons
b. Escape systems; ejection seats, canopy/hatch removal or penetration systems, sequencing systems, restraint systems, seat survival kits, parachutes, emergency exits, slides, crashworthy seats, armored seats, personal connection systems
c. Crash protection devices; includes attenuating seats, airbag systems and inflatable restraints
d. Search and rescue equipment
e. Aero-medical equipment (AE)
f. Canopy/wind screen systems; transparencies, seals, actuators, frames
g. Crew, passenger, and troop compartment geometry and design, secondary structure, interior/exterior lighting, seat installations, consoles, instrument panels, glare shields, personal cargo stowage, and waste management systems
h. Display/control interfaces; display/control locations and configuration, display symbology definition, helmet mounted devices, lighting, switches, pedals, control grips such as those for the stick/yoke, throttle, cyclic and collective
i. Human interface; human factors design features, speech intelligibility, and anthropometry for air vehicle interface, control and mission tasks
j. Crew environment habitability considerations; acoustical noise, radiation hazard, thermal environment, relative humidity, air velocity and pressurization
k. Integration tests related to human interface with the air vehicle, including part task and full mission simulations, workload and situational awareness evaluations, life support system man rating, ejection tests, bailout or emergency egress, and lighting mockup evaluations

Excludes, for example:

a. Primary structure supporting seat installations and restraints covered under the airframe WBS element
b. Displays hardware/software covered under the data display and controls WBS element
c. Wiring and plumbing for air crew support covered under the airframe WBS element

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.7 Environmental Control Subsystem. Environmental equipment and distribution systems on board the air vehicle for air conditioning and cooling equipment compartments, pressurization of seals, fuel tanks and anti-icing. The distribution system provides for air ducts, cooling lines and other plumbing required in supplying air and other cooling media from supply sources to the controlled environment.

Includes, for example:

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a. Environmental and distribution systems on board the air vehicle to include fabricated air ducts, cooling lines and other plumbing required for cockpit air conditioning and pressurization
b. Equipment compartment and individual air units air conditioning, pressurization of canopy seal, and fuel tanks
c. Bleed air for the gun gas purging; and windshield anti-icing and defogging subsystems
d. Air refrigeration system, liquid cooling system, air flow regulation system, and a suit ventilation system.
e. Environmental control, racks, mounts, intersystem cables and distribution boxes, etc., which are inherent to, and non-separable from, the assembled structure

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.8 Fuel Subsystem. Equipment and distribution systems installed in the air vehicle to provide fuel to the engines and the auxiliary power unit, including associated functions such as fuel pressurization, venting, gauging, defueling etc.

Includes, for example:
a. Equipment and distribution systems to provide fuel to the engines
b. Associated functions included in the system are fuel storage, pressurization, venting, gauging, defueling, and in-flight refueling
c. rotary wing pylons, air induction system, thrust reversers, thrust vector devices, starters, exhausts, fuel management, inlet control system
d. Fuel lines, plumbing etc., which interconnect the fuel subsystem equipment and storage cell in the air vehicle

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.3.9 Landing Gear. The structural and mechanical gear and associated equipment, including doors, for maneuvering of the air vehicle while on the ground, the devices for extension, retraction, and locking this gear, and the mechanical devices for arresting the air vehicle.

Includes, for example:
a. Alighting gear; tires, tubes, wheels, brakes, hydraulics, etc.
b. Main landing gears, nose landing gear
c. Arresting hook system and related doors and mechanisms

A.4.2.3.10 Rotor Group. Items that impart the pitch, raw, roll, and thrust forces, which provide the lift and direction for Air Vehicle powered flight for rotary aircraft.

Includes, for example:
a. Main rotor blade
b. Main rotor head
c. Tail rotor blade
d. No tail rotor

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A.4.2.3.11 Drive System. Those items that pertain to the engine control units such as transmissions and gear boxes.

Includes, for example:

a. Dynamic systems; transmissions, gear boxes, propellers, if not furnished as an integral part of the propulsion unit

A.4.2.3.12 Vehicle Subsystems Software Release 1…n. All vehicle subsystem software not associated with a specific Level 4 element.

NOTE 1: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

A.4.2.3.13 Other Vehicle Subsystems 1…n (Specify). This element should be replaced with other product-oriented vehicle subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4 Avionics. Mission equipment on board the air vehicle, which is primarily electronic in nature.

A.4.2.4.1 Avionics Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the avionics suite parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

A.4.2.4.2 Communication/Identification. That equipment (hardware/software) installed in the air vehicle for communications and identification purposes.

Includes, for example:

a. Intercoms, radio system(s), identification equipment (IFF), data links, and control boxes associated with the specific equipment
b. Integral communication, navigation, and identification package (if used)

Excludes, for example:

a. Speech intelligibility work performed under the Crew Station WBS element
b. Survival/radios/beacons included under the Crew Station WBS element
c. Aircrew mounted communication components included under the Crew Station WBS element

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.3 Navigation/Guidance. That equipment (hardware/software) installed in the air vehicle to perform the navigational guidance function.

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Includes, for example:

a. Radar, radio, or other essential navigation equipment, radar altimeter, direction finding set, doppler compass, computer, and other equipment homogeneous to the navigation/guidance function

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.4 Mission Computer/Processing. The master data processing unit(s) responsible for coordinating and directing the major avionic mission systems.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.5 Fire Control. That equipment (hardware/software) installed in the air vehicle, which provides the intelligence necessary for weapons delivery such as bombing, launching, and firing.

Includes, for example:

a. Radars and other sensors
b. Apertures/antennas, if integral to the fire control system, necessary for search, target identification, rendezvous and/or tracking
c. Self-contained navigation and air data systems
d. Dedicated displays, scopes, or sights
e. Bombing computer and control and safety devices

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.6 Data Display and Controls. The equipment (hardware/software) that visually presents processed data by specially designed electronic devices through interconnection (on or off-line) with computer or component equipment and the associated equipment needed to control the presentation of the primary flight information and tactical information to the crew.

Includes, for example:

a. Multi-function displays, control display units, display processors, and on-board mission planning systems

Excludes, for example:

a. Indicators and instruments not controlled by keyboard via the multiplex data bus and panels and consoles, which are included under the crew station
b. Display size/location and symbology definition included under the crew station

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.7 Survivability. Those equipments (hardware/software) installed in, or attached to, the air vehicle, which assist in penetration for mission accomplishment.

Includes, for example:

a. Ferret and search receivers, warning devices and other electronic devices, electronic countermeasures, jamming transmitters, chaff, infra-red jammers, terrain-following radar, and other devices typical of this mission function

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.8 Reconnaissance. Those equipments (hardware/software) installed in, or attached to, the air vehicle necessary to the reconnaissance mission.

Includes, for example:

a. Photographic, electronic, infrared, and other sensors
b. Search receivers
c. Recorders
d. Warning devices
e. Magazines
f. Data link

Excludes, for example:

a. Gun cameras

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.9 Automatic Flight Control. Those electronic devices and sensors, which, in combination with the flight controls subsystem (under vehicle subsystems), enable the crew to control the flight path of the aircraft and provide lift, drag, trim, or conversion effects.

Includes, for example:

a. Flight control computers, software, signal processors, and data transmitting elements that are devoted to processing data for either primary or automatic flight control functions
b. Electronic devices required for signal processing, data formatting, and interfacing between the flight control elements; the data buses, optical links, and other elements devoted to transmitting flight control data
c. Flight control sensors such as pressure transducers, rate gyros, accelerometers, and motion sensors

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Excludes, for example:

a. Devices—linkages, control surfaces, and actuating devices—covered under the airframe WBS element
b. Avionics devices and sensors--central computers, navigation computers, avionics data buses and navigation sensors, which are included under other avionics WBS elements

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.10 Health Monitoring System. That equipment (hardware/software) installed in the air vehicle for malfunction detection and reporting.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.11 Stores Management. The avionics subsystem that controls and monitors the operational state of aircraft installed stores and provides and manages the communications between aircraft stores, other aircraft subsystems and weapons.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.4.12 Avionics Software Release 1…n. All avionics software not associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

A.4.2.4.13 Other Avionics Subsystems 1…n (Specify). This element should be replaced with other product-oriented avionics subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.5 Armament/Weapons Delivery. That equipment (hardware/software) installed in the air vehicle to provide the firepower functions and weapons delivery capability.

Includes, for example:

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a. Guns, high energy weapons, mounts, turrets, weapon direction equipment, ammunition feed and ejection mechanisms, and gun cameras
b. Launchers, pods, bomb racks, pylons, integral release mechanisms, and other mechanical or electro-mechanical equipments specifically oriented to the weapons delivery function

Excludes, for example:
a. Bombing/navigation system (included in the fire control element)

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.6 Auxiliary Equipment. Auxiliary airframe, electronics, and/or armament/weapons delivery equipment not allocable to individual element equipments, or which provide the ancillary functions to the applicable mission equipments.

Includes, for example:
a. Auxiliary airframe equipment such as external fuel tanks, pods, and rotodomes
b. Multi-use equipment like antennas, control boxes, power supplies, environmental control, racks, and mountings, not homogeneous to the prescribed WBS elements

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

A.4.2.7 Furnishing and Equipment. This element includes the provisions that sustain and support the passengers, typically consists of non-mission specific removable items.

Includes, for example:
a. Carpets
b. Executive interiors
c. Seats

Excludes, for example;
a. All items pertaining to the crew station subsystem element
b. Primary structure supporting seat installations and restraints covered under the airframe WBS element
c. Displays hardware/software covered under the data display and controls WBS element
d. Wiring and plumbing for air crew support covered under the Airframe WBS element

A.4.2.8 Air Vehicle Software Release 1…n. All air vehicle software not associated with a specific Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

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A.4.2.9 Air Vehicle Integration Assembly, Test, and Checkout. All efforts as identified in Appendix L: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all Level 3 elements to form the air vehicle as a whole.

A.4.3 Common WBS Elements. Definitions for Common WBS elements applicable to the Aircraft, and all other defense material items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX B: ELECTRONIC SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

B.1 SCOPE

This appendix provides the Work Breakdown Structure and definitions for the prime mission product (PMP) and platform integration. Definitions for WBS elements common to Electronic Systems and all defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

B.2 APPLICABLE DOCUMENTS

B.2.1 Government Publications. The following standards form a part of this document to the extent specified herein.

Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the:

Acquisition Streamlining and Standardization Information System (ASSIST) database (https://assist.daps.dla.mil)
Document Automation & Production Service
700 Robbins Avenue
Building 4/D
Philadelphia, PA 19111

STANDARDS

MIL-STD-196E, *Joint Electronics Type Designation System*
MIL-STD-1464A, *Army Nomenclature System*
MIL-STD-1661, *Mark and Mod Nomenclature System*
MIL-HDBK-1812, *Type Designation, Assignment and Method for Obtaining*

B.2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

IEEE/EIA 12207-2008*; GUIDE FOR SYSTEMS AND SOFTWARE ENGINEERING – SOFTWARE LIFE CYCLE PROCESSES*

ANSI Standards can be found online at:
http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036
or
The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

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B.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Electronic System			
1.1		Prime Mission Product (PMP) 1...n (Specify)		
1.1.1			PMP Subsystem 1...n (Specify)	
1.1.1.1				PMP Subsystem Hardware 1...n
1.1.1.2				PMP Subsystem Software Release 1...n
1.1.1.3				Subsystem Integration, Assembly, Test and Checkout
1.1.2			PMP Software Release 1...n (Specify)	
1.1.2.1				Software Product Engineering
1.1.2.2				Computer Software Configuration Item (CSCI) 1...n
1.1.2.3				Subsystem Integration, Assembly, Test and Checkout
1.1.3			PMP Integration, Assembly, Test and Checkout	
1.2		Platform Integration, Assembly, Test and Checkout		
1.3		System Engineering		
1.4		Program Management		
1.5		System Test and Evaluation		
1.5.1			Development Test and Evaluation	
1.5.2			Operational Test and Evaluation	
1.5.3			Mock-ups / System Integration Labs (SILs)	
1.5.4			Test and Evaluation Support	
1.5.5			Test Facilities	
1.6		Training		
1.6.1			Equipment	
1.6.2			Services	
1.6.3			Facilities	
1.7		Data		
1.7.1			Technical Publications	
1.7.2			Engineering Data	
1.7.3			Management Data	
1.7.4			Support Data	
1.7.5			Data Depository	
1.8		Peculiar Support Equipment		
1.8.1			Test and Measurement Equipment	
1.8.2			Support and Handling Equipment	
1.9		Common Support Equipment		
1.9.1			Test and Measurement Equipment	
1.9.2			Support and Handling Equipment	
1.10		Operational/Site Activation		
1.10.1			System Assembly, Installation and Checkout on Site	
1.10.2			Contractor Technical Support	
1.10.3			Site Construction	
1.10.4			Site/Ship/Vehicle Conversion	
1.10.5			Sustainment/Interim Contractor Support	
1.11		Industrial Facilities		
1.11.1			Construction/Conversion/Expansion	
1.11.2			Equipment Acquisition or Modernization	
1.11.3			Maintenance (Industrial Facilities)	
1.12		Initial Spares and Repair Parts		

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B.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; Acquisition Logistics; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

B.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

3) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

4) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

B.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

B.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

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B.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

B.4 DEFINITIONS

B.4.1 Electronic System. The complex of equipment (hardware/software), data, services, and facilities required to develop and produce an electronic system capability such as a command and control system, radar system, communications system, information system, sensor system, navigation/guidance system, electronic warfare system, support system, etc.

NOTE 1: To differentiate between the Electronic System category and other defense materiel item categories, use the following rule: When the item is a stand-alone system or used on several systems but not accounted for within the system, use the Electronic System category.

NOTE 2: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in this appendix apply.

B.4.2 Prime Mission Product (PMP) 1…n (Specify). The hardware and software used to accomplish the primary mission of the defense materiel item. This WBS element includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use) and is comprised of the sub elements listed below.

Includes, for example:

a. All integration, assembly, test and checkout, as well as all technical and management activities associated with individual hardware/software elements
b. Integration, assembly, test and checkout associated with the overall prime mission product (PMP). when the electronic system comprises several PMPs, each PMP will be listed separately at Level 2
c. All whole and partial prime contractor, subcontractor, and vendor breadboards, brass boards, and qualification test units
d. The design, development and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use)
e. Factory special test equipment, special tooling, and production planning required to fabricate the PMP

Excludes, for example:

a. Only those "less than whole" units (e.g., test, spares, etc.) Consumed or planned to be consumed in support of system level tests
b. Duplicate or modified factory special test equipment delivered to the Government for depot repair (should be included in the peculiar support equipment element)

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B.4.2.1 Prime Mission Product Subsystem 1…n (Specify). The hardware and software components of the specific electronic subsystem.

Includes, for example:

a. All associated special test equipment, special tooling, production planning, and all technical and management activities
b. Software components, consisting of the applications and system software required to direct and maintain the specific electronic subsystem
c. All in-plant integration, assembly, test, and checkout of hardware components and software into an electronic subsystem, including the subsystem hardware and software integration and test
d. Interface materials and parts required for the in-plant integration and assembly of other Level 4 components into the electronic subsystem and all materials and parts or other mating equipments furnished by/to an integrating agency or contractor
e. Cables, conduits, connectors, shelters, and other devices associated with the operational electronic subsystem
f. The design, development, production, and assembly efforts to provide each electronic subsystem as an entity

Excludes, for example:

a. All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the prime mission product

NOTE: All software that is an integral part of any specific equipment system, subsystem or component specification or specifically designed and developed for system test and evaluation should be identified with that system, subsystem, component or effort. It may be appropriate to collect lower level information when it exists. In such cases, the following structure and definitions should be used:

LEVEL X	**LEVEL Y**
PMP Subsystem Hardware 1…n (Specify)	
PMP Subsystem Software Release 1...n (Specify)	
	Software Product Engineering (defined per 4.2.1.2.1)
	Computer Software Configuration Item (CSCI) 1…n (defined per 4.2.1.2.2)
	Subsystem Integration, Assembly, Test and checkout (defined per 4.2.1.2.3)
Subsystem Integration, Assembly, Test and Checkout	

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B.4.2.1.1 Prime Mission Product Subsystem Hardware 1…n (Specify). The hardware and associated resource components of the specific electronic/automated software subsystem.

B.4.2.1.2 Prime Mission Product Subsystem Software Release 1…n (Specify). The resources associated with the PMP subsystem software that is associated with the PMP subsystem for release 1…n. A software release is an aggregate of one or more CSCIs that satisfies a specific set or subset of requirements. When incremental, spiral, or other software development methods are used, multiple releases may be necessary to meet program requirements. A release is a separately tested and delivered product. Within releases are CSCIs. When a release is complete, a portion or all of one or more CSCIs will be completed. Therefore, a CSCI may appear in one or more releases, but will be successively more functional as each release is completed.

Includes, for example:
a. Software product engineering,
b. Computer Software Configuration Item (CSCI) 1…n
c. Subsystem Integration, Assembly, Test and Checkout

B.4.2.1.2.1 Software Product Engineering. All of the resources associated with the PMP software product engineering efforts. Software product engineering is focused on process maturity and continuous improvement. Sound software product engineering is a systematic framework, which breaks down the software development process by relating each level to a knowledge domain and localizing exactly on those qualities that become visible in that knowledge domain.

B.4.2.1.2.2 Computer Software Configuration Item (CSCI) 1…n (Specify). An aggregation of software or any of its discrete portions that satisfies an end use function and has been designated by the Government or Contractor, if the Government did not specify, for configuration management. CSCIs are the major software products of a system acquisition, which are developed in accordance with standard DoD or commercial practices and processes.

Includes, for example:
a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software Integration
e. Software qualification testing
f. Commercial off the Shelf (COTS)/Government off the Shelf (GOTS) approach
g. COTS/GOTS component identification
h. COTS/GOTS assessment and selection
i. COTS/GOTS prototyping
j. COTS/GOTS glue code development
k. COTS/GOTS tailoring and configuration

When software development is accomplished, items (a) through (e) are typical development activities. When COTS/GOTS is to be used and integrated, items (f) through (i) are typical integration activities.

B.4.2.1.2.3 Subsystem Integration, Assembly, Test and Checkout. The resources specifically related to evaluating the CSCIs and hardware operation as a subsystem. (ANSI/IEEE 12207)

Includes, for example:
a. All resources necessary to integrate the subsystem components as a complete subsystem
b. Subsystem integration management
c. Requirements definition, planning and scheduling
d. Development of integration plans and procedures
e. Integration test preparations, conduct and teardown and review, analysis and documentation of subsystem integration results.

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B.4.2.2 Prime Mission Product Software Release 1…n (Specify). The resources associated with PMP subsystem software that is not associated with the PMP subsystem (i.e., Distributed SW environment) for release (1...n).

Includes, for example:
a. Software product engineering,
b. Computer Software Configuration Item (CSCI) 1…n
c. Subsystem Integration, Assembly, Test and Checkout

B.4.2.2.1 Software Product Engineering. All of the resources associated with the PMP software product engineering efforts. Software product engineering is focused on process maturity and continuous improvement. Sound software product engineering is a systematic framework, which breaks down the software development process by relating each level to a knowledge domain and localizing exactly on those qualities that become visible in that knowledge domain.

B.4.2.2.2 Computer Software Configuration Item (CSCI) 1…n (Specify). An aggregation of software or any of its discrete portions that satisfies an end use function and has been designated by the Government or Contractor, if the Government did not specify, for configuration management. CSCIs are the major software products of a system acquisition, which are developed in accordance with standard DoD or commercial practices and processes.

Includes, for example:
a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software integration
e. Software qualification testing
f. Commercial off the Shelf (COTS)/Government off the Shelf (GOTS) approach
g. COTS/GOTS component identification
h. COTS/GOTS assessment and selection
i. COTS/GOTS prototyping
j. COTS/GOTS glue code development
k. COTS/GOTS tailoring and configuration

B.4.2.2.3 Subsystem Integration, Assembly, Test and Checkout. The resources specifically related to evaluating the CSCIs and hardware operation as a subsystem. (ANSI/IEEE 12207)

Includes, for example:
a. All resources necessary to integrate the subsystem components as a complete subsystem
b. Subsystem integration management
c. Requirements definition, planning and scheduling
d. Development of integration plans and procedures
e. Integration test preparations, conduct and teardown and review, analysis and documentation of subsystem integration results

B.4.2.3 Prime Mission Product Integration, Assembly, Test and Checkout. This WBS element contains all of the resources in order to perform integration, assembly, test, and check out of the PMP. This is the process of combining and evaluating CSCIs and Hardware of a system or segment of a system that have undergone individual CSCI and hardware qualification test.

B.4.3 Platform Integration, Assembly, Test and Checkout. The effort involved in providing technical and engineering services to the platform manufacturer or integrator during the installation and integration of the PMP into the host system.

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Includes, for example:

a. Labor required to analyze, design, and develop the interfaces with other host vehicle subsystems
b. Drawing preparation and establishment of equipment requirements and specifications
c. Technical liaison and coordination with the military services subcontractors, associated contractors, and test groups

Excludes, for example:

a. All integration effort not directly associated with the host vehicle and management liaison with the military services, subcontractors, and associated contractors

B.4.4 Common WBS Elements. Remaining Common WBS Elements. Definitions for Common WBS elements applicable to the Electronics Systems, and all other defense materiel items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX C: MISSILE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

C.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for missile systems. Definitions for WBS elements common to the missile system and all other defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

C.2 APPLICABLE DOCUMENTS

C.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

ANSI Standards can be found online at:

http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

American Society for Testing and Materials (ASTM)

ASTM F2541-06 Guide for Unmanned Underwater Vehicle (UUV) Autonomy and Control

ASTM Standards can be found online at:

http://www.astm.org

100 Barr Harbor Drive
West Conshohocken, Pennsylvania, USA
Phone: (610) 832-9500 Fax: (610) 832-9555

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C.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Missile System			
1.1		Air Vehicle		
1.1.1			Airframe	
1.1.1.1				Airframe Integration, Assembly, Test and Checkout
1.1.1.2				Primary Structure
1.1.1.3				Secondary Structure
1.1.1.4				Aero-Structures
1.1.1.5				Other Airframe Components 1…n (Specify)
1.1.2			Propulsion Subsystem (1…n) Specify	
1.1.2.1				Propulsion Integration, Assembly, Test and Checkout
1.1.2.2				Motor/Engine (Specify)
1.1.2.3				Thrust Vector Actuation
1.1.2.4				Attitude Control System
1.1.2.5				Fuel/Oxidizer Liquid Management
1.1.2.6				Arm/Fire Device
1.1.2.7				Flight Termination/Mission Termination
1.1.2.8				Propulsion Software Release 1…n
1.1.2.9				Other Propulsion Subsystems 1…n (Specify)
1.1.3			Power and Distribution	
1.1.3.1				Power and Distribution Integration, Assembly, Test and Checkout
1.1.3.2				Primary Power
1.1.3.3				Power Conditioning Electronics
1.1.3.4				Distribution Harness
1.1.3.5				Power and Distribution Software Release 1…n
1.1.3.6				Other Power and Distribution Subsystems 1…n (Specify)
1.1.4			Guidance	
1.1.4.1				Guidance Integration, Assembly, Test and Checkout
1.1.4.2				Dome Assembly
1.1.4.3				Seeker Assemblies
1.1.4.4				Guidance Software Release 1…n
1.1.4.5				Other Guidance Subsystems 1…n (Specify)
1.1.5			Navigation	
1.1.5.1				Navigation Integration, Assembly, Test and Checkout
1.1.5.2				Sensor Assemblies
1.1.5.3				Navigation Software Release 1…n (Specify)
1.1.5.4				Other Navigation Subsystems 1…n (Specify)
1.1.6			Controls	
1.1.6.1				Controls Integration, Assembly, Test and Checkout
1.1.6.2				Primary Structure
1.1.6.3				Fin/Canard Deployment System
1.1.6.4				Actuators
1.1.6.5				Control Power
1.1.6.6				Controls Software Release 1…n
1.1.6.7				Other Control Subsystems 1…n (Specify)
1.1.7			Communications	
1.1.7.1				Communications Integration, Assembly, Test and Checkout
1.1.7.2				Antenna Assembly
1.1.7.3				Communications Software Release 1…n
1.1.7.4				Other Communications Subsystems 1…n (Specify)
1.1.8			Payload	
1.1.8.1				Payload Integration, Assembly, Test and Checkout
1.1.8.2				Target Detection Mechanism
1.1.8.3				Target Detection Device

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1.1.8.4 Fuze
1.1.8.5 Payload Software Release 1…n
1.1.8.6 Other Payload Subsystems 1…n (Specify)
1.1.9 Reentry System
1.1.10 Post Boost System
1.1.11 Ordnance Initiation Set
1.1.12 On Board Test Equipment
1.1.13 On Board Training Equipment
1.1.14 Auxiliary Equipment
1.1.15 Air Vehicle Software Release 1…n
1.1.16 Air Vehicle Integration, Assembly, Test and Checkout
1.2 Encasement Device
1.2.1 Encasement Device Integration, Assembly, Test and Checkout
1.2.2 Encasement Device Structure
1.2.3 Encasement Device Software Release 1…n
1.2.4 Other Encasement Device Subsystems 1…n (Specify)
1.3 Command and Launch
1.3.1 Command and Launch Integration, Assembly, Test and Checkout
1.3.2 Surveillance, Identification and Tracking Sensors
1.3.3 Launch and Guidance Control
1.3.4 Communications
1.3.5 Launcher Equipment
1.3.6 Auxiliary Equipment
1.3.7 Booster Adapter
1.3.8 Command and Launch Software Release 1…n
1.3.9 Other Command and Launch 1…n (Specify)
1.4 Missile System Software Release 1…n
1.5 Missile System Integration, Assembly, Test and Checkout
1.6 System Engineering
1.7 Program Management
1.8 System Test and Evaluation
1.8.1 Development Test and Evaluation
1.8.2 Operational Test and Evaluation
1.8.3 Mock-ups / System Integration Labs (SILs)
1.8.4 Test and Evaluation Support
1.8.5 Test Facilities
1.9 Training
1.9.1 Equipment
1.9.2 Services
1.9.3 Facilities
1.10 Data
1.10.1 Technical Publications
1.10.2 Engineering Data
1.10.3 Management Data
1.10.4 Support Data
1.10.5 Data Depository
1.11 Peculiar Support Equipment
1.11.1 Test and Measurement Equipment
1.11.2 Support and Handling Equipment
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1.13.5		Sustainment/Interim Contractor Support
1.14	Industrial Facilities	
1.14.1		Construction/Conversion/Expansion
1.14.2		Equipment Acquisition or Modernization
1.14.3		Maintenance (Industrial Facilities)
1.15	Initial Spares and Repair Parts	

C.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

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2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

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C.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

C.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

C.4 DEFINITIONS

C.4.1 Missile System. The complex of hardware, software, data, services, and facilities required to develop and produce the capability of employing a missile weapon in an operational environment to detect and defeat selected targets. Specific examples include, but are not limited to: AIM-9X, AMRAAM, ESSM, HARM, Javelin, TOW, RAM, Stinger, Standard Missile, Tomahawk, JASSM, Minuteman, GMLRS, JAGM, Patriot, AARGM, and Trident.

C.4.2 Air Vehicle. An Air vehicle is a guided weapon self-propelled after leaving its launching device that has as its purpose the delivery of a payload for destruction (or defeat) of some object or target. Missiles may be classified as tactical or strategic (such as ballistic missiles). It also includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use).

C.4.2.1 Airframe. This element comprises the structural framework that provides the aerodynamic shape, mounting surfaces and environmental protection for the air vehicle components, which are not directly applicable to other specific Level 3 air vehicle subsystems.

Includes, for example:

a. Wings and fins that provide aerodynamic flight control in response to electro-mechanical signals and are attached to the air vehicle body
b. Structural body assemblies including the structure, fuel tanks that integral with the structure, covers, skins, adhesives, and fairings not directly applicable to any other Level 3 air vehicle subsystem
c. Protection devices for stressing environmental conditions such as thermal protection system or rain erosion that are not directly applicable to other Level 3 air vehicle subsystems

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C.4.2.1.1 Airframe Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Airframe.

C.4.2.1.2 Primary Structure. This element comprises the structural framework that provides for load carry hardware such as the air carry system, interfaces to loading and launching devices, and other hard points needed to protect the air vehicle from environmental induced loads.

C.4.2.1.3 Secondary Structure. This element comprises the secondary hardware needed to maintain aerodynamic shapes, interfaces between other subsystems, fuel tanks, protection subsystems such as a Thermal Protection System (TPS), and other structure not directly associated with the primary structure or other Level 3 subsystems.

C.4.2.1.4 Aero – Structures. This element comprises the hardware needed for aerodynamic flight effects. It includes, for example, the wings, fins, canards, stability systems, and inlets for air breathing propulsion.

C.4.2.1.5 Other Airframe Components 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

C.4.2.2 Propulsion Subsystem 1…n (Specify). The equipment to provide thrust to propel the air vehicle on its intended flight. The total propulsion system may be composed of one or more subsystems that ignite, burn, and may be jettisoned sequentially over the course of flight. Individual subsystems may employ solid, liquid, or air-breathing technologies. This element and the Level 4 elements below comprise the equipment to make up a single propulsion system.

C.4.2.2.1 Propulsion System Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Propulsion System. For example, this element includes those structural elements that transfer the thrust loads or provide the primary path for vehicle loads through the propulsion system such as forward and aft skirts and/or interstages or other components through which the propulsion system is attached to the missile air vehicle and transfers primary loads. In addition it includes the hardware and secondary structure to provide interfaces to other elements such as raceways, connectors, cutouts, access doors, etc. or any other hardware that interfaces with other elements of the air vehicle except for primary structural elements.

C.4.2.2.2 Motor/Engine (Specify). The structure (integral to the propulsion system), propellant, controls, instrumentation, and all other installed subsystem equipment integral to the rocket motor or engine as an entity within itself.

Includes, for example:

a. Solid Rocket Motor. This element is applicable to a solid propulsion system and consists of the thrust producing component in which solid propellant, made up of fuel and oxidizer, is combusted and expelled through a nozzle. It includes the pressure vessel, an igniter, internal insulation, solid propellant and a nozzle. If applicable it includes the functionality to move the nozzle or a portion of the nozzle but not the actuation subsystem to cause that movement. Where applicable, may include Booster Adapter.
b. Liquid Rocket Engine. This element is applicable to a liquid propulsion system and is a thrust producing device in which liquid fuel and oxidizer are delivered to the engine. Within the engine the fuel and oxidizer are combusted and expelled through a nozzle to produce thrust. It includes any turbines, pumps, valves, etc. to deliver the fuel and oxidizer to the combustion chamber. It may include valves or other control components to throttle the thrust level during operation as well as additional

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thrusters for vehicle control. If applicable, it includes the functionality to move the engine or a portion of the engine for thrust vector control but not the actuation subsystem to cause that movement.

c. Air Breathing Engine. This element is applicable to an air breathing propulsion system in which a stream of air is supplied to the engine along with a liquid fuel. The engine operates to mix and combust the air and fuel and to expel the products through a nozzle to produce thrust. It includes all the turbines, compressors, injectors, etc. to act on the air and fuel from the inlet to the engine through the exhaust from the engine. It does not include aerodynamic inlets on the air vehicle to deliver air to the engine.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.2.3 Thrust Vector Actuation. Those items integral to the propulsion system to move the nozzle, engine or a portion of the nozzle or engine.

Includes, for example:

a. Actuator and all of the components needed to move the actuator

Excludes, for example:

a. Vanes or other similar items mounted external to the propulsion system that may act on the exhaust from the propulsion system unless they are part of a item integral to the propulsion system
b. Any other part of the control system for the air vehicle

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.2.4 Attitude Control System. The Attitude Control System (ACS) or Divert/Attitude Control Systems (DACS) that are separate from the propulsion rocket motor or engine. These systems can be of any type: cold gas, warm gas, liquid propellant, solid propellant, etc.

Includes, for example:

a. All of the thrusters, lines, valves, propellant tanks, gas tanks, manifolds
b. Control system for the ACS/DACS to the extent that the control system is integral to the propulsion system

Excludes, for example:

a. The control system or elements of the control system if these are separate from the ACS/DACS with the only interface being a signal to a valve or distributor on the ACS/DACS

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

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C.4.2.2.5 Fuel/Oxidizer Liquid Management. All of the tanks, lines, pressurization system and/or pressure control, pumps, valves, etc. to deliver the fuel and oxidizer to the engine at the required conditions.

C.4.2.2.6 Arm/Fire Devices. Hardware to arm, disarm and initiate operation of the propulsion system.

C.4.2.2.7 Flight Termination/Mission Termination. Hardware and ordnance to cause the propulsion system to cease operation and, if applicable, cause the propulsion system to break up. It may include the ability to arm and disarm.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.2.8 Propulsion Software Release 1…n. All propulsion subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.2.9 Other Propulsion Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

C.4.2.3 Power and Distribution. This element comprises prime power and distribution for the air vehicle.

C.4.2.3.1 Power and Distribution Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Power and Distribution.

C.4.2.3.2 Primary Power. This element comprises primary power for the air vehicle.

Excludes, for example:

a. Batteries, which may be integral to other Level 3 elements

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.3.3 Power Conditioning Electronics. This element comprises prime power conditioning electronics. It excludes power conditioning integral to other Level 3 elements.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.3.4 Distribution Harness. This element comprises prime power distribution harnesses.

Excludes, for example:
a. Harnessing integral to other Level 3 elements

C.4.2.3.5 Power and Distribution Software Release 1…n. All power and distribution subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.3.6 Other Power and Distribution Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.4 Guidance. Guidance is the process of maneuvering the air vehicle to engage the intended target. This WBS element is the compliment of hardware, software and equipment for target detection, signal processing, implementation of guidance laws and generation of guidance commands.

Excludes, for example:
a. Navigation
b. Control

C.4.2.4.1 Guidance Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Guidance.

C.4.2.4.2 Dome Assembly. Windows, domes or radomes, and associated retention mechanisms, to cover the seeker(s) apertures used for target detection and are suitable to support seeker functionality. Contingent upon the design, this may be included within the Seeker Assemblies WBS element.

C.4.2.4.3 Seeker Assemblies. This element comprises the sensors (RF, EO, SAL, etc., as applicable), sensor electronics, gimbal assembly, on-gimbal electronics and integral structure(s), which constitutes the seeker assembly.

Includes, for example:
a. Radio frequency (RF), electro optical (EO), and semi-active laser (SAL) sensors

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

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C.4.2.4.4 Guidance Software Release 1…n. All guidance subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.4.5 Other Guidance Subsystems 1…n (Specify). This element should be replaced with other product-oriented guidance subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.5 Navigation. The compliment of hardware, software and equipment to measure or determine body angles and /or body linear motion and generation of navigation commands.

Excludes, for example:
a. Guidance
b. Control

C.4.2.5.1 Navigation Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Navigation.

C.4.2.5.2 Sensor Assemblies. Hardware that provides data for determination of air vehicle location and orientation.

Includes, for example:
a. Global Positioning System (GPS) receiver and antenna
b. Inertial sensors
c. Altimeter

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.5.3 Navigation Software Release 1…n. All navigation subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.5.4 Other Navigation Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.6 Controls. The hardware, software and equipment for controlling the motion of the air vehicle from launch to intercept.

Includes, for example:
a. Control devices for canard, wing, tail, etc.
b. Thrust vector / jet van
c. Explosive charge / lateral thrusters

Excludes, for example:
a. Control surfaces themselves (such as canards, wings, tails, etc.) included in the Airframe element

C.4.2.6.1 Controls Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Controls.

C.4.2.6.2 Primary Structure. The structural framework not part of the Airframe element.

C.4.2.6.3 Fin/Canard Deployment System. The hardware for fin/canard deployment.

C.4.2.6.4 Actuators. The hardware for actuation to include motors and servos.

C.4.2.6.5 Control Power. This element comprises power for the control element.

Excludes, for example:
a. Central power sources included in the Power and Distribution WBS element

C.4.2.6.6 Controls Software Release 1…n. All controls subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.6.7 Other Control Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.7 Communications. The data link equipment to enable communications between the air vehicle and an external entity (or entities). Data links can be either receive only or send only (one-way) or bidirectional (two way).

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Includes, for example:

a. Data transmission and reception for networking, command and control, battle space awareness, and air traffic management enabling the air vehicle to be a node in the net

C.4.2.7.1 Communications Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout the Level 4 elements below into their Level 3 element, Communication.

C.4.2.7.2 Antenna Assembly. The hardware comprising the Antenna Assembly or Assemblies.

C.4.2.7.3 Communication Software Release 1…n. All communication subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.7.4 Other Communications Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.8 Payload. The Target Defeat Mechanism (TDM) and its support assemblies. Normally, payload consists only of the TDM and its associated target detection, arming and fuzing equipment. However, with complex air vehicles containing subair vehicles (submunitions), the payload subsystem may mimic the larger system by having its own guidance and control, fuze, safe-arm, and propulsion. In multi-mission or adaptable payloads there may be a communication device that provides data to payload for output yield, real-time directions for aimable capabilities or layer-counting type applications.

C.4.2.8.1 Payload Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the =Level 4 elements below into their Level 3 element, Payload.

C.4.2.8.2 Target Defeat Mechanism. The hardware and software that produce(s) the desired effect on the target. TDMs include, but are not limited to, conventional high explosives (explosive outputs of blast, fragmentation, and penetrator-forming), directed energy devices, kinetic energy devices, dispensed submunitions or others.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.8.3 Target Detection Device (TDD). The hardware and software that detects and signals the presence of a target. TDDs include, but are not limited to, contact sensors (make or break electronics), EO or RF based proximity sensors and necessary hardware and software for signal processing.

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.8.4 Fuze. The equipment in the air vehicle that controls the capability of initiating the TDM (e.g., mechanical, hydrostatic, inertial, counters, and timers). It includes the hardware and software for the Safe, Arm and Fire (SAF) function; sensors and algorithms, if applicable, to enable "smart fuzing"; and the hardware and software associated with the firing train.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.8.5 Payload Software Release 1…n. All payload subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.8.6 Other Payload Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.9 Re-entry System. For exo-atmospheric missiles, the reentry system is the aggregate of prime equipment items consisting of a deployment module, reentry vehicles, payload, penetration aids and ascent shroud, which provide structural support and environmental protection of nuclear payloads during the ground deployment and flight.

Includes, for example:

a. Reentry vehicle (aero-structure), which provides reentry protection for the internally carried warheads
    1. For independent maneuvers, the reentry vehicle will contain navigation, guidance, control, sensors, and processing systems, which provide the reentry systems capability to acquire and track targets and execute the necessary flight path to the selected target
b. The arming and fuzing system, which provides the proper electrical signals to detonate the warhead

Excludes, for example:

a. All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.10 Post Boost System.

Includes, for example:
a. Exo-atmospheric missiles; provides the roll rate control and the final velocity to adjust and deploy the payload
b. Single warhead missile; structure, external protection material, velocity control system, and deployment group
c. Multiple warhead missile; structure, axial engines, attitude control equipment, propellant storage assembly, and pressurized system

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.11 Ordnance Initiation Set. In exo-atmospheric missiles, the ordnance initiation set initiates all ordnance events throughout the missile and ground system (except reentry system components). Upon receipt of an electrical signal from the missile guidance and control system, the ordnance initiation set firing units convert the signal into ordnance outputs to the detonating cords. Among these ordnance events are stage separation, motor ignition, gas generator ignition, shroud separation, etc.

Includes, for example:
a. Through bulkhead initiators, ordnance test harnesses, and firing units/exploding bridgewires

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.12 On Board Test Equipment. This element comprises the payload that is interchangeable with the live warhead and suitable for development or operational testing in a free flight (post launch) environment.

Includes, for example:
a. Recovery systems
b. Special instrumentation
c. Telemetry equipment,
d. Flight termination equipment, etc., suitable for a launch and free flight environment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

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C.4.2.13 On Board Training Equipment. This element comprises the payload that is interchangeable with the live warhead and suitable for testing in a non-launch environment. Includes, for example, special instrumentation, telemetry equipment, etc., suitable for a non-launch environment.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.14 Auxiliary Equipment. This element comprises the complex of additional external equipment generally excluded from other specific Level 3 elements. Includes, for example, (a) Environmental control, safety and protective subsystems, destruct systems, etc., if these were not accounted for in other WBS elements, and (b) Equipment of a single purpose and function, which is necessary for accomplishing the assigned mission.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the air vehicle is excluded.

C.4.2.15 Air Vehicle Software Release 1…n. All air vehicle software not associated with a specific Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.2.16 Air Vehicle Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the above Level 3 elements into their Level 2 element, Air Vehicle.

C.4.3 Encasement Device. The hardware and software associated with the Air Vehicle Canister or Encasement device.

C.4.3.1 Encasement Device Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 3 elements below into their Level 2 element, Encasement Device.

C.4.3.2 Encasement Device Structure. This element comprises the primary structure of the canister or encasement device.

C.4.3.3 Encasement Software Release 1…n. All Encasement software not associated with a specific Level 3 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.3.4 Other Encasement Device Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 3 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 2 element.

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Encasement Device element is excluded.

C.4.4 Command and Launch. The subsystems installed at a launch site or aboard launch vehicles required to store, make ready, and launch the air vehicles of the missile system.

Includes, for example:

a. Those equipments required to acquire and condition the necessary intelligence of selected targets, reach launch decisions, command the launch, and provide guidance and control where such capability is not self contained aboard the air vehicle
b. Design, development and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use)

C.4.4.1 Command and Launch Integration Assembly Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 3 elements below into their Level 2 element, Command and Launch.

C.4.4.2 Surveillance, Identification, and Tracking Sensors. The sensors required to support missile systems by maintaining surveillance against incoming targets and providing the data required for targeting, launch, midcourse guidance, and homing where such capability is not self-contained aboard a missile system air vehicle. For all classes of missiles:

Includes, for example:

a. Tracking of the missile system air vehicles as required for guidance and control or range safety
b. Sensors of any spectrum (radar, optical, infrared, etc.), which are external to the air vehicle

Excludes, for example:

a. Subsystems used in safety, destruct, test, or training activities
b. Unless they are required operational items

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Command and Launch element is excluded.

C.4.4.3 Launch and Guidance Control. The equipment to target air vehicles, make launch decisions, and command launch.

Includes, for example:

a. Control and checkout console, data displays, secure code device, programmer group, communication control console, command message processing group, and digital data group
b. Equipment at the launch facility/vehicle and/or the launch control center(s) (air, sea, or mobile)
c. Launch code processing system

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Command and Launch element is excluded.

C.4.4.4 Communications. The equipment, not resident on the air vehicle, which distributes intelligence between the air vehicle and the command and launch equipment.

Includes, for example:

a. Inter-communication subsystems of launch sites for tactical and administrative message flow and ties between sensor, data processing, launch, and guidance control subsystems
b. Communications may interface with existing fixed communication facilities or communication subsystems of launch platforms, which are associated systems to the missile system

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Command and Launch element is excluded.

C.4.4.5 Launcher Equipment. The means to launch the missile air vehicle from stationary sites or mobile launch platforms.

Includes, for example:

a. Vehicles, rail launchers, canisters, capsules, tubes, pods, and devices, which support, suspend, or encase the air vehicle for firing. Such devices would be in addition to any encasement, if applicable, integral to an air vehicle
b. Associated hardware such as umbilicals, harnesses, pyrotechnics, and electronics
c. Storage facilities and checkout stations for readiness verification when these are integral to the launcher
d. Safety and protective elements when these are not integral to the launch platform or site facilities

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Command and Launch element is excluded.

