PROJECT PERFORMANCE INTERNATIONAL

helping projects succeed...
www.ppi-int.com

DATA ITEM DESCRIPTION

1. TITLE	2. IDENTIFICATION NUMBER
OPERATIONAL AND SUPPORT CONCEPT DESCRIPTION (O&SCD)	PPA-002588-3 19 November 2020

3. DESCRIPTION/PURPOSE

3.1 The Operational and Support Concept Description (O&SCD) describes, for a system, subsystem, HWCI, component or other item, who the users of the system are, what are the intended uses of the system, how and where it is intended that the system be used, and a representative set of scenarios of use. These scenarios, each associated with a particular mission, are chosen to represent both typical and design limit conditions of use.

3.2 The Operational and Support Concept Description (O&SCD) also describes how and where it is intended that the system be supported and by whom, and a representative set of scenarios of support. These scenarios, each associated with a particular mission, are chosen to represent both typical and design limit conditions of support.

3.3 The O&SCD is used as a vehicle for achieving a complete and shared understanding between the system users, operators, maintainers, acquirers, requirements analysts, designers, constructors and testers, as a basis for procurement, design and qualification testing of the system and of its support. Throughout this DID, the term “system” may be interpreted to mean "segment", "subsystem", "element", "HWCI", component or other item, as applicable.

4. APPLICATION/INTERRELATIONSHIP

4.1 This Data Item Description (DID) may be cited in a Statement of Requirement (SOR), Statement of Work (SOW), a Contract Data Requirements List (CDRL), or within a standard invoked by a SOR or SOW.

4.2 This DID incorporates and adopts some non-copyrighted material contained in a Recommended Technical Practice of the American Institute of Aeronautics and Astronautics (AIAA) of the United States of America, titled “Operational Concept Document (OCD) Preparation Guidelines”.

5. PREPARATION GUIDELINES

5.1 General Instructions

a. **Form of Data.** The term “document” in this DID means data and its medium, regardless of the manner in which the data are recorded. Use of computer-assisted techniques is encouraged.

b. **Alternative presentation styles.** Diagrams, tables, matrices and other presentation styles are acceptable substitutes for text when data required by this DID can be made more readable using these styles.

continued next page

6. SOURCE

5. PREPARATION GUIDELINES *continued*

5.2 Guidelines in the Preparation of an O&SCD

5.2.1 Operational Concept Description

5.2.1.1 Purpose of the O&SCD

The purposes of the O&SCD with respect to the system aspects are to:

a. describe the system characteristics from an operational perspective;
b. facilitate understanding of the overall system goals with users (including recipients of the products of the system where applicable), buyers, implementors, architects, testers and managers;
c. form an overall basis for long-range operations planning and provide guidance for development of subsequent system definition documents such as the system specification, interface specification, etc; and
d. describe the user organization and mission from an integrated system/user point of view.

Note that the O&SCD is an important complementary document to the system specification. It should be prepared before the system specification. It should serve as a reference during the system requirements analysis and design phases to provide the necessary framework within which system requirements can be interpreted and proposed system design and implementation alternatives can be evaluated. The O&SCD can also be used as an element in evaluating the completeness and consistency of a system design or implementation. The use of an Operational and Support Concept Description should not be constrained to only the highest system level, O&SCDs can and should be developed for elements at lower levels in a system hierarchy.

The purposes of the O&SCD with respect to the support aspects are to:

a. describe the support concept from a system operational and support operational perspective;
b. facilitate understanding of the overall support goals by support personnel, users, purchasers, implementors, architects testers and managers;
c. form an overall basis for long-range support planning and provide guidance for development of subsequent support definition documents such as the Integrated Logistics Support Plan, Integrated Support Plan, etc.; and
d. describe the support organization and mission from an integrated support system/user point of view.