C.4.4.6 Auxiliary Equipment. The general purpose/multi-usage ground equipment utilized to support the various operational capabilities of the command and launch equipments, which is generally excluded from other specific Level 3 elements.

Includes, for example:

a. Power generators, power distribution systems, environmental control, cabling, malfunction detection, fire prevention, security systems, and other common-usage items not applicable to specific elements of the ground based equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Command and Launch element is excluded.

C.4.4.7 Command and Launch Software Release 1…n. All command and launch software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.4.8 Other Command and Launch 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 3 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 2 element.

C.4.5 Missile System Software Release 1…n. All Missile System software not associated with a specific Level 2, Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

C.4.6 Missile System Integration Assembly Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the above Level 2 elements into their Level 1 element, Missile System.

C.4.7 Common WBS Elements. Definitions for Common WBS elements applicable to the Missile System, and all other defense materiel items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX D: ORDNANCE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

D.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for the munition and launch system. Definitions for WBS elements common to the ordnance system and all other defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

D.2 APPLICABLE DOCUMENTS

D.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

ANSI Standards can be found online at:

http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

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D.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Ordnance System			
1.1		Munition		
1.1.1			Airframe	
1.1.1.1				Airframe Integration, Assembly, Test and Checkout
1.1.1.2				Primary Structure
1.1.1.3				Secondary Structure
1.1.1.4				Aero-Structures
1.1.1.5				Other Airframe Components 1…n (Specify)
1.1.2			Propulsion	
1.1.2.1				Propulsion Integration, Assembly, Test and Checkout
1.1.2.2				Motor/Engine
1.1.2.3				Fuel Management
1.1.2.4				Arm/Fire Device
1.1.2.5				Propulsion Software Release 1…n
1.1.2.6				Other Propulsion Subsystems 1…n (Specify)
1.1.3			Power and Distribution	
1.1.3.1				Power and Distribution Integration, Assembly, Test and Checkout
1.1.3.2				Primary Power
1.1.3.3				Power Conditioning Electronics
1.1.3.4				Distribution Harnesses
1.1.3.5				Power and Distribution Software Release 1…n
1.1.3.6				Other Power and Distribution Subsystems 1…n
1.1.4			Guidance	
1.1.4.1				Guidance Integration, Assembly, Test and Checkout
1.1.4.2				Dome Assembly
1.1.4.3				Seeker Assemblies
1.1.4.4				Guidance Software Release 1…n
1.1.4.5				Other Guidance Subsystems 1…n (Specify)
1.1.5			Navigation	
1.1.5.1				Navigation, Integration, Assembly, Test and Checkout
1.1.5.2				Sensor Assemblies
1.1.5.3				Navigation Software Release 1…n
1.1.5.4				Other Navigation Subsystems 1…n (Specify)
1.1.6			Controls	
1.1.6.1				Controls Integration, Assembly, Test and Checkout
1.1.6.2				Primary Structure
1.1.6.3				Fin/Canard Deployment System
1.1.6.4				Actuators
1.1.6.5				Control Power
1.1.6.6				Controls Software Release 1…n
1.1.6.7				Other Controls Subsystems 1…n (Specify)
1.1.7			Communications	
1.1.7.1				Communications Integration, Assembly, Test and Checkout
1.1.7.2				Antenna Assembly
1.1.7.3				Communications Software Release 1…n
1.1.7.4				Other Communications Subsystems 1…n (Specify)
1.1.8			Payload	
1.1.8.1				Payload Integration, Assembly, Test and Checkout
1.1.8.2				Target Defeat Mechanism
1.1.8.3				Target Detection Device
1.1.8.4				Fuze
1.1.8.5				Payload Software Release 1…n
1.1.8.6				Other Payload Subsystems 1…n (Specify)

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1.1.9		On Board Test Equipment
1.1.10		On Board Training Equipment
1.1.11		Auxiliary Equipment
1.1.12		Munition Software Release 1…n
1.1.13		Munition Integration, Assembly, Test and Checkout
1.2	Encasement Device	
1.2.1		Encasement Device Integration, Assembly, Test and Checkout
1.2.2		Encasement Device Structure
1.2.3		Encasement Device Software Release 1…n
1.2.4		Other Encasement Device Subsystems 1…n (Specify)
1.3	Launch System	
1.3.1		Launch System Integration, Assembly, Test and Checkout
1.3.2		Launcher
1.3.3		Carriage
1.3.4		Fire Control
1.3.5		Ready Magazine
1.3.6		Adapter Kits
1.3.7		Launch System Software Release 1…n
1.3.8		Other Launch System 1…n
1.4	Ordnance System Software Release 1…n	
1.5	Ordnance System Integration, Assembly, Test and Checkout	
1.6	System Engineering	
1.7	Program Management	
1.8	System Test and Evaluation	
1.8.1		Development Test and Evaluation
1.8.2		Operational Test and Evaluation
1.8.3		Mock-ups / System Integration Labs (SILs)
1.8.4		Test and Evaluation Support
1.8.5		Test Facilities
1.9	Training	
1.9.1		Equipment
1.9.2		Services
1.9.3		Facilities
1.10	Data	
1.10.1		Technical Publications
1.10.2		Engineering Data
1.10.3		Management Data
1.10.4		Support Data
1.10.5		Data Depository
1.11	Peculiar Support Equipment	
1.11.1		Test and Measurement Equipment
1.11.2		Support and Handling Equipment
1.12	Common Support Equipment	
1.12.1		Test and Measurement Equipment
1.12.2		Support and Handling Equipment
1.13	Operational/Site Activation	
1.13.1		System Assembly, Installation and Checkout on Site
1.13.2		Contractor Technical Support
1.13.3		Site Construction
1.13.4		Site/Ship/Vehicle Conversion
1.13.5		Sustainment/Interim Contractor Support
1.14	Industrial Facilities	
1.14.1		Construction/Conversion/Expansion
1.14.2		Equipment Acquisition or Modernization
1.14.3		Maintenance (Industrial Facilities)
1.15	Initial Spares and Repair Parts	

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D.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

D.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

D.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

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D.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

D.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

D.4 DEFINITIONS

D.4.1 Ordnance System. The complex of hardware, software, data, services, and facilities required to develop and produce the capability for applying munitions to a target.

D.4.2 Munition. Historically, munitions were unguided weapons unpowered after leaving its launching device that has as its purpose the destruction of some object or target. The term includes, but is not limited to, such items as ammunition, projectiles, mines, bombs, rockets, mortars, depth charges and torpedoes. If guidance and control components are added to munitions to increase accuracy those modified systems are still classified as munitions. Specific examples of munitions include, but are not limited to: Excalibur, JSOW, MRM, Paveway, SDB I, SDB II. This WBS element includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use) and is comprised of the sub elements listed below.

D.4.2.1 Airframe. This element comprises the structural framework that provides the aerodynamic shape, mounting surfaces and environmental protection for the munition components, which are not directly applicable to other specific Level 3 munition subsystems.

Includes, for example:

a. Wings and fins that provide aerodynamic flight control in response to electro-mechanical signals and are attached to the munition body
b. Structural body assemblies including the structure, covers, skins, adhesives, and fairings not directly applicable to any other Level 3 munition subsystem
c. Protection devices for stressing environmental conditions such as thermal protection system or rain erosion that are not directly applicable to other Level 3 munition subsystems

D.4.2.1.1 Airframe Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Airframe.

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D.4.2.1.2 Primary Structure. This element comprises the structural framework that provides for load carry hardware such as the air carry system, interfaces to loading and launching devices, and other hard points needed to protect the munition from environmental induced loads.

D.4.2.1.3 Secondary Structure. This element comprises the secondary hardware needed to maintain aerodynamic shapes, interfaces between other subsystems, fuel tanks, protection subsystems such as a Thermal Protection System (TPS), and other structure not directly associated with the primary structure or other Level 3 subsystems.

D.4.2.1.4 Aero – Structures. This element comprises the hardware needed for aerodynamic flight effects.

Includes, for example:

a. Wings, fins, canards, stability systems, and inlets for air breathing propulsion

D.4.2.1.5 Other Airframe Components 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

D.4.2.2 Propulsion. The element comprises the equipment integral to the munition, which provides supplemental forces post launch to propel the munition from its launch position to the target or to assist in countering the forces of drag (i.e., base bleed). The equipment may employ solid rocket motor or air-breathing technologies.

D.4.2.2.1 Propulsion System Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Propulsion System. For example, this element includes those structural elements that transfer the thrust loads or provide the primary path for vehicle loads through the propulsion system such as forward and aft skirts and/or interstages or other components through which the propulsion system is attached to the munition and transfers primary loads. In addition it includes the hardware and secondary structure to provide interfaces to other elements such as raceways, connectors, cutouts, access doors, etc. or any other hardware that interfaces with other elements of the munition except for primary structural elements.

D.4.2.2.2 Motor/Engine (Specify). The structure (integral to the propulsion system), propellant, controls, instrumentation, and all other installed subsystem equipment integral to the rocket motor or engine as an entity within itself.

Includes, for example:

a. Rocket Motor. This element is applicable to a solid propulsion system and consists of the thrust producing component in which solid propellant, made up of fuel and oxidizer, is combusted and expelled through a nozzle. It includes the pressure vessel, an igniter, internal insulation, solid propellant and a nozzle. If applicable it includes the functionality to move the nozzle or a portion of the nozzle but not the actuation system to cause that movement.
b. Air Breathing Engine. This element is applicable to an air breathing propulsion system in which a stream of air is supplied to the engine along with a liquid fuel. The engine operates to mix and combust the air and fuel and to expel the products through a nozzle to produce thrust. It includes all the turbines, compressors, injectors, etc. to act on the air and fuel from the inlet to the engine through the exhaust from the engine. It does not include aerodynamic inlets on the munition to deliver air to the engine.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

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D.4.2.2.3 Fuel Management. All of the tanks, lines, pressurization system and/or pressure control, pumps, valves, etc. to deliver the fuel and oxidizer to the engine at the required conditions.

D.4.2.2.4 Arm/Fire Devices. Hardware to arm, disarm and initiate operation of the propulsion system.

D.4.2.2.5 Propulsion Software Release 1...n. All propulsion subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.2.6 Other Propulsion Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.3 Power and Distribution. This element comprises prime power and distribution for the munition.

D.4.2.3.1 Power and Distribution Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the above Level 4 elements into their Level 3 element, Power and Distribution.

D.4.2.3.2 Primary Power. This element comprises primary power for the munition.

Excludes, for example:
a. Batteries that may be integral to other Level 3 elements.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.3.3 Power Conditioning Electronics. This element comprises prime power conditioning electronics. It excludes power conditioning integral to other Level 3 elements.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

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D.4.2.3.4 Distribution Harness. This element comprises prime power distribution harnesses.

Excludes, for example:
a. Harnessing integral to other Level 3 elements.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.3.5 Power and Distribution Software Release 1…n. All power and distribution subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.3.6 Other Power and Distribution Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.4 Guidance. Guidance is the process of maneuvering the munition to engage the intended target. This WBS element is the compliment of hardware, software and equipment for target detection, signal processing, implementation of guidance laws and generation of guidance commands.

Excludes, for example:
a. Navigation
b. Control

D.4.2.4.1 Guidance Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Guidance.

D.4.2.4.2 Dome Assembly. Windows, domes or radomes, and associated retention mechanisms, to cover the seeker(s) apertures used for target detection and is suitable to support seeker functionality. Contingent upon the design, this may be included within the Seeker Assemblies WBS element.

D.4.2.4.3 Seeker Assemblies. This element comprises the sensors (RF, EO, SAL, etc., as applicable), sensor electronics, gimbal assembly, on-gimbal electronics and integral structure(s), which constitutes the Seeker Assembly.

Includes, for example:
a. Radio frequency (RF), electro optical (EO), and semi-active laser (SAL) sensors

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.4.4 Guidance Software Release 1…n. All guidance subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.4.5 Other Guidance Subsystems 1…n (Specify). This element should be replaced with other product-oriented guidance subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.5 Navigation. The compliment of hardware, software and equipment to measure or determine body angles and /or body linear motion and generation of navigation commands.

Excludes, for example:
a. Guidance
b. Control

D.4.2.5.1 Navigation Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout the Level 4 elements below into their Level 3 element, Navigation.

D.4.2.5.2 Sensor Assemblies. Hardware that provides data for determination of munition location and orientation.

Includes, for example:
a. Global Positioning System (GPS) receiver and antenna
b. Inertial sensors
c. Altimeter

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

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D.4.2.5.3 Navigation Software Release 1…n. All navigation subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.5.4 Other Navigation Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.6 Controls. The hardware, software and equipment for controlling the motion of the munition from launch to impact.

Includes, for example:
a. Control devices for canard, wing, tail, etc.
b. Thrust vector / jet van
c. Explosive charge / lateral thrusters

Excludes, for example:
a. the control surfaces themselves (such as canards, wings, tails, etc.) included in the Airframe element

D.4.2.6.1 Controls Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Controls.

D.4.2.6.2 Primary Structure. The structural framework not part of the Airframe element.

D.4.2.6.3 Fin/Canard Deployment System. The hardware for fin/canard deployment.

D.4.2.6.4 Actuators. The hardware for actuation to include motors and servos.

D.4.2.6.5 Control Power. This element comprises power for the control element.

Excludes, for example:
a. Central power sources included in the Power and Distribution WBS element

D.4.2.6.6 Controls Software Release 1…n. All controls subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.6.7 Other Control Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/ Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.7 Communication. This data link equipment to enable communications between the munition and an external entity (or entities). Data links can be either receive only or send only (one-way) or bidirectional (two way).

Includes, for example:

a. Data transmission and reception for networking, command and control, battle space awareness, and air traffic management enabling the munition to be a node in the net

D.4.2.7.1 Communications Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the =Level 4 elements below into their Level 3 element, Communication.

D.4.2.7.2 Antenna Assembly. The hardware comprising the Antenna Assembly or Assemblies.

D.4.2.7.3 Communication Software Release 1…n. All communication subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.7.4 Other Communications Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.8 Payload. The Target Defeat Mechanism (TDM) and its support assemblies. Normally, payload consists only of the TDM and its associated target detection, arming and fuzing equipment. However, with complex munitions containing submunitions, the payload subsystem may mimic the larger system by having its own guidance and control, fuze, safe-arm, and propulsion. In multi-mission or adaptable payloads there may be a communication device that provides data to payload for output yield, real-time directions for aimable capabilities or layer-counting type applications.

D.4.2.8.1 Payload Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 4 elements below into their Level 3 element, Payload.

D.4.2.8.2 Target Defeat Mechanism. The hardware and software that produce(s) the desired effect on the target. TDMs include, but are not limited to, conventional high explosives (explosive outputs of blast, fragmentation, and penetrator-forming), directed energy devices, kinetic energy devices, dispensed submunitions or others.

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.8.3 Target Detection Device (TDD). The hardware and software that detects and signals the presence of a target. TDDs include, but are not limited to, contact sensors (make or break electronics), EO or RF based proximity sensors and necessary hardware and software for signal processing.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the munition is excluded.

D.4.2.8.4 Fuze. The equipment in the munition that controls the capability of initiating the TDM (e.g., mechanical, hydrostatic, inertial, counters, and timers). It includes the hardware and software for the Safe, Arm and Fire (SAF) function; sensors and algorithms, if applicable, to enable "smart fuzing"; and the hardware and software associated with the firing train.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.8.5 Payload Software Release 1…n. All payload subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.8.6 Other Payload Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.9 On Board Test Equipment. This element comprises the payload that is interchangeable with the live warhead and suitable for development or operational testing in a free flight (post launch) environment.

Includes, for example:

a. Recovery systems
b. Special instrumentation
c. Telemetry equipment
d. Flight termination equipment, etc., suitable for a launch and free flight environment.

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.10 On Board Training Equipment. This element comprises the payload that is interchangeable with the live warhead and suitable for testing in a non-launch environment. Includes, for example, special instrumentation, telemetry equipment, etc., suitable for a non-launch environment.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.11 Auxiliary Equipment. This element comprises the complex of additional external equipment generally excluded from other specific Level 3 elements.

Includes, for example:

a. Environmental control, safety and protective subsystems, destruct systems, etc., if these were not accounted for in other WBS elements
b. Equipment of a single purpose and function, which is necessary for accomplishing the assigned mission

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Munition is excluded.

D.4.2.12 Munition Software Release 1…n. All munition software not associated with a specific Level 3 or 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.2.13 Munitions Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 3 elements below into their Level 2 element, Munitions.

D.4.3 Encasement Device. The hardware and software associated with the Munition Canister or Encasement device.

D.4.3.1 Encasement Device Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the above Level 3 elements into their Level 2 element, Encasement Device.

D.4.3.2 Encasement Device Structure. This element comprises the primary structure of the canister or encasement device.

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D.4.3.3 Encasement Software Release 1…n. All Encasement software not associated with a specific Level 3 element above.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.3.4 Other Encasement Device Subsystems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 3 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 2 element.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Encasement Device element is excluded.

D.4.4 Launch System. The equipment (hardware/software) for controlling or sending forth the munitions on a desired course or trajectory.

Includes, for example:

a. Rifles, artillery pieces, naval guns, mortar cannons, machine guns, and the equipment for launching torpedoes and rockets or dropping bombs (e.g., the launcher, fire control equipment, and the ready magazine).
b. All effort associated with the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use).

D.4.4.1 Launch System Integration, Assembly, Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the Level 3 elements below into their Level 2 element, Launch System.

D.4.4.2 Launcher. The structural device designed to support and hold munitions in position for firing or release.

Includes, for example:

a. Suspension and release systems, rail, rocket pods, mine racks or dispensers, and torpedo tubes and other devices which support, suspend, or encase the munition for firing. These other devices would be in addition to any encasement, if applicable, integral to a munition.
b. (For guns and artillery) tubes, recoil assemblies, breech mechanisms, mounts, and rifle stocks

D.4.4.3 Carriage. The primary equipment (hardware/software), which serves as a platform to accommodate the other Level 3 elements and provides mobility to the complete launch system (e.g., T-frame, hull/chassis, wheels, tires, tubes, brakes, hydraulics, and secondary power batteries/generators), which are an integral part of the carriage itself and not directly a part of other Level 4 elements.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the Launch System is excluded.

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D.4.4.4 Fire Control. The equipment (hardware/software) for controlling the direction, volume, and time of fire or release of munitions through the use of electrical, electronic, optical, or mechanical systems, devices or aids.

Includes, for example:

a. (For rifles and small arms) sighting devices and trigger mechanisms
b. (For artillery, naval guns, and heavy mortars) aiming mechanisms in traverse and elevation, radar and other sensors, computers and other equipment for performing fire control computations
c. (For air-dropped munitions) gunsights, intervalometers, and other sensor and computational devices for controlling the release of the munitions
d. (For torpedoes) sonar and other sensors, computers, control consoles, and devices for presetting torpedo speed and direction

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the Launch System is excluded.

D.4.4.5 Ready Magazine. The structure or compartment for storing ammunition or explosives in a ready-for-use condition or position (e.g., the part of a gun or firearm that holds the ammunition ready for chambering and feed mechanisms for placing the ammunition in a position ready for chambering).

D.4.4.6 Adapter Kits. The equipment (hardware/software) for adapting the launch system to particular applications (e.g., vehicle adapter kits for adaptation to different aircraft models, kits for backpacking, etc.).

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the Launch System is excluded.

D.4.4.7 Launch System Software Release 1…n. All launch system software not associated with a specific Level 3 or 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

D.4.4.8 Other Launch systems 1…n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/ Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch System is excluded.

D.4.5 Ordnance System Software Release 1…n. All Ordnance System software not associated with a specific Level 2, Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

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D.4.6 Ordnance System Integration Assembly Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly and checkout of the above Level 2 elements into their Level 1 element, Ordnance System.

D.4.7 Common WBS Elements. Definitions for Common WBS elements applicable to the Ordnance System, and all other defense materiel items, are listed in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX E: SEA SYSTEMS
WORK BREAKDOWN STRUCTURE AND DEFINITIONS

E.1 SCOPE

This appendix provides the Work Breakdown Structure and definitions for the Sea System. Definitions for WBS elements common to the sea system and all other defense materiel items are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

This WBS should be used for ship acquisition pricing data, ship design, weight data, configuration management and Integrated Logistics Support engineering data. It is permissible for the contactor's internal work breakdown structure to differ from these summary elements; however, the internal WBS should be mapped to the WBS and definitions defined in this appendix.

E.2 APPLICABLE DOCUMENTS

"Users Guide for Expanded Ship Work Breakdown Structure (ESWBS) for All Ships and Ship/Combat Systems, S9040-AA-IDX-020/SWBS 5D Volumes 1 and 2"

If there are high costs, high risk or high technical interest elements that must be reported below Level 3 of the WBS, users should reference the Navy ESWBS document in order to ensure consistency in reporting.

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E.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3
1.0	Sea System		
1.1		Ship	
1.1.1			Hull Structure
1.1.2			Propulsion Plant
1.1.3			Electric Plant
1.1.4			Command, Communications and Surveillance
1.1.5			Auxiliary Systems
1.1.6			Outfit and Furnishings
1.1.7			Armament
1.1.8			Total Ship Integration/Engineering
1.1.9			Ship Assembly and Support Services
1.2		System Engineering	
1.3		Program Management	
1.4		System Test and Evaluation	
1.4.1			Development Test and Evaluation
1.4.2			Operational Test and Evaluation
1.4.3			Mock-ups / System Integration Labs (SILs)
1.4.4			Test and Evaluation Support
1.4.5			Test Facilities
1.5		Training	
1.5.1			Equipment
1.5.2			Services
1.5.3			Facilities
1.6		Data	
1.6.1			Technical Publications
1.6.2			Engineering Data
1.6.3			Management Data
1.6.4			Support Data
1.6.5			Data Depository
1.7		Peculiar Support Equipment	
1.7.1			Test and Measurement Equipment
1.7.2			Support and Handling Equipment
1.8		Common Support Equipment	
1.8.1			Test and Measurement Equipment
1.8.2			Support and Handling Equipment
1.9		Operational/Site Activation	
1.9.1			System Assembly, Installation and Checkout on Site
1.9.2			Contractor Technical Support
1.9.3			Site Construction
1.9.4			Site/Ship/Vehicle Conversion
1.9.5			Sustainment/Interim Contractor Support
1.10		Industrial Facilities	
1.10.1			Construction/Conversion/Expansion
1.10.2			Equipment Acquisition or Modernization
1.10.3			Maintenance (Industrial Facilities)
1.11		Initial Spares and Repair Parts	

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E.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering/Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

E.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers. For lower level elements, reference the ESBS.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

E.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

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E.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

E.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

E.4 DEFINITIONS

E.4.1 Sea System. Identifies the function of equipment (hardware/software), data, services, and facilities required to attain the capability of operating or supporting the operation of naval missions or performing other naval tasks at sea.

E.4.2 Ship. The waterborne vessel and components of a sea system.

Includes, for example:

a. All classes of surface and subsurface water vessels such as combatants, auxiliaries, amphibious, and special-purpose ships
b. Design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)

NOTE: Further breakouts of Level 3 elements under the Level 2 Ship element are defined in the Expanded Ship Work Breakdown Structure (ESWBS).

E.4.2.1 Hull Structure. The assembled main hull body including all hull support structure, superstructure, bulkheads, platforms, masts, and foundations.

Includes, for example:

a. Shell plating, longitudinal and transverse framing, platforms and decks, superstructure, foundations, structural bulkheads, enclosures and sponsons
b. Castings, forgings, and welds; fixed ballast; doors and closures; king-posts, masts, and service platforms; and sonar domes
c. Tank/compartment tightness testing

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E.4.2.2 Propulsion Plant. The major components installed primarily for propulsion and the systems necessary to make these components operable.

Includes, for example:

a. Boilers and energy converters, propulsion units, main condensers and air ejectors, shafting, bearings, propellers, combustion air supply system, uptakes, propulsion control equipment, main steam, feed water and condensate, circulating and cooling water, fuel oil service and lubricating oil system
b. Electric power
c. Nuclear steam generators, reactors, reactor coolant and auxiliary systems, nuclear power plant control, and radiation shielding

E.4.2.3 Electric Plant. The power generating and distribution systems installed primarily for ship service and emergency power and lighting.

Includes, for example:

a. Electric power generation, power distribution switchboards, power distribution system, and lighting system

E.4.2.4 Command, Communication and Surveillance. The equipment (hardware/software) and associated systems installed to receive information from off-ship source, to transmit to off-ship receivers, and to distribute information throughout the ship.

Includes, for example:

a. Sensing and data systems required for navigation and weapon fire control
b. Navigation equipment, interior communication systems, gun fire control system, non-electronic countermeasure systems, electronic countermeasure systems, missile fire control systems, antisubmarine warfare fire control and torpedo fire control systems, radar systems, radio communication systems, electronic navigation systems, Space Vehicle electronic tracking systems, sonar systems, electronic tactical data systems, all associated software, computer systems, fiber optic plant, inter/intranet and entertainment systems

NOTE 1: If lower level information can be collected, use the ESWBS.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the ship is excluded.

E.4.2.5 Auxiliary Systems. The support systems for ship control, main propulsion components, ship safety, deck operations and environmental control.

Includes, for example:

a. The auxiliary machinery and piping systems; the hull mechanical handling systems; and ship control systems and surfaces such as rudders, hydrofoils, and diving planes
b. Heating, ventilation, and air conditioning systems; refrigeration plant and equipment
c. Gasoline, JP-5, all liquid cargo piping, oxygen-nitrogen and aviation lubricating oil systems
d. Plumbing installation, saltwater service systems, fire extinguishing systems, drainage, ballast, trimming, heating, and stabilizer tank systems
e. Fresh water system, scuppers and deck drains
f. Fuel and diesel oil filling, venting, stowage and transfer systems
g. Tank heating systems, compressed air system, auxiliary steam, exhaust steam and steam drains, buoyancy control system, distilling plant
h. Mooring, towing, anchor and aircraft handling systems; deck machinery; elevators; moving stairways; stores strikedown and stores handling equipment; operating gear for retracting and elevating units; aircraft elevators

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i. Aircraft arresting gear, barriers, and barricades
j. Catapults and jet blast deflectors, replenishment at sea and cargo handling systems
k. Design, development, production, and assembly efforts to provide each auxiliary system as an entity

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the ship is excluded.

E.4.2.6 Outfit and Furnishings. The outfit equipments and furnishings required for habitability and operability, which are not specifically included in other ship elements.

Includes, for example:
a. Hull fittings
b. Boats, boat stowage and handlings
c. Rigging and canvas; ladders and gratings; nonstructural bulkheads and doors; painting, deck covering, hull insulation; cathodic protection systems; refrigerated spaces; storerooms, stowage and lockers
d. Equipment for utility space, workshops, laboratories, test areas, galley, pantry, scullery and commissary outfit
e. Furnishings for living spaces, offices, control centers, machinery spaces, medical, dental and pharmaceutical spaces; and nonpropulsion space shielding
f. Design, development, production, and assembly efforts to provide the outfit and furnishing element as an entity

E.4.2.7 Armament. The complex of armament and related ammunition handling, stowage, and support facilities; and cargo munitions handling, stowage, and support facilities.

Includes, for example:
a. Guns and gun mounts; ammunition handling systems and stowage; special weapons handling and storage
b. Rocket and missile launching devices, handling systems and stowage
c. Air launched weapons handling systems and stowage; and cargo munitions handling and stowage
d. Torpedo, mines, small arms and pyrotechnic launching devices, handling systems and stowage systems
e. Design, development, production, and assembly efforts to provide the armament element as an entity

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the ship is excluded.

E.4.2.8 Total Ship Integration/Engineering. The engineering effort and related material associated with the design, development, and rework to provide the ship as a whole exclusive of that included under the Systems Engineering/Program Management element.

Includes, for example:
a. Construction drawings, engineering calculations, weighing and weight calculations, photographs, models, and shipbuilders information drawings

E.4.2.9 Ship Assembly and Support Services. The efforts and material associated with construction that cannot be logically and practicably identified with, or related to, other Level 3 elements.

Includes, for example:
a. Staging, scaffolding, and cribbing; temporary utilities and services; molds, templates, jigs, fixtures, and special production tools; dry-docking, inspection, insurance, launching, and delivery

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b. Production and construction planning; dock, sea and inclining trials

E.4.3 WBS Common Elements. Definitions for common WBS elements applicable to the sea system and all other defense materiel items are found in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

Sea specific common elements are identified in Appendix L see L.3.2, L.3.3, L.3.4.1, L.3.6.1, L.3.6.2 and L.3.6.3.

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APPENDIX F: SPACE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

F.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for Space Vehicles, Ground Segments, Orbital Transfer Vehicles, and Launch Vehicles as they relate to Earth-Orbiting, Unmanned Space Systems. This WBS may also be used for interplanetary and other missions. However, additional WBS elements (for example, probes) may be required. Definitions for WBS elements common to the Space System are defined in Appendix L: Common Elements, Work Breakdown Structures and Definitions in section L.4.

F.2 APPLICABLE DOCUMENTS

F.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*
ANSI Standards can be found online at:
http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

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F.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4	Level 5
1.0	Space System				
1.1		SEIT/PM and Support Equipment (1…s) 1			
1.1.1			Systems Engineering		
1.1.2			Assembly, Integration and Test		
1.1.3			Program Management		
1.1.4			Support Equipment		
1.2		Space Vehicle 1..n (Specify)2			
1.2.1			SEIT/PM and Support Equipment		
1.2.1.1				Systems Engineering	
1.2.1.2				Assembly, Integration and Test	
1.2.1.3				Program Management	
1.2.1.4				Support Equipment	
1.2.2			Bus		
1.2.2.1				SEIT/PM and Support Equipment	
1.2.2.1.1					Systems Engineering
1.2.2.1.2					Assembly, Integration and Test
1.2.2.1.3					Program Management
1.2.2.1.4					Support Equipment
1.2.2.2				Structures and Mechanisms (SMS)	
1.2.2.2.1					SEPM
1.2.2.2.2					Assembly, Integration and Test
1.2.2.2.3					Support Equipment
1.2.2.2.4					Structures
1.2.2.2.5					Mechanisms and Pyrotechnics
1.2.2.2.6					SMS Other
1.2.2.3				Thermal Control (TCS)	
1.2.2.3.1					SEPM
1.2.2.3.2					Assembly, Integration and Test
1.2.2.3.3					Support Equipment
1.2.2.3.4					Cryogenic Devices
1.2.2.3.5					Liquid Loops
1.2.2.3.6					Electric Coolers
1.2.2.3.7					Heaters, Thermisters and Thermostats
1.2.2.3.8					Passive Devices
1.2.2.3.9					TCS Other
1.2.2.4				Electrical Power (EPS)	
1.2.2.4.1					SEPM
1.2.2.4.2					Assembly, Integration and Test
1.2.2.4.3					Support Equipment
1.2.2.4.4					Solar Array
1.2.2.4.5					Solar Array Positioner
1.2.2.4.6					Radioisotope Thermionic Generator
1.2.2.4.7					Other Power Sources
1.2.2.4.8					Power Control, Switching and Distribution Electronics
1.2.2.4.9					Power Conditioning, Conversion and Regulation
1.2.2.4.10					Power Dissipation Devices
1.2.2.4.11					Rechargeable Batteries
1.2.2.4.12					Charge Control Electronics
1.2.2.4.13					Harnesses and Cables
1.2.2.4.14					EPS Other
1.2.2.5				Attitude Control (ACS)	
1.2.2.5.1					SEPM
1.2.2.5.2					Assembly, Integration and Test
1.2.2.5.3					Support Equipment

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1.2.2.5.4 Star Tracker/Sensors 1…n (Specify)
1.2.2.5.5 Earth (Horizon) Sensors 1…n (Specify)
1.2.2.5.6 Sun Sensors 1…n (Specify)
1.2.2.5.7 Magnetometers
1.2.2.5.8 Global Positioning System (GPS) Receiver
1.2.2.5.9 Inertial Reference Unit-IRU / Inertial Measurement Unit-IMU 1…n (Specify)
1.2.2.5.10 Rate Gyros 1…n (Specify)
1.2.2.5.11 Accelerometers 1…n (Specify)
1.2.2.5.12 Bearing and Power Transfer Assy (BAPTA)
1.2.2.5.13 Attitude Control Wheels 1…n (Specify)
1.2.2.5.14 Magnetic Control Devices
1.2.2.5.15 Spin Control Devices
1.2.2.5.16 Control Electronics 1…n (Specify)
1.2.2.5.17 ACS Other
1.2.2.6 Propulsion 1..n (Specify)
1.2.2.6.1 SEPM
1.2.2.6.2 Assembly, Integration and Test
1.2.2.6.3 Support Equipment
1.2.2.6.4 Tanks 1…n (Specify)
1.2.2.6.5 Plumbing
1.2.2.6.6 Thrusters 1…n (Specify)
1.2.2.6.7 Solid Rocket Motors
1.2.2.6.8 Liquid Propellant and Pressurant
1.2.2.6.9 Power Electronics
1.2.2.6.10 Propulsion Other
1.2.2.7 Telemetry, Tracking, and Command (TTandC)
1.2.2.7.1 SEPM
1.2.2.7.2 Assembly, Integration and Test
1.2.2.7.3 Support Equipment
1.2.2.7.4 Antennas
1.2.2.7.5 Passive Signal Flow Control
1.2.2.7.6 Transmitter/Receiver/Transceiver/Transponder 1..n (Specify)
1.2.2.7.7 Modulators/Demodulators/Modems
1.2.2.7.8 Amplifiers
1.2.2.7.9 Frequency Upconverter/Downconverter
1.2.2.7.10 Computers and Processors 1…n (Specify)
1.2.2.7.11 Command/Telemetry Units 1…n (Specify)
1.2.2.7.12 Command Sensors 1…n (Specify)
1.2.2.7.13 Frequency and Timing
1.2.2.7.14 Signal Conditioners
1.2.2.7.15 Communications Security 1…n (Specify)
1.2.2.7.16 Data Storage, Handling and Interface 1…n (Specify)
1.2.2.7.17 TTandC Other
1.2.2.8 Bus Flight Software
1.2.2.8.1 SEPM
1.2.2.8.2 Assembly, Integration and Test
1.2.2.8.3 Support Equipment
1.2.2.8.4 CSCI 1…n (Specify)
1.2.3 SEIT/PM and Support Equipment (If applicable for integration of Multiple Payloads)
1.2.3.1 Systems Engineering
1.2.3.2 Assembly, Integration and Test
1.2.3.3 Program Management
1.2.3.4 Support Equipment
1.2.4 Payload 1...n (Specify)
1.2.4.1 SEIT/PM and Support Equipment
1.2.4.1.1 Systems Engineering
1.2.4.1.2 Assembly, Integration and Test

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1.2.4.1.3	Program Management
1.2.4.1.4	Support Equipment
1.2.4.2	Structures and Mechanisms
1.2.4.2.1	SEPM
1.2.4.2.2	Assembly, Integration and Test
1.2.4.2.3	Support Equipment
1.2.4.2.4	Structures
1.2.4.2.5	Mechanisms and Pyrotechnics
1.2.4.2.6	Structures and Mechanisms Other
1.2.4.3	Thermal Control
1.2.4.3.1	SEPM
1.2.4.3.2	Assembly, Integration and Test
1.2.4.3.3	Support Equipment
1.2.4.3.4	Cryogenic Devices
1.2.4.3.5	Liquid Loops
1.2.4.3.6	Electric Coolers
1.2.4.3.7	Electric Heaters, Thermisters and Thermostats
1.2.4.3.8	Passive Devices
1.2.4.3.9	Sun Shields
1.2.4.3.10	Thermal Control Other
1.2.4.4	Electrical Power
1.2.4.4.1	SEPM
1.2.4.4.2	Assembly, Integration and Test
1.2.4.4.3	Support Equipment
1.2.4.4.4	Power Sources
1.2.4.4.5	Power Control Switching and Distribution Electronics
1.2.4.4.6	Power Conditioning, Conversion and Regulation
1.2.4.4.7	Harnesses and Cables
1.2.4.4.8	Electrical Power Other
1.2.4.5	Pointing, Command, and Control Interface
1.2.4.5.1	SEPM
1.2.4.5.2	Assembly, Integration and Test
1.2.4.5.3	Support Equipment
1.2.4.5.4	Computers and Processors 1…n (Specify)
1.2.4.5.5	Command/Telemetry Units 1…n (Specify)
1.2.4.5.6	Control Electronics 1...n (Specify)
1.2.4.5.7	Pointing Sensors 1…n (Specify)
1.2.4.5.8	Payload Positioners1...n (Specify)
1.2.4.5.9	Security, Encryption and Decryption Devices1...n (Specify)
1.2.4.5.10	Data Storage, Handling and Interface 1…n (Specify)
1.2.4.5.11	Multifunctional Digital Electronic Boxes 1…n (Specify)
1.2.4.5.12	Pointing, Command, and Control Interface Other
1.2.4.6	Payload Antenna1..n (Specify)
1.2.4.6.1	SEPM
1.2.4.6.2	Assembly, Integration and Test
1.2.4.6.3	Support Equipment
1.2.4.6.4	Structures and Mechanisms
1.2.4.6.5	Antenna Positioners
1.2.4.6.6	Reflector/Horn1…n (Specify)
1.2.4.6.7	Feed1…n (Specify)
1.2.4.6.8	Waveguide/Coax/Cabling
1.2.4.6.9	Transmit/Receive Modules
1.2.4.6.10	Antenna Other
1.2.4.7	Payload Signal Electronics
1.2.4.7.1	SEPM
1.2.4.7.2	Assembly, Integration and Test
1.2.4.7.3	Support Equipment

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1.2.4.7.4 Passive Signal Flow Control
1.2.4.7.5 Transmitter/Receiver/Transceiver/Transponder 1…n (Specify)
1.2.4.7.6 Modulators/Demodulators/Modems 1…n (Specify)
1.2.4.7.7 Multiplexers/Demultiplexers 1…n (Specify)
1.2.4.7.8 Amplifiers 1…n (Specify)
1.2.4.7.9 Frequency Upconverters/Downconverters 1…n (Specify)
1.2.4.7.10 Frequency and Timing 1…n (Specify)
1.2.4.7.11 Signal Conditioners 1…n (Specify)
1.2.4.7.12 Multifunctional Signal Electronic Boxes 1…n (Specify)
1.2.4.7.13 Signal Electronics Other
1.2.4.8 Optical Assembly
1.2.4.8.1 SEPM
1.2.4.8.2 Assembly, Integration and Test
1.2.4.8.3 Support Equipment
1.2.4.8.4 Structure/Outerbarrel/Cover
1.2.4.8.5 Mirrors and Optics 1…n (Specify)
1.2.4.8.6 Aft Optics Assembly
1.2.4.8.7 Alignment and Calibration 1…n (Specify)
1.2.4.8.8 Optical Assembly Other
1.2.4.9 Sensor
1.2.4.9.1 SEPM
1.2.4.9.2 Assembly, Integration and Test
1.2.4.9.3 Support Equipment
1.2.4.9.4 Enclosure 1..n (Specify)
1.2.4.9.5 Focal Plane Array 1…n (Specify)
1.2.4.9.6 Sensor Positioners 1…n (Specify)
1.2.4.9.7 Sensor Electronics 1…n (Specify)
1.2.4.9.8 Alignment and Calibration 1…n (Specify)
1.2.4.9.9 Magnetometer (1…n (Specify))
1.2.4.9.10 Spectrometer 1…n (Specify)
1.2.4.9.11 Radiometer 1…n (Specify)
1.2.4.9.12 Camera 1…n (Specify)
1.2.4.9.13 Sounder 1…n (Specify)
1.2.4.9.14 Other Sensor Types 1…n (Specify)
1.2.4.9.15 Mission Sensor Other
1.2.4.10 Payload Flight Software
1.2.4.10.1 SEPM
1.2.4.10.2 Assembly, Integration and Test
1.2.4.10.3 Support Equipment
1.2.4.10.4 CSCI 1…n (Specify)
1.2.4.11 Payload Other
1.2.5 Booster Adapter
1.2.6 Space Vehicle Storage
1.2.7 Launch Systems Integration (LSI)
1.2.8 Launch Operations
1.2.9 Mission Operations Support
1.2.10 Space Vehicle Other
1.3 Ground Operations and Processing Center 1…n (Specify) 2
1.3.1 SEIT/PM and Support Equipment
1.3.1.1 Systems Engineering
1.3.1.2 Assembly, Integration and Test
1.3.1.3 Program Management
1.3.1.4 Support Equipment
1.3.2 Function (1…F) [3]
1.3.2.1 SEIT/PM and Support Equipment
1.3.2.1.1 Systems Engineering
1.3.2.1.2 Assembly, Integration and Test

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1.3.2.1.3 Program Management
1.3.2.1.4 Support Equipment
1.3.2.2 COTS Hardware
1.3.2.2.1 SEPM
1.3.2.2.2 Assembly, Integration and Test
1.3.2.2.3 Support Equipment
1.3.2.2.4 Workstations 1…n (Specify)
1.3.2.2.5 Servers 1…n (Specify)
1.3.2.2.6 Storage and Archive 1…n (Specify)
1.3.2.2.7 network Equipment
1.3.2.2.8 Interface Equipment
1.3.2.2.9 Security Encryption/Decryption 1…n (Specify)
1.3.2.2.10 Data Processing 1…n (Specify)
1.3.2.2.11 COTS Hardware Other
1.3.2.2.12 Pre-Ops Maintenance 1…n (Specify)
1.3.2.3 Custom Hardware
1.3.2.3.1 SEPM
1.3.2.3.2 Assembly, Integration and Test
1.3.2.3.3 Support Equipment
1.3.2.3.4 Custom Hardware Configured Item 1…n (Specify)
1.3.2.3.5 Pre-Ops Maintenance 1…n (Specify)
1.3.2.4 GOPC Software
1.3.2.4.1 SEPM
1.3.2.4.2 Assembly, Integration and Test
1.3.2.4.3 Support Equipment
1.3.2.4.4 CSCI 1..n (Specify)
1.3.2.4.5 Pre-Ops Maintenance 1…n (Specify)
1.3.2.5 Pre-Operations Mission Support
1.4 Ground Terminal/Gateway (GT) 1…n (Specify) [2]
1.4.1 SEIT/PM and Support Equipment
1.4.1.1 Systems Engineering
1.4.1.2 Assembly, Integration and Test
1.4.1.3 Program Management
1.4.1.4 Support Equipment
1.4.2 Antenna 1..n (Specify)
1.4.2.1 SEPM
1.4.2.2 Assembly, Integration and Test
1.4.2.3 Support Equipment
1.4.2.4 Pedestal
1.4.2.5 Radome
1.4.2.6 Other Structure and Mechanisms
1.4.2.7 Aperture
1.4.2.8 Feed 1...n (Specify)
1.4.2.9 Waveguide/Coax/Cabling
1.4.2.10 Antenna Other
1.4.3 Optical Communication Assembly 1...n (Specify)
1.4.3.1 SEPM
1.4.3.2 Assembly, Integration and Test
1.4.3.3 Support Equipment
1.4.3.4 Structure/Outerbarrel/Cover
1.4.3.5 Mirror/Optics 1..n (Specify)
1.4.3.6 Aft Optics and Bench
1.4.3.7 Alignment Sensors/Calibration
1.4.3.8 Optical Assembly Other
1.4.4 RF Electronics (Band 1…n (Specify))
1.4.4.1 SEPM
1.4.4.2 Assembly, Integration and Test

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1.4.4.3			Support Equipment
1.4.4.4			Passive Signal Flow Control
1.4.4.5			Transmitter/Receiver/Transceiver/Transponder 1…n (Specify)
1.4.4.6			Modulators/Demodulators/Modems 1…n (Specify)
1.4.4.7			Multiplexers/Demultiplexers 1…n (Specify)
1.4.4.8			Power Amplifiers 1…n (Specify)
1.4.4.9			Frequency Upconverters/Downconverters 1…n (Specify)
1.4.4.10			Signal Conditioners 1…n (Specify)
1.4.4.11			Signal Electronic Boxes 1…n (Specify)
1.4.4.12			Focal Plane Array 1…n (Specify)
1.4.4.13			RF Electronics Other
1.4.5		Timing	
1.4.5.1			SEPM
1.4.5.2			Assembly, Integration and Test
1.4.5.3			Support Equipment
1.4.5.4			Receiver
1.4.5.5			Antenna 1...n (Specify)
1.4.5.6			Frequency and Timing Generators
1.4.5.7			Amplifier and Distribution 1…n (Specify)
1.4.5.8			Timing Other
1.4.6		Baseband-network	
1.4.6.1			SEPM
1.4.6.2			Assembly, Integration and Test
1.4.6.3			Support Equipment
1.4.6.4			Switches/Hubs and Routers
1.4.6.5			network Interface and Other Hardware
1.4.6.6			Modems
1.4.6.7			Security/Encryption and Decryption Devices 1...n (Specify)
1.4.6.8			Baseband-network Electronic Boxes 1…n (Specify)
1.4.6.9			Baseband-network Other
1.4.7		Monitor and Control Hardware	
1.4.7.1			SEPM
1.4.7.2			Assembly, Integration and Test
1.4.7.3			Support Equipment
1.4.7.4			Workstations 1…n (Specify)
1.4.7.5			Servers 1…n (Specify)
1.4.7.6			Hardware Configured Item 1…n (Specify)
1.4.8		GT Software	
1.4.8.1			SEPM
1.4.8.2			Assembly, Integration and Test
1.4.8.3			Support Equipment
1.4.8.4			CSCI 1…n (Specify)
1.4.9		Pre-Operations Maintenance 1…n (Specify)	
1.4.10		Pre-Operations Mission Support	
1.5	External network (T-COMM)		
1.5.1		SEIT/PM and Support Equipment	
1.5.1.1			Systems Engineering
1.5.1.2			Assembly, Integration and Test
1.5.1.3			Program Management
1.5.1.4			Support Equipment
1.5.2		Leased Circuits	
1.5.2.1			Leased Circuit 1…n (Specify)
1.5.3		Purchased Circuits	
1.5.3.1			Purchased Circuit 1…n (Specify)
1.5.3.2			Pre-Ops Maintenance 1…n (Specify)
1.6	User Equipment		
1.6.1		SEIT/PM and Support Equipment	

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1.6.1.1			Systems Engineering
1.6.1.2			Assembly, Integration and Test
1.6.1.3			Program Management
1.6.1.4			Support Equipment
1.6.2		Equipment 1..n (Specify)	
1.6.2.1			SEPM
1.6.2.2			Assembly, Integration and Test
1.6.2.3			Support Equipment
1.6.2.4			Hardware Configured Item 1...n (Specify)
1.6.2.5			CSCI 1…n (Specify)
1.6.3		Pre-Ops Maintenance 1…n (Specify)	
1.7	Facilities 1..n (Specify)		
1.7.1		SEIT/PM and Support Equipment	
1.7.1.1			Systems Engineering
1.7.1.2			Assembly, Integration and Test
1.7.1.3			Program Management
1.7.1.4			Support Equipment
1.7.2		Site Preparation	
1.7.2.1			SEPM
1.7.2.2			Assembly, Integration and Test
1.7.2.3			Support Equipment
1.7.2.4			Graded Land
1.7.2.5			Roads
1.7.2.6			Pads
1.7.2.7			Retaining Walls / Fencing
1.7.2.8			Utilities
1.7.2.9			Site Preparation Other
1.7.3		Landscape	
1.7.4		Buildings 1…n (Specify)	
1.7.4.1			SEPM
1.7.4.2			Assembly, Integration and Test
1.7.4.3			Support Equipment
1.7.4.4			Foundation and Sub Structure
1.7.4.5			Superstructure and Finishing
1.7.4.6			Buildings Other
1.7.5		Equipment and Building Fit Out 1...n (Specify)	
1.7.5.1			SEPM
1.7.5.2			Assembly, Integration and Test
1.7.5.3			Support Equipment
1.7.5.4			HVAC
1.7.5.5			Power Conditioning/UPS
1.7.5.6			network Wiring/Cable Trays
1.7.5.7			Generators
1.7.5.8			Computer Flooring
1.7.5.9			Appliances
1.7.5.10			Furniture
1.7.5.11			Equipment and Building Fit Out Other
1.7.6		Pre-Operations Maintenance 1…n (Specify)	
1.8	Vehicles and Shelters		
1.8.1		SEIT/PM and Support Equipment	
1.8.1.1			Systems Engineering
1.8.1.2			Assembly, Integration and Test
1.8.1.3			Program Management
1.8.1.4			Support Equipment
1.8.2		Vehicles	

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1.8.2.1			Vehicle 1…n (Specify)
1.8.3		Shelters	
1.8.3.1			Shelter 1...n (Specify)
1.8.4		Pre-Operations Maintenance 1…n (Specify)	
1.9	Insurance		
1.9.1		SEPM	
1.9.2		Insurance Policy	
1.9.3		Insurance Settlements	
1.10	Task Orders		
1.10.1		Task Order 1...n (Specify)	
1.11	Orbital Transfer Vehicle (OTV)		
1.12	Launch Vehicle 1...n (Specify)		

F.3.1 Application of Common WBS Elements as they pertain to Space (Appendix L – Section L.4) (including SEIT/PM and Support Equipment). Normally, WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; Acquisition Logistics; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support; however, Space System Work Breakdown Structure, all common elements, applicable to Space Systems are now captured within Appendix F. The following new elements are now included as part of Appendix-F: Systems Engineering, Integration and Test, Program Management, and Support Equipment. Systems Engineering and Program Management are combined into a single SEPM element at Level 5. These elements are found throughout all levels of a WBS. Definitions for the Space Unique Common WBS elements, and all other defense materiel items, are included in Appendix L. Section L.4 consists of Definitions of Common Elements Applicable to Space Programs.

F.3.2 Contract WBS Naming Conventions. The contract WBS shall use the appropriate Space System WBS elements and shall not include elements that are not within the scope of the contract. The contract element titles need not be identical to the Space WBS and may use the contractor names of hardware units and software CSCIs. Wherever possible, these titles should be descriptive of the element and not generic. For example, the following should not be used as complete titles: Other Costs, Digital Electronic Box 1, Bus Flight Software CSCI Application 2. As a specific example, the preferred title is “S-Band Helix Antenna”, as opposed to merely “Antenna” or “S-Band Helix”. Additionally, SEIT/PM and Support Equipment references should be replaced with terminology that accurately reflects its level and specific content, such as: “Space Vehicle Systems Engineering”. WBS elements that appear within multiple legs of the WBS should also indicate to which portion of the WBS it belongs. For example, a Receiver within an EHF Payload could be name “Wideband EHF Receiver”.

F.3.3 Application of (1...n), and (1…F) convention. This document uses a (1...n) after WBS element titles where the element may have multiple unique occurrences. When creating the WBS for a specific program or contract, the (1...n) shall be replaced with a specific name for the item. For example, where this WBS references Star Trackers (1…n) and the Attitude Control subsystem contains two types of Star Trackers, the contract WBS shall specifically identify them as separate Level 5 elements; such as Narrow Field Of View (NFOV) Star Tracker and Wide Field Of View (WFOV) Star Tracker. Fifth level elements without the (1...n) convention are primarily a collection of items that do not need to be extended to lower levels for reporting or other purposes. The contract dictionary definition for these elements shall be clear as to which Space System WBS element it belongs.

NOTE: The (1…F) convention is similar to the 1…n convention above, but is for functional breakout of specific GOPC systems. See Note 1 within F.4.3.3.1 for a detailed explanation.

F.3.4 Use of “Other” WBS Elements, The Other WBS elements at the system, subsystem, and element (product) levels are restricted to products that have not been envisioned or predicted in the other defined WBS elements. This element should only be used when all other elements have been thoroughly examined and do not fit the definition of the “other” product. Multiple elements, with appropriate titling, should be detailed down to the element level (Level 5) whenever possible. In addition the WBS dictionary should clearly define the elements. The program WBS index shall describe the element(s) and avoid any reference to “other”.

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F.3.5 Use of the word "seperable". Some of the definitions use the term "separable" with reference to hardware or software. Hardware and software are "separable" (from other hardware and software) if their costs are identifiable from each other.

F.3.6. Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

F.3.7 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

F.3.7.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and

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assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

F.3.7.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

F.4 DEFINITIONS

F.4.1 Space System. The complex of equipment (Hardware/Software) and all of the resources associated with the design, development, production, integration, assembly, test, and operation of the entire Space System.

Includes, for example:

a. Space vehicle(s); ground operations and processing center(s); ground terminals; launch vehicle(s); and any mission equipment or other items necessary to provide an operational capability in space.
b. Any efforts done within a development/acquisition contract, including such things as integrated logistic planning, space vehicle on-orbit checkout, calibration, and orbit raising.
c. Program management, system engineering, integration and test, support equipment at all levels of indenture where they are necessary

Excludes, for example:

a. On-orbit operations beyond checkout and acceptance
b. Ground operations and maintenance

F.4.2 Space Vehicle 1…n (Specify). A complete Space Vehicle in a multiple or dissimilar Space Vehicle configuration. This WBS element is intended for Space Vehicle(s) that are unmanned satellites orbiting the earth. It contains all of the resources associated with the design, development, production, integration, assembly, and test to include verification testing of each Space Vehicle as required.

Includes, for example:

a. The design, development, and production, integration, assembly, test, and checkout of complete elements (i.e., the prototype or operationally configured elements, which satisfy the requirements of their applicable specification, regardless of end use)
b. Sub-elements to the Space Vehicle-Bus, Payload; Booster Adapter; Space Vehicle Storage; Launch Systems Integration; Launch Operations and Mission Operations Support (F.4.2.1-F.4.2.7)

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L section L.4.

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F.4.2.1 Bus. The portion of the Space Vehicle that serves as a housing or platform for carrying Payloads and provides necessary support functions (power, thermal control, etc.). It also interfaces with the Launch Vehicle (F.4.7) via the Booster Adapter (F.4.2.3).

Includes, for example:

a. Structures and Mechanisms (S&M), Thermal Control (TCS), Electrical Power (EPS), Attitude Control (ACS), Propulsion (PS), Telemetry, Tracking, and Command (TT&C) subsystems; and Bus Flight Software
b. All design, development, production, and assembly, test, and checkout efforts to provide the Bus as an entity or as subsystems for integration with other WBS Level 3 elements (i.e., Payload Equipment) hardware elements

NOTE 1: On more complicated Space Vehicles, there may be an integrated digital system (single electronic box or set of boxes) that performs processing functions for both the Bus and Payloads. In these cases it is acceptable to consider the Multi-Processor system as a single Payload or as part of a specific Payload. The Multi-Processor System may integrate functions normally included under ACS, TT&C, Communication and other Payloads. The relevant point is to keep the cost in a single element and not allocate over multiple WBS elements.

NOTE 2: For lower level Common Elements such as SEIT/PM, reference Appendix L, section L.4.

F.4.2.1.1 Structures and Mechanisms (SMS). This subsystem provides structural support, deployment and locking functions for the Space Vehicle.

Includes, for example:

a. Items such as structure, mechanisms, structures with integral (non-removable) thermal control, pyrotechnics
b. Equipment compartments, trusses, frames and shells for carrying primary loads; and secondary structures for equipment support; structural assemblies for interfacing with the Booster Adapter and/or with the Launch Vehicle.
c. All load carrying devices, such as Payload equipment panels that are provided to Payload equipment suppliers for supporting Payload equipment components
d. Springs, cables, latches and other mechanisms and support structures that are not defined elsewhere within the WBS and are cost separable

Excludes, for example:

a. Mechanisms that are identified with specific elements they support, such as Solar Array Positioners and gimbals for antennas
b. Booster adapters not integral with spacecraft structures
c. Payload fairings that are included in the launch vehicle element
d. Small equipment compartments or pallets that house Payload electronics, which are part of the Payload element
e. Booms that are used to exclusively support Payload components or assemblies in the Payload element

NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.1.1.1 Structures. This collection of items provides structural support for all Bus and Payload components and assemblies. They include items such as equipment compartments (structural elements that protect from radiation, thermal, electromagnetic, and other effects; excluding single unit chassis integral to that unit); trusses, frames and shells for carrying primary loads; and secondary structures for equipment support. This element includes all load-carrying devices, such as Payload equipment panels that are provided to Payload Equipment suppliers for supporting Payload Equipment components. However, structural elements such as small equipment

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compartments or pallets that house Payload electronics and are provided as part of Payload equipment are excluded from this WBS element and included in the appropriate Payload equipment Structures element. Booms exclusively for supporting payload equipment components or assemblies are also included in payload structures.

F.4.2.1.1.2 Mechanisms and Pyrotechnics. The collection of items that deploy or lock Space Vehicle components, excluding Antenna and Solar Array mechanisms (to the extent that the Mechanisms are separable from the components they support). This element also includes items that provide reaction force to initiate release for separation or deployment. These devices include squibs and ordnance separation units. Pyrotechnic initiation electronics are normally included within the Electrical Power subsystem.

Includes, for example:
a. Hinges
b. Springs
c. Cables
d. Latches
e. Motors
f. Separation bolts
g. Squibs

Excludes, for example:
a. Antenna
b. Optics
c. Sensor
d. Solar array mechanisms

F.4.2.1.1.3 SMS Other. This WBS element contains all the resources associated with unique Structures and Mechanisms subsystem hardware not included in WBS elements above.

F.4.2.1.2 Thermal Control (TCS). This subsystem maintains the temperatures of all Bus components, and those Payload suites without their own Thermal Control provisions, within acceptable limits.

Includes, for example:
a. Active and passive components such as Cryogenic Devices, Liquid Loops, Electric Coolers, multi-layer thermal insulation blankets (MLI), surface coatings (thermal paint), mirrors, thermal tape, heat pipes, heat sinks, insulation, conductive structures and materials, louvers, sun shields, Electric Coolers, Heaters, Thermisters, Thermostats, shutters, thermal conducting elements, and radiator panels/fins

NOTE 1: In cases where a Payload contains its own thermal control provisions, the Thermal Control components are included in the Payload WBS element.

NOTE 2: When a component or unit has integral (non-removable) thermal control provisions such as heat sinks, thermisters, or heaters then that item should be included within that component or unit.
NOTE 3: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.1.2.1 Cryogenic Devices. This collection of items facilitates the control of operating temperatures of Bus components and those Payload suites without their own Thermal Control provisions by obtaining or operating at cryogenic (below 150 degrees centigrade) temperatures. Examples include cryocoolers and cryostats.

F.4.2.1.2.2 Liquid Loops. This collection of items compose a heat transfer system that helps control temperatures of Bus components, and those Payload suites without their own Thermal Control provisions. This system is usually comprised of fluid (gas or liquid) conduits (tubing), heat exchangers, and pumps.

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F.4.2.1.2.3 Electric Coolers. This collection of items electrically reduces operating temperatures of Bus components, and those Payload suites without their own thermal control provisions.

Includes, for example:
a. Peltier devices
b. Peltier diodes
c. Peltier heat pumps
d. Solid state refrigerators
e. Thermoelectric coolers (tecs) or any electronics for controlling the coolers

F.4.2.1.2.4 Heaters, Thermisters and Thermostats. This collection of items actively controls heat loss by generating heat and controlling and monitoring temperatures. Thermisters and Thermostats are equivalent terms. Heater switching is included within the Electrical Power subsystem.

F.4.2.1.2.5 Passive Devices. This collection of items passively maintain the temperatures of all Bus components, and those Payload suites without their own Thermal Control provisions.

Includes, for example:
a. Radiator panels/fins
b. Coatings
c. Heat pipes
d. Insulation
e. Conductive structures
f. Louvers and sun shields

F.4.2.1.2.6 TCS Other. This WBS element contains all the resources associated with unique Thermal Control subsystem hardware items not included in WBS elements above.

F.4.2.1.3 Electrical Power (EPS). This subsystem generates, converts, regulates, stores, distributes, and switches electrical energy to Bus and Payload components.

Includes, for example:
a. Electric power generation: solar array (to include substrates, solar cells, support structure), solar array positioner (to include drive assembly and drive electronics), radioisotope thermionic generator, other power sources
b. Electric power conditioning and distribution: power control electronics (to include junction boxes and pyrotechnics/heater controls), power conversion electronics (to include inverters, converters and regulators), power dissipation devices (to include shunt resistor banks and dissipaters)
c. Electric power storage: rechargeable batteries (to include cells, support structure and interconnects), charge control electronics
d. Harnesses and cables

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.1.3.1 Solar Array. These elements generate power by converting solar energy into electricity with strings of solar cells. This WBS includes substrates, solar cells, interconnecting wiring, concentrators, cover-glass and supporting structure, which together form a solar panel. A Solar Array is made up of one or more solar panels (for example, a Solar Array wing) and mechanisms for deployment and latching.

F.4.2.1.3.2 Solar Array Positioner. This element orients the Solar Array to get the best sun incidence angle in order to maximize solar cell efficiency. This WBS includes both the drive assembly and any integral drive control electronics. Control Electronics for the positioner are typically located in the Attitude Control subsystem.

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F.4.2.1.3.3 Radioisotope Thermionic Generator. This element converts heat into electricity via thermionic emission using nuclear-reactor or radioisotope energy sources. They are typically used for deep space missions where long mission life is required and when distances from the sun are large enough to render Solar Arrays ineffective.

F.4.2.1.3.4 Other Power Sources. These elements contain all the resources associated with electrical power generation hardware not included in WBS elements above. These elements include items such as non-rechargeable batteries and fuel cells (which convert chemical energy into electrical energy) and are typically used as backup power systems, using an energy source other than the Space Vehicle's main power source.

F.4.2.1.3.5 Power Control, Switching and Distribution Electronics. This collection of items allow for power flow throughout the Space Vehicle. This WBS element includes power control, switching and distribution units; junction boxes; Pyrotechnics initiation, Heater switching, Propulsion Valve Drive Modules (PVDM), and battery switching units.

F.4.2.1.3.6 Power Conditioning, Conversion and Regulation. This collection of items condition, convert and regulate power throughout the Space Vehicle.

Includes, for example:
a. Inverters, converters, and regulators

F.4.2.1.3.7 Power Dissipation Devices. This collection of items dissipate power not used by the Space Vehicle electrical loads. This includes shunt resistor banks and other dissipaters.

F.4.2.1.3.8 Rechargeable Batteries. This collection of items stores and subsequently releases electrical energy. Batteries convert chemical energy into electrical energy during discharge and electrical energy into chemical energy during charge.

Includes, for example:
a. Battery cells
b. Supporting structure (or packs)
c. Interconnects
d. Reconditioning equipment

F.4.2.1.3.9 Charge Control Electronics. This collection of items charges the batteries. This element controls the level to which a battery is charged or discharged. This includes battery charge assembly (BCA) and diodes.

F.4.2.1.3.10 Harnesses and Cables. This element is the collection of items used to route and provide electrical power and signals throughout the Space Vehicle. This is also commonly referred to as "wiring."

Includes, for example:
a. Coaxial
b. Fiber optic cables
c. Installation hardware

Excludes, for example:
a. Harnessing within a Payload

F.4.2.1.3.11 EPS Other. This WBS element contains all the resources associated with unique Electrical Power subsystem hardware items not included in WBS elements above.

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F.4.2.1.4 Attitude Control (ACS). This element determines and controls Space Vehicle orbital positions, attitudes, velocities and angular rates using onboard sensors and torque application devices. It may also send control signals to Propulsion subsystem components (e.g., Thrusters), the Electrical Power subsystem, Solar Array Positioners, and communication/ Payload positioner electronics.

Includes, for example:

a. Attitude determination: attitude reference (to include star tracker/sensors, earth (horizon) sensors, sun sensors, magnetometers), inertial reference (to include inertial reference units, rate gyros, accelerometers), bearing and power transfer assemblies (BAPTAs), and global position system (GPS) receivers
b. Attitude control: gyro stabilization devices [to include reaction wheels, momentum wheels, control moment gyros, energy storage devices (flywheels)], magnetic control devices, spin control devices, control electronics

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.1.4.1 Star Tracker/Sensors 1...n (Specify). These elements are optical devices measuring the direction to one or more stars, typically using a photocell or solid-state Camera to observe the star(s).

F.4.2.1.4.2 Earth (Horizon) Sensors 1...n (Specify). These elements are optical instruments that detect light from the 'limb' of the Earth's atmosphere, i.e., at the horizon. This can be a scanning or a staring instrument. Infrared is often used, which can function even on the dark side of the Earth. These elements provide orientation with respect to the Earth about two orthogonal axes.

F.4.2.1.4.3 Sun Sensors 1...n (Specify). These elements sense the direction to the Sun. This can be as simple as some solar cells and shades, or as complex as a steerable telescope, depending on mission requirements.

F.4.2.1.4.4 Magnetometers. These elements are used to measure the strength and/or direction of the Earth's magnetic field. A commonly used device is a Three Axis Magnetometer (TAM), which helps the momentum management functions to generate signals to the Magnetic Torque Assembly (MTA). The TAM outputs three analog signals that are proportional to the components of the Earth's magnetic field in the Magnetometer coordinate frame.

F.4.2.1.4.5 Global Positioning System (GPS) Receiver. This element calculates position by using timing signals sent by the constellation of GPS satellites. A GPS constellation is comprised of Medium Earth Orbit satellites that transmit precise microwave signals, that enable GPS Receivers to determine their location, speed, direction, and time. Excluded from this is the GPS Antenna and coax cabling that is included in the TT&C subsystem.

F.4.2.1.4.6 Inertial Reference Unit-IRU / Inertial Measurement Unit-IMU 1…n (Specify). These elements are a type of inertial sensor that uses only gyroscopes to determine a the Space Vehicle's change in angular direction (referred to as "delta-theta" or $\Delta\theta$) over a period of time. Unlike an Inertial Measurement Unit, Inertial Reference Units (IRUs) are generally not equipped with Accelerometers, which measure acceleration forces. IRUs are typically used for Attitude Control and navigation of vehicles with relatively constant acceleration rates, such as geosynchronous satellites and deep space probes.

F.4.2.1.4.7 Rate Gyros 1...n (Specify). These elements are sensors used to measure the angular rate measurements (3 degree axis - roll, pitch and yaw) of the Space Vehicle to help with maintaining the stabilization and pointing accuracy of the Space Vehicle.

F.4.2.1.4.8 Accelerometers 1...n (Specify). These elements are devices for measuring acceleration and gravity induced reaction forces. Single- and multi-axis models are available to detect magnitude and direction of the acceleration as a vector quantity. Accelerometers can be used to sense inclination, vibration, and shock.

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F.4.2.1.4.9 Bearing and Power Transfer Assembly (BAPTA). This element is a mechanism that transmits electrical power and signals across rotating joints between the "spun" and "despun" sections of spin-stabilized space vehicles. They also control the orientation of the despun section about the spin axis in inertial space. A BAPTA usually consists of three main parts: (1) a bearing unit, (2) a drive unit and (3) a slip ring unit.

F.4.2.1.4.10 Attitude Control Wheels 1...n (Specify). These elements, also known as Gyro Stabilization Devices, provide angular stabilization of the Space Vehicle. These wheels control the attitude via the internal torques created by the electrically generated rotation of wheels. Usually, the wheels can be commanded to spin in either a clockwise or a counterclockwise direction, thereby creating the necessary angular momentum to counter the Space Vehicle's momentum, in order to provide stability and pointing accuracy. Examples include: reaction wheels, control moment gyros (CMGs) and momentum wheels. Control electronics for wheel devices are included in the Control Electronics element (F.4.2.1.4.13) if they are separable from the wheel devices.

F.4.2.1.4.11 Magnetic Control Devices. These elements are electromagnets that apply torques to the Space Vehicle by interacting with the Earth's magnetic field. They typically consist of a solid metal core, which is wound with two independent coils of copper wire, a case that protects them from physical damage and ultraviolet radiation, and mounting blocks and a connector.

F.4.2.1.4.12 Spin Control Devices. These elements dampen disturbance accelerations in spin-stabilized space vehicles. They include nutation and wobble dampers.

F.4.2.1.4.13 Control Electronics 1...n (Specify). These elements provide electrical interfaces between the Space Vehicle processor and sensors and effectors (reaction control wheels, BAPTAs, Magnetic Control Devices, Solar Array Positioners, Valves and Thrusters, etc.). This WBS element also includes computers or processors that are dedicated to Attitude Control subsystem functions. For effectors, the Control Electronics receive the input command from the Space Vehicle processor and convert it to the corresponding electrical interface stimulus, e.g., pulses, digital to analog converter (DAC), etc. for the effector. For sensors, the Control Electronics condition the telemetry signal (such as tach pulses, active analogs, etc.) to either an analog signal within the Analog-to-Digital Converter (ADC) range and/or convert to a corresponding digital output.

F.4.2.1.4.14 ACS Other. This WBS element contains all the resources associated with unique Attitude Control subsystem hardware items not included in WBS elements above.

F.4.2.1.5 Propulsion 1...n (Specify)[1]. This subsystem provides thrust for attitude control and orbit corrections as required to accomplish the specified mission. It may also provide thrust for orbit injection and changes.

Includes, for example:

a. Tanks, plumbing, thrusters, solid rocket motors, liquid propellant and pressurant

NOTE 1: A propulsion subsystem can either be liquid or electric; if the Space Vehicle contains both types, create two separate subsystems (1...n). Solid fuel Propulsion components, integral to the Space Vehicle, are booked with liquid Propulsion subsystem items.

NOTE 2: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.1.5.1 Tanks 1…n (Specify). These elements provide for storage of propellants and pressurants used in the Propulsion subsystem. Includes, for example, fuel tanks, oxidizer tanks, monopropellant tanks, helium (pressurant) tanks, xenon tanks, etc.

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F.4.2.1.5.2 Plumbing. This collection of items provides for the Distribution and flow control of Propellants and Pressurants. Includes, for example, lines (tubing), fittings, regulators, filters, valves (squib, latch, fill/drain and check), manifolds, transducers, and installation hardware.

F.4.2.1.5.3 Thrusters 1...n (Specify). Thrusters provide the force to alter the attitude and velocity of a space vehicle. Includes, for example, Liquid Apogee Engine (LAE), liquid apogee motor, and thrusters of different LBFs (Pounds force), monopropellant, bipropellant, Xenon, and Hall Effect. This element also includes any Gimbal mechanism required for vector movement. This element excludes the electronics controlling the liquid thrusters, which are included in either the Attitude Control Subsystem or the TT&C Subsystem.

F.4.2.1.5.4 Solid Rocket Motors. These elements provide reaction force for the final Space Vehicle maneuver into orbit and for orbit changes. Nozzles may be fixed or steerable. Includes, for example, nozzle, casing, solid fuel propellant (grain), and igniter. Motors may be single use only, extinguished and re-ignited, or contain segments that are ignited by command. One specific example would be an Apogee Kick Motor (AKM).

F.4.2.1.5.5 Liquid Propellant and Pressurant. This collection of items provides for the propellant and pressurant (liquids and gasses) used to generate force (Delta V) or pressure. Includes, for example, bipropellant fuel and oxidizer, monopropellant fuel, helium pressurant, xenon (for electric propulsion) and other gasses/fuel used in the Propulsion subsystem.

F.4.2.1.5.6 Power Electronics. This element is a collection of items provide for the electric power used for an electric Propulsion subsystem. Includes, for example, power supplies and relay units. Excludes the power generation and distribution associated with the Electrical Power subsystem.

F.4.2.1.5.7 Propulsion Other. This element contains all the resources associated with unique Propulsion subsystem hardware items not included in WBS elements above.

F.4.2.1.6 Telemetry, Tracking, and Command (TT&C). This element performs functions such as: formatting and transmitting telemetry (typically on narrowband links); accepting, decoding, verifying, and storing uplink commands; and generating command and control signals for the Bus and Payload suites based on uplink commands and/or internally generated data. The TT&C subsystem may also: provide central processing functions, provide timing signals to the Bus and Payload suites; perform on-board attitude determination, ephemeris calculations and Attitude Control equipment control (if these are not performed by dedicated Attitude Control computers/electronic components); and perform Thruster control, Positioner control, Electrical Power monitoring/and control (if this is not performed by dedicated Electrical Power subsystem components).

Includes, for example:

a. Passive radio frequency (RF) components (such as antennas, passive signal flow control), other RF equipment (such as transmitters, receivers, transponder, modulators, demodulators, power amplifiers, traveling wave tube assembly, solid state power amplifiers, downconverters, and upconverters), processors (such as onboard computers [obcs]), solid state memory, decoders, command units, telemetry units, command sequencers, timing units, frequency generators, signal conditioners, data switches, and other electronics

Excludes, for example:

a. Pointing command and control equipment integral or dedicated to payload functions

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

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F.4.2.1.6.1 Antennas. These elements are primarily used for TT&C specific functions. They receive RF signals for the command and control of the Space Vehicle and transmit Space Vehicle telemetry to the ground. These elements are typically omni-directional antennas including support structure and mechanisms, but can also be Feeds, Reflectors, and arrays. Antennas that are primarily used for mission objectives should be located within the Payload WBS. Includes the antenna for the GPS receiver.

F.4.2.1.6.2 Passive Signal Flow Control. This element is a collection of items that provide various passive RF signal flow and conditioning functionality within the TT&C subsystem. Includes, for example, RF plumbing, diplexers, triplexers, multiplexers, multicouplers, coaxial switches, RF switches, filters, waveguides, TT&C internal harnesses and cables, and other similar low-value items.

F.4.2.1.6.3 Transmitter/Receiver/Transceiver/Transponder 1...n (Specify). These electronics send and/or receive signals to and/or from TT&C antennas and separate them into analog or digital signals. TT&C transmitters typically convert digital telemetry signals into modulated RF signals. TT&C receivers receive RF signals and convert them to digital command signals. TT&C transceivers contain both a transmitter and a receiver. TT&C transponders relay RF signals.

F.4.2.1.6.4 Modulators/Demodulators/Modems. Modulators modify the amplitude, phase frequency of sinusoidal "carrier" signals to include information in the resultant (modulated) output signal. The input signals to modulators are usually digital signal streams, such as telemetry. Demodulators perform the inverse of modulators, separating digital information from carrier signals. Modems, which perform both operations, are also included in this WBS element.

F.4.2.1.6.5 Amplifiers. These elements are devices that change/increase the amplitude of a signal.

Includes, for example:
a. Solid state power amplifiers (SSPAs)
b. Traveling wave tube amplifiers (TWTAs)
c. Low noise amplifiers (LNAs)

F.4.2.1.6.6 Frequency Upconverter/Downconverter. These elements receive RF signals of one frequency and output at a different frequency. This is typically done by combining (mixing) the input signal with a sinusoidal signal from a local oscillator.

Includes, for example:
a. Frequency converters, upconverters and downconverters. A RF Upconverter is a device that takes an input of radio frequency energy of a specific frequency range and outputs it on a higher frequency. Likewise, Downconverters take an input frequency and reduce it to a lower output frequency.

F.4.2.1.6.7 Computers and Processors 1…n (Specify). These elements process data according to a list of computer software instructions (see Bus Flight Software) controlling the Bus subsystems and Payload functions not handled by Payload specific Processors. This includes, for example, Central Processing Units (CPUs) or Onboard Computers (OBCs). Computer and Processor memory may also be included within this WBS element.

Includes, for example:
a. Computers and processors that perform general spacecraft bus (and possibly payload) computing functions, such as command execution.

Excludes, for example:
a. Computers and processors dedicated to ACS attitude determination and control functions, or to payload functions, to the extent that those are separable from the TT&C computers and processors performing general functions

F.4.2.1.6.8 Command/Telemetry Units 1…n (Specify). These elements (digital) provide the engineering definitions used to configure and determine the health and status of the Space Vehicle. Typical Command units include: on/off, enable/disable, Flight Software (FSW) modes and states, unit configurations and operations, such as

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Reaction Control Wheel speed bias, voltage regulation percentage, Thruster valve firing durations, Solar Array angles, etc. Telemetry units are used in conjunction with calculation curves to convert raw data telemetry to engineering units, in order to determine the health and status of the Space Vehicle. Typical Telemetry Units include unit configuration and operational status: on/off, converter voltages, current draw, On-Board Fault Management (OBFM) configuration and status, FSW modes and states, attitude rates, RF signal strength, etc.

Includes, for example:

a. Command processing units
b. Telemetry processing units
c. Integrated command and telemetry (C&T) processing units (Many Space Vehicles employ both central command and telemetry units as well as remote units that interface with a limited number of payload or bus equipment)
d. Central and remote C&T elements

F.4.2.1.6.9 Command Sensors 1…n (Specify). These elements are sensors (survivability, proximity, etc.) that detect events (e.g., nuclear, electromagnetic) or the presence of nearby objects without any physical contact for the safety of the Space Vehicle. A proximity sensor often emits an electromagnetic or electrostatic field, or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor requires a metal target.

F.4.2.1.6.10 Frequency and Timing. These elements provide stable timing and frequency reference signals (RF and digital) to other Space Vehicle electronics components including Payload components without their own frequency and timing capabilities. This WBS element includes frequency generators, oscillators and timing units.

F.4.2.1.6.11 Signal Conditioners. These elements alter (e.g., filter, eliminate noise, compress, amplify) analog signals to meet the requirements of the next processing stage. For example, the output of an electronic temperature sensor may be too low for an analog-to-digital converter (ADC) to process directly. In such a case, the signal conditioner will amplify the sensor output to bring the voltage level up to that required by the ADC.

F.4.2.1.6.12 Communications Security 1...n (Specify). Communications security (COMSEC) electronics encrypt digital telemetry data and decrypt digital command data. It may also encrypt low-volume payload digital data. Inputs to encryption devices usually come from telemetry units, while decryption inputs are usually the outputs of command receivers.

In some cases COMSEC circuit boards or chips may be packaged along with command and telemetry electronics. In these cases, the integrated electronic box is included in the Command and Telemetry Electronics WBS element. Similarly, if COMSEC equipment is integrated with TT&C transmitters or receivers, the electronics box is included in the Transmitters, Receivers and Transponders WBS element.

F.4.2.1.6.13 Data Storage, Handling and Interface 1...n (Specify). These elements carry, process, and/or store housekeeping, telemetry and mission data and may interface between Bus and/or Payload units. Includes, for example, interface units, data handling units, solid state recorders (SSRs), telemetry storage units (TSUs), tape recorders and disk recorders. These elements can include compression, and other interface functions, and digital multiplexers/demultiplexers. Excludes data storage units used primarily for storing payload data.

F.4.2.1.6.14 TT&C Other. This WBS element contains all the resources associated with unique TT&C subsystem hardware items not included in WBS elements above.

F.4.2.1.7 Bus Flight Software. This element includes all resources associated with bus flight software functions. Reference Appendix B for Software definitions.

The following CSCIs should be used when applicable (lower levels of these CSCIs may be used if more appropriate): Operating System and/or Boot Code, Command and Data Handling; Database; Health Maintenance and Status; Telemetry, Tracking and Control; Attitude Control; Electrical Power Management; and Thermal Control. The Bus Flight Application Software should be more than a single CSCI.

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Excludes, for example:

a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to recurring Bus hardware units (Level 5 items)

NOTE 1: Flight Software that is not segregable between the Bus and Payload is included within this WBS. Otherwise, software for performing Payload processing is included in the Payload Flight Software WBS element. Payload TT&C SW CSCIs that run on the bus processor is included in the Bus Flight Software WBS element. Space Framework software is also included here.

NOTE 2: For lower level Common elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

NOTE 3: For lower level software information, use the structure and definitions in Appendix B, Electronics Systems.

F.4.2.2 Payload 1...n (Specify). Payloads are the sets of hardware and software on a space vehicle that perform mission functions. Examples of space system mission functions are communications, remote sensing, surveillance and scientific exploration. A space vehicle may have multiple payloads, numbered here from 1 to N. All elements and components that are shared between distinct payloads can either be included within the first payload or a separate unique payload can be created for the shared units. A typical space vehicle configuration includes a communication subsystem (e.g., Payload 1) and optionally a complement of one or more sensing, surveillance, additional communication or exploration payloads. On a communication satellite each service or band should be considered a payload. A SV with a space to ground link, a crosslink, and a phased array system should have 3 distinct payloads. Common Items between them could be included in one of them or a 4th payload can be used to house the common HW, SW and or SEIT/PM. For a weather satellite that includes an imager, instrument B, and instrument C, and two communication services should have 5 distinct payloads.

Includes, for example:

a. All of the resources associated with the design, development, production, integration, assembly, and test to include verification testing of the Payload WBS equipment
b. Payload subsystems: Structures and Mechanisms, Thermal Control, Electrical Power, Pointing Command and Control Interface, Antenna, Signal Electronics, Optical Assembly, Prime Mission Sensor, and Payload Flight Software
c. Hardware components shared with the TT&C, such as Antennas and RF electronics, that are primarily used for mission objectives (see a. below)
d. Command and Telemetry/Interface Units that are integral to the Payload suite (see b. below)

Excludes, for example:

a. Hardware components that are devoted primarily to TT&C functions (except the command and telemetry interfaces described in c. above)
b. Command and Telemetry/Interface Units that interface with Payload equipment are included in the Bus TT&C subsystem unless they are integral to the Payload suite

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.1 Structures and Mechanisms. This subsystem is a summing element for payload structures and mechanisms. It includes structure, mechanisms, pyrotechnics devoted to payload functions (see Bus Structures and Mechanisms for further definition).

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NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.1.1 Structures. This collection of items provides structural support for all Payload equipment, components and assemblies.

Includes, for example:
a. Structural support components
b. Booms (excluding antenna booms)
c. Frames, optical benches (that support the whole Payload)
d. Equipment compartments or pallets that house Payload components and are integral to the Payload equipment.
e. Optical benches may also be present within the Optical Assembly and Aft Optics elements

F.4.2.2.1.2 Mechanisms and Pyrotechnics. These elements are hardware end items, which stow, deploy, lock or support Payload components (excluding gimbals or positioners). This element also includes items that provide reaction force to initiate release for separation or deployment specific to the Payload. These elements are specific to the Payload.

Excludes, for example:
a. Payload gimbals and positioners

For a general definition, see Mechanisms and Pyrotechnics within the Bus Structures and Mechanisms subsystem.

F.4.2.2.1.3 Structures and Mechanisms Other. This element contains all the resources associated with unique Payload Structures and Mechanisms subsystem hardware items not included in elements above.

F.4.2.2.2 Thermal Control. This element uses Payload-specific thermal control equipment to maintain Payload component temperatures.

Includes, for example:
a. Active and passive components such as cryogenic devices,
b. Liquid loops
c. Electric coolers
d. Multi-layer thermal insulation blankets (MLI)
e. Surface coatings (thermal paint)
f. Mirrors
g. Thermal tape
h. Heat pipes and sinks
i. Insulation
j. Conductive structures
k. Louvers
l. Sun shields
m. Electric coolers
n. Heaters
o. Thermisters
p. Thermostats
q. Shutters
r. Thermal conducting elements
s. Radiator panels/fins

NOTE 1: In cases where Payload thermal control is an integral portion of Bus thermal control, the Payload thermal control equipment is included in the Bus Thermal Control subsystem.

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NOTE 2: When a payload component or unit has integral (non-removable) thermal control provisions such as heat sinks, thermisters, or heaters then that item should be included within that component or unit.

NOTE 3: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.2.1 Cryogenic Devices. This collection of items facilitates the control of operating temperatures of Payload components by obtaining or operating at cryogenic (below minus 150 degrees centigrade) temperatures.

Includes, for example:
a. Cryocoolers and cryostats

F.4.2.2.2.2 Liquid Loops. This collection of items compose a heat transfer system that helps control temperatures within Payload components. This system is usually comprised of fluid (gas or liquid) conduits (tubing), heat exchangers, and pumps.

F.4.2.2.2.3 Electric Coolers. This collection of items electrically reduces operating temperatures of Payload components.

Includes, for example:
a. Peltier devices
b. Peltier diodes
c. Peltier heat pumps
d. Solid state refrigerators
e. Thermoelectric coolers (TECs)
f. Electronics for controlling the coolers

F.4.2.2.2.4 Electric Heaters, Thermisters and Thermostats. This collection of items actively controls Payload heat loss by generating heat and controlling and monitoring temperatures. Thermisters and Thermostats are equivalent terms. Heater switching is included within the Payload Electrical Power or the Bus Electrical Power subsystems.

F.4.2.2.2.5 Passive Devices. This collection of items passively maintain the temperatures of all Payload components. Examples include radiator panels/fins, coatings, heat pipes, insulation, conductive Structures, and louvers.

F.4.2.2.2.6 Sun Shields. These elements, which are deployable, minimize thermal (and other energy) fluctuations by shielding the Payload from the sun. Additionally, sunshields can be employed to compensate for solar disturbances to pitch and yaw (solar torque balancing). Low-cost (passive) Payload sun shields may be included within Passive Devices.

F.4.2.2.2.7 Thermal Control Other. This element contains all the resources associated with unique Payload Thermal Control subsystem hardware items not included in elements above.

F.4.2.2.3 Electrical Power. This element generates, converts, regulates, stores and distributes electrical energy to the Payload. Included in the Payload Electrical Power subsystem are Power Supplies, Power Control Switching and Distribution, Power Conversion, and Harnesses and Cables. It excludes Electrical Power supply equipment in the Bus.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

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F.4.2.2.3.1 Power Sources. This collection of items generates and sometimes stores the Electrical Power for Payload elements requiring a power alternative to the power generated in the Bus Electrical Power subsystem. Includes, for example, Solar Arrays, batteries, and capacitors.

F.4.2.2.3.2 Power Control Switching and Distribution Electronics. This element is a collection of electronics specific to the Payload that provides electrical power to Payload components.

Includes, for example:
a. Payload power control
b. Switching and distribution electronics
c. Payload junction boxes
d. Payload pyrotechnics initiation electronics
e. Payload heater switching electronics
f. Payload battery switching electronics

F.4.2.2.3.3 Power Conditioning, Conversion and Regulation. These elements condition, convert and regulate power throughout the payload.

Includes, for example:
a. Inverters, converters, power supplies, and regulators

F.4.2.2.3.4 Harnesses and Cables. This collection of items is used to route and provide Electrical Power and signals throughout the Payload. For a general definition, see Harnesses and Cables within the Bus Electrical Power subsystem.

F.4.2.2.3.5 Electrical Power Other. This element contains all the resources associated with unique Payload Electrical Power subsystem hardware items not included in WBS elements above.

F.4.2.2.4 Pointing, Command, and Control Interface System. This element determines and controls payload positions and pointing orientations, independent of the space vehicle. This subsystem also provides processing primarily associated with payload. It is also the primary electronic interface between the payload and the spacecraft bus and/or other payloads. It may also send control signals to other payload equipment.

Includes, for example:
a. Computers and processors
b. Command and telemetry electronics
c. Control electronics
d. Pointing sensors
e. Payload positioners
f. Data handling/switching

Excludes, for example:
a. Positioners dedicated to payload antennas
b. Optical assemblies and sensors

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.4.1 Computers and Processors 1…n (Specify). These elements process payload data according to a list of computer software instructions (see Payload Flight Software) for the Payload subsystems. This excludes payload functions handled by Bus processors. This includes, for example, Central Processing Units (CPUs) or Onboard Computers (OBCs). Computer and Processor memory may also be included within this WBS element.