5.2.1.2 Overview of the O&SCDs Role

5.2.1.2.1 Definition of "System”

A "System", in the context of this document, is defined as: "a collection of hardware, software, people, facilities, and procedures, as applicable, organised to accomplish some common objectives" (after the Institute of Electrical and Electronics Engineers, Inc (IEEE) ANSI/IEEE Std 729-1983, IEEE Standard Glossary of Software Engineering Terminology). It may consist of several levels, where each element at each lower level may by this definition itself be considered a "system", i.e., a subsystem of a large system may itself possess all of the attributes of a system. For this reason, the O&SCD may be applied at these levels as well, resulting potentially in several O&SCDs at different levels of abstraction within a given system.

5.2.1.2.2 Perspectives of O&SCD Application

An O&SCD communicates to system developers, users and support personnel, in the user's language, the desired interoperation and other characteristics of a system and its support in its environment of use. To do so, two different categories of information must be provided for each of the system and its support.

These are, for the operational system:

a. the "System Context", which consists of:
    i. mission objectives including rationale;
    ii. overall system operational philosophies;
    iii. operational system characteristics;
    iv. constraints placed and limitations on the system by its environment;
    v. relevant customer/developer policies and organizations;
    vi. system external interfaces;
    vii. external requirements (i.e., changes to existing external elements that are necessary for the proposed system to correctly interface and function); and

viii. user organization (e.g., functions, responsibilities, capabilities and interfaces).

b. a user's operational view. This contains both static and dynamic view of the proposed system operating in its environment with the required operational characteristics and within applicable constraints. It provides the rationale behind the proposed system and should consist of at least:
   i. mission description;
   ii. description of the operational environment(s);
   iii. description of the support environment;
   iv. an envelope of system capabilities and constraints (in user's terminology); and
   v. a set of operational scenarios (a dynamic view of the system in operation in its environment, again with emphasis on the user's point of view).

These are, for the support system:

a. the "Support System Context", which consists of:
   i. support objectives including rationale, related to mission objectives;
   ii. overall support system operational philosophies;
   iii. support system characteristics;
   iv. constraints placed and limitations on the support system by its environment;
   v. relevant customer/developer/maintainer policies and organizations;
   vi. support system external interfaces;
   vii. external requirements (i.e., changes to existing external support elements that are necessary for the proposed support to correctly interface and function); and
   viii. support organization (e.g., functions, responsibilities, capabilities and interfaces).

b. a maintainer's operational view. This contains both static and dynamic views of the proposed support system operating in its environment with the required support characteristics and within applicable constraints. It provides the rationale behind the proposed support system and should consist of at least:
   i. support mission description;
   ii. description of the support environment(s);
   iii. an envelope of support system capabilities and constraints (in maintainer's terminology); and
   iv. a set of support scenarios (a dynamic view of the support system in operation in its environment, again with emphasis on the maintainer's point of view).

The O&SCD provides a mechanism to trigger questions and raise issues regarding use and support related requirements and design trades, both with respect to the operational system and the support system. The O&SCD can serve in a number of ways. Three major ways are:

a. to act as a catalyst to stimulate the development of complete, consistent, testable requirements and designs, with emphasis upon those attributes are influence the usefulness of the system to the user and the effectiveness of the support system;
b. to provide guidance for the development of the subsequent system and support system definition documentation (e.g., system specification, interface control documents, ILSP, etc.); and
c. to provide a foundation for long range operational and support planning activities (i.e., staffing, provision of facilities, training, security, safety, logistics, etc.).

The O&SCD should not contain specific implementation or design-dependent constraints.