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F.4.2.2.4.2 Command/Telemetry Elements 1…n (Specify). These elements (digital) provide the engineering definitions used to configure and determine the health and status of the Payload. For a general definition, see Command/Telemetry Units within the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.4.3 Control Electronics 1...n (Specify). These elements provide electrical interfaces between the Payload and/or Bus processor(s)/sensors and payload effectors. For a general definition, see Control Electronics within the Bus Attitude Control subsystem.

F.4.2.2.4.4 Pointing Sensors 1…n (Specify). These elements provide directional information for Payloads. Includes Star Trackers and Sun Sensors, inertial reference units and other sensors dedicated to payload pointing/positioning. For a general definition, see corresponding sensors within the Bus Attitude Control subsystem.

F.4.2.2.4.5 Payload Positioners 1...n (Specify). These elements position, point and/or move the entire payload. This excludes those positioning elements dedicated to payload antennas, optical assemblies and sensors, which are included within the corresponding WBS elements below.

F.4.2.2.4.6 Security, Encryption and Decryption Devices 1...n (Specify). These elements encrypt and/or decrypt Payload data. For a general definition, see Communications Security (COMSEC / Encryption and Decryption devices) within the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.4.7 Data Storage, Handling and Interface 1...n (Specify). These elements carry, process, and/or store housekeeping, telemetry and mission data and may interface with Payload units.

Includes, for example:
a. Interface units, data handling units
b. Solid state recorders (SSRs)
c. Telemetry storage units (TSUs)
d. Tape recorders and disk recorders
e. Compression, and other interface functions

Excludes, for example:
a. Data storage units used primarily for storing Bus data

F.4.2.2.4.8 Multifunctional Digital Electronic Boxes 1...n (Specify). These elements are unique digital electronic devices that may combine multiple functions identified above and therefore do not fit into a single element above and are specific to the Payload. These units may also include functions from other subsystems such as Multifunctional Signal Electronic Boxes (therefore these units can include Analog/RF devices also). These units are likely to contain ASICs, FPGA, or processors and may also run software.

Includes, for example:
a. Digital signal processors, A/D and D/A converters, Digital Channelizers
b. Digital modems, routers
c. Remote access servers

F.4.2.2.4.9 Pointing, Command, and Control Interface System Other. This WBS element contains all the resources associated with unique Pointing, Command, and Control Interface subsystem hardware items not included in elements above.

F.4.2.2.5 Payload Antenna 1...n (Specify). These units transmit and/or receive RF signals. These antennas are primarily used for mission data and may also carry TT&C data. It includes structure and mechanisms, feeds, reflectors, positioners, wiring and waveguides and, for phased array antennas, transmit/receive modules.

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NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.5.1 Structures and Mechanisms. This element is a collection of items that provides structural support for Antenna equipment and components.

Includes, for example:
a. Antenna structural support components
b. Booms
c. Locks
d. Small equipment compartments or pallets that house antenna electronics and are integral to the Payload Antenna

F.4.2.2.5.2 Antenna Positioners. These elements typically point entire antennas in a desired direction. Alternatively, antenna positioners might move a reflector or feed to point the antenna beam in the desired direction.

Includes, for example:
a. Positioner mechanism and its control electronics if integral with the mechanism
b. Control electronics in separate enclosures are included in Payload Control Electronics above

F.4.2.2.5.3 Reflector 1...n (Specify). These elements focus received and/or transmitted electromagnetic waves (signals). The most common reflectors are parabolic reflectors, which focus a received signal into one point or direct a transmitted signal into a beam; flat reflectors that reflect the signal like a mirror and are often used as passive repeaters; and corner reflectors that reflect the incoming signal back in the direction it came from. A horn is an open-ended waveguide of increasing cross-sectional area, which feeds a reflector that forms a beam, or alternatively radiates directly (without a reflector).

Includes, for example:
a. Both primary and sub-reflectors

F.4.2.2.5.4 Feed 1...n (Specify). These elements receive and/or transmit signals. Functionally, they are usually located between a reflector and an amplifier, such as a high power amplifier (HPA), used for transmitting signals, or a low noise amplifier (LNA), used for receiving signals. A feed typically consists of a horn, spiral element or a set of dipoles and RF components (if they are not separable from the feed itself), such as orthomode transducers, polarizers, frequency diplexers and waveguide or coaxial cable connections. This element also includes complete antennas.

Includes, for example:
a. Horn
b. Spiral
c. Patch
d. Dipole, and helix
e. Anything that cannot be separated into components

F.4.2.2.5.5 Waveguide/Coax/Cabling. This element is a collection of items that route transmitted signals to the antenna feed or feed electronics. It also routes received signals to the first stage receiving electronics. Other signal and power routing, such as for antenna positioners, is also included in this element.

F.4.2.2.5.6 Transmit/Receive Modules. These elements provide power amplification of input signals for transmission, low noise amplification of received signals, both coupled to and received from the module's radiating elements, phase shifting in the transmit and receive mode for beam steering, and variable gain setting for aperture weighting during reception. Phased array antennas are typically made up of arrays of transmit/receive modules, coupled to a common signal source or load, to produce a directional radiation pattern. In some cases transmit/receive modules are fully integrated assemblies in the form of "tiles" that can be laid side-by-side on support structures.

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F.4.2.2.5.7 Antenna Other. This element contains all the resources associated with unique Payload Antenna subsystem Hardware not included in WBS elements above.

F.4.2.2.6 Payload Signal Electronics. This subsystem is a summing element for a wide range of Payload RF and analog signal processing electronics and RF plumbing.

Includes, for example:
a. Passive signal flow control
b. Transmitters, receivers
c. Transceivers
d. Modulators
e. Demodulators
f. Multiplexers
g. Demultiplexers
h. Power amplifiers
i. Frequency converters
j. Frequency and timing units
k. Signal conditioners

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.6.1 Passive Signal Flow Control. This element is a collection of items including a wide range of RF and other analog signal processing electronics and RF plumbing within the Payload.

Includes, for example:
a. Multicouplers, coaxial switches
b. RF switches
c. Filters
d. Waveguides (excluding those in Antenna)
e. Payload internal harnesses and cables
f. Other similar low-value items

F.4.2.2.6.2 Transmitter/Receiver/Transceiver/Transponder 1...n (Specify). These elements are electronic devices that send and/or receive signals to and/or from Antennas and separate them into useful analog or digital signals. These elements are specific to the Payload. For a general definition, see Transmitters/Receivers/ Transceivers within the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.6.3 Modulators/Demodulators/Modems 1...n (Specify). These elements include modulators, demodulators and modems that are specific to the Payload. For a general definition, see TT&C Modulators and Demodulators in the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.6.4 Multiplexers/Demultiplexers. These elements allow efficient transmission and subsequent reception of multiple signals via a single signal. A multiplexer combines several input signals into one output signal containing several communication channels. A demultiplexer separates a single input signal that carries many channels into multiple output signals.

Includes, for example:
a. Only RF and analog multiplexers and demultiplexers

Excludes, for example:
a. Digital multiplexers/demultiplexers that are located in Data Storage Handling, and Interface

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F.4.2.2.6.5 Amplifiers 1...n (Specify). These elements are devices that change/increase the amplitude of payload signals. This element includes amplifiers that are specific to the Payload. For a general definition, see TT&C Amplifiers in the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.6.6 Frequency Upconverter/Downconverter 1...n (Specify). These elements receive radio signals of one frequency and output at a different frequency. These elements are specific to the Payload. For a general definition, see Frequency Upconverters / Downconverters within the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.6.7 Frequency and Timing 1...n (Specify). These elements provide stable timing and frequency reference signals (RF and digital) to the other Payload electronics units.

Includes, for example:
a. Frequency generators
b. Oscillators
c. Timing units

F.4.2.2.6.8 Signal Conditioners 1...n (Specify). These elements alter (e.g., filter, eliminate noise, compress, amplify) analog signals to meet the requirements of the next processing stage. These elements are specific to the Payload. Excludes Power Amplifiers. For a general definition, see Signal Conditioners within the Bus Telemetry, Tracking, and Command subsystem.

F.4.2.2.6.9 Multifunctional Signal Electronic Boxes 1...n (Specify). These elements are unique analog electronic devices, which may combine multiple functions identified above and therefore do not fit into a single element above and are specific to the Payload.

Excludes, for example:
a. Units that contain Digital Electronics (See F.4.2.2.4.8 Multifunctional Digital Electronic Boxes)

F.4.2.2.6.10 Signal Electronics Other. This element contains all the resources associated with unique Payload Signal Electronics hardware items not included in WBS elements above.

F.4.2.2.7 Optical Assembly. Optical Assemblies (e.g., telescopes) have optical elements that collect and focus optical energy or create optical waveforms for transmission. They are often used to place images or optical patterns on focal plane sensors for detection, or for transmitting optical communication signals as in laser communications terminals.

Includes, for example:
a. Optical assembly structure and mechanisms
b. Thermal control provisions
c. Fore optics
d. Aft optics
e. Alignment sensors
f. Positioners and calibration equipment

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.7.1 Structure/Outerbarrel/Cover. This equipment supports and stabilizes optical elements, sensors and other optical assembly equipment.

Includes, for example:
a. Enclosing structure (including tubes/outer barrel, tube doors, and associated integration, mounting, and interface hardware)

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b. Load-bearing structure (includes equipment compartment, equipment shelf, support tubes, mounts, struts, and associated integration, mounting, and interface hardware and secondary hardware if not separable)
c. Secondary structure (including baffles), and integration, mounting, and interface hardware)
d. Door actuators (includes control electronics if costs not separable); optical bench (supporting entire optical assembly)
e. Optical-assembly specific thermal control elements (including thermostats, thermistors, thermal control electronics, heaters, insulation, and paints)
f. Other structures and mechanisms

Excludes, for example:
a. Sun shields (which are in payload thermal control) if separable

F.4.2.2.7.2 Mirrors/Optics 1...n (Specify). These elements are principal light-gathering surfaces of a reflective (using mirrors) and refractive (using lenses) telescopes and related instruments. Primary Mirrors can be monolithic blocks of glass or other material, curved to exact shapes and coated with a reflective layer; or constructed from small segments of mirrors, merged (by physical contact or later by optics) into one large Primary Mirror. Primary Optics (also called objective) refers to the lens in a refractive telescope, camera or other optical instrument that receives the first light rays from the object being observed. A Secondary Mirror (or secondary) is a second light gathering and focusing surface in a Reflector telescope. Light gathered by the Primary Mirror is directed towards a focal point typically past the location of the secondary. The secondary directs the light either out a side opening of the tube (Newtonian Reflector) or back towards a focal point behind and through the Primary Mirror/Optics. Tertiary Optics is used to change the focal point to a convenient viewing angle or location. This element includes primary, secondary, tertiary mirror assemblies (assembly may include associated mounts, mount pads, and other frame).

F.4.2.2.7.3 Aft Optics Assembly. This element is a collection of items that provide additional focusing and manipulation of radiation from the tertiary optics before it enters the collection sensor. Optical splitters, prisms, filters and relay mirrors are typical aft optical elements. Optical benches supporting the aft optics and collection sensor are made of very thermally stable materials such as Invar or graphite epoxy composites. This optical bench is integral to the Aft Optics. This WBS element excludes collection sensors that are contained in Payload Sensors.

F.4.2.2.7.4 Alignment and Calibration. This element is a collection of items that compensate for the effects of launch shock and vibration, temperature changes, release of gravitational stress, age-related distortion and other changes to the optical assembly equipment alignment. These elements are specifically designed for and dedicated to the optics assembly.

Includes, for example:
a. Alignment positioners
b. Actuators
c. Sensors
d. Integral electronics
e. Internal cables
f. Calibration light sources
g. Optics dedicated to calibration
h. Lasers used for alignment

F.4.2.2.7.5 Optical Assembly Other. This element contains all the resources associated with unique Optical Payload Assembly hardware items not included in WBS elements above.

F.4.2.2.8 Sensor. Payload sensors collect photonic, electromagnetic, and other energy and convert it into electrical signals. The most common sensors detect light in various spectrums (such as ultra-violet, visible, infrared, x-ray). Mission Sensors may include enclosures, focal planes, electronics, positioners, calibration equipment, and other sensors. Thermal control and optics equipment are also included if they are integral to the sensor (i.e., not separable).

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NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.8.1 Enclosure 1...n (Specify). These elements are a collection of items that are cabinets or housings to protect the critical elements of the sensor equipment from the environment. Enclosures protect against mechanical loads and vibration, stabilize sensor temperatures, provide electromagnetic interference (EMI) and RF interference (RFI) shielding for electronic components and prevent contamination. Focal planes and optics are typically protected by enclosures.

Excludes, for example:
a. Enclosures that are integral to the sensors

F.4.2.2.8.2 Focal Plane Array 1...n (Specify). Focal planes convert photonic radiation (visible, IR, etc.) into electronic pixels representing the image projected on a plane. Focal planes have image-sensing detectors arranged in arrays (typically rectangular) on sensor chip assemblies (SCAs). One or more SCAs comprise the total focal plane complement of detectors. A focal plane assembly includes SCAs, support structure, optical filters, wiring and thermal control devices such as cold fingers and thermal enclosures.

F.4.2.2.8.3 Sensor Positioners 1...n (Specify). These elements position, point and/or move the sensor. This excludes those positioning elements dedicated to complete payloads, antennas, and optical assemblies.

F.4.2.2.8.4 Sensor Electronics 1...n (Specify). These elements perform front-end signal conditioning/processing, signal analog-to-digital conversion, digital-to-analog conversion, focal plane excitation, command execution, telemetry feed-back, and other related electrical power, analog and digital functions. This element only includes electronics that are segregable from the sensor.

F.4.2.2.8.5 Alignment and Calibration 1...n (Specify). These elements are a collection of items that compensate sensors for the effects of launch shock and vibration, temperature change, release of gravitational stress, age-related and other changes to sensor equipment alignment. This alignment function may be accomplished with the use of an alignment sensor and positioners.

Includes, for example:
a. Black bodies
b. Light sources
c. RASNIKS
d. Lamps

F.4.2.2.8.6 Magnetometer 1...n (Specify). These elements measure the magnitude and/or direction of the Earth's magnetic field. Excludes Magnetometers used on the Bus for attitude control.

F.4.2.2.8.7 Spectrometer 1...n (Specify). These elements measure properties of light over a specific portion of the electromagnetic spectrum. They are typically used in spectroscopic analysis to identify materials. They usually separate the light signals into different frequencies, producing a dispersive or non-dispersive spectrum. A dispersive spectrometer is like a prism: it scatters light of different energies to different locations. A non-dispersive Spectrometer measures the energy directly.

F.4.2.2.8.8 Radiometer 1...n (Specify). These elements detect and measure the intensity of radiation. Radiometers can also be applied to detectors operating any wavelength in the electromagnetic spectrum. Radiometers can measure radiation from clouds, snow, ice, bodies of water, the Earth's surface and the Sun.

F.4.2.2.8.9 Camera 1...n (Specify). These elements usually employ a sensor charge coupled device (CCD) or composite metal oxide semiconductor (CMOS) charge injection device (CID) focal planes to record images.

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Excludes, for example:

a. Complex imaging payloads that are segregable into their major components (optical assembly, sensor, structure, etc.)

F.4.2.2.8.10 Sounder 1...n (Specify). These elements measure the vertical distribution of physical properties of the atmosphere such as pressure, temperature, wind speed and direction (thus deriving wind shear), liquid water content, ozone concentration, and pollution. Remote sensing soundings generally use passive infrared and microwave radiometers but some actively transmit a signal and use the returned signal to measure characteristics of the atmosphere.

F.4.2.2.8.11 Other Sensor Types 1...n (Specify). These elements are other types of sensors not listed above.

F.4.2.2.8.12 Mission Sensor Other. This element contains all the resources associated with unique Prime Mission Sensor subsystem hardware items not included in elements above.

F.4.2.2.9 Payload Flight Software. This element includes all resources associated with payload flight software functions. Reference Appendix B for Software definitions.

The payload flight software is segregated into logical products (CSCIs). The following CSCIs should be used when applicable (lower levels of these CSCIs may be used if more appropriate): Operating System and/or Boot Code, payload management, thermal control, payload processing, alignment, calibration, and payload control.

Excludes, for example:

a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to recurring payload hardware elements (Level 5 items)

NOTE 1: Flight Software for performing Payload Processing is included here. Flight Software that cannot be separated between the Bus and the Payload equipment is included within the Bus Flight Software WBS element. Payload TT&C SW CSCIs that run on the bus processor is included in the Bus Flight Software WBS element.

NOTE 2: For lower level software information, use the structure and definitions in Appendix B, Electronics Systems.

NOTE 3: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.2.2.10 Payload Other. This element contains all the resources associated with unique Payload system hardware or software items not included in WBS elements above and not applicable within the provided Payload subsystems.

F.4.2.3 Booster Adapter. The Booster Adapter provides the mechanical and electrical interface between the Launch Vehicle's uppermost stage and the Space Vehicle. It can be as simple as a snap ring device, but it is usually a more complex shell or frame structural assembly. This element is also called a payload adapter or payload attach fitting.

Includes, for example:

a. All of the material and effort associated with the design, development, production, integration, assembly, and test of the booster adapter

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b. Adapter structures, attachment and release devices, thermal control, instrumentation, and umbilical provisions
c. Adapters located between space vehicles on a multi-vehicle launch that are segregable

Excludes, for example:
a. Booster adapters integral to bus structure
b. Adapters included as part of the Launch Vehicle

F.4.2.4 Space Vehicle Storage. This element contains activities associated with storing Space Vehicles or portions of Space Vehicles. This includes preparation for storage, recovery from storage and post storage testing. The costs of holding portions of the space vehicle while waiting for the use of test facilities and/or equipment, or the completion of other portions of the Space Vehicle are also included. The storage period typically starts when production testing is complete and continues until the Space Vehicle is ready for shipping to the launch site.

Includes, for example:
a. Planning, preparation, movement, storage, maintenance, removal, refurbishment, and retesting of the Space Vehicle and/or its subsystems
b. Costs for storage facility use and environmental control equipment
c. Reinstallation of previously installed and tested components
d. Shipping between storage and refurbishment sites, including any required shipping container/packing material (if the same shipping container is used during Launch Operations then the container falls within the F.4.2.6 Launch Operations element

Excludes, for example:
a. Final space vehicle assembly and test activities of previously unassembled and/or untested portions of the Space Vehicle
b. Shipping to the launch site

F.4.2.5 Launch Systems Integration (LSI). LSI effort is primarily the engineering studies and analyses required to integrate a Space Vehicle with its Launch Vehicle and Orbital Transfer Vehicle, and insure the Space Vehicle is placed into orbit, as required. LSI effort is a coordinated activity between the Space Vehicle developer and the Launch Vehicle provider. The effort within this element is performed by Space Vehicle developer with support from the Launch Vehicle provider. The Launch Vehicle element also contains an associated LSI element.

Includes, for example:
a. Space Vehicle contractor studies, analysis, and tests supporting the integration of the Space Vehicle with the Launch Vehicle
b. Review, verification, and validation of Launch Vehicle capability and compatibility with the Space Vehicle
c. Definition, allocation, and decomposition of requirements to be placed on the Space Vehicle and Launch Vehicle, and the review, verification, and validation of these requirements
d. Development and analyses of interface control documents with the Launch Vehicle to the Space Vehicle or Ground Segment
e. Launch and range safety compliance, environmental test plans, and mission analysis.
f. Space Vehicle contractor inputs to the Launch Vehicle provider to support the Launch Vehicle provider Launch System Integration activities
g. Trajectory analyses, coupled dynamic loads analyses, induced environments analyses (acoustic, shock, vibration, thermal loads)

Excludes, for example:
a. Booster adapters that are in the Booster Adapter WBS
b. Physical integration of the Launch Vehicle with the Space Vehicle
c. Integration activities performed by the Launch Vehicle provider, which are included in the Launch Vehicle portion of the WBS

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NOTE: The complete suite of Launch Systems Integration activities normally occurs only once with each Launch Vehicle type, but a smaller subset of these activities is repeated for each launch, primarily for Launch Vehicle trajectory and performance analyses. Other Launch Systems Integration activities may be repeated for subsequent launches due to mission changes that could impact the Launch Vehicle, Booster Adapter, Orbital Transfer Vehicle, or launch site facilities.

F.4.2.6 Launch Operations. Launch Operations are those efforts performed by the provider(s) of the Space Vehicle and Payload(s) to prepare for and support Space Vehicle launches, primarily at the launch base and, to a lesser degree, the Space Vehicle factory.

Includes, for example:

a. Satellite contractor effort associated with pre-launch planning and preparation to include: training; trailblazers; pathfinders; and documentation
b. Preparation of the Space Vehicle for shipment to the launch site
c. Shipping of the Space Vehicle to the launch site, including any required shipping container/packing material
d. Payload (Space Vehicle) processing facility services
e. Final assembly, test and checkout, fueling of the Space Vehicle at the launch site
f. setup of support equipment
g. Mating the Space Vehicle to the Launch Vehicle
h. Engineering and maintenance support of the Space Vehicle at the launch site
i. Pack-up and shipment of any support equipment back from the launch site
j. Final reports

Excludes, for example:

a. Launch Systems Integration that is contained in its own Level 3 element

F.4.2.7 Mission Operations Support. This element encompasses the resources required for the deployment and operations of the Space Vehicle to achieve Initial Operational Capability (IOC).

Includes, for example:

a. telemetry (health and status) monitoring during launch, and separation;
b. planning, commanding, monitoring, and reporting for orbital maneuvers, deployment, calibration, on-orbit engineering tests (as required), and initial operations;
c. preparation, planning, and coordination of the hand-over to the long-term Mission Operations Team, which includes:

- Orbit maneuvering
- Deployment
- Initial calibration
- On-orbit testing
- Monitoring of space vehicle health and status
- Fault detection
- Anomaly investigation and resolution
- Transition activity for long-term mission operations team

NOTE: The Mission Operations Support period typically begins pre-launch and ends when the Space Vehicle achieves Initial Operational Capability.

F.4.2.8 Space Vehicle Other. This element contains all the resources associated with the Space Vehicle not included in elements above.

F.4.3 Ground Operations and Processing Center (GOPC) 1...n (Specify). These elements command the Space Vehicle, and/or process and disseminate Bus and Payload data. Each GOPC provides one or more functions

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such as: command and control (CC), mission management (MM), mission data processing, mission data analysis, engineering development network, collection management, and infrastructure and framework (I&F).

Includes, for example:
a. All of the resources associated with its design, development, production, procurement, integration, assembly, and test of GOPC hardware and software
b. Commercial Off-The-Shelf (COTS) hardware
c. custom hardware
d. Software (custom and COTS)

Excludes, for example:
a. GOPC buildings and other facilities. These are included within Facilities

NOTE 1: The intent of this (1...n) WBS structuring is to allow for separate unique GOPCs.

NOTE 2: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.3.1 Functions 1…F (Specify). This element provides for a functional breakout of the GOPC. The appropriate functional structure should be used. Functions may be combined or modified based on architecture and include their own storage and archival equipment and software. Common acquisition of equipment (e.g., Workstations) across functions can be collected within the Infrastructure and Framework (I&F) function. The I&F function can collect all the resources for that equipment/commodity, which reduces the need for allocations. The I&F function also includes any hardware or software that interfaces between multiple functions.

Includes, for example:
a. Mission Management (MM) - The Mission (Payload data) Management function receives tasking, generates and provides the system and mission plans, schedules, and timelines for the Space Vehicle(s) and GOPC(s).
b. Command and Control (CC) - The Command and Control function decodes, demultiplexes, and decrypts space vehicle telemetry, generates and encrypts commands for transmission to the spacecraft, and processes tracking data to generate space vehicle ephemeris. This function provides the capability to prepare and output commands to, receive and process telemetry from the Space Vehicle, tracking, and other non-mission data. This function includes CC for the bus and may also include CC for the payload if not included in the Mission Data Processing function.
c. Mission Data Processing - The Mission Data Processing function decodes, demultiplexes, decrypts and processes Mission data from the Payload(s) and may generate commands for Payload control if not included in CC function. Further data processing may take place external to this GOPC such as: a second GOPC, a national processing center, and/or on end-user equipment.
d. Mission Data Analysis - The Mission Data Analysis function is responsible for examination of mission data (dissection, investigation, cross-referencing, etc.), from the Payload(s) on the Space Vehicle.
e. Collection Management - The Collection Management function supports the end user by generating requests for tasking and subsequently tracking the fulfillment of each request. This function may also receive and analyze processed mission data and other external information. It could include the collection of tasking for multiple Space Systems, which subsequently forwards tasking to the Mission Management function.
f. Infrastructure and Framework (I&F) - The Infrastructure and Framework function is responsible for the interchange or transfer of wideband data, narrowband data, command and control, telemetry, and other support data between functions internally within the GOPC (e.g., between the Mission Data Processing and Mission Data Analysis functions). It also can include hardware and/or software that are common to multiple functions, the engineering development or administrative networks, or required to interface to other GOPCs (other programs) at the same Ground Site. This function is also responsible for encryption and external transmission of data from the GOPC.

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NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.3.1.1 COTS Hardware. This subsystem covers all commercial off-the-shelf (COTS) hardware items required to implement the intended function(s) of the GOPC.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.3.1.1.1 Workstations 1...n (Specify). These elements are computers often optimized for displaying and manipulating complex data such as engineering simulation, animation, image rendering, and mathematical plots. For further definition, see Workstations within the Ground Terminal Monitor and Control Hardware subsystem.

F.4.3.1.1.2 Servers 1...n (Specify). These elements are computers dedicated to providing one or more services over a computer network. For further definition, see Servers within the Ground Terminal Monitor and Control Hardware subsystem. This WBS element includes, for example, super-computers, mainframes, and mini-computers.

F.4.3.1.1.3 Storage and Archive 1...n (Specify). These elements store housekeeping, telemetry and mission data for processing and dissemination by other GOPC equipment.

Includes, for example:
a. Magnetic tape
b. Magnetic disks
c. Optical disks
d. High density digital recorders (HDDR)
e. Longitudinal recorders
f. Helical recorders (video-cassette tapes)
g. Direct archiving
h. Reconfigurable frame recorders (RFR)
i. Redundant array of independent discs (RAID)
j. Network-Attached Storage (NAS)
k. Storage Area Network (SAN)
l. Tape/optical libraries or juke boxes
m. RAM disks (solid state memory)

Excludes, for example:
a. Storage devices integral to Workstation elements

F.4.3.1.1.4 Network Equipment. This element is a collection of items that facilitate the use of a computer network.

Includes, for example:
a. Routers
b. Switches
c. Hubs
d. Gateways
e. Access points
f. Network interface cards
g. Network bridges
h. Modems

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i. ISDN adapters
j. Firewalls and other related hardware

F.4.3.1.1.5 Interface Equipment. These elements enable the recovery or creation of digital data from other formats (e.g., RF to digital, serial to parallel, fiber optic to RJ11) or to convert digital information into other formats for interfacing with other Ground equipment.

Excludes, for example:
a. Network equipment (including Modems)

F.4.3.1.1.6 Security Encryption/Decryption 1...n (Specify). These elements encrypt and/or decrypt data. For a general definition, see Communications Security (COMSEC / Encryption and Decryption devices) within the Bus Telemetry, Tracking, and Command subsystem.

F.4.3.1.1.7 Data Processing 1...n (Specify). These elements are COTS equipment that perform specialized data processing functions; typically using ASIC or FPGA technologies. Note that the resources required to develop and produce custom ASICs or to program an included FPGA is under Custom Hardware below.

Excludes, for example:
a. Workstations and servers that perform data processing functions

F.4.3.1.1.8 COTS Hardware Other. These elements contain all the resources associated with unique GOPC COTS Hardware subsystem hardware not included in elements above.

F.4.3.1.1.9 Pre-Ops Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (Pre-Ops) maintenance of GOPC COTS Hardware subsystem equipment. This function begins with the acceptance of the COTS Hardware and ends with the start of Operations.

F.4.3.1.2 Custom Hardware. This element covers all custom (non-COTS) hardware items required to implement the intended function(s) of the GOPC. This WBS element contains all the resources associated with the design, development, production, procurement, assembly, and test of GOPC custom equipment. Includes the resources required to develop and produce custom ASICs or to program FPGAs (including those inserted into COTS hardware).

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.3.1.2.1 Custom Hardware Configured Item 1...n (Specify). These elements are custom hardware devices that perform unique or specific GOPC functions.

F.4.3.1.2.2 Pre-Ops Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (Pre-Ops) maintenance of GOPC Custom Hardware subsystem equipment. This function begins with the acceptance of the Custom Hardware and ends with the start of Operations.

F.4.3.1.3 GOPC Software. This element includes all resources associated with a GOPC software function as listed in F.4.3.1 Functions. Reference Appendix B for Software definitions.

This element includes all resources associated with a GOPC software configuration item.

Includes, for example:
a. Pre-Ops Maintenance 1...n (Specify) that contains all the resources related to the pre-operations (Pre-Ops) maintenance of GOPC software. This function begins with the acceptance of the software and ends with the start of Operations

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Excludes, for example:
a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to recurring GOPC hardware elements (Level 5 items)

NOTE 1: For lower level software information, use the structure and definitions in Appendix B, Electronics Systems.

NOTE 2: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.3.1.4 Pre-Operations Mission Support. This element includes all the resources required for the operation of the GOPC prior to turn-over.

Includes, for example:
a. On-orbit testing
b. Routine monitoring of Space Vehicle equipment health and status
c. Fault detection
d. Anomaly investigation and resolution. (The Mission Support period typically begins after installation and a specified time prior to launch and ends when the Space Vehicle achieves initial operational capability.)

F.4.4 Ground Terminal/Gateway (GT) 1...n (Specify). These elements receive, demodulate, and condition telemetry, tracking, command, and mission (Payload) data. In addition, this subsystem generates the radio frequency (RF) uplink, accepts tracking and command signals, and modulates them onto the RF uplink.

Includes, for example:
a. Resources associated with the design, development, production, procurement, assembly, test, and site activation of the Ground Terminal (GT)
b. Antenna
c. RF electronics
d. Timing subsystem equipment
e. Baseband/network equipment
f. Monitor and control hardware
g. Ground terminal software

Excludes, for example:
a. Ground terminal buildings and other facilities. These are included within facilities above.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.1 Antenna 1...n (Specify). These elements transmit and/or receive RF signals that carry TT&C and/or mission data.

Includes, for example:
a. Pedestals
b. Radomes
c. Other structures
d. Mechanisms
e. Apertures

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f. Feeds
g. Waveguides/coax/cabling

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.1.1 Pedestal. This element is the structure that supports and positions the Antenna Aperture in both azimuth and elevation. It also may serve as a housing or enclosure for other Antenna equipment.

Includes, for example:
a. Structure
b. Gimbals
c. Support

F.4.4.1.2 Radome. This element protects the Antenna from weather hazards (e.g., wind, rain, sand, ultraviolet (UV) light, ice, etc.). The material used in building the Radome allows for unattenuated electromagnetic signals. Radomes can be constructed in several shapes (spherical, geodesic, planar, etc.) using various materials (fiberglass, polytetrafluoroethylene (PTFE) coated fabric, etc.).

F.4.4.1.3 Other Structure and Mechanisms. This element is a collection of items that include equipment compartments, racks, or pallets that house Antenna related electronics, and other structural or mechanical elements not integral to the other Antenna equipment.

Excludes, for example:
a. Parts integral to the Pedestal (e.g., pointing gimbals)

F.4.4.1.4 Aperture. This element determines the aperture (effective area of radiation/energy absorption/generation) of the Antenna. This can be as simple as a reflector or a complex phased-array. In most cases a parabolic reflector with an associated Feed (see below) is used.

F.4.4.1.5 Feed 1...n (Specify). These elements receive and/or transmit signals. Feed refers to the components functionally between a reflector and an amplifier. A feed may consist of a horn, spiral element or a set of dipoles; an orthomode transducer, a polarizer, a frequency diplexer and a waveguide or coaxial cable connection.

F.4.4.1.6 Waveguide/Coax/Cabling. This collection of items routes transmitted signals to the antenna feed or feed electronics. It also routes received signals to the first stage receiving electronics. Other signal and power routing, such as to the Pedestal, is also included in this element.

F.4.4.1.7 Antenna Other. This element contains all the resources associated with unique Ground Antenna subsystem hardware items not included in elements above.

F.4.4.2 Optical Communication Assembly 1...n (Specify). An Optical Communication Assembly (e.g., telescope) has optical elements that collect and focus optical energy or that create optical waveforms for transmission. It is used for transmitting and receiving optical communication signals as in laser communications terminals.

Includes, for example:
a. Optical assembly structure and mechanisms
b. Thermal control provisions
c. Fore optics
d. Aft optics
e. Alignment sensors
f. Positioners
g. Calibration equipment

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NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.2.1 Structure/Outerbarrel/Cover. This equipment supports and stabilizes optical elements, sensors and other optical assembly equipment.

Includes, for example:

a. Enclosing structure (including tubes/outer barrel, tube doors, and associated integration, mounting, and interface hardware)
b. Load-bearing structure (includes equipment compartment, equipment shelf, support tubes, mounts, struts, and associated integration, mounting, and interface hardware and secondary hardware if not separable)
c. Secondary structure (including baffles), and integration, mounting, and interface hardware)
d. Door actuators (includes control electronics if costs not separable)
e. Optical-assembly specific thermal control elements (including thermostats, thermistors, thermal control electronics, heaters, insulation, and paints)
f. Other structures and mechanisms

F.4.4.2.2 Mirror/Optics 1...n (Specify). These elements are principal light-gathering surfaces of a reflective (using mirrors) and refractive (using lenses) telescopes and related instruments. Primary Mirrors can be monolithic blocks of glass or other material, curved to exact shapes and coated with a reflective layer; or constructed from small segments of mirrors, merged (by physical contact or later by optics) into one large Primary Mirror. Primary Optics (also called objective) refers to the lens in a refractive telescope, or other optical instrument that receives the first light rays from the object being observed. A Secondary Mirror (or secondary) is a second light gathering and focusing surface in a Reflector telescope. Light gathered by the Primary Mirror is directed towards a focal point typically past the location of the secondary. The secondary directs the light either out a side opening of the tube (Newtonian Reflector) or back towards a focal point behind and through the Primary Mirror/Optics. Tertiary Optics are used to change the focal point to a convenient viewing angle or location.

Includes, for example:

a. Primary, secondary, tertiary mirror assemblies (assembly may include associated mounts, mount pads, and other frame)

F.4.4.2.3 Aft Optics and Bench. This collection of items provides additional focusing and manipulation of radiation from the tertiary optics before it enters the collection sensor. Optical splitters, shutters, prisms, filters and relay mirrors are typical aft optical elements. Optical benches usually support the aft optics and collection sensor and are made of very thermally stable materials such as Invar or graphite epoxy composites. This optical bench is integral to the Aft Optics.

F. 4.4.2.4 Alignment Sensors/Calibration. This collection of items compensates for the effects of vibration, temperature changes, age-related distortion and other changes to the optical assembly equipment alignment. These elements are specifically designed for and dedicated to the optics assembly.

Includes, for example:

a. Alignment positioners
b. Actuators
c. Sensors
d. Integral electronics
e. Internal cables
f. Calibration light sources
g. Optics dedicated to calibration
h. Lasers used for alignment

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F. 4.4.2.5 Optical Assembly Other. This element contains all the resources associated with unique Optical Communication Assembly hardware items not included in WBS elements above.

F.4.4.3 RF Electronics Band 1...n (Specify). These elements are a summing element for a wide range of Ground Terminal RF and analog signal processing electronics and RF plumbing.

Includes, for example:
a. Passive signal flow control
b. Transmitters, receivers
c. Transceivers
d. Modulators
e. Demodulators
f. Multiplexers
g. Demultiplexers
h. Power amplifiers
i. Frequency converters
j. Signal conditioners
k. Focal-plane arrays for optical communications

NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.3.1 Passive Signal Flow Control. This collection of items includes a wide range of RF and other analog signal processing electronics and RF plumbing within the Ground Terminal.

Includes, for example:
a. Multicouplers
b. Coaxial switches
c. RF switches
d. Filters
e. Waveguides (excluding those in antenna)
f. Ground terminal interconnecting harnesses and cables
g. Other similar low-value items

F.4.4.3.2 Transmitter/Receiver/Transceiver/Transponder 1...n (Specify). These elements are electronic devices that send and/or receive signals to and/or from Antennas and separate them into useful analog or digital signals. For a general definition, see Transmitters/Receivers/ Transceivers within the Bus Telemetry, Tracking, and Command subsystem.

F.4.4.3.3 Modulators/Demodulators/Modems 1...n (Specify). Modulators modify the amplitude and phase the frequency of sinusoidal “carrier” signals to include information in the resultant (modulated) output signal. The input signals to Modulators are usually digital signal streams. Demodulators perform the inverse of modulators, separating digital information from carrier signals. Modems, which perform both operations, are also included in this element.

F.4.4.3.4 Multiplexers/Demultiplexers 1...n (Specify). These elements allow efficient transmission and subsequent reception of multiple signals via a single signal. A multiplexer combines several input signals into one output signal containing several communication channels. A demultiplexer separates a single input signal that carries many channels into multiple output signals. This element includes only RF and analog multiplexers and demultiplexers.

F.4.4.3.5 Power Amplifiers 1…n (Specify). These elements are devices that change/increase the amplitude of signals. Includes, for example, solid state power amplifiers (SSPAs), traveling wave tube amplifiers (TWTAs), and low noise amplifiers (LNAs), and optical power amplifiers.

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F.4.4.3.6 Frequency Upconverter/Downconverter 1...n (Specify). These elements receive radio signals of one frequency and output at a different frequency. For a general definition, see Frequency Upconverters / Downconverters within the Bus Telemetry, Tracking, and Command subsystem.

F.4.4.3.7 Signal Conditioners. These elements alter (e.g., filter, eliminate noise, compress, amplify) analog signals to meet the requirements of the next processing stage. Excludes Power Amplifiers. For a general definition, see Signal Conditioners within the Bus Telemetry, Tracking, and Command subsystem.

F.4.4.3.8 Signal Electronic Boxes 1...n (Specify). These elements are RF electronic devices that may combine multiple functions identified above and therefore do not fit into a single element above.

F. 4.4.3.9 Focal Plane Array 1...n (Specify). Focal planes convert photonic radiation (visible, IR, etc.) into electronic pixels representing the image projected on a plane. Focal planes have image sensing detectors arranged in arrays (typically rectangular) on sensor chip assemblies (SCAs). One or more SCAs comprise the total focal plane complement of detectors. A focal plane assembly includes SCAs, support structure, optical filters, wiring and thermal control devices such as cold fingers and thermal enclosures.

F.4.4.3.10 RF Electronics Other. This element contains all the resources associated with unique Ground Terminal RF Electronics subsystem hardware items not included in WBS elements above.

F.4.4.4 Timing. The subsystem generates and distributes accurate and stable timing and frequency references.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.4.1 Receiver. This element calculates position by using timing signals sent by the constellation of GPS satellites (or other timing sources).

F.4.4.4.2 Antenna 1...n (Specify). These elements receive RF signals for the Receiver. Most current systems use GPS (L-band), while in some systems the signals could be WWV (HF-band) or other source.

F.4.4.4.3 Frequency and Timing Generators. These elements provide stable timing and frequency reference signals (RF and digital) to the other electronics elements.

Includes, for example:
a. Frequency generators
b. Oscillators
c. Timing units

F.4.4.4.4 Amplifier and Distribution 1...n (Specify). These elements increase the frequency signal received from the Antenna and optionally distributes the frequency to several receivers.

Includes, for example:
a. Any cabling between antennas and receivers

F.4.4.4.5 Timing Other. This element contains all the resources associated with unique Timing subsystem hardware items not included in WBS elements above.

F.4.4.5 Baseband-Network. This element receives RF signals from the RF Electronics subsystem, converts them into a digital (or baseband signal) format, and subsequently interfaces with the Terrestrial Communications element. It also receives digital (or baseband signal) information from the Terrestrial Communication element, converts it to the proper RF signal interfacing with the RF electronics.

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NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.5.1 Switches/Hubs and Routers. These elements provide junctions for digital equipment and route and forward the information to other electronic equipment.

F.4.4.5.2 Network Interface and Other Hardware. These elements interconnect, interface, and can house other Baseband-Network equipment. These elements may also interface with the network or communications hardware within a GOPC(s) or the External Network. Includes, for example, networking hardware, cables, racks, etc.

F.4.4.5.3 Modems. These elements convert digital information into the baseband RF signal or the baseband signal into digital format, depending on the direction of information flow.

F.4.4.5.4 Security/Encryption and Decryption Devices 1...n (Specify). These elements encrypt and/or decrypt Ground data. For a general definition, see Communications Security (COMSEC / Encryption and Decryption devices) within the Bus Telemetry, Tracking, and Command subsystem.

F.4.4.5.5 Baseband-Network Electronic Boxes 1...n (Specify). These elements are electronic devices that may combine multiple functions identified above and therefore do not fit into a single element above.

F.4.4.5.6 Baseband-Network Other. This element contains all the resources associated with unique Ground Terminal Baseband-Network subsystem hardware or software items not included in WBS elements above.

F.4.4.6 Monitor and Control Hardware. This element configures (e.g., power, antenna position, frequency) the station for communications to the Space Vehicle (for a satellite pass) and monitors (usually autonomous) other Ground Terminal subsystem equipment. In addition, it can provide monitoring, health status and commanding of the Space Vehicle as a back-up to GOPC(s).

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.4.6.1 Workstations 1...n (Specify). These elements are computers often optimized for displaying and manipulating complex data such as engineering simulation, animation, image rendering, and mathematical plots. They can support multiple displays. These elements are intended for use by one person at a time and are commonly connected to each other through a local area network via a Server.

Includes, for example:
a. Workstations
b. Desktop and laptop computers
c. Displays (monitors)
d. Keyboards, mice, cables and software bought as part of the workstation

F.4.4.6.2 Servers 1...n (Specify). These elements are computers dedicated to providing processing services over a computer network. These services are furnished by specialized server applications, which are computer programs designed to handle multiple concurrent requests.

Includes, for example:
a. Application servers

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F.4.4.6.3 Hardware Configured Item 1...n (Specify). These elements are hardware devices that perform unique or specific Ground Terminal, Monitor and Control functions.

Excludes, for example:
a. Workstations and servers

F.4.4.7 GT Software. This element includes all resources associated with GT software functions.

Excludes, for example:
a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to recurring GT hardware units (Level 4 items)

NOTE 1: For lower level software information, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: For lower level Common Elements (e.g., SEIT/PM), reference Appendix L, section L.4.

F.4.4.8 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (Pre-Ops) maintenance (hardware repair and software updates) of Ground Terminal equipment and software. This function begins with the acceptance of the Ground Terminal element and ends with the start of Operations.

F.4.4.9 Pre-Operations Mission Support. This element includes all the resources required for the operation of the Ground Terminal prior to turn-over.

Includes, for example:
a. On-orbit testing; routine monitoring of Space Vehicle equipment health and status
b. Fault detection
c. Anomaly investigation and resolution. (The Mission Support period typically begins after installation and a specified time prior to launch and ends when the Space Vehicle achieves initial operational capability.)

F.4.5 External Network (T-COMM). This element contains all the resources associated to design, develop, produce, procure, lease, assemble, and test external communication. External communication refers to hardware (equipment, lines or circuits) and software effort required for a system that moves data along external communication paths between required points.

Includes, for example:
a. Leased and owned transmissions methods transmitted through analog, digital, electronic, optical, or other methods and can be via terrestrial, undersea, or space

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.5.1 Leased Circuits. This element is associated with the leased transmission circuits.

F.4.5.1.1. Leased Circuit 1...n (Specify). These elements include all the resources required for each point-to-point leased circuit.

F.4.5.2 Purchased Circuits. This element is associated with the purchased transmission circuits.

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F.4.5.2.1 Purchased Circuit 1...n (Specify). These elements include all the resources required for each point-to-point purchased circuit.

F.4.5.2.2 Pre-Ops Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (Pre-Ops) maintenance of Purchased Circuit equipment. This function begins with the acceptance of the circuit and ends with the start of Operations.

F.4.6 User Equipment. This element (hardware/software) pertains to end-user equipment purchased or built as part of the Space System acquisition. User equipment includes, for example, satellite phones, field terminals (mobile or fixed), satellite modems, and hand-held GPS receivers.

For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.6.1 Equipment 1...n (Specify). These elements are a collection of items for a complete delivered unit of unique User Equipment.

F.4.6.1.1 Hardware Configured Item 1...n (Specify). These elements are the unique configuration-controlled portions or sub-units whose totality composes a completed piece of User Equipment.

F.4.6.1.2 Equipment Software (Specify). This element includes all resources associated with a single user equipment software configuration item.

NOTE: For lower level software information, use the structure and definitions in Appendix B, Electronics Systems.

F.4.6.2 Pre-Ops Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (Pre-Ops) maintenance of User Equipment. This function begins with the acceptance of the User Equipment and ends with the start of Operations.

F.4.7 Facilities 1...n (Specify). These elements encompasses all the physical infrastructure required to access, house and support Ground Terminal, GOPC, and External network equipment and personnel.

Includes, for example:

a. All of the resources associated with the design, development, construction, integration, landscaping, and fitting of the Facilities WBS entities
b. Facilities subsystems: Site Preparation, Landscape, Buildings, Equipment and Building Fit Out, Pre-Ops Maintenance, and Mission Support

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.7.1 Site Preparation. This subsystem includes the Grading (Land Preparation), Roads, Pads, Walls, Fencing, Utilities and subsystem other related costs needed to house, service and operate a Space System Ground site(s).

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

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F.4.7.1.1 Graded Land. This item comprises the acquisition and the effort (land preparation) and resources necessary for ensuring a level (or possibly sloped to specific degree) base for a construction work such as: Pads or other foundations; or the base course for Roads or railways.

F.4.7.1.2 Roads. This element provides access to the Ground Segment buildings and equipment and encompasses all the effort and resources for road construction including excavation, removal of material, filling, compacting, construction, trimming, and finishing (paving, gravel, etc.).

F.4.7.1.3 Pads. This element provides for a flat stable base for antennas, telescopes, and other structures or equipment. Pads are usually composed of concrete.

F.4.7.1.4 Retaining Walls / Fencing. These items retain earth, and can restrict vision and or passage to Ground equipment, housing, and other Ground facilities.

F.4.7.1.5 Utilities. This element delivers utility services (electricity, water, gas, etc.) up to Ground Buildings or to other structures and comprises the effort and resources for the installation of the utility infrastructure (electrical cables, pipes, transformers, etc.).

F.4.7.1.6 Site Preparation Other. This element contains all the resources associated with unique Site Preparations subsystem resource items not included in WBS elements above.

F.4.7.2 Landscape. This collection of items improves the appearance of the ground segment.

Includes, for example:
a. Trees, shrubs, or grass, altering the contours of the ground, or other aesthetic material or objects

F.4.7.3 Buildings 1...n (Specify). These items permanently support and shelter Ground equipment and occupancy use.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.7.3.1 Foundation and Sub Structure. This element transfers the weight of Buildings into the ground strata or earth. A common type of shallow foundation is a slab-on-grade foundation where the weight of the building is transferred to the soil through a concrete slab placed at the surface. Deeper foundations are used to transfer a load from a structure through an upper weak layer of soil to a stronger deeper layer of soil.

Includes, for example:
a. Helical piles
b. Impact driven piles
c. Drilled shafts, caissons, piers, and earth stabilized columns
d. Basements and fallout shelters

F.4.7.3.2 Superstructure and Finishing. This element provides protection from the elements (wind, rain, sun, etc.) and partitioning for equipment and personnel. It includes, for example, roofing, walls, floors, framing, exterior and interior wall finishing. It excludes specialized flooring for computers and other equipment.

F.4.7.3.3 Buildings Other. This element contains all the resources associated with unique Building subsystem resource items not included in the WBS elements above.

F.4.7.4 Equipment and Building Fit Out 1...n (Specify). These elements adapt equipment and buildings for suitability to accomplish their designed purposes.

Includes, for example:

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a. Heating, venting, and air conditioning (HVAC)
b. Power conditioning/ uninterrupted power supply (UPS)
c. Network wiring/cable trays, generators
d. Computer flooring, appliances
e. Furniture and subsystem other items needed to build, service and operate the Space System Ground Segment

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.7.4.1 Heating Venting and Air Conditioning (HVAC). These elements maintain desired air temperatures and flow for comfort, safety, and proper operating environments. This includes equipment related to the heating, venting, and air conditioning (HVAC) needed to accommodate facilities and equipment at a Space System Ground site.

F.4.7.4.2 Power Conditioning/Uninterruptible Power Supplies (UPS). These elements provide stable electrical power within a Ground Terminal or Station.

Includes, for example:
a. Power conditioning units and Uninterruptible Power Supplies (UPS) themselves, as well as the building modifications, cabling, and other support hardware required for the installation and operation of the units

Excludes, for example:
a. Elements and related hardware external to and leading up to Buildings, which is included under Utilities within Site Preparation
b. Motor generators (included within Generators)

F.4.7.4.3 Network Wiring/Cable Trays. This collection of items holds up and distributes cables and wiring. A cable tray system is a unit or assembly of units or sections (including associated fittings) that form a rigid structural system used to securely fasten or support cables and wiring. This element includes raceways.

F.4.7.4.4 Generators. These elements generate electrical energy, generally using electromagnetic induction. Generators are often employed for “back-up” electrical power generation for Ground equipment during extended periods when the normal electrical supply is interrupted. This includes motor generators.

F.4.7.4.5 Computer Flooring. This element provides a means of routing interconnecting cables and wires and often the cooled air required by computing and related electrical equipment. A computer floor is a raised floor in offices, labs, and stations with a high requirement for servicing/change-out.

Includes, for example:
a. Tiles
b. Framing
c. Structural support

F.4.7.4.6 Appliances. This element performs various simple or narrow functions, such as providing light. Appliances are usually operated electrically.

Includes, for example:
a. Lamps and other lighting
b. Refrigerators and freezers
c. Individual room heaters and air conditioners, sinks, toilets, etc.

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Excludes, for example:
a. Telecommunications equipment and computer and network appliances such as servers and back-up units

F.4.7.4.7 Furniture. This collection of items supports the human body, provide storage, or hold objects. Storage furniture is used to hold or contain smaller objects such as tools, books, small equipment, and other goods.

Includes, for example:
a. Chairs, tables, desks, cabinets, and shelves

F.4.7.4.8 Equipment and Building Fit Out Other. This WBS element contains all the resources associated with unique Equipment and Building Fit Out subsystem items not included in WBS elements above.

F.4.7.5 Pre-Operations Maintenance 1...n (Specify). These subsystems contain all the resources related to the pre-operations (Pre-Ops) maintenance of the building(s) and other Facilities. This function begins with the completion and initial functioning of the items (buildings, roads, etc.) and ends with the start of Operations.

F.4.8 Vehicles and Shelters. These elements provide the ability for GOPCs and terminals to be transportable.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

F.4.8.1 Vehicles. The summing element is for powered vehicles used for transportable GOPCs and Terminals.

Includes, for example:
a. Trucks and humvees

F.4.8.1.1 Vehicle 1...n (Specify). These items include all the resources required for each unique vehicle.

F.4.8.2 Shelters. The summing element is for items that protect and house transportable GOPC and Ground Terminal equipment.

Includes, for example:
a. Shelters, trailers, and shells

F.4.8.2.1 Shelter 1...n (Specify). These items include all the resources required for each unique shelter. A shelter is usually made of foam-and-beam sandwich panels that consist of a polyurethane foam core, aluminum skins and a framework of high strength aluminum alloy extrusions.

F.4.8.3 Pre-Ops Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (Pre-Ops) maintenance of the specified type of Vehicles and Shelters. This function begins with acceptance of the Vehicles and Shelters and ends with the start of Operations.

F.4.9 Insurance. This element includes the resources pertaining to the acquisition and settlement of Insurance coverage for the entirety or portions of the Space System.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix L, section L.4.

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F.4.9.1 Insurance Policy. These elements are a form of risk management primarily used to hedge against the risk of loss. Insurance contracts or policies provide a means of controlling the cost impact of loss and/or damage to portions or all of the Space System.

Includes, for example:
a. Launch insurance
b. On-orbit life insurance
c. General liability coverage

F.4.9.2 Insurance Settlements. These items are the securities delivered (usually a credit payment) that satisfy the contractual obligations of the Insurance Policies above (e.g., an insurance payment to cover damage to Space Vehicle components due to a fire).

F.4.10 Task Orders. These items are miscellaneous services and products procured during the Space System acquisition under separate Task Order Contract Line Items (CLINS).

F.4.10.1 Task Order 1...n (Specify). These elements are for all the resource required to fulfill an individual Task Order.

F.4.11 Orbital Transfer Vehicle (OTV). This element is a single propulsion upper-stage that thrusts the Space Vehicle into a new orbit, for example, a low earth orbit to a medium or high earth orbit.

Includes, for example:
a. Inertial Upper Stage (IUS)
b. Transfer Orbit Stage (TOS)
c. Payload Assist Module (PAM), and Centaur

These elements are separate from the Space and Launch Vehicles. They can be solid or liquid propulsion systems. If the Booster Adapter is not captured under the Space Vehicle element, it should be captured within this element or the Launch Vehicle element.

F.4.12 Launch Vehicle 1...n (Specify). A complete Launch Vehicle in a multiple or dissimilar Launch Vehicle configuration. This WBS element is intended for Launch Vehicle(s) that boost unmanned satellites into earth orbits. It contains all of the resources associated with the design, development, production, integration, assembly, and test to include verification testing of each Launch Vehicle as required, as well as commercial-like launch services. This element also includes the Launch Vehicle contractors' efforts to receive, store, and transport the Launch Vehicle and associated Ground equipment; to stack and assemble the Launch Vehicle; to mate the Space Vehicle to the Launch Vehicle; to perform integrated system test and checkout; and to track and measure Launch Vehicle performance during the ascent phase. List each unique configuration as a separate Launch Vehicle using sequential indices for each configuration; e.g., first configuration is Launch Vehicle 1, second configuration is Launch Vehicle 2, etc.

Includes, for example:
a. Design, development, and production, integration, assembly, test, and checkout of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification, regardless of end use)
b. If the Booster Adapter is not captured under the Space Vehicle element, it should be captured within this element or the OTV element.
c. Payload fairings

NOTE: For lower level information, use the structure and definitions in Appendix J, Launch Vehicle if required.

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APPENDIX G: SURFACE VEHICLE SYSTEMS WORKBREAKDOWN STRUCTURE AND DEFINITIONS

G.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for the surface vehicle systems definitions. WBS elements common to all defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

G.2 APPLICABLE DOCUMENTS

G.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI/IEEE STD 610.12-1990(R2002), *Standard Glossary of Software Engineering Terminology*
ANSI Standards can be found online at:
http://webstore.ansi.org/ansidocstore/default.asp

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

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G.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3
1.0	Surface Vehicle System		
1.1		Primary Vehicle	
1.1.1			Primary Vehicle Integration, Assembly, Test and Checkout
1.1.2			Hull/Frame/Body/Cab
1.1.3			System Survivability
1.1.4			Turret Assembly
1.1.5			Suspension/Steering
1.1.6			Vehicle Electronics
1.1.7			Power Package/Drive Train
1.1.8			Auxiliary Automotive
1.1.9			Fire Control
1.1.10			Armament
1.1.11			Automatic Ammunition Handling
1.1.12			Navigation and Remote Piloting
1.1.13			Special Equipment
1.1.14			Communications
1.1.15			Primary Vehicle Software Release 1…n
1.1.16			Other Vehicle Subsystems 1…n (Specify)
1.2		Remote Control System (UGV specific)	
1.2.1			Remote Control System Integration, Assembly, Test and Checkout
1.2.2			Ground Control Systems
1.2.3			Command and Control Subsystem
1.2.4			Remote Control System Software Release 1…n
1.2.5			Other Remote Control System 1…n (Specify)
1.3		Secondary Vehicle	
1.4		System Engineering	
1.5		Program Management	
1.6		System Test and Evaluation	
1.6.1			Development Test and Evaluation
1.6.2			Operational Test and Evaluation
1.6.3			Mock-ups / System Integration Labs (SILs)
1.6.4			Test and Evaluation Support
1.6.5			Test Facilities
1.7		Training	
1.7.1			Equipment
1.7.2			Services
1.7.3			Facilities
1.8		Data	
1.8.1			Technical Publications
1.8.2			Engineering Data
1.8.3			Management Data
1.8.4			Support Data
1.8.5			Data Depository
1.9		Peculiar Support Equipment	
1.9.1			Test and Measurement Equipment
1.9.2			Support and Handling Equipment
1.10		Common Support Equipment	
1.10.1			Test and Measurement Equipment
1.10.2			Support and Handling Equipment
1.11		Operational/Site Activation	
1.11.1			System Assembly, Installation and Checkout on Site
1.11.2			Contractor Technical Support

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1.11.3		Site Construction
1.11.4		Site/Ship/Vehicle Conversion
1.11.5		Sustainment/Interim Contractor Support
1.12	Industrial Facilities	
1.12.1		Construction/Conversion/Expansion
1.12.2		Equipment Acquisition or Modernization
1.12.3		Maintenance (Industrial Facilities)
1.13	Initial Spares and Repair Parts	

G.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

G.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented

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WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

G.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

G.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

G.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

G.4 DEFINITIONS

G.4.1 Surface Vehicle System. The complex of vehicle electronics equipment, data, services, and facilities required to develop and produce a vehicle system with the capability to navigate over the surface. Surface vehicle categories include vehicles primarily intended for general purpose applications and those intended for mating with specialized payloads.

Includes, for example:
a. Manned and unmanned cargo and logistics vehicles, trucks, mobile work units, and combat vehicles
b. Combat vehicles serving as armored weapons platforms, reconnaissance vehicles, and amphibians

G.4.2 Primary Vehicle. The mobile element of the system embodying means for performing operational missions that exists on its own. (reference Family of Systems description in Guidance, paragraph 3.2.2 for applications of the WBS when variants/family of vehicles exists).

Includes, for example:
a. Means of propulsion and structure for adaptation of mission equipment or accommodations for disposable loads
b. Design, development, and production of complete units (i.e., prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)

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G.4.2.1 Primary Vehicle Integration Assembly Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the vehicle subsystem parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

G.4.2.2 Hull/Frame/Body/Cab. The vehicle's primary load bearing component, which provides the structural integrity to withstand the operational loading stresses generated while traversing various terrain profiles (Hull/Frame), and (if applicable) the major component to be mated to a chassis to provide a complete vehicle having a defined mission capability (Body/Cab).

Includes, for example:

a. Simple wheeled vehicle frame or combat vehicle hull that satisfies the structural requirements including armor integral to the frame
b. Structural subassemblies and appendages that attach directly to the primary structure
c. Towing and lifting fittings, bumpers, hatches, and grilles
d. Provision to accommodate other subsystems such as mountings for suspension, weapons, turret, truck body, cab, special equipment loads
e. Accommodations for personnel, cargo, and such subsystems as need to be placed in proximity to operators

Excludes, for example:

a. non-integral armor and radiological shielding (included in survivability element)

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.3 System Survivability. The equipment required to maximize the survivability of the crew and the system.

Includes, for example:

a. Non-integral armor (turret)
b. Non-integral armor (hull/frame/body/cab)
c. Active protection systems and defensive aids for both short and long range threats
d. Radiological shielding for hull and turret. This includes supplemental ballistic protection, attachment approaches for external armor, liners, and behind armor debris shielding
e. Signature management hardware associated with reducing system susceptibility and vulnerability
f. Improvised explosive device (IED) countermeasure subsystems
g. Fire detection and suppression
h. Survivability systems control hardware. This includes electronics, sensors, and miscellaneous equipment that have functionality in more than one survivability WBS element.
i. Ballistic crew seats for crew protection during ballistic events
j. Sensor subsystems, threat warning systems and hostile weapon fire detection sensor subsystems
k. Chemical, biological, radiological and nuclear
l. Combat identification systems
m. Anti-tamper systems

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

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G.4.2.4 Turret Assembly. The structure, including armor integral to the turret and equipment installations required to provide the fighting compartment element of combatant vehicles.

Includes, for example:
a. Turret rings, slip rings
b. Attachments and appendages such as hatches and cupolas
c. Accommodations for personnel, weapons, and command and control
d. Drive motors
e. Turret drive stabilization system

Excludes, for example:
a. Non- integral armor and radiological shielding (included in survivability element)

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.5 Suspension/Steering. The means for generating tractive efforts, thrust, lift, and steering forces generally at or near the earth's surface and adapting the vehicle to the irregularities of the surface.

Includes, for example:
a. Wheels, tracks, brakes, and steering gears for traction and control functions
b. Rudder thrust devices and trim vanes for amphibians
c. Springs, shock absorbers, skirts, and other suspension members

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.6 Vehicle Electronics. All electronic subsystems and components (hardware/software), distributed throughout the vehicle not directly attributable to other WBS Level 3 elements.

Includes, for example:
a. Computers and other devices for command and control
b. Data control and distribution
c. Controls and displays
d. Power distribution and management
e. Health management systems

Excludes, for example:
a. Hardware and software directly associated with other WBS elements

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.7 Power Package/Drive Train. The means for generating and delivering power.

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Includes, for example:
a. Engine
b. Engine-mounted auxiliaries such as air ducting and manifolds, controls and instrumentation, exhaust systems, and cooling means
c. Power transport components as clutches, transmission, shafting assemblies, torque converters, differentials, final drivers, and power takeoffs
d. Brakes and steering when integral to power transmission rather than in the suspension/steering element
e. Hybrid electric drive systems
f. Energy storage systems
g. Raw power generators

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.8 Auxiliary Automotive. Hardware and software subsystems that provide services to all of the primary vehicle subsystems (as distinguished from the mission equipment subsystems).

Includes, for example:
a. On-board diagnostics/prognostics system not included in other subsystems
b. Winch and power take-off, tools and on-vehicle equipment
c. Crew accommodations (when otherwise not provided for)
d. Lighting systems

Excludes, for example:
a. Electrical subsystems and components that are now included in the vetronics WBS element
b. Fire detection and suppression system and controls associated with Survivability

G.4.2.9 Fire Control. The equipment (hardware and software) installed in the vehicle, which provides intelligence necessary for weapons delivery such as launching and firing.

Includes, for example:
a. Radars and other sensors necessary for search, recognition and/or tracking
b. Controls and displays
c. Sights or scopes
d. Range finders, computers, computer programs, gun drivesand stabilization systems

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.10 Armament. The equipment (hardware and software) for vehicles to deliver fire on targets.

Includes, for example:
a. Main gun and secondary guns
b. Missile launchers
c. Non-lethal weapons
d. Other offensive weapon systems

Excludes, for example:
a. Fire control systems

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NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.11 Automatic Ammunition Handling. The equipment (hardware and software) for selecting ammunition from a stored position in the vehicle, transferring it, and loading the armament system.

Includes, for example:
a. The means to eject spent cases and misfired rounds
b. Ammunition storage racks, transfer/lift mechanisms, ramming and ejecting mechanisms, as well as specialized hydraulic and electrical controls

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.12 Navigation and Remote Piloting Systems. The equipment (hardware and software) installed in the vehicle that enables the vehicle or its operators to plan and control vehicle speed and direction, determine vehicle location, plot the course of the vehicle and perform other mission functions.

Includes, for example:
a. Equipment that senses and processes imagery data such as vision systems, laser scanners, multiple sensor-fusion algorithms and processors, image-enhancement algorithms and processors, etc.
b. Equipment that performs mobility intelligence analysis and planning functions such as automated route planners, image-understanding algorithms and processors, computer-aided-driving algorithms and processors, etc.
c. Navigation systems such as dead reckoning, inertial, and global positioning systems
d. Landmark recognition algorithms and processors

Excludes, for example:
a. Remote control system, which is in the Remote Control System (Unmanned Ground Vehicle specific) element

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.13 Special Equipment. The equipment (hardware and software) to be mated to a Hull/Frame/Body/Cab assembly to achieve a special mission capability.

Includes, for example:
a. All items required to convert basic vehicle configurations to special-purpose configurations
b. Blades, booms, winches, robotic arms or manipulators, etc., to equip wreckers, recovery vehicles, supply vehicles and other field work units
c. Furnishings and equipment for command, shop, medical and other special-purpose vehicles
d. Specialized sensors not included elsewhere
e. Mine detection, neutralization and marking equipment

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NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Primary Vehicle is excluded.

G.4.2.14 Communications. The equipment (hardware and software) within the system for communicating information to systems and personnel interior and exterior to operating vehicles.

Includes, for example:

a. Radio frequency equipment, microwave and fiber optic communication links, networking equipment for multiple vehicle control, and intercom and external phone systems
b. Means for supplementary communication like visual signaling devices
c. Network integration equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the primary vehicle is excluded.

G.4.2.15 Primary Vehicle Software Release 1…n. All primary vehicle software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

G.4.2.16 Other Vehicle Subsystems 1…n (specify). This element should be replaced with other product-oriented vehicle subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the primary vehicle is excluded.

G.4.3 Remote Control System (UGV specific). The Remote Control System is defined as a fixed, transportable, or mobile assembly of hardware, software, and firmware that has a communications interface with the vehicle to receive only, or to receive and transmit data generated and mission data collected by the vehicle. In addition, vehicle telemetry, tracking and command (TT&C) and mission data may be processed within collocated facilities or alternatively in remotely located facilities.

Includes, for example:

a. All of the resources associated with its design, development, production, procurement, integration, assembly, and test
b. Support for the system and vehicle level integration and testing provided by the producer/integrator of the remote control portion of the system
c. Sub-elements to remote control system, launch and recovery equipment, transport vehicles, system software and integration, assembly, test and checkout

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G.4.3.1 Remote Control System Integration Assembly Test and Checkout. The efforts as identified in Appendix L: Common Elements, Work Breakdown Structure and Definitions, to provide a complete remote control system.

G.4.3.2 Ground Control Systems (GCS). This is the command and control center for the surface vehicle system. It is utilized during pre-launch, launch, recovery, and operation of surface vehicles and payloads; data link that the data to be sent between the GCS and the mission vehicle and is composed of transceivers and controls and may include a global positioning system (GPS).

This subsystem receives, down converts, demodulates, and conditions telemetry, tracking, command, and mission (payload) data. In addition, this subsystem generates the RF uplink, accepts tracking and command signals, and modulates them onto the RF uplink.

Includes, for example:

a. Resources associated with the design, development, production, procurement, assembly, test, and operational site activation of the remote control system
b. Antennas, feeds, antenna positioners, antenna support pedestals, radomes, transmitters, receivers, up/down frequency converters, modulators, demodulators, front-end equipment (encryptors/decryptors, synchronizers), etc.
c. Remote control facilities/buildings, remote control factory/contractor support facility, remote control initial support, remote control support equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Remote Control System is excluded.

G.4.3.3 Command and Control Subsystem. This subsystem decodes, demultiplexes, and decrypts vehicle telemetry, generates commands for transmission to the vehicle system. This subsystem supports all remote control subsystems that require the capability to prepare and output commands to, and receive and process data from, the surface vehicle while in operation or under test.

Includes, for example:

a. Resources associated with the design, development, production, procurement, assembly, test, and operational site activation of the Command and Control Subsystem
b. Network, computer processing and display hardware such as routers, switches, servers, workstations, storage devices, etc.
c. Software for handling, processing, and executing air vehicle commands, as well as processing and analyzing vehicle telemetry

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Remote Control System is excluded.

G.4.3.4 Remote Control System Software Release 1…n. All remote control system software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

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G.4.3.5 Other Remote Control Subsystems 1…n (specify). This element should be replaced with other product-oriented remote control subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Remote Control System is excluded.

G.4.4 Secondary Vehicle. The vehicles required to supplement, expand, or otherwise contribute to the capabilities of primary vehicles to provide the vehicle system with the required operational characteristics. Secondary vehicles are not necessarily self-contained operational units capable of operating outside the system.

Includes, for example:

a. Cargo and tank trainers of truck-trailers systems; carriers and tanker units of articulated train-type systems; and transporters as employed in systems when the primary vehicle has limited roadability
b. The design, development, and production of complete units (i.e., prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use)

NOTE: Work breakdown structure and definitions for Secondary Vehicle are the same as those for the primary vehicle.

G.4.5 Common WBS Elements. Definitions for Common WBS elements applicable to the Surface Vehicle, and all other defense materiel items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX H: UNMANNED AIR VEHICLE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

H.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for the Unmanned Air Vehicle Definitions for WBS elements common to all defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

H.2 APPLICABLE DOCUMENTS

H.2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*
ANSI Standards can be found online at:
http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

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H.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	UAV System			
1.1		Air Vehicle		
1.1.1			Airframe	
1.1.1.1				Airframe Integration, Assembly, Test and Checkout
1.1.1.2				Fuselage
1.1.1.3				Wing
1.1.1.4				Empennage
1.1.1.5				Nacelle
1.1.1.6				Other Airframe Components 1…n (Specify)
1.1.2			Propulsion	
1.1.3			Vehicle Subsystems	
1.1.3.1				Vehicle Subsystems Integration, Assembly, Test and Checkout
1.1.3.2				Flight Control Subsystem
1.1.3.3				Auxiliary Power Subsystem
1.1.3.4				Hydraulic Subsystem
1.1.3.5				Electrical Subsystem
1.1.3.6				Environmental Control Subsystem
1.1.3.7				Fuel Subsystem
1.1.3.8				Landing Gear
1.1.3.9				Rotor Group
1.1.3.10				Drive System
1.1.3.11				Vehicle Subsystems Software Release 1…n
1.1.3.12				Other Vehicle Subsystems 1…n (Specify)
1.1.4			Avionics	
1.1.4.1				Avionics Integration, Assembly, Test and Checkout
1.1.4.2				Communication/Identification
1.1.4.3				Navigation/Guidance
1.1.4.4				Automatic Flight Control
1.1.4.5				Health Monitoring System
1.1.4.6				Stores Management
1.1.4.7				Mission Computer/Processing
1.1.4.8				Fire Control
1.1.4.9				Avionics Software Release 1…n
1.1.4.10				Other Avionics Subsystems 1…n (Specify)
1.1.5			Auxiliary Equipment	
1.1.6			Air Vehicle Software Release 1…n	
1.1.7			Air Vehicle Integration, Assembly, Test and Checkout	
1.2		Payload		
1.2.1			Payload Integration, Assembly, Test and Checkout	
1.2.2			Survivability Payload 1...n (Specify)	
1.2.3			Reconnaissance Payload 1...n(Specify)	
1.2.4			Electronic Warfare Payload 1...n (Specify)	
1.2.5			Armament/Weapons Delivery Payload 1..N (Specify)	
1.2.6			Payload Software Release 1…n	
1.2.7			Other Payload 1…n (Specify)	
1.3		Ground/Host Segment		
1.3.1			Ground Segment Integration, Assembly, Test and Checkout	
1.3.2			Ground Control Systems	
1.3.3			Command and Control Subsystem	
1.3.4			Launch and Recovery Equipment	
1.3.5			Transport Vehicles	

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1.3.6			Ground Segment Software Release 1…n
1.3.7			Other Ground/Host Segment 1…n (Specify)
1.4	UAV Software Release 1…n		
1.5	UAV System Integration, Assembly, Test and Checkout		
1.6	System Engineering		
1.7	Program Management		
1.8	System Test and Evaluation		
1.8.1			Development Test and Evaluation
1.8.2			Operational Test and Evaluation
1.8.3			Mock-ups/System Integration Labs (SILs)
1.8.4			Test and Evaluation Support
1.8.5			Test Facilities
1.9	Training		
1.9.1			Equipment
1.9.2			Services
1.9.3			Facilities
1.10	Data		
1.10.1			Technical Publications
1.10.2			Engineering Data
1.10.3			Management Data
1.10.4			Support Data
1.10.5			Data Depository
1.11	Peculiar Support Equipment		
1.11.1			Test and Measurement Equipment
1.11.2			Support and Handling Equipment
1.12	Common Support Equipment		
1.12.1			Test and Measurement Equipment
1.12.2			Support and Handling Equipment
1.13	Operational/Site Activation		
1.13.1			System Assembly, Installation and Checkout on Site
1.13.2			Contractor Technical Support
1.13.3			Site Construction
1.13.4			Site/Ship/Vehicle Conversion
1.13.5			Sustainment/Interim Contractor Support
1.14	Industrial Facilities		
1.14.1			Construction/Conversion/Expansion
1.14.2			Equipment Acquisition or Modernization
1.14.3			Maintenance (Industrial Facilities)
1.15	Initial Spares and Repair Parts		

H.3.1 Application of Common WBS Elements (Appendix L). WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

H.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements

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and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

H.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

H.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

H.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever

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possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

H.4 DEFINITIONS

H.4.1 Unmanned Air Vehicle System. The complex of equipment (hardware/software), data, services, and facilities required to design, develop, produce and support unmanned air vehicle systems.

Includes, for example:
a. Those employing fixed, movable, rotary, compound wing or dirigibles
b. Those unmanned air vehicles designed for powered or unpowered movement (i.e., gliders)

H.4.2 Air Vehicle. The complete flying aircraft. It also includes, design, development, and production of complete units—prototype and operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use.

Includes, for example:
a. Airframe, propulsion, and all other installed equipment

H.4.2.1 Airframe. The assembled structural and aerodynamic components of the air vehicle that support subsystems essential to designated mission requirements.

Includes, for example:
a. Basic structure: fuselage, wing, empennage, fuselage, and nacelle and all other airframe

H.4.2.1.1 Airframe Integration, Assembly, Test and Checkout. The integration, assembly, test and checkout element includes all efforts as identified in Appendix L: Common Elements, Work Breakdown Structure and Definitions, to provide a complete airframe, less other Level 3 elements.

H.4.2.1.2 Fuselage. The structural airframe encompassing the forward, center and aft fuselage sections of the aircraft.

Includes, for example:
a. Structural fuselage section for the forward, center and aft fuselage sections to include the main and secondary structures
b. Efforts required to splice the forward, center and aft sections
c. Access doors
d. Mounting provisions for mission peculiar avionics, armament/weapons delivery systems

H.4.2.1.3 Wing. The structure used to produce lift for flight during the air

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Includes, for example:

a. Wing torque box, inner and outer wing panels, leading edge extension wing tip, movable control surfaces to include ailerons and leading and trailing edge flaps, attach fittings for pylons, wing fold mechanism, installation of airframe related subsystems, and installation of flight test instrumentation
b. Fitting for store stations
c. Material for sealing the integral fuel tanks
d. Provisions for the electrical, hydraulic, fuel, flight controls, etc.

Excludes, for example:

a. Efforts for the structural splicing of the wing to the fuselage as provided by the Airframe Integration, Assembly, Test and Checkout

H.4.2.1.4 Empennage. The structural tail group encompassing the fin, stabilator and rudder as well as provisions for electrical wiring, plumbing, control linkages and associated equipments.

Includes, for example:

a. Structural stabilators, vertical tails, rudders, installation of airframe related subsystems, and installation of flight test instrumentation
b. Tail boom for rotary wing

H.4.2.1.5 Nacelle. This element is a separate streamlined enclosure from the fuselage on an aircraft that is used for sheltering the crew, cargo or housing an engine.

H.4.2.1.6 Other Airframe Components 1...n (Specify). This element includes other products/services related to airframe that are either not listed above or tasks that cannot be categorized into one of the above elements in which each additional element is to be clearly identified and defined.

H.4.2.2 Propulsion. That portion of the air vehicle that pertains to installed equipment (propulsion unit and other propulsion) to provide power/thrust to propel the aircraft through all phases of powered flight.

Includes, for example:

a. The engine as a propulsion unit within itself (e.g., reciprocating, turbo with or without afterburner, or other type propulsion) suitable for integration with the airframe
b. Thrust reversers, thrust vector devices, transmissions, gear boxes, and engine control units, if furnished as integral to the propulsion unit
c. Other propulsion equipment required in addition to the engine but not furnished as an integral part of the engine, such as booster units
d. The design, development, production, and assembly efforts to provide the propulsion unit as an entity

Excludes, for example:

a. All effort directly associated with the integration, assembly, test, and checkout of these elements into the air vehicle
b. All ancillary equipments that are not an integral part of the engine required to provide an operational primary power source—air inlets, instruments, controls, etc.

NOTE: For lower level information, use the structure and definitions in Appendix B, Electronic Systems and the associated WBS template for propulsion.

H.4.2.3 Vehicle Subsystems. The collection of core non-avionics subsystems.

H.4.2.3.1 Vehicle Subsystems Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the vehicle subsystem parts and

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subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.2.3.2 Flight Control Subsystem. Primary and secondary mechanical devices and automatic equipment installed in the air vehicle when used with control surfaces, to control the flight path of the air vehicle as well as to provide additional lift, drag and trim effect.

Includes, for example:

a. Primary and secondary mechanical controls, linkage, and control surface actuators for ailerons, rudders, stabilators, leading edge flaps, trailing edge flaps, and speed brakes, which are used to control the flight path of the air vehicle and provide additional lift, drag and trim effect

Excludes, for example:

a. Structural control surfaces, ailerons, rudder, stabilizer, etc. included in airframe as well as the installation of flight control subsystems into the appropriate basis structures element

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.3 Auxiliary Power Subsystem. The equipment that performs engine start up on the ground, emergency starting during flight, ground checkout operations of aircraft accessories, and power takeoff for hydraulic pumps and electrical generator system and fuel motive flow pumps.

Includes, for example:

a. Power takeoff shafts and oil cooling lines
b. Auxiliary power unit (APU)
c. Airframe mounted accessory drive (AMAD)
d. Air turbine starter
e. Secondary power, furnishings—cargo, etc.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronics Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.4 Hydraulic Subsystem. This system provides hydraulic power for the actuation of landing/launching gear subsystems, in-flight re-fueling probe, gun drive and flight control surfaces.

Includes, for example:

a. Design, production, material and equipment procurements including associated vendor design/development efforts to provide for the Hydraulic Subsystem
b. Pumps, reservoirs, accumulators, valves, regulators and associated plumbing distribution systems to provide hydraulic power
c. Hydraulic tubing, check valves, etc. that interconnect the hydraulic equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.5 Electrical Subsystem. Equipment installed to provide electrical power function, the AC and DC distribution of this power supply and the provision for exterior lighting.

Includes, for example:

a. Wire bundles and miscellaneous electrical parts, which provide the electrical power function, the AC and DC distribution of this power supply and exterior lighting in the center fuselage, aft fuselage and vertical tail
b. Generator system, battery system, a transformer rectifier unit and power contactors
c. Power relays, circuit breakers and distribution systems between electronic mission equipments

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.6 Environmental Control Subsystem. Environmental equipment and distribution systems on board the air vehicle for air conditioning and cooling equipment compartments, pressurization of seals, fuel tanks and anti-icing. The distribution system provides for air ducts, cooling lines and other plumbing required in supplying air and other cooling media from supply sources to the controlled environment.

Includes, for example:

a. Equipment compartment and individual air units, air conditioning and fuel tanks;
b. Bleed air for the gun gas purging
c. Air refrigeration system, liquid cooling system, air flow regulation system
d. Environmental control, racks, mounts, intersystem cables and distribution boxes, etc., which are inherent to, and non-separable from, the assembled structure

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.7 Fuel Subsystem. Equipment and distribution systems installed in the air vehicle to provide fuel to the engines and the auxiliary power unit, including associated functions such as fuel pressurization, venting, gauging, defueling etc.

Includes, for example:

a. Equipment and distribution systems to provide fuel to the engines
b. Associated functions included in the system are fuel storage, pressurization, venting, gauging, defueling, and in-flight refueling
c. rotary wing pylons, air induction system, thrust reversers, thrust vector devices, starters, exhausts, fuel management, inlet control system
d. Fuel lines, plumbing etc., which interconnect the fuel subsystem equipment and storage cell in the air vehicle

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.8 Landing Gear. The structural and mechanical gear and associated equipment including doors for maneuvering of the air vehicle while on the ground, the devices for extension, retraction, and locking this gear, and the mechanical devices for arresting the air vehicle.

Includes, for example:
a. Alighting gear; tires, tubes, wheels, brakes, hydraulics, etc.
b. Main landing gears, nose landing gear
c. Arresting hook system and related doors and mechanisms

H.4.2.3.9 Rotor Group. Items that impart the pitch, raw, roll, and thrust forces, which provide the lift and direction for Air Vehicle powered flight for rotary aircraft.

Includes, for example:
a. Main rotor blade
b. Main rotor head
c. Tail rotor blade
d. No tail rotor

H.4.2.3.10 Drive System. Those items that pertain to the engine control units such as transmissions and gear boxes.

Includes, for example:
a. Dynamic systems; transmissions, gear boxes, propellers, if not furnished as an integral part of the propulsion unit

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.3.11 Vehicle Subsystems Software Release 1…n. All vehicle subsystem software not associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

H.4.2.3.12 Other Vehicle Subsystems (1…n) (Specify). This element should be replaced with other product-oriented vehicle subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4 Avionics. Mission equipment on board the air vehicle that is primarily electronic in nature.

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H.4.2.4.1 Avionics Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the avionics suite parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.2.4.2 Communication/Identification. That equipment (hardware/software) installed in the air vehicle for communications and identification purposes.

Includes, for example:

a. Radio system(s), identification equipment (IFF), data links, and control boxes associated with the specific equipment
b. Integral communication, navigation, and identification package (if used)

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4.3 Navigation/Guidance. That equipment (hardware/software) installed in the air vehicle to perform the navigational guidance function.

Includes, for example:

a. Radar, radio, or other essential navigation equipment, radar altimeter, direction finding set, doppler compass, computer, and other equipment homogeneous to the navigation/guidance function

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4.4 Automatic Flight Control. Those electronic devices and sensors, which, in combination with the flight controls subsystem (under vehicle subsystems), enable the crew to control the flight path of the aircraft and provide lift, drag, trim, or conversion effects.

Includes, for example:

a. Flight control computers, software, signal processors, and data transmitting elements that are devoted to processing data for either primary or automatic flight control functions
b. Electronic devices required for signal processing, data formatting, and interfacing between the flight control elements; the data buses, optical links, and other elements devoted to transmitting flight control data
c. Flight control sensors such as pressure transducers, rate gyros, accelerometers, and motion sensors

Excludes, for example:

a. Devices—linkages, control surfaces, and actuating devices—covered under the airframe WBS element
b. Avionics devices and sensors--central computers, navigation computers, avionics data buses and navigation sensors, which are included under other avionics WBS elements

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4.5 Health Monitoring System. That equipment (hardware/software) installed in the air vehicle for malfunction detection and reporting.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4.6 Stores Management. The avionics subsystem that controls and monitors the operational state of aircraft installed stores and provides and manages the communications between aircraft stores, other aircraft subsystems and weapons.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4.7 Mission Computer/Processing. The master data processing unit(s) responsible for coordinating and directing the major avionic mission systems.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.4.8 Fire Control. That equipment (hardware/software) installed in the air vehicle, which provides the intelligence necessary for weapons delivery such as bombing, launching, and firing.

Includes, for example:

a. Radars and other sensors including radomes
b. Apertures/antennas, if integral to the fire control system, necessary for search, target identification, rendezvous and/or tracking
c. Self-contained navigation and air data systems
d. Bombing computer and control and safety devices

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

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H.4.2.4.9 Avionics Software Release 1…n. All avionics software not associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

H.4.2.4.10 Other Avionics Subsystems 1…n (Specify). This element should be replaced with other product-oriented avionics subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional task is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.5 Auxiliary Equipment. Auxiliary airframe, propulsion, electronics, and/or vehicle subsystems equipment not allocable to individual element equipments, or which provide the ancillary functions to the applicable mission equipments.

Includes, for example:

a. Auxiliary airframe equipment such as external fuel tanks, pods, and rotodomes
b. Multi-use equipment like antennas, control boxes, power supplies, environmental control, racks, and mountings, not homogeneous to the prescribed WBS elements

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/ Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Air Vehicle is excluded.

H.4.2.6 Air Vehicle Software Release 1…n. All air vehicle software not associated with a specific Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

H.4.2.7 Air Vehicle Integration Assembly, Test, and Checkout. All efforts as identified in Appendix L: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all Level 3 elements to form the air vehicle as a whole.

H.4.3 Payload. Unmanned Air Vehicles (UAVs) may have a single or multiple payloads represented at Level 3 of the WBS. In addition to the types of payloads listed below, an UAV may also have other payloads. If a UAV has other payloads, they too should be represented within the WBS structure at Level 3 below the Level 2 Payload element. Examples of other payloads include targeting and ranging systems, bio/chemical detection sensors, meteorological sensors, and communication relay systems.

H.4.3.1 Payload Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the payload suite parts and subsystems

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equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.3.2 Survivability Payload (1…n). Those equipments (hardware/software) installed in, or attached to, the air vehicle that assists in penetration for mission accomplishment.

Includes, for example:

a. Ferret and search receivers, warning devices and other electronic devices, electronic countermeasures, jamming transmitters, chaff, infra-red jammers, terrain-following radar, and other devices typical of this mission function

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

H.4.3.3 Reconnaissance Payload (1…n). Those equipments (hardware/software) installed in, or attached to, the air vehicle necessary to the reconnaissance mission.

Includes, for example:

a. Photographic, electronic, infrared, and other sensors
b. Search receivers
c. Recorders
d. Warning devices
e. Magazines
f. Data link

Excludes, for example:

a. Gun cameras

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/ Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

H.4.3.4 Electronic Warfare Payload (1…n). That electronic warfare equipment (hardware/software) installed in the unmanned vehicle to provide the functions of electronic warfare support, electronic attack, and electronic protection (i.e., electronic countermeasures, electronic counter-countermeasures, or electronic warfare support measures). This element involves the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy.

Includes, for example:

a. Electronic countermeasures, jamming transmitters, chaff, infra-red jammers, other jamming equipment, electromagnetic deception equipment, or weapons that use electromagnetic or directed energy such as laser, RF weapons, or particle beams

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

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H.4.3.5 Armament/Weapons Delivery Payload (1…n). That equipment (hardware/software) installed in the air vehicle to provide the firepower functions and weapons delivery capability.