5.2.1.2.3 Intended Audience

The information in an O&SCD is intended for communication and fostering of understanding between several key players. These players and the specific uses that each will make of an O&SCD, are listed below:

a. system users/operators/maintainers. These people use the O&SCD for:
   i. planning organization, operational and logistical support aspects, including available resources;
   ii. determining technical attributes concerned with human-machine interfaces and interactions, inter and intra-system hardware and software interfaces, components, locations, sequences, functions and requirements;
   iii. development of philosophies and policies regarding operational and depot level maintenance levels, operational constraints related to maintenance, accessibility of the system, maximum acceptable downtimes, etc.; and
   iv. early definition of user constraints, capabilities, operating procedures, resources, responsibilities and user/system integration, for use by the development community.

b. system engineers and architects. These people use the O&SCD as a framework to:
    i. facilitate understanding by the development team of the mission needs, and to provide a basis for comparing alternative system designs;
    ii. establish the system context, as defined above, to include a description of interfaces to external systems and to other things, e.g. people;
    iii. develop understanding of mission objectives and priorities and the rationale behind them; and
    iv. determine relationships of the system to relevant development and user organizational elements within development and user organization structure.

c. system implementors use the O&SCD to provide:
    i. a brief overview of the system context, with emphasis on the objectives and constraints, together with high level information on operational issues such as logistics, facilities, standards, timelines, end-to-end information flows, etc.;
    ii. an understanding of the rationale behind system objectives; and
    iii. insight into the role of the proposed system with respect to interfacing systems, and the place of the proposed system in the overall environment.

d. customers and buyers. These people use the O&SCD to:
    i. facilitate an understanding of mission objectives, system goals, constraints and external interface agreements;
    ii. form a basis for development of system acceptance criteria; and
    iii. place into proper context the influence of relevant funding and schedule constraints

e. testers. These people use the O&SCD to:
    i. facilitate an understanding of mission objectives and system goals, in order to ensure correct prioritisation of test time and focus;
    ii. understand operational philosophies, to facilitate appropriate test focus (e.g., effective use of operational sequences and data); and
    iii. understand the operational attributes of external interfaces, to ensure thorough testing of the associated system elements.

f. customer and development organisation management. These people use the O&SCD to:
    i. focus on the system context, with emphasis on mission objectives and system goals, policies and philosophies and constraints; and
    ii. facilitate an understanding of the effect of the envisioned system upon the elements and activities external to the system.

5.2.1.2.4 When to Generate an O&SCD

The best time to generate an O&SCD is during the concept definition phase for a given system. This activity should begin prior to the initiation of the system requirements analysis phase and, in fact, should support the activities of that phase.

Systems are normally structured in a hierarchical manner and consist of multiple levels of items within systems. In the Department of defence (DOD) parlance of System, Segment, Subsystem and Component, an O&SCD could be used to great advantage early in the process of defining the operation concept of each "system" at each of these levels (i.e., one O&SCD for the system and one for each segment, subsystem, etc). For a given level, the generation of an O&SCD should begin during the earliest steps in the conceptual definition of each system at that level. In this recommended practice, no distinction is intended regarding the hierarchical level of the system and there may be several O&SCDs at various levels in a system hierarchy. At some level in the hierarchy, the value added by generation of an O&SCD for each element will not justify the cost. At this level, O&SCD generation is not recommended.

5.2.1.2.5 Maintenance of the O&SCD

Since O&SCDs are used to aid communications throughout the system development phases, they should be considered "living documents" and updated as the system design evolves. This updating should be done via the configuration management process, with change approval authority placed at the lowest practical level. For systems expected to be in place for many years after being put into service, and particularly those that are planned to be evolved during their lifetimes, the O&SCD should be used after initial system deployment to support the development of enhancements or new system capabilities. This practice will enable developers to better understand the operational impacts of proposed modifications. Maintaining the O&SCD consistent with the current system implementation provides a very useful source of information to help familiarize new personnel.

5.2.2 Background

During the 1980s, efforts to describe the need for "Operational Concept" information and encourage its preparation originated on at least three different fronts.