Includes, for example:
a. Guns, high energy weapons, mounts, turrets, weapon direction equipment, ammunition feed and ejection mechanisms, and gun cameras
b. Launchers, pods, bomb racks, pylons, integral release mechanisms, and other mechanical or electro-mechanical equipments specifically oriented to the weapons delivery function

Excludes:
a. Bombing/navigation system (included in the fire control element)

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

H.4.3.6 Payload Software Release 1…n. All payload software not associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

H.4.3.7 Other Payload 1…n (Specify). Any other product or equipment not already mentioned in the above definition, but that is also transported or delivered by the UAV system.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

H.4.4 Ground/Host Segment. The Ground segment is defined as a fixed, transportable, or mobile assembly of hardware, software, and firmware that has a communications interface with the vehicle to receive only, or to receive and transmit data generated and mission data collected by the air vehicle. In addition, vehicle telemetry, tracking and command (TT&C) and mission data may be processed within collocated facilities or alternatively in remotely located facilities. For example, Ground 1 could represent an operations center and Ground 2 a network operations center or some other type of command and control facility.

Includes, for example:
a. Support for the system and vehicle level integration and testing provided by the producer/integrator of the ground portion of the system

H.4.4.1 Ground Segment Integration, Assembly, Test and Checkout. The efforts as identified in Appendix L: Common Elements, Work Breakdown Structure and Definitions, to provide a complete ground system.

H.4.4.2 Ground Control Systems (GCS). This is the command and control center for the UAV system. It is utilized during pre-launch, launch, recovery, and operation of UAVs and payloads; data link that the data to be sent between the GCS and the mission vehicle and is composed of transceivers and controls and may include a

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global positioning system (GPS). This subsystem receives, down converts, demodulates, and conditions telemetry, tracking, command, and mission (payload) data. In addition, this subsystem generates the RF uplink, accepts tracking and command signals, and modulates them onto the RF uplink.

Includes, for example:

a. Antennas, feeds, antenna positioners, antenna support pedestals, radomes, transmitters, receivers, up/down frequency converters, modulators, demodulators, front-end equipment (encryptors/decryptors, synchronizers), etc.
b. Ground terminal (GT) facilities/buildings, GT factory/contractor support facility, GT initial support, GT support equipment
c. Generators, environmental control units (air conditioners), power Generators, etc. that are required for operation of the ground control stations

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Ground/Host Segment is excluded.

H.4.4.3 Command and Control Subsystem. This subsystem decodes, demultiplexes, and decrypts air vehicle telemetry, generates commands for transmission to the aircraft, and processes tracking data to generate air vehicle ephemeris. This subsystem supports all Ground subsystems that require the capability to prepare and output commands to, and receive and process data from, the air vehicle while in operation or under test.

Includes, for example:

a. Network, computer processing and display hardware such as routers, switches, servers, workstations, storage devices, etc.
b. Software for handling, processing, and executing air vehicle commands, as well as processing and analyzing air vehicle telemetry
c. Command and control ground facilities/building, command and control factory/contractor support facility, command and control initial support and support equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Ground/Host Segment is excluded.

H.4.4.4 Launch and Recovery Equipment. This is the equipment necessary to launch and recover air vehicles during the performance of its mission.

Includes, for example:

a. Equipment required to launch the air vehicle with its mission payloads into flight
b. Air vehicle hydraulic/pneumatic launcher, rail, an jet/rocket assisted take-off (JATO/RATO) bottles for short take-off
c. Automatic landing beacon system
d. Arresting net or arresting lines
e. Parachute

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NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Ground/Host Segment is excluded.

H.4.4.5 Transport Vehicles. Any vehicles that have been specifically designed or modified for the transportation of air vehicles, ground control station equipment or other mission equipment. This includes any vehicles used to perform movement of the prime mission vehicle, crew, maintenance equipment, and direct maintenance personnel, or any other special transport systems used in the relocation of the prime mission equipment so that it may perform its mission.

H.4.4.6 Ground Segment Software Release 1…n. All Ground Segment software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

H.4.4.7 Other Ground Segment 1...n (Specify). This element should be replaced with other product-oriented Ground Segment elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Ground/Host Segment is excluded.

H.4.5 Unmanned Air Vehicle (UAV) Software Release 1…n. All UAV software not associated with a specific Level 3 or Level 4 elements.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

H.4. 6 Unmanned Air Vehicle System Integration Assembly, Test, and Checkout. All efforts as identified in Appendix L: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all Level 2 elements into the UAV System as a whole.

H.4.7 Common WBS Elements. Definitions for Common WBS elements applicable to the Unmanned Aircraft, and all other defense materiel items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX I: UNMANNED MARITIME SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

I.1 SCOPE

This appendix provides the Work Breakdown Structure and definitions for the Unmanned Maritime System (UMS). Definitions for WBS elements common to the sea system and all other defense materiel items are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

I.2 APPLICABLE DOCUMENTS

Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

ANSI Standards can be found online at:
http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

American Society for Testing and Materials (ASTM)

ASTM F2541-06, *Guide for Unmanned Underwater Vehicle (UUV) Autonomy and Control*

ASTM Standards can be found online at:

http://www.astm.org

100 Barr Harbor Drive
West Conshohocken, Pennsylvania, USA
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I.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Unmanned Maritime System			
1.1		Maritime Vehicle		
1.1.1			Hull and Structure	
1.1.2			Propulsion	
1.1.3			Energy Storage / Conversion	
1.1.4			Electrical Power	
1.1.5			Vehicle Command and Control	
1.1.5.1				Vehicle Command and Control Integration, Assembly, Test and Checkout
1.1.5.2				Mission Control
1.1.5.3				Navigation
1.1.5.4				Guidance and Control
1.1.5.5				Health Status Monitoring
1.1.5.6				Rendezvous, Homing and Docking Systems
1.1.5.7				Fire Control
1.1.5.8				Vehicle Command and Control Software Release 1…n
1.1.5.9				Other Vehicle Command and Control 1…n (Specify)
1.1.6			Surveillance	
1.1.7			Communications/Identification	
1.1.8			Ship Control Systems	
1.1.8.1				Ship Control System Integration, Assembly, Test and Checkout
1.1.8.2				Steering and Dive Control
1.1.8.3				Hovering and Depth Control
1.1.8.4				Ballast and Trim
1.1.8.5				Maneuvering System
1.1.8.6				Ship Control Systems Software Release 1…n
1.1.8.7				Other Ship Control Systems 1…n (Specify)
1.1.9			Auxiliary Systems	
1.1.9.1				Auxiliary Equipment Integration, Assembly, Test and Checkout
1.1.9.2				Emergency Systems
1.1.9.3				Launch and Recovery System
1.1.9.4				Environmental Control System
1.1.9.5				Anchoring, Mooring and Towing
1.1.9.6				Miscellaneous Fluid Systems
1.1.9.7				Auxiliary Systems Software Release 1…n
1.1.9.8				Other Auxiliary Systems 1…n (Specify)
1.1.10			Vehicle Software Release 1…n	
1.1.11			Vehicle Integration, Assembly, Test and Checkout	
1.2		Payload 1…n		
1.2.1			Payload Integration, Assembly, Test and Checkout	
1.2.2			Survivability Payload 1…n (Specify)	
1.2.3			Intelligence, Surveillance Reconnaissance (ISR) Payload 1...n (Specify)	
1.2.4			Armament/Weapons Delivery Payload 1…n (Specify)	
1.2.5			Mission Payload 1…n (Specify)	
1.2.7			Payload Software Release 1…n	
1.2.8			Other Payload 1…n (Specify)	
1.3		Shipboard Segment		
1.3.1			Shipboard Segment Integration, Assembly, Test and Checkout	
1.3.2			Shipboard UM Command and Control Subsystem	
1.3.2.1				UM Control Console(s)
1.3.2.2				Payload Control Console(s)
1.3.3			Shipboard Communication Subsystem	
1.3.4			Shipboard Power Subsystem	

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1.3.5		Launch and Recovery Equipment
1.3.6		Storage Subsystems
1.3.7		Vehicle Handling Equipment
1.3.8		Shipboard (or Shore Based) Auxiliary Equipment
1.3.9		Shipboard Software Release 1…n
1.3.10		Other Shipboard Segment 1…n (Specify)
1.4	Shore Segment (Duplicate any shipboard segment elements as appropriate)	
1.5	Transportation Segment/Vehicles	
1.6	UM System Software Release 1…n	
1.7	UM System Integration, Assembly, Test and Checkout	
1.8	System Engineering	
1.9	Program Management	
1.10	System Test and Evaluation	
1.10.1		Development Test and Evaluation
1.10.2		Operational Test and Evaluation
1.10.3		Mock-ups/System Integration Labs (SILs)
1.10.4		Test and Evaluation Support
1.10.5		Test Facilities
1.11	Training	
1.11.1		Equipment
1.11.2		Services
1.11.3		Facilities
1.12	Data	
1.12.1		Technical Publications
1.12.2		Engineering Data
1.12.3		Management Data
1.12.4		Support Data
1.12.5		Data Depository
1.13	Peculiar Support Equipment	
1.13.1		Test and Measurement Equipment
1.13.2		Support and Handling Equipment
1.14	Common Support Equipment	
1.14.1		Test and Measurement Equipment
1.14.2		Support and Handling Equipment
1.15	Operational/Site Activation	
1.15.1		System Assembly, Installation and Checkout on Site
1.15.2		Contractor Technical Support
1.15.3		Site Construction
1.15.4		Site/Ship/Vehicle Conversion
1.15.5		Sustainment/Interim Contractor Support
1.16	Industrial Facilities	
1.16.1		Construction/Conversion/Expansion
1.16.2		Equipment Acquisition or Modernization
1.16.3		Maintenance (Industrial Facilities)
1.17	Initial Spares and Repair Parts	

I.3.1 Application of Common WBS Elements (Appendix L). Common WBS elements (i.e., Integration, Assembly, Test and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

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I.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

I.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

I.3.3.1. “Other” WBS Elements. All appendices contain a WBS element titled as “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the “other” WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

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I.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

I.3.4 Unmanned Maritime SystemWBS guidance. The following guidance may be used to help determine which Unmanned Maritime System WBS element should include different types of material:

a. If an item has more than one function it is grouped with its primary function.
b. Welding materials, hardware, fittings, and similar items are included with the functional system.
c. Insulation should be classified with the system where the insulation is installed.
d. Foundations that are integral with the component supported are included with the component system.
e. Mechanical and electrical penetration sleeves into structural members are part of the mechanical or electrical system that they support.
f. Pipe markings are included in the system where they are applied.
g. Piping is included with the system with which it is associated.
h. Equipment such as heat exchanger for a cooling system is associated with that system.
i. Electric driven pumps and electric motors are included within the system they service.
j. Electric signal cabling is included with the system that produces the signal up to the first panel or signal processor of another system.
k. Electric power cabling is included with the system that consumes the power. The boundary is at the power distribution system bus bar.
l. If the electrical cabling cannot be easily separated into subsystems because there is a single wire harness, there may be a single WBS element for cabling.
m. Built-in tanks that have at least one surface homogeneous with principal structure are included in the structural group. All other tanks are included in the system they support.
n. Items such as hull fasteners, pipe hangers, associated valves, valve operators, strainers, filters, flex connections, resilient and sound mounts, are included within the system they support.
o. Label plate installation is included in the system where they are attached.
p. Elements attached to or an integral part of a system are considered parts of the component and belong to that system unless specifically not included in the boundary definitions.
q. Attached or local indicating instrumentation is included with the supported system.
r. Remote reading instrumentation that is part of the general indicating system servicing many individual systems will be found under one of the interior sensing systems.
s. Fluid coolers are included within the system whose fluid they cool.
t. Hydraulic control valves, and associated hydraulic piping, including hydraulic valve actuators, hydraulic cylinders, or hydraulic pumps and motors are included in the hydraulic system.
u. Valve actuators (electric, air, mechanical) are include in the system they support.

I.4 DEFINITIONS

I.4.1 Unmanned Maritime System (UMS). The complex of equipment (hardware/software), data, services, and facilities required to design, develop, produce, test, operate and support unmanned maritime systems.

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Includes all classes of surface and subsurface (undersea) water vessels:

a. Unmanned Surface Vehicles (USVs)
b. Unmanned Undersea Vehicles (UUVs)

I.4.2 Maritime Vehicle. The complete waterborne vessel. It also includes design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use).

Includes, for example:

a. Hull and structure, propulsion, energy storage/conversion, electrical power, vehicle command and control, surveillance, communications/identification, ship control systems and other installed equipment

I.4.2.1 Hull and Structure. The assembled structural and hydrodynamic components including primary pressure vessels, hatches, access panels, hull and support structures, and bulkheads.

Includes, for example:

a. Pressure hull, shell plating, longitudinal and transverse framing, foundations, structural bulkheads,
b. Non-pressure hull and supporting structures
c. Primary structural frame if there is no pressure hull per se
d. Ballast and trim tanks and other tanks that are integral to the structure
e. Hull structure watertight closures and access panels
f. Water tight hatches and doors including their respective hinge and operating mechanisms (electrical and mechanical)
g. Special structures such as castings, forgings, weldments, stiffeners, inserts, etc.
h. Exostructure including supporting structure, hydrodynamic fairings, sonar domes, access panels
i. Foundations (internal and external), sponsons, mounting provisions for mission peculiar equipment, armament/weapons delivery systems
j. Fixed ballast and floatation with associated mounts, brackets and fasteners
k. Equipment masts, foundations, hinges, and associated operating mechanisms, and electrical devices (sensors, switches)
l. Pressure hull inserts and penetrations
m. Hull and structure assembly, test and checkout including pressure testing, tank/compartment tightness testing

Excludes, for example:

a. Piping
b. Sacrificial anodes
c. Equipment inside the pressure hull, housings, or structure
d. Sound or shock/vibration mounts integral with mounted components. (They belong with the supported system.)
e. Tanks, ballast and trim systems that are not integral to the structure
f. Pressure housings, pressure bottles, and end plates and associated support structures that are not integral to the primary hull and structure. (This would include energy storage, ballast and trim tanks, and other pressure vessels that house equipment that are part of other subsystems).

I.4.2.2 Propulsion. The equipment and assembled components installed primarily to propel the vehicle and the systems necessary to make these components operable.

Includes, for example:

a. Main, secondary and auxiliary propulsion units (e.g., engines or propulsion motors)
b. Transmission, gearing, shafting, bearings, propellers, propulsors, tracks, treads
c. Propulsion shrouds and ducts
d. Propulsion control equipment (e.g., motor controllers)

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e. Supporting systems such as circulating and cooling water, and lubricating oil system necessary to make these components operable
f. Associated structural foundations, resilient mounts to support the equipment
g. Associated piping
h. Associated cabling
i. Associated electrical equipment e.g., control sensors, valves and actuators
j. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Energy sources, energy storage, energy conversion such as batteries or fuel cells, which are included under Energy/Storage/Conversion
b. All effort directly associated with the integration, assembly, test, and checkout of these elements into the maritime vehicle
c. All ancillary equipments that are not an integral part of the propulsion units required to provide an operational system, e.g., instruments, controls, etc.

NOTE: For lower level information, use the structure and definitions in Appendix B, Electronic Systems.

I.4.2.3 Energy Storage / Conversion. The energy storage, conversion, monitoring and control systems that are separate from electrical power and distribution systems.

Includes, for example:
a. Energy storage and conversion system
b. Energy storage and conversion monitoring and control system
c. Associated enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment such as batteries, fuses, bus bars, sensors, battery scanners
g. Supporting systems such as fuel tanks, fuel pumps, fuel monitoring and control, etc.
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Power distribution system
b. Peculiar support equipment – battery handling equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.4 Electrical Power. The power generating, monitoring and control, and distribution systems to provide electrical power and lighting.

Includes, for example:
a. Electric power generation
b. Power conversion equipment
c. Power relays, circuit protection, power distribution system
d. General purpose lighting (if any)(internal and external)
e. Electric power monitoring and control system

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f. Electrical wiring and cabling to provide power to other equipment
g. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes:
a. Special lighting for electro-optical sensor systems
b. Navigation lighting

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.5. Vehicle Command and Control. The onboard equipment (hardware/software) that allows a properly designated command authority to exercise control over the UMS in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission and may include Shipboard and/or shore based Command and Control equipment.

I.4.2.5.1 Vehicle Command and Control Integration, Assembly Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the Vehicle Command and Control parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

I.4.2.5.2 Mission Control. That equipment (hardware/software) installed in the UMS to provide mission control functions and facilitate its autonomy. Autonomy is the UMS's own ability of sensing, perceiving, analyzing, communicating, planning, decision making, and acting, to achieve its goals as assigned by its authorized client(s). (Source: ASTM F2541-06 Guide for UUV Autonomy and Control).

Includes, for example:
a. Mission or sortie control computers, software, algorithms
b. Autonomous mission or sortie control computers, software, algorithms
c. Vehicle control computers, software, algorithms
d. Payload control computers, software, algorithms
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Communication

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.5.3 Navigation. That equipment (hardware/software) installed in the UMS to perform the navigation function.

Includes, for example:

a. Electrical and electronic navigation equipment and systems
b. Integrated navigation systems
c. Inertial navigation sensors and systems
d. Heading, attitude, velocity and depth sensors
e. Radio navigation, satellite navigation, radar
f. Acoustic navigation equipment, sonar altimeter, upward looking sonar
g. Terrain and/or obstacle avoidance sonar
h. Navigation lights
i. Navigation computer
j. Other equipment essential to the navigation/guidance function
k. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
l. Associated cabling
m. Associated electrical equipment e.g., control sensors, actuators
n. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Rendezvous, homing and docking systems (reference I.4.3.5.5)

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.5.4 Guidance and Control. That equipment (hardware/software), which, in combination with the propulsion, hovering, depth, steering and dive control subsystems (under vehicle control subsystems), provide guidance and control the flight path and vehicle state (i.e., speed, depth, heading, pitch, yaw, roll).

Includes, for example:

a. Guidance and control computers
b. Vehicle state (i.e., speed, depth, heading, pitch, yaw, roll) control software, algorithms and/or sensors such as pressure transducers, rate gyros, accelerometers, and motion sensors
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, actuators
f. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Hovering and depth control thrusters, jets or control surfaces or actuators
b. Steering and dive control thrusters, jets or control surfaces or actuators, central computers, navigation computers, data buses and navigation sensors, which are included under other WBS elements

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.5.5 Health Status Monitoring. That equipment (hardware/software) installed in the vehicle for malfunction detection and reporting.

Includes, for example:

a. Health monitoring hardware/software such as temperature and water intrusion sensors that are dedicated to that function and not part of another system
b. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
c. Associated cabling
d. Associated electrical equipment e.g., control sensors, valves and actuators
e. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Health monitoring hardware/software that is an integral part of other systems (e.g., motor speed sensors, hydraulic leak detection sensors or computer built-in-test)

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.5.6 Rendezvous, Homing and Docking Systems. That equipment (hardware/software) installed in the vehicle for rendezvous, homing and docking.

Includes, for example:

a. Rendezvous or homing beacon or receiving system, docking sonar
b. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
c. Associated cabling
d. Associated electrical equipment e.g., control sensors, valves and actuators
e. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Hardware/software that is part of other systems

I.4.2.5.7 Fire Control. The equipment (hardware/software) installed in the vehicle that provides the intelligence necessary for weapons delivery such as launching and firing.

Includes, for example:

a. Sonars, radars and other sensors including sonar and radomes
b. Transducers, antennas, if integral to the fire control system, necessary for search, target identification, rendezvous and/or tracking
c. Self-contained navigation and air data systems
d. Weapon control and safety devices

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e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.5.8 Vehicle Command and Control Software Release 1…n. All vehicle command and control software that cannot be associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

I.4.2.5.9 Other Vehicle Command and Control 1...n (Specify). These elements should be replaced with other product-oriented Vehicle Command and Control elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.6. Surveillance. That equipment (hardware/software) installed in the vehicle that provides the UMS with situational awareness needed for the operation and safety of the system, regardless of the mission.

Includes, for example:
a. Electronic countermeasures (ECM) equipment such as radar warning detection systems
b. Acoustic intercept systems
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, valves and actuators
f. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Special or mission specific ISR equipment that would be part of a mission payload

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

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I.4.2.7 Communications/Identification. That equipment (hardware/software) installed in the maritime vehicle for communications and identification purposes.

Includes, for example:

a. Radio communication system(s), including transceivers, amplifiers, couplers, antennas, and associated controls
b. Underwater communication systems, including transceivers, amplifiers, projectors, hydrophones, transducers and associated controls
c. Automatic identification systems (AIS), including transceivers, amplifiers, couplers, antennas, and associated controls
d. Communication security systems such as identification equipment (IFF) and crypto equipment
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Internal data processing communication systems (i.e., data buses) that are part of other systems

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.8 Ship Control Systems.

a. Steering and diving control
b. Hovering and depth control
c. Ballast and trim system
d. Maneuvering system

I.4.2.8.1 Ship Control System Integration, Assembly, Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the Ship Control parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

I.4.2.8.2 Steering and Diving Control. Equipment (hardware/software) associated with controlling the vehicle heading, driving/surfacing, ballast, trim, maneuvering and stability.

Includes, for example:

a. Rudders, stabilizing fins, dive planes
b. Control actuators
c. Deployment/retraction mechanisms
d. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

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Excludes, for example:

a. Ballast and trim systems

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.8.3 Hovering and Depth Control Equipment. (hardware/software) associated with controlling a predetermined assigned depth/altitude and to remain, or hover, at that predetermined location for a given period of time.

Includes, for example:

a. Depth control thrusters
b. Deployment/retraction mechanisms
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Ballast and trim systems

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.8.4 Ballast and Trim. That equipment (hardware/software) installed in the vehicle to control vehicle buoyancy and trim.

Includes, for example:

a. Flood, drain and trim equipment
b. Trim and ballast tanks that are not integral to the hull and structure
c. Ballast and trim pumps or other mechanisms
d. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment such as control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Fixed ballast
b. Trim and ballast tanks that are integral to the hull structure
c. Vehicle buoyancy/trim control software that is part of the guidance and control function

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.8.5 Maneuvering System. That equipment (hardware/software) installed in the vehicle to assist in controlling the vehicle, usually at slow speeds, if separate from the steering, diving and hovering systems.

Includes, for example:
a. Slow speed propulsion, steering and/or depth control thrusters
b. Deployment/retraction mechanisms
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Trim and ballast tanks that are integral to the hull structure
b. Steering and diving control

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.8.6 Ship Control Systems Software Release 1…n. All ship control systems software that cannot be associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

I.4.2.8.7 Other Ship Control Systems 1...n (Specify). This element should be replaced with other product-oriented ship control system elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.9 Auxiliary Systems. Auxiliary support systems for vehicle emergency systems, on-board launch and recovery mechanisms, environmental control, anchoring and mooring, mast or buoy deployment mechanisms, sensor or other device deployment.

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I.4.2.9.1 Auxiliary Equipment Integration, Assembly, Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the Auxiliary parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

I.4.2.9.2 Emergency Systems. That equipment (hardware/software) installed in the vehicle to provide emergency functions such as surface, scuttle, emergency location aids.

Includes, for example:
a. Emergency floatation or scuttling systems
b. Emergency location devices and actuators
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Ship control systems (steering and diving control, hovering and depth control, ballast and trim system, maneuvering system)
b. Hardware/software that is integral to other equipment (e.g., anti-tamper devices)

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.9.3 Launch and Recovery Systems. That equipment (hardware/software) installed in the vehicle to facilitate or enable launch and recovery.

Includes, for example:
a. Launch release mechanisms, recovery lines and floats, mechanisms, devices, controllers that are part of the vehicle
b. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
c. Associated piping
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, valves and actuators
f. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Rendezvous, homing and docking systems that are part of the vehicle command and control system
b. Launch and recovery systems that are part of the shipboard equipment

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.9.4 Environmental Control System. Environmental equipment and distribution systems that provide control of temperature, humidity, pressurization, or other environmental parameters. The distribution systems provides for air ducts, cooling lines and other plumbing required in supplying air and other cooling media from supply sources to the controlled environment.

Includes, for example:

a. Air refrigeration system, liquid cooling system, air or liquid flow regulation system such as compressors, heat exchangers, pumps
b. Humidity or condensation control
c. Heaters, heater blankets, deicing equipment
d. Temperature or humidity controller
e. Air ducts, refrigerant cooling lines, plumbing
f. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
g. Associated piping
h. Associated cabling
i. Associated electrical equipment e.g., control sensors, valves and actuators
j. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Environmental control hardware/software that is an integral part of other systems (e.g., computer heat sinks, fans) and not integrated with other systems

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.9.5 Anchoring, Mooring and Towing. Equipment that provides capabilities to anchor, moor or tow the UMS.

Includes, for example:

a. anchors, anchor handling and stowage system, winches
b. Control actuators
c. Deployment/retraction mechanisms
d. Mooring and towing cables
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Mooring and towing systems that are part of the shipboard equipment

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.9.6 Miscellaneous Fluid Systems. Equipment that provides miscellaneous fluid systems.

Includes, for example:

a. Hydraulic power for the actuation mechanical systems such as mast or thruster deployment, flight control surfaces
b. Pumps, reservoirs, accumulators, valves, regulators and associated plumbing distribution systems to provide hydraulic power or compensation systems
c. Hydraulic tubing, check valves, etc. That interconnect the hydraulic equipment
d. Fire extinguishing systems
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Fluid system hardware/software that is an integral part of other systems (e.g., local motor lubrication or hydraulic system) and not integrated with other systems

I.4.2.9.7 Auxiliary Systems Software Release 1…n. All auxiliary systems software that cannot be associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

I.4.2.9.8 Other Auxiliary 1…n (Specify). This element should be replaced with other product-oriented auxiliary elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Maritime Vehicle is excluded.

I.4.2.10 Vehicle Software Release 1…n. All maritime vehicle software that cannot be associated with a specific Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

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I.4.2.11 Vehicle Integration, Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing and software required for the integration, assembly, test and checkout of the above Level 3 subsystems equipment (hardware/software) elements into their Level 2 element, Maritime Vehicle Segment Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

I.4.3 Payload 1…n (Specify). Unmanned Maritime Systems (UMSs) may have a single or multiple payloads represented at Level 3 of the WBS. In addition to the types of payloads listed below, an UM system may also have other payloads. If a UM system has other payloads, they too should be represented within the WBS structure at Level 3 below the Level 2 Payload element. Examples of other payloads include targeting and ranging systems, bio/chemical detection sensors, meteorological sensors, and communication relay systems.

I.4.3.1 Payload Integration, Assembly, Test and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the payload suite parts and subsystems equipment (hardware/software) elements. Reference Appendix L: Common Elements, Work Breakdown Structure and Definitions for further detail.

I.4.3.2 Survivability Payload 1…n (Specify). Those equipments (hardware/software) installed in, or attached to, the maritime vehicle that assists in penetration for mission accomplishment.

Includes, for example:

a. Sonar or radar detection receivers, warning devices and other electronic devices, electronic countermeasures, jamming transmitters, chaff, infra-red jammers, acoustic jammers, countermeasures, and other devices typical of this mission function

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

I.4.3.3 Intelligence, Surveillance, Reconnaissance (ISR) Payload 1…n (Specify). Those equipments (hardware/software) installed in, or attached to, the marine vehicle necessary to provide capabilities peculiar to the ISR mission.

Includes, for example:

a. Acoustic sensors
b. RF sensors
c. Photographic, electro-optic, infrared, and other sensors
d. Sensor data recorders
e. Sensor processing
f. Payload controller
g. Data link
h. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
i. Associated cabling
j. Associated electrical equipment e.g., control sensors, valves and actuators
k. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Sensors or processing provided for vehicle functions required for all or most missions

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

I.4.3.4 Armament/Weapons Delivery Payload 1…n (Specify). That equipment (hardware/software) installed in the maritime vehicle to provide the firepower functions and weapons delivery capability.

Includes, for example:

a. Torpedoes, mines, guns, high energy weapons, mounts, turrets, weapon direction equipment, ammunition feed and ejection mechanisms, and gun cameras
b. Launchers, pods, torpedo or mine racks, pylons, integral release mechanisms, and other mechanical or electro-mechanical equipments specifically oriented to the weapons delivery function
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment such as control sensors, valves and actuators
g. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Navigation or fire control

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

I.4.3.5. Mission Payload 1…n (Specify). That equipment (hardware/software) installed in the maritime vehicle to provide a mission specific capability not listed above.

Includes, for example:

a. Mine warfare (MIW) including offensive mining and/or mine countermeasures (MCM)
b. Anti-submarine warfare (ASW)
c. Electronic warfare (EW) to include electronic countermeasures, jamming transmitters, chaff, infra-red jammers, other jamming equipment, electromagnetic deception equipment, or weapons that use electromagnetic or directed energy such as laser, RF weapons, or particle beams
d. Information operations (IO), oceanography, or other payload equipment specific to a Naval Warfare mission
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

I.4.3.6 Payload Software Release 1…n. All payload software not associated with a specific Level 3 payload element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

I.4.3.7 Other Payload 1…n (Specify). Any other product or equipment not already mentioned in the above definition, but that is also transported or delivered by the UMS.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Payload is excluded.

I.4.4 Shipboard (or Shore Based) Segment. The shipboard (or shore based) segment of the UMS includes all shipboard (or shore based) equipment (hardware/software) that provides command and control, communication, power generation, conditioning and distribution, launch/recovery, storage, handling and auxiliary support capabilities deployed on the host platform. This equipment is used during pre-launch, launch, mission/sortie, recovery, and post-recovery operations.

Includes, for example:

a. Design, development, and production of complete units (for example, the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)
b. Integration and test of subsystems into the shipboard systems

I.4.4.1 Shipboard (or Shore) Segment Integration, Assembly Test and Checkout. All efforts as identified in Appendix L: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all elements into the Shipboard/host deployed system to form the maritime vehicle as a whole.

I.4.4.2 Shipboard (or Shore Based) Unmanned Maritime System Command and Control. Equipment (hardware/software) that provides the capability to command and control the unmanned vehicle from the ship, deployment platform or shore based facility. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, procedures and systems employed by a commander or command team in planning, directing, coordinating, and controlling the UMS and its operations in the accomplishment of the mission.

Includes, for example:

a. Operator control console(s), computers, software, algorithms
b. Mission planning console(s), computers, software, algorithms
c. Shipboard communication equipment
d. Integration and test of subsystems into the shipboard systems
e. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

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Excludes, for example:

a. Command and control equipment located in or on the UM system

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.2.1 Unmanned Maritime System Control Console(s). Equipment (hardware/software) that provides shipboard operator(s) with the capabilities to plan, checkout, launch/recover, control, communicate with, and/or operate one or more UMSs and/or payloads. Note – there may be more than one operator console, such as a vehicle control console, a mission planning console, and a payload control console.

Includes, for example:

a. Equipment (hardware/software) that provides the mission planning capability by which goals, constraints, capabilities, and environmental data are processed to create a plan to include tactical goals, a route (general or specific), command structure, coordination, and timing. Plans can be generated either in advance by authorized clients or in real-time by the onboard software systems by or external control. (Source: ASTM F 2541 – 06, Standard Guide for Unmanned Undersea Vehicles (UUV) Autonomy and Control)
b. Equipment (hardware/software) that provides post-mission analysis capability, which may include extraction, review, and/or analysis of mission data and results, generation of mission reports, and archiving data

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.2.2 Payload Control Console(s). Equipment (hardware/software) that provides shipboard operator(s) with the capabilities to plan, checkout, control, communicate with, and/or operate one or more UMSs payloads. There may be more than one operator console, for example, a vehicle control console, a mission planning console, and a payload control console.

Includes, for example:

a. Equipment (hardware/software) that provides the capability to directly control the payload from the ship, deployment platform or shore facility
b. Payload control computers, software, algorithms
c. Payload planning computers, software, algorithms
d. Dedicated payload communication equipment
e. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity
i. Equipment (hardware/software) that provides for the storage, retrieval or dissemination of payload data
j. Computers, software, data storage and recording devices
k. Equipment (hardware/software) that provides information processing, operations (e.g., handling, merging, sorting, and computing) of payload data

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Excludes, for example:
a. Payload control equipment that is part of the vehicle command and control system
b. Payload control equipment located in or on the UMS
c. Data storage equipment that is part of the vehicle command and control system
d. Data processing equipment that is part of the vehicle command and control system

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.3 Shipboard (or Shore Based) Communication Subsystem. This subsystem includes shipboard equipment (hardware/software) to provide communications with unmanned maritime systems, other manned or unmanned air, surface and subsurface vehicles, satellites and/or ground stations. This subsystem supports all shipboard subsystems that require the capability to prepare and output commands to, and receive and process data from, the maritime vehicle while in operation or under test.

Includes, for example:
a. Network, computer processing and display hardware such as routers, switches, servers, workstations, storage devices, etc.
b. Software for handling, processing, and executing maritime vehicle commands, as well as processing and analyzing maritime vehicle telemetry
c. RF, laser, or acoustic antennas, transmitters, receivers, processing, etc.
d. Communication enclosures (e.g., ISO van), factory/contractor support facility, initial support and support equipment
e. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Communication equipment that is organic to the ship

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.4 Shipboard (or Shore Based) Power Subsystem. Equipment (hardware/software) associated with generating, conditioning, monitoring, controlling and distribution of power to shipboard components of the UMS.

Includes, for example:
a. Electric power generation such as a diesel power generator dedicated to the UMS
b. Power distribution switchboards, circuit protection, power distribution system
c. Ground fault detection and interruption
d. Power monitor and control system
e. Battery charging system
f. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
g. Associated cabling

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h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Power generation and distribution equipment that is organic to the host ship or shore facility

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.5 Launch and Recovery Equipment. Equipment that provides the capability to launch and recover unmanned surface or underwater vehicles from a ship or shore based facility.

Includes, for example:
a. Launch and recovery ramps, track systems, lifting equipment
b. Vehicle capture and release mechanisms installed on the ship or dockside equipment
c. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Handling and lifting equipment that is organic to the ship or dockside facility and not dedicated to support of UMS
b. Rendezvous, homing and docking sensors/systems used to control the vehicle

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.6 Storage Subsystem. Equipment that provides shipboard (or Shore Based) storage of the vehicle and its equipment.

Includes, for example:
a. Shipboard (or shore based) storage van/shelter, maintenance van/shelter, equipment storage containers
b. Self contained heating, air conditioning or other environmental control systems
c. Self contained power conversion and distribution equipment
d. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

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Excludes, for example:
a. Buildings, shelters or other enclosures located at dockside facilities that are not dedicated to support of UMS system

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.4.7 Vehicle Handling Equipment. Shipboard (or shore based) equipment dedicated to handling the vehicle.

Includes, for example:
a. Dollies, maintenance cradles, track systems, lifting equipment
b. Integral power and control systems
c. Integral electrical or hydraulic systems
d. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment such as control sensors, valves and actuators
h. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Launch and recovery system
b. Handling and lifting equipment that is organic to the ship and not dedicated to support of UMS

I.4.4.8 Shipboard (or Shore Based) Auxiliary Equipment. Auxiliary shipboard/shore based systems, equipment not allocable to individual elements equipment.

Includes, for example:
a. Battery charging equipment, hydraulic system support equipment, refrigerant purge/charge equipment, pressure housing dry nitrogen backfill equipment
b. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
c. Associated piping
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, valves and actuators
f. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Other peculiar support equipment such as special test equipment that is needed for intermediate or depot level maintenance, but not shipboard operation and maintenance

I.4.4.9 Shipboard Software Release 1…n. All Shipboard software not associated with a specific Level 3 or Level 4 elements.

NOTE: Refer to Appendix B, Electronic Systems further breakout and definitions for Software.

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I.4.4.10 Other Shipboard Subsystems 1…n (Specify). This element should be replaced with other product-oriented auxiliary elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Shipboard Segment is excluded.

I.4.5 Shore Segment. The Shore Segment of the UMS includes all shore based equipment (hardware/software), if any, that provides command and control, communication, power generation, conditioning and distribution, launch/recovery, storage, handling and auxiliary support capabilities at a temporary or permanent shore base supporting UMSs. This equipment is used during pre-launch, launch, mission/sortie, recovery, and post-recovery operations. This is essentially the same type of equipment that would be included in the Shipboard Segment. Most UMSs are ship deployed, but some systems may be launched and recovered from a shore base. A system may have only a Shipboard or Shore Segment, or some systems may include both segments.

Includes, for example:

a. Sub-elements to the shipboard segment found under I.4.4
b. Design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)
c. Integration and test of subsystems into the shore based systems

I.4.6 Transportation Segment or Vehicles. Any vehicles that have been specifically designed or modified for the transportation of the unmanned maritime vehicles, shipboard equipment or other mission equipment. This includes any vehicles used to perform movement of the prime mission vehicle, crew, maintenance equipment, and direct maintenance personnel, or any other special transport systems used in the relocation of the prime mission equipment so that it may perform its mission.

Includes, for example:

a. Transport trailers that are dedicated to the Unmanned Maritime Systems and its equipment

Excludes, for example:

a. Ship or shore based handling equipment

I.4.7 Unmanned Maritime System Software Release 1…n. All UMS system level software not associated with a specific Level 3 or 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

I.4.8 UMS System Integration Assembly Test and Checkout. All efforts as identified in Appendix L: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all elements into the maritime vehicle to form the unmanned maritime system as a whole. Includes efforts associated with integrating the maritime vehicle, payloads, shipboard segment and shore segment systems to form the UMS system.

I.4.9 Common WBS Elements. Definitions for Common WBS elements applicable to the Unmanned Maritime, and all other defense materiel items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX J: LAUNCH VEHICLE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

J.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions Launch Vehicle Systems. This WBS applies to interplanetary and earth orbital missions. This WBS is not intended for weapon systems. Definitions for WBS elements common to all defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions and common elements applied uniquely to Launch Vehicles are in Section L.5 of Appendix L.

J.2 APPLICABLE DOCUMENTS

J.2. 1 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

ANSI Standards can be found online at:

http://webstore.ansi.org/ansidocstore/default.asp

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Service Center
445 Hoes Lane
Piscataway, NJ 08855-1331
www.ieee.org

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J.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Launch Vehicle System			
1.1		System Engineering, Integration, Test, Program Management (SEIT/PM)		
1.1.1			System Engineering (SE)	
1.1.2			Integration and Test	
1.1.3			Program Management	
1.2		Launch Vehicle		
1.2.1			SEIT/PM	
1.2.2			Stages 1…n (Specify)	
1.2.2.1				SEIT/PM
1.2.2.2				Structures and Mechanisms
1.2.2.3				Propulsions System
1.2.2.4				Reaction Control System
1.2.2.5				Recovery System
1.2.2.6				Environmental Control System
1.2.2.7				Stage Peculiar Avionics
1.2.2.8				Other Systems 1…n (Specify)
1.2.3			Payload Accommodations 1…n (Specify)	
1.2.3.1				SEIT/PM
1.2.3.2				Payload Fairing
1.2.3.3				Payload Adapter (Pedestals)
1.2.3.4				Mission Unique Hardware (Launch vehicle) 1…n (Specify)
1.2.4			Avionics	
1.2.4.1				SEIT/PM
1.2.4.2				Guidance navigation and Control
1.2.4.3				Power
1.2.4.4				Data Acquisition and Telemetry
1.2.4.5				Range Tracking & Safety (Airborne)
1.2.4.6				Flight Software Release 1…n
1.2.4.7				Other Avionics 1…n (Specify)
1.3		Mission Integration and Analysis 1…f (Specify)		
1.3.1			Mission Standard Integration & Analysis	
1.3.2			Mission Unique Integration & Analysis 1...n (Specify)	
1.4		Launch Operations Site 1...n (Specify)		
1.4.1			SEIT/PM	
1.4.2			Vehicle Processing and Checkout	
1.4.3			Mission Services	
1.4.3.1				Mission Unique Hardware (Launch Operations) 1…n (Specify)
1.4.3.2				Space Vehicle Processing
1.4.4			Launch	
1.4.5			Flight Operations	
1.4.6			Post Launch	
1.4.6.1				Recovery Operations and Services
1.4.6.2				Post Launch Refurbishment
1.4.7			Site Maintenance	
1.4.8			Base Support	
1.4.9			Range Tracking & Safety (Ground)	
1.4.9.1				Range Ground System
1.4.9.2				Range Operations
1.5		Launch Site 1…n (Specify)		
1.5.1			SEIT/PM	
1.5.2			Operational/Site Activation	
1.5.3			Peculiar Support Equipment	

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1.5.4		Ground Command, Control and Communications (GC3)
1.5.4.1		SEIT/PM
1.5.4.2		Command, Control and Communication
1.5.4.3		Other Ground 1…n (Specify)
1.6	System Test and Evaluation	
1.6.1		Development Test and Evaluation
1.6.2		Operational Test and Evaluation
1.6.3		Mock-ups/System Integration labs (SILs)
1.6.4		Test and Evaluation Support
1.6.5		Test Facilities
1.7	Training	
1.7.1		Equipment
1.7.2		Services
1.7.3		Facilities
1.8	Data	
1.8.1		Technical Publications
1.8.2		Engineering Data
1.8.3		Management Data
1.8.4		Support Data
1.8.5		Data Depository
1.9	Peculiar Support Equipment	
1.9.1		Test and Measurement Equipment
1.9.2		Support and Handling Equipment
1.10	Common Support Equipment	
1.10.1		Test and Measurement Equipment
1.10.2		Support and Handling Equipment
1.11	Industrial Facilities	
1.11.1		Construction/Conversion/Expansion
1.11.2		Equipment Acquisition or Modernization
1.11.3		Maintenance (Industrial Facilities)
1.12	Initial Spares and Repair Parts	

J.3.1 Application of Common WBS Elements (Appendix L). For Launch Vehicles, the common WBS elements must include, as a minimum, systems engineering, integration and test, and program management (SEIT/PM). Common elements are found throughout all levels of a WBS and are located one WBS level below the product oriented WBS they support (e.g., Launch Vehicle SEIT/PM would be captured at Level 3 under the Launch Vehicle element). Other common elements, such as training or data, as applicable, should be included in the WBS structure. The WBS structure is not complete without the application of common elements. Definitions for all common elements are in Appendix L. For the uniquely applied System Engineering, Integration and Test, Program Management (SEIT/PM) and Operational Site Activation for Launch Vehicles, reference Appendix L, section L.5.

J.3.2 Application of (1...n), and (1…f) convention. This document uses a (1...n) after WBS element titles where the element may have multiple unique occurrences. When creating the WBS for a specific program or contract, the (1...n) shall be replaced with a specific name for the item.

NOTE: The (1…f) convention is similar to the 1…n convention above, but is refers to different payload "flight" configurations.

J.3.3 Use of "Other" WBS Elements. The Other WBS elements at the system, subsystem, and element (product) levels are restricted to products that have not been envisioned or predicted in the other defined WBS elements. This element should only be used when all other elements have been thoroughly examined and do not fit the definition of the "other" product. In addition the WBS dictionary should clearly define the elements. The program WBS index shall describe the element(s) and avoid any reference to "other".

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J.3.4 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

J.3.5 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

J.3.5.1. “Other” WBS Elements. All appendices contain a WBS element titled as “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the “other” WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

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J.3.5.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

J.4 DEFINITIONS

J.4.1 Launch Vehicle System. The complex of equipment (Hardware/Software), facilities and all of the resources associated with the design, development, production, refurbishment, integration, assembly, test, and operation of the entire payload lift Launch Vehicle System required to insert the Space Vehicle or probe into a space orbit/trajectory.

J.4.2. Launch Vehicle. Includes all resources associated with the design, development, production, refurbishment, integration, assembly, test and evaluation, and launch operations support of the entire Launch Vehicle. The Launch Vehicle is an earth-to-space transfer vehicle that is self propelled after leaving its launching platform. It can be expendable or reusable as it relates to the delivery of payloads to specific trajectories or orbits in space.

Includes, for example:
a. All applicable stages
b. Payload accommodations
c. Avionics
d. Requalification and inventory restock due to obsolescence and/or shelf life

NOTE: For lower level Common Elements, e.g., SEIT/PM, reference Appendix L section L.5.

J.4.2.1 Stages 1…n. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operations support and support of the Stages of the Launch Vehicle. A launch vehicle can be comprised of multiple (expandable and/or reusable) stages (1…n). The purpose of each stage is to propel the remaining portion of the Launch Vehicle and/or Space Vehicles to a certain elevation, trajectory and orbit.. During flight, as each stage is expended, it is typically separated from the active portion of the Launch Vehicle to improve efficiency and eliminate unnecessary mass.

As an example, a multi-stage Launch Vehicle could consist of a liquid core booster stage (Stage 1) with attached solid rocket motors (Stage 2), known as "strap-ons", and with additional sequential numbered stages being liquid (or solid) propulsion system, (Stage 3). Stage 4, etc. The numeric "Stage" numbering continues until the stage below the payload and launch vehicle adapters.

The elements of a Stage may include a wide variety of sub-systems depending on the design, configuration and the specific mission.

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Includes, for example:
a. Structures and mechanisms (including operational ordnances and range safety ordnances),
b. Propulsion system
c. Power systems
d. Reaction control system,
e. Recovery system (if required)
f. Environmental control systems deemed necessary
g. Stage peculiar avionics

J.4.2.1.1 Structures and Mechanisms. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operations support and support of the Structures and Mechanisms element of the Launch Vehicle.

Includes, for example:
a. The structural framework that provides the aerodynamic shape, mounting surfaces and physical structures and tanks such as environmental protection for the Launch Vehicle stage elements
b. Mechanical elements for the Launch Vehicle stages containing structural members that serve some functional mechanical movements that interfaces with other dynamic or static elements or subsystems. Mechanical elements may be actuated by electrical, gas, pyrotechnic or hydraulic forces
c. Stage separation mechanisms such as ordnance bolts and springs (e.g., retro rockets, staging motors, pyrotechnic valves and bolts)
d. Paint and corrosion control
e. Other mechanisms and support structures that are not defined elsewhere within the WBS and are cost separable

Examples of Structures include:
a. Wings, tails, fins, canards and other control surfaces that provide aerodynamic flight control in response to actuators, electro-mechanical signals and are attached to the air vehicle body
b. Structural body assemblies including the structure, pipe and tube lines, and fuel tanks that are integral with the structure
c. Electrical harnesses, cords and wiring with associated brackets, stays, fasteners and grommets
d. Thrust structure, heat shields, intertank adapters and connectors, interstage adapters, skirts, nose cones and miscellaneous mounting brackets and supporting structures

Examples of Mechanisms include
a. Miscellaneous deployment devices, landing gear and struts

Excludes, for example:
a. Adapters that fall under payload accommodations

J.4.2.1.2 Propulsion System. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operations support, and support of the Propulsion System element of the Launch Vehicle. The Propulsion System includes the equipment to provide thrust to propel the launch vehicle on its intended flight. The total propulsion system may be composed of one or more subsystems that ignite, burn, and may (or may not) be jettisoned sequentially over the course of flight. Individual subsystems may employ solid, liquid, and/or air-breathing technologies.

Includes, for example:
a. Primary propulsion elements such as solid rocket motors, liquid rocket engines, and/or air breathing engines
b. Subsystems required to generate propulsion such as manifolds, bell-housing, pumps, lines and tubing, fuel and oxidizer injectors, valves (mechanical, electro-servo, pyrotechnic etc.), start cartridges and engine/motor performance sensors
c. Components associated with Thrust Vector Control (TVC) and fuel/oxidizer liquid management (i.e., feed lines, pressurization system and/or pressure control, pumps, valves, actuators etc.)

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NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.1.3 Reaction Control System (RCS). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the RCS element of the Launch Vehicle. The RCS includes hardware resident on a stage used for attitude control and steering. The RCS is capable of providing small amounts of thrust in any desired direction or combination of directions, providing torque to allow control of rotation (pitch, yaw, and roll). The RCS often uses combinations of large and smaller (vernier) thrusters (e.g., cold gas, warm gas, liquid propellant, solid propellant), to allow different levels of response from the combination.

Includes, for example:
a. All of the thrusters, lines, valves, propellant tanks, gas tanks, manifolds, etc. associated with the RCS

Excludes, for example:
a. The control system or elements of the control system if these are separate from the RCS (i.e., included under the Guidance Navigation and Control element) with the only interface being a signal to a valve, actuators or distributor on the RCS
b. The thrust vector control (TVC) system associated with the main propulsion system, which is included within the Propulsion System

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.1.4 Recovery System. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the Recovery System element of the Launch Vehicle.

Includes, for example:
a. Equipment required to control final descent velocity and attitude after separation,
b. Items used to protect hardware being recovered from adverse environmental elements
c. Equipment used to facilitate recovery and transport operations
d. Parachutes, methods of sequencing and deploying these parachutes and parachute separation components
e. Flotation and/or landing pad devices and/or landing gear
f. Impact resilient devices
g. Location aids that assist in the search and retrieval operations for the expended elements

Excludes, for example:
a. Recovery operations and services, which are included under Recovery Operations and Services

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

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NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.1.5 Environmental Control System. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the ECS for the Launch Vehicle. The ECS is used to maintain and control an appropriate heat balance between absorbed radiation, internal heat dissipation and emitted energy within the Stage(s). It includes both active and passive thermal control (as applicable).

Includes, for example:

a. Active thermal control elements that may include pumped-loop systems, heaters and mechanical refrigerators
b. Passive thermal control elements that may include radiator panels/fins, coatings, thermal paint, heat shield tiles, heat pipes, insulation, conductive structures and materials, and louvers and sunshields
c. Acoustic or shock absorbing materials or devices

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.1.6 Stage Peculiar Avionics. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment and support of any avionics elements whose functionality is specifically associated with Stages 1...n. Stage peculiar avionics is separate from the main launch vehicle avionics system.

Includes, for example:

a. Power elements such as batteries and harnesses that provide and distribute power to components located on a specific Stage
b. Instrumentation componentry used for collecting in-flight data form a specific Stage
c. Separate and independent avionics (power systems, telemetry, command and control) for an Upper Stage for transfer orbital insertions

J.4.2.1.7 Other Systems (Specify). This element should be replaced with other product-oriented stage subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.2 Payload Accommodations 1...n (Specify). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support required to implement the physical integration of the Space Vehicle(s) with the Launch Vehicle, resulting in successful delivery of the Space Vehicle to the specified orbit to meet mission requirements. In order to deliver a payload to its intended orbit/trajectory certain considerations must be taken into account to protect the payload from unacceptable environmental conditions during flight. The purpose of the Payload Accommodations is to assure the payload arrives at its final destination safely. This element also includes all physical mechanical/electrical

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interfaces between the Launch Vehicle and Space Vehicle. Payload Accommodations includes the following elements, which vary as a function of mission requirements.

Includes, for example:
a. Payload fairing
b. Payload adapter
c. Mission unique hardware

J.4.2.2.1 Payload Fairings. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the Payload Fairing element of the Launch Vehicle. The Payload Fairing consists of the aerodynamic shroud and equipment mated to the launch vehicle that protects the Space Vehicle from external environments and contamination. The Payload Fairing provides this protection from encapsulation of the Space Vehicle and its upper stage, as applicable, through atmospheric phase of the launch vehicle flight.

Includes, for example:
a. Payload fairing structure (e.g., panels, modules and nose assemblies) and mechanisms
b. Separation ordnance and other necessary mechanisms to assure that the payload fairing successfully separates from the launch vehicle and space vehicle
c. Environmental control systems, including thermal paint, insulation, heat shields and tiles or any other active or passive means necessary to maintain appropriate temperature of the shroud and mission equipment within it. structural interface required between the shroud and launch vehicle, such as an interstage adapter or boat tail

Excludes, for example:
a. The hardware production and installation activities associated with implementing mission unique hardware requirements to the Payload Adapter, which are included under WBS J.4.2.2.3 - Mission Unique Hardware (Launch Vehicle) 1..n (Specify))
b. The engineering and analysis activities performed to define mission unique hardware requirements (included under WBS J.4.3.2-Mission Unique Integration and Analysis 1..n (Specify)
c. Linear pyrotechnic separation cords
d. Thermal blankets and/or installations
e. Payload access windows and doors

J.4.2.2.2 Payload Adapter. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the Payload Adapter element of the Launch Vehicle. This element may be called a payload adapter, booster adapter or payload attach fitting or pedestal. The Payload Adapter includes the physical mechanical and electrical interface between the Launch Vehicle's uppermost stage and the Space Vehicle's attach points. It can be as simple as a snap ring device, but it is typically a more complex shell or frame structural assembly.

Includes, for example:
a. Adapter structures and Space Vehicle(s) separation mechanisms for each payload
b. Hardware and brackets
c. Attachment and release devices/deployment devices
d. Umbilical provisions
e. Adapters located between Space Vehicles on a multi-launch configuration
f. Harnesses, cords and plugs

Excludes, for example:
a. The hardware production and installation activities associated with implementing mission unique hardware requirements to the Payload Adapter, which are included under WBS J.4.2.2.3 - Mission Unique Hardware 1..n (Specify)
b. The engineering and analysis activities performed to define mission unique hardware requirements (included under WBS J.4.3.2 Mission Unique Integration and Analysis 1..n (Specify)

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J.4.2.2.3 Mission Unique Hardware (Launch Vehicle) 1...n (Specify). Includes all resources required to produce and install mission hardware necessary to meet mission unique (i.e., non-standard) Space Vehicle electrical/mechanical interface requirements with the Launch Vehicle (i.e., airborne) element.

Includes, for example:
a. Adapters for Space Vehicle
b. Spin table for Space Vehicle
c. Umbilical retract system
d. Air conditioning ducting

Excludes, for example:
a. The engineering and analysis activities performed to define mission unique hardware requirements (included under WBS J.4.3.2 -Mission Unique Integration and Analysis 1..n (Specify)
b. The hardware production and installation activities associated with implementing mission unique hardware requirements associated with Launch Operations , Mission Services included in WBS Element – J.4.4.2.1 Mission Unique Hardware (Launch Operations) 1..n (Specify)

J.4.2.3 Avionics. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the Avionics element of the Launch Vehicle. Guidance elements are used for generating or receiving telemetry data to produce command and control signals. Instrumentation elements are used for collecting specified vehicle performance and health data and relaying these data to the telemetry collection system.

Includes, for example:
a. Power, data acquisition, communications and other Avionics functions required for a specific Launch Vehicle
b. Flight software to support all processing activities associated with the power-up, prelaunch and flight states of the launch vehicle
c. The software resident within the on-board Inertial Navigation Unit (INU) (or equivalent) and Flight Control Subsystem (FCS) processor of the Launch Vehicle avionics system
d. The flight termination system(s) used to intentionally destroy the Launch Vehicle if needed and determined by Flight Range Safety

Excludes, for example:
a. Physical control such as Thrust Vector Control (TVC) and Reaction Control System (RCS)
b. Guidance Navigation and Control (GN&C)
c. Power systems and batteries

J.4.2.3.1 Guidance Navigation and Control (GN&C). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the GN&C element. The purpose of the GN&C system is to achieve precise injection of the Space Vehicle into its required orbit while maintaining Launch Vehicle stability and control. During the Launch Vehicle flight trajectory, GN&C components determine and provide (autonomously) the following functions: 1) guidance - steering the vehicle to its final target, 2) navigation - determining the vehicle's position, velocity and attitude and 3) control - implementing guidance commands to achieve propulsion deflections or changes in thrust vector.

Includes, for example:
a. Inertial measurement unit (IMU)
b. Inertial navigation unit (INU)
c. Gyros
d. Accelerometers
e. Altimeters
f. Flight computer
g. Control units
h. GPS receiver

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Excludes, for example:

a. Control actuators such as the Thrust Vector Control (TVC) for the main propulsion system, which is included under WBS J.4.2.1.2 Propulsion Systems

J.4.2.3.2 Power. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the Power element of the Launch Vehicle. The Power element includes equipment required for generation, conversion, regulation, storage, distribution and switching of electrical energy to Launch Vehicle components.

Includes, for example:

a. Batteries
b. Generators
c. Power conditioners
d. Switches
e. Distribution harnesses and cables
f. Connectors.

Excludes, for example:

a. Power components (e.g., batteries) for the Flight Termination System (FTS), which are included under Range Tracking and Safety

J.4.2.3.3 Data Acquisition and Telemetry. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the Data Acquisition and Telemetry element of the Launch Vehicle. The Data Acquisition and Telemetry system provides the means of collecting and transmitting measured instrumentation data either directly back to a ground receiving station or indirectly via an airborne or space-based relay communication asset.

Includes, for example:

a. The data acquisition system, which provides launch vehicle and payload conditioned, digitized, vehicle health and system performance information (e.g., guidance and navigation data, vibration, temperature, fuel and liquid levels, pressures and G-force) during pre-launch, launch and post-flight operations
b. The telemetry system, which, after receiving data from the data acquisition system, encrypts, encodes and modulates, and transmits the data via a telemetry transmitter

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.3.4 Range Tracking and Safety (Airborne). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the Range Tracking and Safety system.

Includes, for example:

a. On-board tracking system (e.g., Global Positioning System, C-Band receivers and transmitters) that provides the necessary data to determine vehicle position in support of the Flight Termination System (FTS) from liftoff through park orbit insertion. The tracking system enables ground tracking and airborne/space radar systems to accurately track the vehicle through its flight
b. Transponders and antennas for telemetry data and for command and control instructions
c. Flight Termination System (FTS), which provides Range Safety, the capability to destroy the launch vehicle during non-nominal performance either by secure radio link (i.e., command destruct system), or autonomously after the detection of a vehicle break-up, or unintentional separation of launch vehicle stages (automatic destruct system)

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d. Batteries, command receiver decoders (CRDs), antennas, safe/arm devices, pyrotechnic initiators, and destruct ordnance

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.2.3.5 Flight Software Release 1…n. All avionics flight software not associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic Systems for further breakout and definitions for Software.

J.4.2.3.6 Other Avionics (Specify). This element should be replaced with other product-oriented avionics subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.3 Mission Integration and Analysis (1…f). Includes all resources associated with the design, development, dissemination and verification of requirements and schedules and for ensuring hardware configuration and schedule compliance with mission requirements. Includes both the Standard and Mission Unique integration and analysis efforts required to define integration requirements to unite the Space Vehicle with the Launch System to achieve the specified orbit.

J.4.3.1 Mission Standard Integration and Analysis. Includes engineering and services pertaining to "standard" mission integration tasks for all missions.

Includes, for example:

a. Mission Integration Control Documentation (ICD)
b. Mission design and performance definition
c. Flight software parameters
d. Environmental analysis
e. Guidance system analysis
f. Launch vehicle/Space Vehicle coupled loads analysis
g. Integrated launch vehicle/Space Vehicle thermal analysis
h. Space Vehicle separation analysis
i. electrical analysis
j. Post launch/flight analysis
k. Independent Verification and Validation (IV&V) is conducted for flight readiness

J.4.3.2 Mission Unique Integration and Analysis (1…n). Includes all engineering, analysis and management resources required to define the airborne and ground mission hardware and software necessary to meet mission unique (i.e., non-standard) Space Vehicle electrical/mechanical interface requirements with the Launch System.

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Includes, for example:
a. Mission unique design modifications to Launch Vehicle hardware (engineering and analysis only)
b. Mission unique design modifications to Launch Operations hardware (engineering and analysis only)
c. Other engineering and analysis not considered to be part of J.4.3.1 Mission Standard Integration and Analysis element
d. Vault or sensitive compartmented information facility (SCIF) activities

Excludes, for example:
a. Modifications or updates to standard integration configurations
b. The hardware production and installation activities associated with implementing mission unique hardware requirements to the Launch Vehicle, which are included under WBS J.4.2.2.3 – Mission Unique Hardware (Launch Vehicle)1..n (Specify)
c. The hardware production and installation activities associated with implementing mission unique hardware requirements at the Launch Site, which are included under WBS J.4.4.2.1 – Mission Unique Hardware (Launch Operations) 1..n (Specify)

J.4.4 Launch Operations Site (1...n). Includes all activities at the launch operations site(s) required to receive, inspect, store, process, assemble, checkout, monitor, test, conduct launch operations, control, track, recover (as applicable), and logistically support the Launch System. It includes the maintenance and refurbishment of the facilities and equipment at the launch site in addition to the ongoing site maintenance and base support activities, which are not directly associated with the launch cycle. Activities included under the Launch Operations element are recurring in nature. Excludes sustaining engineering in support of the Launch Vehicle elements provided during launch operations, which is included under WBS J.4.2 Launch Vehicle elements.

J.4.4.1 Vehicle Processing and Checkout. Includes all technical and management resources required to receive and process the Launch Vehicle at the launch site prior to launch.

Includes, for example:
a. Receipt, inspection and testing of the individual Launch Vehicle elements (e.g., liquid rocket engine and/or solid rocket motor stages, strap-ons (solid rocket motor or liquids, payload fairing, etc.), following delivery from their production facility to the launch site
b. Launch Vehicle Assembly, Integration, Test and Check-out (AIT&CO), during which the Launch Vehicle elements (e.g., assembled Stages, encapsulated Space Vehicle and upper stage, etc.) are assembled into an integrated Launch Vehicle
c. Launch Vehicle subsystem checks and system verification, installing the encapsulated Space Vehicle, performing integrated system test and verification, final installations, and vehicle closeouts
d. Transfer (vertically or horizontally) between the assembly areas, processing areas and/or the launch pad (or runway) if required
e. Fueling of the Launch Vehicle
f. Final test and checkout including post assembly testing and verification of stack integration and flight readiness

J.4.4.2 Mission Services. Includes the hardware production and installation activities associated with implementing mission unique hardware requirements associated with Launch Operations, including Space Vehicle processing.

J.4.4.2.1 Mission Unique Hardware 1...n (Launch Operations) (Specify). Includes all resources required to produce and install mission hardware necessary to meet mission unique (i.e., non-standard) Space Vehicle electrical/mechanical interface requirements with the Launch Operations (i.e., ground) element.

Includes, for example:
a. Mission unique ground support equipment
b. Mission unique umbilicals

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J.4.4.2.2 Space Vehicle Processing. Includes all resources for processing (e.g., fueling) of the spacecraft and encapsulation of the Space Vehicle within the Payload Fairing. It also includes Space Vehicle and upper stage (if required) transportation to the launch vehicle (if required).

J.4.4.3. Launch. Includes the resources associated with launch rehearsal activities, launch countdown operations, launch management functions and launch delays.

J.4.4.4 Flight Operations. Includes all resources required to command, control, track and communicate with the Launch Vehicle during its mission.

Includes, for example:
a. Real-time mission control
b. Telemetry processing
c. Communications
d. Data reduction and analysis

J.4.4.5 Post Launch. Includes all resources associated with Recovery Operations and Post Launch Refurbishment if applicable.

Excludes, for example:
a. Post launch analysis included in J.4.3.1 Mission Standard Integration and Analysis

J.4.4.5.1 Recovery Operations and Services. Includes all resources required to effect recovery of the applicable Launch Vehicle elements identified as reusable/recoverable.

Includes, for example:
a. Transportation to reentry site
b. Reentry site recovery operations
c. Transportation of recovered equipment to assigned facilities
d. Logistics support to recovery operations

J.4.4.5.2 Post Launch Refurbishment. The resources required for the inspection, cleaning, repair, refurbishment, replacement, testing and/or checkout of assets utilized during the launch operations cycle.

J.4.4.6 Site Maintenance. Includes ongoing planned maintenance, preservation, repair and calibration of physical launch operations-related assets utilized during the Launch Operations cycle.

Excludes, for example:
a. Maintenance of industrial facilities

J.4.4.7 Base Support. Includes the physical infrastructure and personnel resources resident at the Launch Site that provides support to, but is not directly attributable to Launch Operations activities.

Includes, for example:
a. Facilities
b. Security, fire and emergency medical support
c. Transportation
d. Roads
e. Food

J.4.4.8 Range Tracking and Safety (Ground). Includes all the resources associated with the design, development, test and evaluation, integration, acquisition, installation, monitoring of launch operations and maintenance of the Range Ground system.

J.4.4.8.1 Range Ground System. Includes all the resources associated with the design, development, test and evaluation, integration, installation and maintenance of the Range Ground system. This WBS Element includes

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the acquisition and maintenance of ground tracking radar systems (hardware and software) used to accurately track the launch vehicle through flight, analyze the data and issue a destruct command if necessary.

J.4.4.8.2 Range Operations. Includes all resources utilized during pre-launch and flight operations to used to accurately track and acquire telemetry data of the launch vehicle in during flight and up to flight termination. This WBS Element includes the operations and maintenance of ground tracking radar and telemetry systems.

J.4.5 Launch Site (1...n). Includes all the development, design, construction, conversion, or expansion of roadways, real estate, utilities, and buildings/facilities required to house, service, process, launch and support launch vehicle hardware/software. Included are the efforts due to environmental concerns or laws regarding impacts to the human, ecological, or biospherical environment. It includes installation design, system assembly, installation and checkout, and integrated system tests for ground command, control and communications mission equipment/software and support equipment/software.

J.4.5.1. Operational/Site Activation. Reference Appendix L Common Appendix for definition.

J.4.5.2 Peculiar Support Equipment. Reference Appendix L Common Appendix for definition.

J.4.5.3 Ground Command, Control and Communication (GC3). Includes all resources associated with the design, development, test and evaluation, integration, launch operations and support of the GC3 system. The system provides the communications, monitoring and ground control between the Launch Vehicle/Space Vehicle and ground processing stations. It consists of the hardware and software used to provide command, control communications and power for Launch Vehicle checkout and launch, and data display from launch vehicle checkout to launch and through flight operations.

J.4.5.3.1 Command, Control and Communication. Includes all ground hardware and software for communications, monitoring, and ground control and communication between the Launch Vehicle and ground processing capabilities.

Includes, for example:

a. Ground based sensors
b. Telemetry, tracking and control
c. External communications
d. Data processing equipment
e. Automated launch processing equipment
f. Software and auxiliary equipment required for conducing Launch Vehicle system mission planning, launch processing, health management, launch and flight operations
g. Range safety

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

J.4.5.3.2 Other GC3 (Specify). This element should be replaced with other product-oriented Ground Command, Control and Communication subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE 1: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic Systems.

NOTE 2: All effort directly associated with the remaining Level 4 WBS elements and the integration, assembly, test, and checkout of these elements into the Launch Vehicle is excluded.

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J.4.6 Common WBS Elements. Definitions for Common WBS elements applicable to the Launch Vehicle System, and all other defense materiel items, are in Appendix L: Common Elements, Work Breakdown Structure and Definitions and Appendix L, Section L.5 for unique applications for systems engineering, integration and test and program management (SEIT/PM) and Operational Site Activation.

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APPENDIX K: AUTOMATED INFORMATION SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

K.1 SCOPE

This appendix provides the Work Breakdown Structure and definitions for Automated Information Systems. Definitions for WBS elements common to all defense materiel items are given in Appendix L: Common Elements, Work Breakdown Structure and Definitions and those unique applications are in section L.6.

K.2 APPLICABLE DOCUMENTS

K.2.1 Government Publications. The following standards form a part of this document to the extent specified herein.

Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the:

Acquisition Streamlining and Standardization Information System (ASSIST) database (https://assist.daps.dla.mil)
Document Automation and Production Service
700 Robbins Avenue
Building 4/D
Philadelphia, PA 19111-5094

STANDARDS

MIL-STD-196E, *Joint Electronics Type Designation System*
MIL-STD-1464A, *Army Nomenclature System*
MIL-STD-1661, *Mark and Mod Nomenclature System*
MIL-HDBK-1812, *Type Designation, Assignment and Method for Obtaining*

K.2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/IEEE STD 610.12-1990 (R2002), *Standard Glossary of Software Engineering Terminology*

IEEE/EIA 12207-2008*; GUIDE FOR SYSTEMS AND SOFTWARE ENGINEERING – SOFTWARE LIFE CYCLE PROCESSES*

ANSI Standards can be found online at:

http://webstore.ansi.org

ANSI Customer Service
25 W 43rd Street, 4th Floor
New York, NY, 10036

or

The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center
445 Hoes Lane
Piscataway, NJ 08854-4141
www.ieee.org

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K.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Automated Information System (AIS)			
1.1		Automated Information System Prime Mission Product Release/Increment X		
1.1.1			Custom Application Software 1…n (Specify)	
1.1.1.1				Subsystem Hardware
1.1.1.2				Subsystem Software CSCI 1…n (Specify)
1.1.1.3				Subsystem Software Integration, Assembly, Test and Checkout
1.1.2			Enterprise Service Element 1…n (Specify)	
1.1.2.1				Enterprise Service Element Hardware
1.1.2.2				Enterprise Service Element Software CSCI 1...n (Specify)
1.1.2.3				Enterprise Service Element Integration, Assembly, Test and Checkout
1.1.3			Enterprise Information System 1…n (Specify)	
1.1.3.1				Business Area Hardware
1.1.3.2				Business Area Software CSCI 1…n (Specify)
1.1.3.3				Business Area Integration, Assembly, Test and Checkout
1.1.4			External System Interface Development 1…n (Specify)	
1.1.4.1				External System Interface Hardware
1.1.4.2				External System Interface Software CSCI 1…n (Specify)
1.1.4.3				External System Interface Integration, Assembly, Test and Checkout
1.1.5			AIS Platform Hardware	
1.1.6			System Level Integration	
1.2		System Engineering		
1.3		Program Management		
1.4		Change Management		
1.5		System Test and Evaluation		
1.5.1			Development Test and Evaluation	
1.5.2			Operational Test and Evaluation	
1.5.3			Mock-ups / System Integration Labs (SILs)	
1.5.4			Test and Evaluation Support	
1.5.5			Test Facilities	
1.6		Training		
1.6.1			Equipment	
1.6.2			Services	
1.6.3			Facilities	
1.7		Data		
1.7.1			Technical Publications	
1.7.2			Engineering Data	
1.7.3			Management Data	
1.7.4			Support Data	
1.7.5			Data Depository	
1.8		Peculiar Support Equipment		
1.8.1			Test and Measurement Equipment	
1.8.2			Support and Handling Equipment	
1.9		Common Support Equipment		
1.9.1			Test and Measurement Equipment	
1.9.2			Support and Handling Equipment	
1.10		Operational/Site Activation		
1.10.1			Site Type 1	
1.10.1.1				Deployment Hardware and Software
1.10.1.2				User Documentation
1.10.1.3				Site Activation
1.10.1.4				User Training
1.10.1.5				Data Migration
1.10.1.6				Management/Engineering Support

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1.10.1.7			Interim Logistics Support
1.11	Industrial Facilities		
1.11.1		Construction/Conversion/Expansion	
1.11.2		Equipment Acquisition or Modernization	
1.11.3		Maintenance (Industrial Facilities)	
1.12	Initial Spares and Repair Parts		

K.3.1 Application of Common WBS Elements (Appendix L). Automated Information Systems uniquely apply common elements. For application of these elements, reference Appendix L, Section L.6. WBS elements that are common (i.e., Integration, Assembly, Test and Checkout; Systems Engineering/Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

K.3.2 Key Principles in Constructing a WBS. In the appendices of MIL-STD-881C, the WBS is defined to Level 3 of that structure and in some cases Level 4 or 5. In order to ensure consistency across all systems and developers, WBS elements in the appendices are extended to levels 4 and 5.

1) The reporting level of the WBS is typically at Level 3 except for those items considered high cost, high risk, or high technical interest. For those elements, extension of the WBS to lower levels is necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. The purpose of going below level 3 within the appendix is to ensure that the higher level elements include the proper lower level elements and when required to report at a lower level, those elements at level 4 or 5 are consistent across all systems and developers.

2) In each of the appendices, an element entitled "Other" is available to provide flexibility within the WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined and it does not currently appear in the appendices of MIL-STD-881C.

3) A key to WBS development is the principle that if you can associate the WBS element with the element it supports, it should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (radar system) has three child elements - transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the radar system and makes it a level equal to the radar, it distorts the effort and resources that are required to complete that radar system because it assumes the transmitter is not included (i.e., a child element to the radar is now missing within the WBS structure).

4) In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter subsystem. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, the software may include more functionality than just for the transmitter subsystem. It may include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to an inability to determine the effort for each functionality developed. Therefore, it is appropriate to associate that software to the next highest level (radar system) of the WBS. It is still included as a part of the radar system at the child level, but we are not trying to allocate effort across multiple WBS elements where we are unable to determine what level of support each gets.

5) Intelligence (Intel) efforts (security, threat, mission data) are often considered late in the acquisition cycle, even after contract award. Identifying where Intel is needed reduces risk and affords a much better opportunity to manage cost, schedule, and performance. The WBS Standard portrays systems in a product-oriented WBS, identifying and considering potential intelligence information and costs using the existing Component cost estimating processes.

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K.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. The purpose for the numbering is to provide a consistent approach to identifying and managing the WBS across like systems regardless of vendor or service. The numbering system is numeric; however, several unique issues arise across appendices which require the numbering system to be modified to accommodate the anomalies.

K.3.3.1. "Other" WBS Elements. All appendices contain a WBS element titled as "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. If it is determined that the "other" WBS is not needed, this element and assigned WBS number should be deleted and not used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element using the assigned WBS number from the appropriate appendix. The newly defined element must be approved by the Government Program Manager and the representative contracting officer.

K.3.3.2 (1…n) WBS Element Definitions. Several appendices identify WBS elements with (1…n) or similar to denote that one or more of that type of item may be used. Where this structure occurs, the parent WBS (e.g., 1…n) shall be decomposed to the next level and then each child WBS use the appropriate WBS title for each element as well as the WBS numbering identification. For example, if a missile system has multiple propulsion subsystems, each Propulsion Subsystem (1…n) shall have a WBS name designation (for example, "Solid Rocket Motor"), and the element Propulsion Subsystem 1 would be at the child level of the parent WBS element (Propulsion Subsystem 1…n) as would Propulsion Subsystem 2 (for example, "Liquid Rocket Engine"), and so forth. Each WBS should be detailed down to the element's lower level (as defined in the appendices) whenever possible, and assigned the next available WBS number in sequence according to the parent child relationship as shown below.

1.1.2.	Propulsion Subsystem (1…n)
1.1.2.1.	Solid Rocket Motor
1.1.2.2.	Liquid Rocket Engine
1.1.2.3.	Backup Rocket Motor

K.4 DEFINITIONS

K.4.1 Automated Information System. The complex of enterprise elements, equipment (hardware), software, legacy systems, users, business rules, data and facilities required to develop, test and deploy an automated information system.

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic Systems, apply.

K.4.2 Automated Information Systems Prime Mission Product (PMP) Release/Increment (Version) X. The hardware, software, and associated effort used to analyze, design, integrate, and test the entire automated information system (AIS) prime mission product.

K.4.2.1 Custom Application Software 1…n. This element includes all the hardware, software, and associated effort needed to analyze, design, build, and test a custom software application, at the system developer's site, to fulfill a capability gap not captured by COTS only software packages. (COTS only are captured under K.4.2.2.2 Enterprise Service Element Software CSCI (1...n)).

Excludes, for example:

a. Software development necessary for external system interfaces

K.4.2.1.1 Subsystem Hardware 1…n. This element includes all the associated hardware equipment needed to analyze, design, build, and test a custom software application at the system developer's site to fulfill a

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capability gap not captured by the COTS only software packages. Use lower levels to identify individual hardware items (servers, routers, etc.).

Includes, for example:
a. Development and test hardware

Excludes, for example:
b. Deployment hardware at each operational site

K.4.2.1.2 Subsystem Software CSCI 1…n. This element includes all the associated effort needed to analyze, design, build, and test a custom software application to fulfill a capability gap not captured by the COTS only software packages. Use lower levels to identify individual custom computer software configuration items (CSCI).

Includes, for example:
a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software integration
e. Software qualification testing
f. Software COTS/GOTS approach (requirements negotiation)
g. Software COTS/GOTS component identification
h. Software COTS/GOTS assessment and selection
i. Software prototyping
j. Software COTS/GOTS glue code development
k. Software COTS/GOTS tailoring and configuration
l. Subsystem software product engineering (e.g., configuration management, quality assurance, managed services, etc.)

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B- Electronic Systems, apply.

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K.4.2.1.3 Subsystem Software Integration, Assembly, Test and Checkout. The element includes the effort and material associated with integrating and testing subsystem software CSCIs and hardware of an individual (or group of) subsystem software application that have undergone individual CSCI qualification test.

Excludes, for example:

a. Software development efforts necessary for external system interfaces

K.4.2.2 Enterprise Service Element 1...n. This element includes all the hardware, software, and associated effort needed for developing functionality or software services: unassociated, loosely coupled units of functionality that have no calls to each other embedded in them. These services can be integrated or used by several organizations, even if their respective client systems are substantially different.

Includes, for example:

a. Enterprise service management (monitoring, fault management)
b. Machine-to-machine messaging
c. Service discovery
d. People and device discovery
e. Metadata discovery
f. Mediation
g. Service security
h. Content discovery and delivery
i. Federated search
j. Enterprise catalog service
k. Data source integration
l. Enterprise content delivery network (caching specification, distributed caching, forward staging)
m. Session management
n. Presence and awareness
o. Audio over internet protocol (IP)
p. Video over IP
q. Text collaboration (chat, instant messaging)
r. White boarding and annotation
s. Application sharing
t. Application broadcasting
u. Virtual spaces
v. Identity management (people and device discovery)
w. Content discovery
x. Collaboration
y. User profiling and customization

NOTE: Service Oriented Architecture is based on a mesh of software services as shown above. It packages functionally as interoperable services.

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K.4.2.2.1 Enterprise Service Element Hardware. This element includes all the associated hardware equipment needed at the system developer's facility for assessing and tailoring COTS software applications or modules that can be attributed to a specific software service or bundle of services within the AIS system. Use lower levels to identify individual hardware items.

Includes, for example:
a. Development and test hardware

Excludes, for example:
a. Deployment hardware at each operational site

K.4.2.2.2 Enterprise Service Element Software CSCI (1…n). This element includes all the associated effort for assessing and tailoring COTS software applications or modules that can be attributed to a specific software service or bundle of services within the AIS system.

Includes, for example:
a. Software COTS/GOTS approach (requirements negotiation)
b. Software COTS/GOTS component identification
c. Software COTS/GOTS assessment and selection
d. Software prototyping
e. Software COTS/GOTS glue code development
f. Software COTS/GOTS tailoring and configuration
g. Subsystem software product engineering (e.g., configuration management, quality assurance, managed service contract, etc.)

Excludes, for example:
a. COTS software procurement: licenses, warranties, etc. include in the operational site activation element

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic Systems, apply.

K.4.2.2.3 Enterprise Service Element Integration, Assembly, Test and Checkout. The element includes the effort and material associated with integrating and testing the required software and hardware of an individual (or group of) Enterprise Service Element(s).

K.4.2.3 Enterprise Information System 1...n. This element includes all the hardware equipment and effort to plan, analyze, design, build, and test functionality(s) of an enterprise information system that uses an integrated database to support typical business processes within business/functional areas and consistent information access across areas and systems.

Includes, for example:
a. Enterprise resource planning
b. Enterprise data warehouse
c. Data mart
d. Operational data store

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Excludes, for example:
a. General ledger
b. Accounts payable
c. Revenue and accounts receivable
d. Funds control and budgetary accounting
e. Cost management
f. Financial reporting
g. Real property inventory and management

K.4.2.3.1 Business Area Hardware. This element includes all the associated hardware equipment needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed, in whole or in-part, to a specific functional/business area or module within the EIS system.

Includes, for example:
a. Development and test hardware

Excludes, for example:
a. Deployment hardware at each operational site

K.4.2.3.2 Business Area Software CSCI (1...n). This element includes all the associated effort needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed, in whole or in-part, to a specific functional/business area or module within the EIS system.

Includes, for example:
a. All necessary labor and materials for analyzing, designing/building/configuring, and testing the required business objects -- reports, forms, interfaces, conversions, workflows, fact tables, dimension tables, scripts, enhancements, etc. -- that can be attributed, in whole or in-part, to a specific functional module or business area within the EIS system
b. Effort for assessing and tailoring COTS software applications or modules that can be attributed, in whole or in-part, to a specific functional module or business area within the EIS system

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic Systems, apply.

K.4.2.3.3 Business Area Integration, Assembly, Test and Checkout. The element includes the effort and material associated with integrating and testing the required software and hardware of an individual (or group of) Business Area Element(s).

K.4.2.4 External System Interface Development 1...n. The hardware equipment and effort necessary for developing the set of software artifacts (threads, reports, queries, or scripts, or data export schemas) for a specific external system interface. Use lower levels to identify each specific external system interface that must be developed or modified.

Includes, for example:
a. Design of the interface specification and the development of the interface

Excludes, for example:
a. Data Migration/Cleansing

NOTE: An external system interface is required for proper transmission of data and/or control between the AIS solution and separate systems for which a mutual dependency exists.

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K.4.2.4.1 External System Interface Hardware. The hardware equipment necessary at the system integrator's facility for developing the set of software artifacts (threads, reports, queries, or scripts, or data export schemas) for a specific external system interface. Use lower levels to identify each specific hardware item.

Includes, for example:
a. Development and test hardware

Excludes, for example:
a. Deployment hardware at each operational site

K.4.2.4.2 External System Interface Software CSCI (1...n). The effort associated with developing the set of software artifacts (threads, reports, queries, or scripts, portlets, or data export schemas) needed for a specific external system interface. Use lower levels to identify specific artifacts that must be developed or modified.

Includes, for example:
a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software integration
e. Software qualification testing
f. Software COTS/GOTS approach (requirements negotiation)
g. Software COTS/GOTS component identification
h. Software COTS/GOTS assessment and selection
i. Software prototyping
j. Software COTS/GOTS glue code development
k. Software COTS/GOTS tailoring and configuration
l. Subsystem software product engineering (e.g., configuration management, quality assurance, managed services, etc.)
m. Both the design of the interface specification and the development of the interface

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic Systems, apply.

K.4.2.4.3 External System Interface Integration, Assembly, Test and Checkout. The element includes the effort and material associated with integrating and testing the required software and hardware of an individual (or group of) External System Interface(s).

K.4.2.5 AIS Platform Hardware. This element includes all effort and equipment to develop a hardware system to host the deliverable AIS software

K.4.2.6 System Level Integration. This element includes all effort and equipment to assemble, integrate, and test the entire AIS system as a whole at the system developer's facility.

K.4.3 Common Elements. Remaining Common WBS Elements. Definitions for Common WBS elements applicable to the Automated Information Systems, and all other defense materiel items, are in Appendix L: Automated Information Systems (AIS) Common Elements, Work Breakdown Structure and Definitions.

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APPENDIX L: COMMON ELEMENTS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

L.1 SCOPE

This appendix provides the WBS elements common to all types of systems. Applicable Government and non-Government documents are listed. Definitions for the common WBS elements are provided in this appendix. Unique uses of common elements are also included to better define the related systems.

Elements defined in this Appendix are elements common to all acquisition programs developed by the Department of Defense. The efforts associated with common elements should be placed at the level where they support a specific element. Common elements can be found at all levels of a WBS.

Using Appendix G Surface Vehicle System as an example, common elements found at Level 2 of the WBS capture efforts associated with the system as a "whole" (i.e., training for the entire surface vehicle system). Level 3 common elements will support Level 2 elements such as the primary vehicle or secondary vehicle. Level 4 common elements, when shown, support the subsystems captured at Level 3 (for example, Training for the Navigation and Remote Piloting System).

Many of the commodity classes apply common elements in a way that is unique to those commodities. This Appendix captures those unique applications for Space Systems (reference L.4), Launch Vehicle Systems (reference L.5) and Automated Information Systems (reference L.6).

L.2 APPLICABLE DOCUMENTS

None

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L.3 DEFINITIONS OF COMMON ELEMENTS

L.3.1 Integration, Assembly, Test and Checkout. In those instances in which an integration, assembly, test, and checkout element is used (Appendices A through K), this element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble the Level 3 equipment (hardware/software) elements into a Level 2 mission equipment (hardware/ software) as a whole and not directly part of any other individual Level 3 element. (Reference Section L.4.1 for space systems application)

Includes, for example:

a. The development of engineering layouts, determination of overall design characteristics, and determination of requirements of design review
b. The set up, conduct, and review of testing assembled components or subsystems prior to installation
c. The detailed production design, producibility engineering planning (PEP), and manufacturing process capability, including the process design development and demonstration effort to achieve compatibility with engineering requirements and the ability to produce economically and consistent quality
d. Inspection activities related to receiving, factory and vendor liaison
e. Design maintenance effort
f. Quality planning and control
g. Tooling (initial production facilities, factory support equipment) including planning, design, and fabrication
h. Administrative engineering
i. The joining or mating and final assembly of Level 3 equipment elements to form a complete prime mission equipment when the effort is performed at the manufacturing facility
j. Integration of software (including loading and verification of firmware)
k. Conduct of production acceptance testing

Excludes, for example:

a. All systems engineering/program management and system test and evaluation that are associated with the overall system

NOTE: When an integration, assembly, test, and checkout element is utilized at lower levels of the contract work breakdown structure, it will be summarized into the next higher level equipment (hardware/software) WBS element and should never be summarized directly into a higher-level integration, assembly, test, and checkout element.

L.3.2. System Engineering. The technical and management efforts of directing and controlling a totally integrated engineering effort of a system or program.

Includes, for example:

a. Effort to define the system and the integrated planning and control of the technical program efforts of design engineering, specialty engineering, production engineering, and integrated test planning
b. Effort associated with developing the Systems Engineering Management Plan (SEMP)
c. Effort to transform an operational need or statement of deficiency into a description of system requirements and a preferred system configuration
d. Technical planning and control effort for planning, monitoring, measuring, evaluating, directing, and re-planning the management of the technical program
e. All programs, where applicable; value engineering, configuration management, Human Systems Integration (Human factors engineering; Personnel; Habitability; Manpower; Training; Environment, Safety and Occupational Health; Survivability), vulnerability, maintainability, reliability, standardization, system analysis, logistic support analysis, etc.
f. Technical baseline management and event based technical reviews with independent subject matter expertise participation
g. Cross product IPT integration

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h. Survivability/vulnerability analysis
i. System of Systems (SoS) and System Level Architecting, modeling and simulation, verification and validation and external interface definition and management
j. For sea systems; the expanded Ship Work Breakdown Structure (ESWBS), configuration management (812 and 813), human factors (892), standardization (893), value engineering (894), and reliability and maintainability (895) elements

Excludes, for example:
a. Actual design engineering and the production engineering directly related to the WBS element with which it is associated

Examples of Systems Engineering efforts are:
a. System requirement and architecture definition, overall system design and margin management, design integrity analysis, system optimization, system/cost effectiveness analysis, and intra-system and inter-system compatibility assurance, etc.; the integration and balancing of reliability, maintainability, producibility, safety engineering, human health, environmental protection, manpower, personnel, training, and survivability; security requirements, quality assurance program, value engineering, preparation of equipment and component performance specifications, design of test and demonstration plans; determination of software development or software test facility/ environment requirements. Assessments of system effectiveness, life cycle costs, schedule, risk and evolutionary growth for each tradeoff following each iteration of the systems engineering process, and develop the associated required systems engineering products.
b. Requirements Management- ensures requirements traceability and version control for all program requirements starting with the Capabilities Development Document (CDD) and Capabilities Production Document (CPD) to the system specification and lower level Configuration Item (CI) specifications.
c. Interface Management - ensures interface compatibility of external and internal interfaces and coordination of changes between associate contractors and Integrated Product Teams (IPTs).
d. Preparation of the Systems Engineering Management Plan (SEMP), specification tree, program risk analysis, system planning, decision control process, technical performance measurement, technical reviews, subcontractor and vendor reviews, work authorization, and technical documentation control.
e. Reliability engineering—the engineering process and series of tasks required to examine the probability of a device or system performing its mission adequately for the period of time intended under the operating conditions expected to be encountered.
f. Maintainability engineering—the engineering process and series of tasks required to measure the ability of an item or system to be retained in or restored to a specified condition of readiness, skill levels, etc., using prescribed procedures and resources at specific levels of maintenance and repair.
g. Human Systems Integration—the engineering process and the series of tasks required to define, as a comprehensive technical and engineering effort involving the integration of the-human operator and maintainer requirements while attempting to minimize lifecycle cost and maximize total system performance.
h. Supportability analyses—an integral part of the systems engineering process beginning at program initiation and continuing throughout program development. Supportability analyses form the basis for related design requirements included in the system specification and for subsequent decisions concerning how to most cost effectively support the system and its infrastructure over its entire life cycle.
i. Configuration Management – supports the identification and management of the technical baselines (functional baseline, allocated baseline, initial product baseline, final product baseline).
j. Data Management – identifies the essential technical data necessary for the definition and sustainment of the system reflected in the respective technical baselines.