As early as January 1980, TRW Defense and Space Systems Group, as part of its TRW Software Series, published a document entitled "A Structured Approach for Operational Concept Formulation (OCF)". At that time, it was recognized that operational concept formulation (i.e., defining system goals, missions and functions) was important to the success of a system development and would have an impact on the overall system design and development process. The purpose of the document was to present a series of ideas, concepts, tools, techniques, and procedures for more effectively accomplishing the system engineering tasks of concept formulation, requirements analysis and definition, architecture formulation and system design. A later paper on the subject by Robert J. Lano, the document's author, was published by the IEEE in IEEE Computer Society Press Tutorial, "System and Software Engineering" by R.H. Thayer and M. Dorfman.

In June 1985, a subgroup under the Department of Defense Joint Logistics Commanders (JLC) produced a Joint Regulation entitled "Management of Computer Resources in Defense Systems". The purpose of the regulation was to establish policy for the acquisition, management, and support of Mission Critical Computer Resources (MCCR) software during all phases of the system life cycle. The Joint Regulation included DOD-STD-2167 (Defense System Software Development), MIL-STD-483A (Configuration Management Practices for Systems, Equipment, Munitions and Computer Programs), MIL-STD-490A (Specification Practices) and MIL-STD-1521B (Technical Reviews and Audits for Systems, Equipments and Computer Programs). Within the associated set of DIDs for DOD-STD-2167 was a DID entitled "Operational and Support Concept Description", the purpose of which was to describe the mission of the system, its operational and support environments, and the functions and characteristics of the computer system within the overall system. During a revision of DOD-STD-2167 (DOD-STD-2167A, February 1988), the Operational and Support Concept Description was dropped in favour of some operational concept information appearing in a System/Segment Design Document.

Also in this timeframe, a "Concept Data Item Description" emerged as a part of National Aeronautics and Space Administrations (NASA's) Product Specification Document Standard (see references). Within the Federal Aviation Agency (FAA), DOD-STD-2167A was adopted as FAA-STD-026. The O&SCD, however, was not dropped. It is still required by the FAA and is typically developed at more than one level within a system (e.g., system and subsystem levels).

The Operational and Support Concept Description is considered by Project Performance International to be a potentially useful document. Development of a set of O&SCDs and related scenarios for each subsystem at each appropriate level in the system hierarchy may become a planned activity of any development life cycle, with O&SCDs and scenarios defined as specific life cycle products.

5.2.3 Contents of a Practical O&SCD

5.2.3.1 Overview

Based on the previously-defined uses, the O&SCD must be somewhat "all things to all people" since the intended audience has a wide range of technical and managerial objectives. At the same time, it must remain readable and understandable. The most practical way to achieve this goal is to write the O&SCD in a narrative form describing, in non-specification-type prose, the way in which the system is envisioned to fit and function within the proposed or expected operational and support environment. Graphics, functional flow diagrams, timelines, etc., should be used to the maximum extent feasible since these visual, pictorial representations significantly enhance the communication of information, particularly to such a wide and varied audience.

5.2.3.2 Content of the O&SCD

In view of the preceding, a good O&SCD should "tell a story", that is, it should be a narrative, pictorial description of the systems' intended use and how it is intended to be supported. This can be accomplished by describing the What, Where, When, Who, Why and How of the system operations and support. These are summarized as follows:

Whats: These are known functions (or tasks) required of the system. The tasks are described from an operation's point of view. Necessary mission phases or modes may also be described here. *Whats* may also refer to physical elements of the system, if such elements are to be mandated by the user rather than be determined by the system designer.

Wheres: These are the environments (geographical and physical locations of customer's facilities, interfacing systems, etc.), within which the functions are required to be performed and supported.

Whens: These describe activities, tasks, flows, precedence, concurrences, and other time/sequent-related aspects necessary to achieve the mission objectives in each of the various mission modes, conditions, etc.

Whos: These describe the interactions among the various human elements within or associated with the system, including their interfaces with people external to the system. The O&SCD and related scenarios should also identify decision points to include who (title) has authority to make those decisions.

Whys: These provide the rationale (when not obvious or when it would benefit reader understanding) behind any established partitioning of the mission tasks between the system and the operators, and the reasoning for specific sequences of activities or tasks. For example, an important function of an O&SCD is to provide the rationale behind the definition of the level of technical expertise required of the system operators.

Hows: These tie together the above elements to describe how the system is expected to be used, operated, and maintained in the given environment, under all significantly different conditions. The emphasis should be on "black box" concepts and should avoid any system design or implementation inferences.

5.2.4 Preparation Guidelines

5.2.4.1 Goals

The two primary goals in the formulation of an operational and support concept are:

a. to provide a forum to stimulate information exchange on major use and programmatic issues among the system's users, developers and maintainers in order to facilitate a clear understanding of the system context and the user's view of the completed system; and
b. to generate a document which can be utilised by all members of the O&SCD "audience" as described in Section 5.2.1.2.3 above.

5.2.4.2 Formulation Process

5.2.4.2.1 Introduction

While not a part of generating an O&SCD per se, it may be necessary to convince the appropriate management and technical personnel of the benefits of such an activity. This process is beyond the scope of this document. However, if schedule, staff, and budget are not specifically allocated for development of an O&SCD, at each appropriate level in the proposed system hierarchy, and an O&SCD is not listed among the deliverables, chances are high that this "sales" step will be necessary before the steps described below can be accomplished.

The content and format of an O&SCD should be defined and understood by all participants. In this guideline, Section 5.2 describes one recommended content for an O&SCD. However, other formats may be appropriate or, in some cases, imposed. For example, a developer may be required to use the "operational concept" section of the DOD-STD-2167A System/Segment Design Document or the NASA Concept Data Item Description (see references).

5.2.4.2.2 Participants

A key element in any major systems engineering endeavour is the establishment of an interdisciplinary team. This team is led by a senior system engineering and is comprised of personnel competent in all of the disciplines relevant to the system context. These competencies may be operational or technical, or, more usually, a mixture of the two.

If the O&SCD is to convey valid information to and from the users, system engineers/architects, system implementors, testers, customers/buyers and customer and contractor managers, then representatives from each of these communities should actively contribute to the O&SCD. The users should be providing the *"what"* in terms of mission requirements, the *"where"* in terms of environments, the *"when"* in terms of mission sequences/scenarios, and the *"who"* in terms of user and operator actions. All categories of user disciplines (operations, maintenance, test, logistics, etc.), require representation. The system engineers/architects, system implementors and testers should provide the bridge between what the users envisage and what technology is capable of.

5.2.4.2.3 Generating O&SCD Content

5.2.4.2.3.1 Overview

The first step in generating an O&SCD is to establish a clear definition of the boundaries of the system, defining specifically the border between what is inside the system and what is outside of it, thus establishing the external interfaces. Once these are established, constraints, including top-level customer policies, operational philosophy and strategies, and negotiated "external requirements" (i.e., changes to existing interfacing elements, outside of the system context, which are necessary to accommodate the proposed system in order for it to interface and function as envisioned) can be described. These, coupled with the top level mission or system objectives, allow the system engineer to begin to define the operational concepts. Of course, the available budget and schedule will also influence the extent to which this work may be accomplished. The following sections describe the steps necessary to develop the content material of an O&SCD.

5.2.4.2.3.2 Defining Useful Operational Scenarios

The key to a successful O&SCD is the development of "Operational Scenarios". These describe the dynamic views of the system's operation, primarily from the users' points of view. It is this articulation of how the system is perceived to function through various modes and mode transitions, including its expected interactions with the external environment, outlining all important anticipated user, tester, operator and maintainer interactions, that provides the basis and framework for the development of system requirements.