L.3.3 Program Management. The business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives, which are not associated with specific hardware elements and are not included in systems engineering.

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Includes, for example:

a. Cost, schedule, performance measurement management, warranty administration, contract management, data management, vendor liaison, subcontract management, etc.
b. Support element management, defined as the logistics tasks management effort and technical control, and the business management of the support elements. The logistics management function encompasses the support evaluation and supportability assurance required to produce an affordable and supportable defense materiel system.
c. Planning and management of all the functions of logistics. Examples are:
    1. maintenance support planning and support facilities planning; other support requirements determination; support equipment requirements determination; supply support; packaging, handling, storage, and transportation; provisioning requirements determination and planning; training system requirements determination; computer resource determination; organizational, intermediate, and depot maintenance determination management; and data management
d. For sea systems; the Expanded Ship Work Breakdown Structure (ESWBS), project management (897); data management (896); and supply support (8643) elements.

L.3.4 System Test and Evaluation. The use of pilot, prototype, production, or specifically fabricated hardware/ software to obtain or validate engineering data on the performance of the system during the developmental phase (normally funded from RDT&E) of the program. It also includes all effort associated with the development of any specialized tools or data in support of the system level test program.

Includes, for example:

a. Detailed planning, conduct, support, data reduction and reports (excluding the contract data requirements list data) from such testing, and test articles that are functionally configured to represent and test subsystems/components of the defense materiel end item being developed or produced
b. Design and production of models, specimens, fixtures and instrumentation

NOTE: Test articles that are functionally configured to represent and test the complete defense materiel end item being developed or produced, are excluded from this WBS element.

Excludes, for example:

a. All formal and informal testing up through the subsystem level, which can be associated with the hardware/software element acceptance testing

NOTE: These excluded efforts are to be included with the appropriate hardware or software elements.

L.3.4.1 Developmental Test and Evaluation. This effort is planned, conducted and monitored by the developing agency of the DoD component. It includes test and evaluation conducted to:

a. Demonstrate that the engineering design and development process is complete
b. Demonstrate that the design risks have been minimized
c. Demonstrate that the system will meet specifications
d. Estimate the system's military utility when introduced
e. Determine whether the engineering design is supportable (practical, maintainable, safe, etc.) For operational use
f. Provide test data with which to examine and evaluate trade-offs against specification requirements, life cycle cost, and schedule
g. Perform the logistics testing efforts to evaluate the achievement of supportability goals, the adequacy of the support package for the system, (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, and personnel skills and training requirements, etc.)

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Includes, for example:

a. All contractor/system developer in-house effort
b. All programs, where applicable; models, tests and associated simulations (e.g., such as wind tunnel, static, drop, and fatigue); integration ground tests; test bed aircraft and associated support; qualification test and evaluation, development flight test, test instrumentation, environmental tests, ballistics, radiological, range and accuracy demonstrations, test facility operations, test equipment (including its support equipment), chase and calibrated pacer aircraft and support thereto, and logistics testing
c. For aircraft; avionics integration test composed of the following:
    1. Test bench/laboratory, including design, acquisition, and installation of basic computers and test equipments that will provide an ability to simulate in the laboratory the operational environment of the avionics system/subsystem
    2. Air vehicle equipment, consisting of the avionics and/or other air vehicle subsystem modules that are required by the bench/lab or flying test bed in order to provide a compatible airframe avionics system/subsystem for evaluation purposes
    3. Flying test bed, including requirements analysis, design of modifications, lease or purchase of test bed aircraft, modification of aircraft, installation of avionics equipment and instrumentation, and checkout of an existing aircraft used essentially as a flying avionics laboratory
    4. Avionics test program, consisting of the effort required to develop test plans/procedures, conduct tests, and analyze hardware and software test results to verify the avionics equipments' operational capability and compatibility as an integrated air vehicle subsystem
    5. Software, referring to the effort required to design, code, de-bug, and document software programs necessary to direct the avionics integration test
d. For engines: engine military qualification tests and engine preliminary flight rating tests
e. For sea systems: model basin, hydrostatic, fatigue, shock, special sea tests and trials, etc., including the Expanded Ship Work Breakdown Structure (ESWBS), trials agenda preparation, data collection and analysis (842); dock and sea trials (868); and hull vibration survey (868 9825) elements
f. For missiles: test articles such as Inert Measurement Vehicles, Launch Separation Vehicles, Separation and Control Test Vehicles, Boost Test Vehicles
g. For ordnance: test articles such as Ballistic Test rounds, Inert Measurement rounds, Dummy rounds, Launch Separation rounds, etc.

L.3.4.2 Operational Test and Evaluation. The test and evaluation conducted by agencies other than the developing command to assess the prospective system's military utility, operational effectiveness, operational suitability, logistics supportability (including compatibility, inter-operability, reliability, maintainability, logistic requirements, etc.), cost of ownership, and need for any modifications.

Includes, for example:

a. Initial operational test and evaluation conducted during the development of a system
b. Such tests as system demonstration, flight tests, sea trials, mobility demonstrations, on-orbit tests, spin demonstration, stability tests, qualification operational test and evaluation, etc., and support thereto, required to prove the operational capability of the deliverable system
c. Contractor support (e.g., technical assistance, maintenance, labor, material, etc.) Consumed during this phase of testing
d. Logistics testing efforts to evaluate the achievement of supportability goals and the adequacy of the support for the system (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, personnel skills and training requirements, and software support facility/environment elements)

L.3.4.3 Mock-ups/System Integration Labs (SILs). The design engineering and production of system or subsystem mock-ups that have special contractual or engineering significance or that are not required solely for the conduct of one of the above elements of testing. SILs are often used in lieu of (or in addition to) mock-ups. SILs are risk reduction facilities where software and hardware can be developed, integrated, tested and evaluated for both stand alone functionality and/or interoperability prior to being fielded.

Includes, for example:

a. Hardware/Lab Equipment

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b. SIL Software (written to simulate the operating environment or written to operate the SIL)

L.3.4.4 Test and Evaluation Support. The support elements necessary to operate and maintain, during test and evaluation, systems and subsystems, which are not consumed during the testing phase and are not allocated to a specific phase of testing.

Includes, for example:
a. Repairable spares, repair of reparables, repair parts, consumables, warehousing and distribution of spares and repair parts, test and support equipment, test bed vehicles, drones, surveillance aircraft, tracking vessels, contractor technical support

Excludes, for example:
a. Operational and maintenance personnel, special fixtures, special instrumentation, etc., that are utilized and/or consumed in a single element of testing and that should be included under that element of testing

L.3.4.5 Test Facilities. The special test facilities required for performance of the various developmental tests necessary to prove the design and reliability of the system or subsystem.

Includes, for example:
a. Test tank test fixtures, propulsion test fixtures, white rooms, test chambers

Excludes, for example:
a. Brick and mortar-type facilities identified as industrial facilities

L.3.5 Training. Deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will learn to operate and maintain the system with maximum efficiency.

Includes, for example:
a. All effort associated with the design, development, and production of deliverable training equipment and its associated software as well as the execution of training services

Excludes, for example:
a. Overall planning, management, and task analysis function inherent in the WBS element systems engineering/program management

L.3.5.1 Equipment. Distinctive deliverable end items of training equipment, assigned by either a contractor or military service, required to meet specific training objectives.

Includes, for example:
a. Operational trainers, maintenance trainers, and other items such as cutaways, mock-ups, and models (e.g. Operational Instructional Equipment, Maintainer Instructional Equipment)

L.3.5.2 Services. Deliverable training services, accessories, and aids necessary to accomplish the objectives of training.

Includes, for example:
a. Training course materials; contractor-conducted training (in-plant and service training); and the materials and curriculum required to design, execute, and produce a contractor developed training program. (e.g. Operator Instructional Software, Maintainer Instructional Software)
b. Materiel, courses, and associated documentation (primarily the computer software, courses and training aids)

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Excludes, for example:
a. Deliverable training data associated with the WBS element support data

L.3.5.3 Facilities. The special construction necessary to accomplish training objectives.

Includes, for example:
a. Modification or rehabilitation of existing training facilities and infrastructure used to accomplish training objectives

Excludes, for example:
a. Installed equipment used to acquaint the trainee with the system or establish trainee proficiency
b. The brick and mortar-type facilities identified as industrial facilities

L.3.6 Data. The deliverable data required to be listed on a contract data requirements list, DD Form 1423.

Includes, for example:
a. Only such effort that can be reduced or avoided if the data item is eliminated
b. Government-peculiar data; acquiring, assembling, reproducing, packaging and shipping the data
c. Transforming data into Government format, reproducing and shipping data identical to that used by the contractor but in a different format

L.3.6.1 Technical Publications. Technical data, providing instructions for installation, operation, maintenance, training, and support, formatted into a technical manual. Data may be presented in any form regardless of the form or method of recording. Technical orders that meet the criteria of this definition may also be classified as technical manuals.

Includes, for example:
a. Operation and maintenance instructions, parts lists or parts breakdown, and related technical information or procedures exclusive of administrative procedures
b. Data item descriptions (DIDs)
c. For sea systems: Expanded Ship Work Breakdown Structure (ESWBS), technical manuals and other data (856) element

L.3.6.2 Engineering Data. Recorded scientific or technical information (regardless of the form or method of recording) including computer software documentation. Engineering data defines and documents an engineering design or product configuration (sufficient to allow duplication of the original items) and is used to support production, engineering and logistics activities.

Includes, for example:
a. All final plans, procedures, reports, and documentation pertaining to systems, subsystems, computer and computer resource programs, component engineering, operational testing, human factors, reliability, availability, and maintainability, and other engineering analysis
b. Technical data package (re-procurement package), which includes all engineering drawings, associated lists, process descriptions, and other documents defining physical geometry, material composition, and performance procedures
c. For sea systems; Expanded Ship Work Breakdown Structure (ESWBS), design support, ship's selected records (8302); design support, services, reproduction (8303); and engineering drawings and specifications (855) elements

Excludes, for example:
a. Computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration

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L.3.6.3 Management Data. The data items necessary for configuration management, cost, schedule, contractual data management, program management, etc., required by the Government.

Includes, for example:
a. Contractor cost reports, cost performance reports, contract funds status reports, schedules, milestones, networks, integrated support plans
b. For sea systems; Expanded Ship Work Breakdown Structure (ESWBS), contract data requirements (988) element

L.3.6.4 Support Data. The data items designed to document support planning in accordance with functional categories

Includes, for example:
a. Supply; general maintenance plans and reports; training data; transportation, handling, storage, and packaging information; facilities data; data to support the provisioning process and all other support data; and software supportability planning and software support transition planning documents

L.3.6.5 Data Repository. The facility, including storage requirements, designated to act as custodian to maintain a master engineering specification and establish a drawing repository service for Government approved documents that are the property of the U.S. Government. As custodian for the Government, the repository, authorized by approved change orders, maintains these master documents at the latest approved revision level. This facility is a distinct entity that may hold electronic or hard copy data.

Includes, for example:
a. All drafting and clerical effort necessary to maintain documents

Excludes, for example:
a. All similar effort for facility's specification and drawing control system, in support of its engineering and production activities.

NOTE: When documentation is called for on a given item of data retained in the Repository, the charges (if charged as direct) will be to the appropriate data element.

L.3.7 Peculiar Support Equipment. The design, development, and production of those deliverable items and associated software required to support and maintain the system or portions of the system while the system is not directly engaged in the performance of its mission, and which are not common support equipment.

Includes, for example:
a. Vehicles, equipment, tools, etc., used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment
b. Any production of duplicate or modified factory test or tooling equipment delivered to the Government for use in maintaining the system. (Factory test and tooling equipment initially used by the contractor in the production process but subsequently delivered to the Government will be included as cost of the item produced.)
c. Any additional equipment or software required to maintain or modify the software portions of the system

Excludes, for example:
a. Overall planning, management and task analysis functions inherent in the Work Breakdown Structure element, systems Engineering/Program Management
b. Common support equipment, presently in the DoD inventory or commercially available, bought by the using command, not by the acquiring command

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L.3.7.1 Test and Measurement Equipment. The peculiar or unique testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support.

Includes, for example:

a. Test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, tapes, and related software, firmware and support hardware (power supply equipment, etc.) Used at all levels of maintenance
b. Packages that enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment

L.3.7.2 Support and Handling Equipment. The deliverable tools and handling equipment used for support of the mission system.

Includes, for example:

a. Ground support equipment, vehicular support equipment, powered support equipment, non-powered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware and software)

L.3.8 Common Support Equipment. The items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems.

Includes, for example:

a. Acquisition of additional quantities of this equipment needed to support the item
b. All efforts required to assure the availability of this equipment to support the item

L.3.8.1 Test and Measurement Equipment. The common testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support.

Includes, for example:

a. Test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, tapes, and related software, firmware and support hardware (power supply equipment, etc.) Used at all levels of maintenance
b. Packages that enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment

L.3.8.2 Support and Handling Equipment. The deliverable tools and handling equipment used for support of the mission system.

Includes, for example:

a. Ground support equipment, vehicular support equipment, powered support equipment, non-powered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware/software)

L.3.9 Operational/Site Activation. The real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch prime mission equipment at the organizational and intermediate level.

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Includes, for example:

a. Conversion of site, ship, or vehicle
b. System assembly, checkout, and installation (of mission and support equipment) into site facility or ship to achieve operational status
c. Contractor support in relation to operational/site activation

L.3.9.1 System Assembly, Installation, and Checkout on Site. The materials and services involved in the assembly of mission equipment at the site.

Includes, for example:

a. Installation of mission and support equipment in the operations or support facilities and complete system checkout or shakedown to ensure operational status. Where appropriate, specify by site, ship or vehicle.
b. The efforts and activities associated with shipping the system from contractor facility to customer site. That site could be a DT&E site, an installation and checkout site or any similar site that is outside the direct control of the contractor.

L.3.9.2 Contractor Technical Support. The materials and services provided by the contractor related to activation.

Includes, for example:

a. Repair of reparables, standby services, final turnover

L.3.9.3 Site Construction. Real estate, site planning and preparation, construction, and other special-purpose facilities necessary to achieve system operational status.

Includes, for example:

a. Construction of utilities, roads, and interconnecting cabling

L.3.9.4 Site/Ship/Vehicle Conversion. The materials and services required to convert existing sites, ships, or vehicles to accommodate the mission equipment and selected support equipment directly related to the specific system.

Includes, for example:

a. Operations, support, and other special purpose facilities conversion necessary to achieve system operational status, e.g., launch. Where appropriate, specify by site, ship or vehicle

L.3.9.5 Sustainment/Interim Contractor Support. The complex of equipment (hardware/software), data, and services required to operate, maintain, support and modernize prime mission product of existing operational systems done before the Material Support Date (MSD).

Includes, for example:

a. Prime Mission Product (PMP) maintenance and modernization. The cost for this element includes maintenance and modernization (including the development and production) of existing, operational systems. It excludes the development and production of the original prime mission product.
b. Support functions required to maintain and modernize the system, such as sustaining engineering, program management, logistics support, and supply chain management
c. Test and evaluation for system and subsystem modifications
d. Replacement of common and peculiar support equipment
e. Replacement of repairable items
f. Operational, maintenance and other personnel required at the operational unit level
g. Unit operations costs, including operating material and support services at the operating unit
h. Installation and personnel support functions in support of the unit level manpower

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L.3.10 Industrial Facilities. The construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance required when that service is for the specific system.

Includes, for example:
a. Equipment acquisition or modernization, where applicable
b. Maintenance of these facilities or equipment
c. Industrial facilities for hazardous waste management to satisfy environmental standards

Excludes, for example:
a. Capital equipment

L.3.10.1 Construction/Conversion/Expansion. The real estate and preparation of system peculiar industrial facilities for production, inventory, depot maintenance, and other related activities.

L.3.10.2 Equipment Acquisition or Modernization. The production equipment acquisition, modernization, or transferal of equipment for the particular system. This pertains to Government owned and leased equipment under facilities contract.

L.3.10.3 Maintenance (Industrial Facilities). The maintenance, preservation, and repair of industrial facilities and equipment.

L.3.11 Initial Spares and Repair Parts. The deliverable spare components, assemblies and subassemblies used for initial replacement purposes in the materiel system equipment end item.

Includes, for example:
a. Repairable spares (repairables) and repair parts required as initial stockage to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline and war reserve quantities, at all levels of maintenance and support

Excludes, for example:
a. Developmental Test spares and spares provided specifically for use during installation, assembly, and checkout on site. Lower level WBS breakouts should be by subsystem.

L.4 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO SPACE SYSTEMS

When the Space Appendix is used the common elements have been specifically grouped into four subcategories. These subcategories shall be used when creating program/contract WBS. Lower level elements to the four categories may be created but must sum to the correct category. The four common elements to be used are systems engineering, integration and test, program management, and support equipment (SEIT/PM and Support Equipment).

L.4.1 Space Systems. The Space community must report, at a minimum, the common elements of systems engineering, integration and test and program management (SEIT/PM) and Support Equipment. The following paragraphs represent WBS elements common to all Space System WBS elements.

L.4.1.1 SEIT/PM and Support Equipment. This section provides the WBS elements common to all Space System WBS elements. Consistent with the manner in which space systems are designed, built, and tested, there are multiple levels of Systems Engineering, Integration and Test, and Program Management (SEIT/PM) and Support Equipment throughout the WBS. It is expected that, whenever possible, SEIT/PM and Support Equipment costs be reported with the item(s) they are supporting. For example, subsystem management of the Attitude Control Subsystem should be booked under the ACS WBS element. If a contractor (or other developer) manages the project by a different means and does not collect SEIT/PM and Support Equipment data at this level, then the costs shall be reported at the next higher-level WBS element. For example, an electronics product manager with areas of responsibility spanning both ACS and the TT&C subsystems cost may have their effort defined and collected within the Spacecraft Bus SEIT/PM elements. SEIT/PM and Support Equipment shall be broken out into their individual

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elements (defined below) for WBS levels one through four (subsystem). At level five (product level), Systems engineering and management (SEPM) responsibilities are often indistinct and may be combined into a single SEPM element.

L.4.1.1.1 Systems Engineering. This WBS element contains all the resources associated with all engineering from functional specialists who provide technical planning, technical management, analysis, and support efforts for development and production activities. The Systems Engineering entity is responsible for the analysis, derivation, allocation, and traceability, of requirements and interfaces.

Includes, for example:

a. Systems definition
b. Systems analysis (e.g., thermal, power, mass properties, environments, dynamics, modeling and simulation)
c. Requirements analysis and allocation
d. Interface definition and control
e. Performance assessment and verification/validation
f. Technical direction (SE leadership, planning, and coordination)
g. System safety
h. Quality assurance, product assurance
i. mission assurance and critical skill protection and retention
j. Logistics Support Analysis (LSA including reliability, availability, maintainability, produceability)
k. Engineering services
l. Configuration control
m. System documentation
n. Algorithm development
o. Recommended Operating Procedures (PROCs), Satellite Databases
p. Risk management
q. Human engineering
r. Security engineering
s. Electro-Magnetic Compatibility (EMC) / Electro-Magnetic Interference (EMI)
t. Radiation and survivability
u. Contamination and control
v. Autonomy and fault management
w. Other specialty engineering
x. Engineering and design (excluding box level) including Electrical Design Integration (EDI), Mechanical Design Integration (MDI), Thermal Design Integration (TDI), and Facility Design
y. Parts, material and processes (PM&P)
z. Trade studies
aa. System studies

Excludes, for example:

a. Systems engineering efforts that can be associated specifically with the equipment (Hardware/Software) for a unit or CSCI (Level 5 element)
b. Launch systems integration that is contained in its own Level 3 element

L.4.1.1.2 Assembly, Integration and Test. This element includes the effort of technical and functional activities required to assemble and test at one level into a next higher level (e.g., from product level to subsystem level) as a whole and not directly part of any other individual element.

Includes, for example:

a. Development of test plans and procedures
b. Test preparations
c. Test support and management
d. HW/SW integration
e. SW CSCI integration
f. HW integration and assembly (e.g., electrical and mechanical integration, including kitting)

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g. Test, checkout, inspection and acceptance
h. System test and evaluation to include: Developmental Test and Evaluation, Operational Test and Evaluation
i. I&T management, leadership, planning and scheduling
j. Analysis and documentation of test results
k. Transportation and movement (excludes transportation of the Space Vehicle to the launch pad covered under the Launch Operations WBS element)
l. Integration hardware
m. Delivered initial spares and repair parts
n. I&T Facilities

Excludes, for example:
a. Integration and test efforts that can be associated specifically with the equipment (Hardware/Software) for a unit or CSCI (Level 5 element)

L.4.1.1.3 Program Management. Program Management (PM) includes the resources necessary to manage, direct, and control all effort contributing to the development, production of custom and commercial off-the-shelf (COTS) procurements and integration. Additionally, it includes training related items used to facilitate instruction through which personnel will learn to operate and maintain the system and elements of the system. Data related items are also captured here, such as the deliverable data required to be listed on a Contract Data Requirements List (CDRL).

Includes, for example:
a. Project management
b. Business management (includes business operations., scheduling, accounting and finance)
c. Project control and planning
d. Configuration management
e. Contract / subcontract management
f. Security management
g. Delivered data, including, for example:
    1. Technical publications and technical manuals
    2. Cost and Schedule Reporting (CPR, CFSR, IMS, WBS, etc.)
    3. Training plans, manuals, guides
h. Data management including data repository and associated drafting and clerical effort to maintain master, Government approved, and Government owned documents
i. Administration
j. Product effectiveness
k. Training services to include: course development, material preparation, and conducting initial training

Excludes, for example:
a. Program management efforts that can be associated specifically with the equipment (Hardware/Software) for a unit or CSCI (Level 5 element)

L.4.1.1.4 Systems Engineering and Program Management (SEPM). This element can be used at Level 5 (and below) of the WBS when Systems Engineering and Program Management are inseparable. This WBS element is a combination of the Systems Engineering and the Program Management responsibility, task, and deliverable content defined above.

L.4.1.1.5 Support Equipment. This element pertains to the design, development, and production of those items and associated software required to build, assemble, integrate, move, support and maintain the system or portions of the system. This also pertains to the testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening, or quality assurance efforts.

Includes, for example:
a. Peculiar Support Equipment (PSE)

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b. Common Support Equipment (CSE)
c. Tooling, (e.g., taps, dies, etc.)
d. Mock-ups/System Integration Labs (SILs), Simulators, Stimulators, and training equipment (excludes EMs of Space Vehicle HW that is included within the Space Vehicle HW WBS elements)
e. Vehicles, equipment, tools, and the like used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment
f. Any production of duplicate or modified factory test or tooling equipment delivered to the government for use in maintaining the system
g. Support and handling equipment including ground, vehicular, powered, non-powered, and materiel handling
h. Electrical Aerospace Ground Equipment and Mechanical (AGE)
i. Precision measuring equipment
j. Automatic test equipment
k. Manual test equipment
l. Test program sets
m. Automated load modules
n. Support equipment software

Excludes, for example:
a. Support equipment efforts that can be associated specifically with the equipment (Hardware/Software) for a unit or CSCI (Level 5 element).

L.5 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO LAUNCH VEHICLE SYSTEMS.

The Launch Vehicle community has unique application of systems engineering, integration and test and program management (SEIT/PM). The following paragraphs represent the SEIT/PM WBS elements common to Launch Vehicle System elements. For the remaining Common Elements, reference paragraph L.3 Definitions of Common Elements.

L.5.1 SEIT/PM. This section provides the WBS elements common to all Launch Vehicle System WBS elements. Consistent with the manner in which launch vehicle systems are designed, built, and tested, there are multiple levels of Systems Engineering, Integration and Test, and Program Management (SEIT/PM) throughout the WBS. It is expected that, whenever possible, SEIT/PM costs be reported with the item(s) they are supporting. For example, subsystem management of the Reaction Control Subsystem should be booked under the Reaction Control System WBS element.

L.5.1.1 Systems Engineering. This WBS element contains all the resources associated with all engineering from functional specialists who provide technical planning, technical management, analysis, and support efforts for development and production activities. The Systems Engineering entity is responsible for the analysis, derivation, allocation, and traceability, of requirements and interfaces.

Includes, for example:
a. Systems definition
b. Systems analysis (e.g., thermal, power, mass properties, environments, dynamics, modeling and simulation)
c. Requirements analysis and allocation
d. Interface definition and control
e. Performance assessment and verification/validation
f. Technical direction (SE leadership, planning, and coordination)
g. System safety
h. Quality assurance, product assurance
i. Mission assurance and critical skill protection and retention
j. Logistics Support Analysis (LSA including reliability, availability, maintainability, produceability)
k. Engineering services
l. Configuration control
m. System documentation

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n. Algorithm development
o. Recommended Operating Procedures (ROPs), Procedures (PROCs), Satellite Databases
p. Risk management
q. Human engineering
r. Security engineering
s. Electro-Magnetic Compatibility (EMC) / Electro-Magnetic Interference (EMI)
t. Radiation and survivability
u. Contamination and control
v. Autonomy and fault management
w. Other Specialty Engineering
x. engineering and design (excluding box level) including Electrical Design Integration (EDI), Mechanical Design Integration (MDI), Thermal Design Integration (TDI), and Facility Design
y. Parts, material and processes (PM&P)
z. Trade studies
aa. System studies

Excludes, for example:
a. Systems engineering efforts that can be associated specifically with the equipment (Hardware/Software)

L.5.1.2 Assembly, Integration and Test. This element includes the effort of technical and functional activities required to assemble and test at one level into a next higher level (e.g., from product level to subsystem level) as a whole and not directly part of any other individual element.

Includes, for example:
a. Development of test plans and procedures
b. Test preparations
c. Test support and management
d. HW/SW Integration
e. SW CSCI Integration
f. HW Integration and Assembly (e.g., Electrical and Mechanical Integration, including kitting)
g. Test, checkout, inspection and acceptance
h. System test and evaluation to include: Developmental Test and Evaluation, Operational Test and Evaluation)
i. I&T management, leadership, planning and scheduling
j. Analysis and documentation of test results
k. Transportation and movement (excludes transportation of the space vehicle to the launch pad (covered under the Launch Operations WBS element)
l. Integration hardware
m. Delivered initial spares and repair parts
n. I&T Facilities

Excludes, for example:
a. Integration and test efforts that can be associated specifically with the equipment (Hardware/Software)

L.5.1.3 Program Management. Program Management (PM) includes the resources necessary to manage, direct, and control all effort contributing to the development, production of custom and commercial off-the-shelf (COTS) procurements and integration. Additionally, it includes training related items used to facilitate instruction through which personnel will learn to operate and maintain the system and elements of the system. Data related items are also captured here, such as the deliverable data required to be listed on a Contract Data Requirements List (CDRL).

Includes, for example:
a. Project management
b. Business management (includes business operations., scheduling, accounting and finance)
c. Project control and planning
d. Configuration management

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e. Contract / subcontract management
f. Security management
g. Delivered data, including, for example:
    1. Technical publications and technical manuals
    2. Cost and Schedule Reporting (CPR, CFSR, IMS, WBS, etc.)
    3. Training plans, manuals, guides
h. Data management including data repository and associated drafting and clerical effort to maintain master, Government approved, and Government owned documents
i. Administration
j. Product effectiveness
k. Training services to include: course development, material preparation, and conducting initial training

Excludes, for example:
a. Program management efforts that can be associated specifically with the equipment (Hardware/Software)

L.5.2 Operational Site Activation. The Common element Operational Site Activation (L.3.9) should be captured under the Launch Vehicle Element Launch Site (1…n) referenced in Appendix J, paragraph J.4.5.

L.6 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO AUTOMATED INFORMATION SYSTEMS.

L.6.1 Systems Engineering or Systems Analysis (Blueprinting). The technical and management efforts of directing and controlling a totally integrated engineering effort of a system or program.

Includes, for example:
a. System definition, overall system design, design integrity analysis, system optimization, system/cost effectiveness analysis, and intra-system and inter-system compatibility assurance, etc.; the integration and balancing of reliability, maintainability, producibility, safety, human health, environmental protection, and survivability; security requirements, configuration management and configuration control; quality assurance program, value engineering, preparation of equipment and component performance specifications, design of test and demonstration plans; determination of software development or software test facility/environment requirements.
b. Preparation of the Systems Engineering Plan (SEP), specification tree, program risk analysis, system planning, decision control process, technical performance measurement, technical reviews, subcontractor and vendor reviews, work authorization, and technical documentation control.
c. Reliability engineering—the engineering process and series of tasks required to examine the probability of a device or system performing its mission adequately for the period of time intended under the operating conditions expected to be encountered.
d. Maintainability engineering—the engineering process and series of tasks required to measure the ability of an item or system to be retained in or restored to a specified condition of readiness, skill levels, etc., using prescribed procedures and resources at specific levels of maintenance and repair.
e. Human systems integration—the engineering process and the series of tasks required to define, as a comprehensive technical and engineering effort, the integration of doctrine, manpower, and personnel integration, materiel development, operational effectiveness, human characteristics, skill capabilities, training, manning implication, and other related elements into a comprehensive effort.
f. Supportability analyses—an integral part of the systems engineering process beginning at program initiation and continuing throughout program development. Supportability analyses form the basis for related design requirements included in the system specification and for subsequent decisions concerning how to most cost effectively support the system and its infrastructure over its entire life cycle.
g. System of Systems (SoS) and System Level Architecting, modeling and simulation, verification and validation and external interface definition and management.
h. Weapon Systems Integration (WSI) – an overarching set of tools and processes which enables the integration of sound engineering practices at the system level; the impetus being the sustainment of safety, suitability and effectiveness for the life of the system. Includes the ability to return systems to

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specification level performance after repair/overhaul activities. WSI is and integral process through which operational safety, suitability, and effectiveness (OSS&E) are implemented.

L.6.2 Program Management. The business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives, which are not associated with specific hardware elements and are not included in systems engineering.

Includes , for example:

a. Cost, schedule, performance measurement management, warranty administration, contract management, data management, vendor liaison, subcontract management, etc.
b. Support element management, defined as the logistics tasks management effort and technical control, and the business management of the support elements. The logistics management function encompasses the support evaluation and supportability assurance required to produce an affordable and supportable defense materiel system
c. Planning and management of all the functions of logistics. Examples are, Maintenance support planning and support facilities planning; other support requirements determination; support equipment; supply support; packaging, handling, storage, and transportation; provisioning requirements determination and planning; training system requirements determination; computer resource determination; organizational, intermediate, and depot maintenance determination management; and data management

L.6.3 Change Management. Change management refers to the broad process for managing organizational change. Change management encompasses planning, oversight or governance, project management, testing and implementation.

L.6.4 System Test and Evaluation. The use of pilot, production, or specifically configured systems to obtain or validate engineering data on the performance of the system during the developmental phase (normally funded from RDT&E) of the program. It also includes all effort associated with the development of any specialized tools or data in support of the system level test program.

Includes, for example:

a. Developmental test and evaluation
b. Operational test and evaluation
c. Mock-ups/System Integration Labs (SIL)
d. Test support
e. Test facilities

L.6.4.1 Developmental Test and Evaluation. This effort is planned, conducted and monitored by the developing agency of the DoD component. It includes test and evaluation conducted to:

a. Demonstrate that the engineering design and development process is complete.
b. Demonstrate that the design risks have been minimized
c. Demonstrate that the system will meet specifications
d. Estimate the system's military utility when introduced
e. Determine whether the engineering design is supportable (practical, maintainable, safe, etc.) For operational use
f. Provide test data with which to examine and evaluate trade-offs against specification requirements, life cycle cost, and schedule
g. Perform the logistics testing efforts to evaluate the achievement of supportability goals, the adequacy of the support package for the system, (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, and personnel skills and training requirements, etc.)

Includes, for example:

a. All system developer in-house effort
b. All programs, where applicable; models, tests and associated simulations; integration ground tests; qualification test and evaluation, test instrumentation, environmental tests, test facility operations, test equipment (including its support equipment), and logistics testing

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c. Qualification test
d. Accreditation
e. Independent verification and validation
f. Test software

L.6.4.2 Operational Test and Evaluation. The test and evaluation conducted by agencies other than the developing command to assess the prospective system's military utility, operational effectiveness, operational suitability, logistics supportability (including compatibility, inter-operability, reliability, maintainability, logistic requirements, etc.), cost of ownership, and need for any modifications.

Includes, for example:
a. Initial operational test and evaluation conducted during the development of a system
b. Such tests as system demonstration, qualification operational test and evaluation, etc., and support thereto, required to prove the operational capability of the deliverable system
c. Contractor support (e.g., technical assistance, maintenance, labor, material, etc.) Consumed during this phase of testing
d. Logistics testing efforts to evaluate the achievement of supportability goals and the adequacy of the support for the system (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, personnel skills and training requirements, and software support facility/environment elements)

L.6.4.3 Mock-ups/System Integration Labs. The design engineering and production of system or subsystem “mock-ups”, which have special contractual or engineering significance, or which are not required solely for the conduct of one of the above elements of testing. SILs are often used in lieu of (or in addition to) mock-ups. SILs are risk reduction facilities where software and hardware can be developed, integrated, tested and evaluated for both stand alone functionality and/or interoperability prior to being fielded.

Includes, for example:
a. Hardware/lab equipment
b. SIL software (written to simulate the operating environment or written to operate the SIL)

L.6.4.4. Test Facilities. The special test facilities required for performance of the various developmental test necessary to prove the design and reliability of the system or subsystem.

Includes, but not limited to:
a. Test tank test fixtures, white rooms, test chambers

Excludes, for example:
a. Brick and mortar-type facilities identified as industrial facilities

L.6.5 Training. Deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will learn to operate and maintain the system with maximum efficiency.

Includes, for example:
a. All effort associated with the design, development, and production of deliverable training equipment and its associated software as well as the execution of training services
b. Operational trainers, maintenance trainers, and other items such as cutaways, mock-ups, and models
c. Training course material development; contractor-conducted training (in-plant and service training); and the materials and curriculum required to design, execute, and produce a contractor developed training program
d. Materiel, courses, and associated documentation (primarily the computer software, courses and training aids)
e. Modification or rehabilitation of existing facilities used to accomplish training objectives
f. Development
g. Training and professional development

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h. Training software

Excludes, for example:
a. User training costs

L.6.6 Data. The deliverable data required to be listed on a contract data requirements list, DD Form 1423.

Includes, for example:
a. Technical publication
b. Engineering data
c. Management data
d. Support data
e. Data repository

L.6.6.1 Technical Publication. Technical data, providing instructions for installation, operation, maintenance, training, and support, formatted into a technical manual. Data may be presented in any form regardless of the form or method of recording. Technical orders that meet the criteria of this definition may also be classified as technical manuals.

Includes, for example:
a. Operation and maintenance instructions, parts lists or parts breakdown, and related technical information or procedures exclusive of administrative procedures
b. Data item descriptions set forth in categories selected from the Acquisition Management Systems and Data Requirements Control List (DoD 5010.12-L)

L.6.6.2 Engineering Data. Recorded scientific or technical information (regardless of the form or method of recording) including computer software documentation. Engineering data defines and documents an engineering design or product configuration (sufficient to allow duplication of the original items) and is used to support production, engineering and logistics activities.

Includes, for example:
a. All final plans, procedures, reports, and documentation pertaining to systems, subsystems, computer and computer resource programs, component engineering, operational testing, human factors, reliability, availability, and maintainability, and other engineering analysis
b. Technical data package (re-procurement package) that includes all engineering drawings, associated lists, process descriptions, and other documents defining physical geometry, material composition, and performance procedures

Excludes, for example:
a. Computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration

L.6.6.3 Management Data. The data items necessary for configuration management, cost, schedule, contractual data management, program management, etc. (required by the Government).

Includes, for example:
a. Contractor cost reports, cost performance reports, contract funds status reports, schedules, milestones, networks, integrated support plans

L.6.6.4 Support Data. The data items designed to document support planning in accordance with functional categories.

Includes, for example:
a. Supply; general maintenance plans and reports; training data; transportation, handling, storage, and packaging information; facilities data; data to support the provisioning process and all other support data; and software supportability planning and software support transition planning documents

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L.6.6.5 Data Repository. The facility designated to act as custodian to maintain a master engineering specification and establish a drawing depository service for Government approved documents that are the property of the U.S. Government. As custodian for the Government, the repository, authorized by approved change orders, maintains these master documents at the latest approved revision level. This facility is a distinct entity.

Includes, for example:
a. All drafting and clerical effort necessary to maintain documents

Excludes, for example:
a. All similar effort for facility's specification and drawing control system, in support of its engineering and production activities

L.6.7 Peculiar Support Equipment. The design, development, and production of those deliverable items and associated software required to support and maintain the system or portions of the system while the system is not directly engaged in the performance of its mission, and which are not common support equipment.

Includes, for example:
a. Any production of duplicate or modified factory test or tooling equipment delivered to the Government for use in maintaining the system. (Factory test and tooling equipment initially used by the contractor in the production process but subsequently delivered to the Government will be included as cost of the item produced.)
b. Any additional equipment or software required to maintain or modify the software portions of the system

Excludes, for example:
a. Overall planning, management and task analysis functions inherent in the work breakdown structure element, systems Engineering/Program Management
b. Common support equipment, presently in the DoD inventory or commercially available, bought by the using command, not by the acquiring command

L.6.8 Common Support Equipment. The items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems.

Includes, for example:
a. Acquisition of additional quantities of this equipment needed to support the item
b. All efforts required to assure the availability of this equipment to support the item

L.6.9 Operational Site Activation (Production/Deployment). The costs associated with deploying the AIS solution at the). user site(s). This should cover only those efforts that are incurred at the implementation site. Any up-front effort involved with designing/engineering the solution for a particular site should be included in under Client-side Site Development. Any effort related to re-design of the solution once implementation has begun should be captured here.

Includes, for example (by site type):
a. Deployment hardware and software
b. Site activation labor
c. User training
d. Data migration

Note: This element will also include the real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch the AIS solution at the user sites.

L.6.9.1 Site Type 1. Captures the costs associated with the primary site type for the AIS implementation. Site types should be specifically defined.

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L.6.9.1.1 Deployment Hardware and Software.

L.6.9.1.1.1 Deployment Hardware. Included in this element should be any Commercial-Off-the-Shelf (COTS) hardware purchased for the primary site type 1.

Includes, for example:
a. Processing equipment (servers, CPUs, etc.)
b. Network/communications
c. Storage
d. Security/crypto
e. UPS
f. Other/ancillary equipment

Excludes, for example:
a. Development /test hardware (captured with the prime mission product)

L.6.9.1.1.2 Deployment Software. Included in this element should be any Commercial-Off-the-Shelf (COTS) deployment software purchased for the primary site type 1. This would include the purchase of software licenses related to the AIS solution.

L.6.9.1.1.3 User Documentation (Place Holder).

L.6.9.1.2 Site Activation. This element includes the costs associated with shipping costs to the site, site survey, site preparation, equipment installation, equipment integration, test and checkout to allow implementation of the AIS solution. This should cover only those efforts that are incurred at the implementation site. Any effort related to re-design of the solution once implementation has begun should be captured here.

L.6.9.1.3 User Training. This element represents the effort involved with training the users of the implemented AIS solution at the user sites. The primary cost captured here will be the labor costs of instructors to train users on the new system and business processes required to operate within the new system(s). Any costs incurred as a result of revising the training courses and/or materials once implementation has begun should also be captured here.

Excludes, for example:
a. Any up-front costs associated with training the trainers, as well as course development and material costs that are not incurred as a result of circumstances encountered at the user sites

L.6.9.1.4 Data Migration. This element includes the effort for translating data from one format to another. This should cover only those efforts that are incurred at the implementation site. Also include any expense associated with the transition of data from the legacy systems to the AIS solution. Use lower levels to identify individual legacy systems.

Includes, for example:
a. Data translation
b. Data cleansing
c. Data loading

Excludes, for example:
a. External System Interface Development

Note: Data migration is necessary when an organization decides to use a new computing systems or database management system that is incompatible with the current system. Typically, data migration is performed by a set of customized programs or scripts that automatically transfer the data.

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L.6.9.1.5 Management/Engineering Support. This element captures those support elements that are attributable only to specific user /implementation sites. This would include systems engineering/program management effort associated with a specific site, as well as any system test and evaluation specific to particular user sites.

L.6.9.1.6 Interim Logistics Support. Interim Logistics Support (ILS) costs represent those costs associated with transitioning the system from a contractor supported system to an organically supported system. This could include system maintenance, business process re-engineering, and change management efforts performed by the contractor in the interim before the Government is able to perform these tasks. Also includes operation and Maintenance up to FOC. This element captures the costs of supporting the AIS solution once Operational Site Activation (element L.6.9) is complete and the system has reach full operational capability (FOC). These could be costs incurred as a result of continuing contractor support or by the Government.

Includes, for example:
a. Systems engineering and program management
b. System operations / sustaining engineering
c. Help desk
d. System database administration
e. Deployment hardware/software refresh
f. Software maintenance
g. Follow on training
h. Accreditation
i. Independent verification and validation

L.6.10 Industrial Facilities. The construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance required when that service is for the specific system. This may be a Software Integration Laboratory (SIL).

Includes, for example:
a. Equipment acquisition or modernization, where applicable
b. Maintenance of these facilities or equipment
c. Industrial facilities for hazardous waste management to satisfy environmental standards

Excludes, for example:
a. Capital equipment

L.6.11 Initial Spares and Repair Parts. The deliverable spare components, assemblies and subassemblies used for initial replacement purposes in the materiel system equipment end item.

Includes, for example:
b. Repairable spares (repairables) and repair parts required as initial stockage to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline and war reserve quantities, at all levels of maintenance and support

Excludes, for example:
b. Developmental test spares and spares provided specifically for use during installation, assembly, and checkout on sit, lower level WBS breakouts should be by subsystem

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CONCLUDING MATERIAL

Custodians:
Army – MI
Navy-SH
Air Force – 10

Preparing Activity
OSD-WB

(Project No. MISC-2010-002)

Review Activities:
Army-AR, AT, AV, CR
Navy-AS, MC, OS
Air Force-11, 16, 19, 70, 71, 84

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.daps.dla.mil

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