A useful scenario is one which describes how a system is to be operated and maintained during a specific time, mission phase, operational mode, critical sequence of activities, etc., within a defined environment. It enables one to establish the "what, where, when, why and how" for the system. For example, a scenario in which the system operates under extreme conditions, such as being required to process the highest input data rates while staffed with the lowest expected personnel levels, provides insight into important system requirements. Attributes such as man-machine interface bottlenecks which could result in an overall system failure if the conditions persist for more than just a few minutes, could be uncovered by walking through such a scenario. In another example, a system constraint limiting pointing of a spacecraft sensor within some number of degrees of the sun, which appears to be adequately met via rigorous operational procedures, could be found to be violated when normal communications are interrupted by a failure mode which limits the pointing control capability. This type of interaction would be uncovered by analysis of carefully selected operational scenarios.

Typically, a set of scenarios will be necessary. Each should focus upon a specific area of interest or concern and not attempt to cover all aspects at one. The scenarios should be selected such that the complete set contains scenarios dealing with all phases of operations including installation, start up, typical examples of normal and contingency operations, shutdown, maintenance, etc. Operations under typical and "stressful" conditions (e.g., maximum I/O rates and loads, minimum personnel staffing, element failure modes, etc.), should be emphasized. One should begin with a typical, normal system operational scenario and later develop those scenarios which focus on "stressful" conditions and operations in the presence of system element faults. The primary focus should be upon the user's view of the system, but with some scenarios devoted to the maintainer's and tester's views. If the system operation includes decision points where operators and users must choose a course of action within some limited timeframe, a set of scenarios should be included which cover these interactions, particularly those under which there is stress on the personnel.

5.2.4.2.3.3 Developing the Scenarios

Developing the scenarios is a matter of combining the topics listed above, that is, assembling an interdisciplinary team with the right set of expertise, defining a good set of scenarios, waling through each scenario step-by-step and recording the results. This effort has an additional benefit in that all of the interdisciplinary team members will gain a thorough understanding of the role the element with which they are associated plays in the context of the other elements, as well as, the rationale behind many of the decisions made as the process evolves. Furthermore, this greater insight enables them to suggest better ways to apply their own expertise. The following sections describe how to develop these scenarios.

Several scenarios will probably be needed. Initially, one which represents the normal expected operations of the system under normal environmental conditions forms a good baseline. This may not be a simple task since there may be many opinions regarding these seemingly obvious things. To begin, conduct a series of interviews with or presentations by the people who can authoritatively define what normal operations are expected to be. Upon defining the normal scenarios, create additional scenarios which focus on specific elements of interact, eg, system operations near boundary conditions, under peak loads or worst case conditions, operations in the presence of failures or degraded system capabilities, etc.

A list of topics which prompts the presenter will be helpful to ensure that all necessary aspects are addressed. This list will vary with the type of system but a good start would be:

a. Overview:
   i. summary of what the system is (context), what it is to do in general (mission), and how it will do it.

b. Sequence:
   i. functional flows;
   ii. mode transitions; and
   iii. decision points (particularly human interactions).

c. Performance:
   i. response time;
   ii. delay points/times;
   iii. throughput/turnaround times expected; and
   iv. reliability, availability, maintainability.

d. Organizational Issues:
   i. user types, technical expertise, etc.;
   ii. user training constraints; and
   iii. user/operator responsibilities and decision authority.

e. System Environment and Existing Facilities:
   i. environment in which system must operate;
   ii. geographical issues;
   iii. safety, security, system integrity needs; and
   iv. interfacing systems description and data flows.

5.2.4.2.3.4 Determining Logical Functional Flows

Once a relatively complete set of data is available, the interdisciplinary team can begin to determine the functional flow of activities necessary for the system to execute a set of normal operations. From the interviews or presentations, it should be possible to define a sequence of events over a period of time that represents some generally complete system functions that once commenced, tend to run to some end. For example, in the case of a spacecraft system of a deep space scientific mission, some typical operational scenarios would be:

a. a launch through early cruse mode sequence, no spacecraft anomalies;
b. a typical scientific data collection sequence of activities in the presence of a spacecraft anomaly;
c. a typical trajectory correction manoeuvre, no anomalies; and
d. response to a spacecraft power system interruption during a trajectory correction manoeuvre.

Having selected a scenario, the team should then iteratively "walkthrough" all of the steps the envisioned system must execute to perform the scenario. This may take some time because states, mode transition steps, etc., will not be clearly defined or understood by all team members. There may, in fact be significant disagreements regarding these definitions. A major purpose here is to come to agreement and record clearly these definitions and descriptions. An example of scenario development is provided in Appendix X.

5.2.4.2.3.5 Validating the Scenarios

Validation of the scenarios is accomplished by performing scenario walkthroughs in accordance with any governing policies and procedures. The scenario walkthrough examines the sequence of events, extremes of environment and inputs and the resultant exercising of system functions and responses. The user and development communities must provide the evaluations required to validate the scenarios.

5.3 Content Requirements

Content requirements begin on the following page. The numbers shown designate the paragraph numbers to be used in the document. Each such number is understood to have a prefix "5.3" within this DID. For example, the paragraph numbered 1.1 is understood to be paragraph 5.3.1.1 within this DID.

TABLE OF CONTENTS

1. SCOPE

This section should be divided into the following paragraphs.

1.1 Identification

This paragraph should contain a full identification of the system to which this document applies, including, as applicable, identification number(s), title(s), abbreviation(s), version number(s) and release number(s). Where the system to which the document applies includes variants of the system, the above information should be provided for each variant. Where the system to which the document applies includes incremental builds of the system which are subject to individual specification, the above information should be provided for each such build.

1.2 Document Overview and Use

This paragraph should summarize the purpose (including intended audience) and contents of this document and should describe any security or privacy considerations associated with its use.

1.3 System Purpose

This paragraph should briefly state the purpose of the system to which the O&SCD applies.

2. REFERENCED DOCUMENTS

This section should list the number, title, revision, and date of each document referenced in the O&SCD. This section should also identify the source of each document not available through normal government channels.

3. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

This section should be divided into the following paragraphs.

3.1 Definitions

This paragraph should list alphabetically and define each word or term used in subsequent sections for which reliance on dictionary definitions is not appropriate. As a guide, terms which are not likely to be in the vocabulary of the intended users of the O&SCD, terms which have multiple dictionary meanings but only a single O&SCD meaning, technical terms and terms which are used with special meanings should be defined in this paragraph.

3.2 Acronyms

This section should list alphabetically each acronym used in the document, together with the acronym's expanded meaning.

3.3 Abbreviations

This section should list alphabetically each abbreviation used in the document, together with the abbreviation's expanded meaning, except that abbreviations within the International System (Si) system of units should not be listed.

4. OPERATIONAL CONCEPT (CONCEPT OF USE)

4.1 Operations

This section should be written from an operations point of view, describing the mission and operations as they currently exist or are envisioned to exist, as applicable to the new system, but without reference to the proposed system, in order to provide a clear context for the future usage of the system.

This section summarizes, in prose style, information regarding the mission of the system, its operational environment and a characterisation of the personnel. It also includes:

a. operational strategies, tactics, policies and constraints that describe *how* the mission is accomplished;

b. personnel organization, activities and interactions that describe *who* the users are and *what* the users do in accomplishing the mission; and

c. operational processes that provide a process model describing *when* and in *what* order operations take place, including such things as dependencies and concurrences.

Subparagraphs of this section are as follows.

4.1.1 Operational Overview

4.1.1.1 Mission

This subsection should describe the applicable primary and secondary mission(s) that the system will address. It should state the overall purpose and intent of operations and should describe, if applicable, such things as threats, geography of operations, strategies used to accomplish the mission, and specific tactics, methods or techniques employed to accomplish the mission.

4.1.1.2 Operational Policies

This subsection should reference the policies and standards governing the mission and describe the use and applicability of the system.

4.1.1.3 Operational Constraints

This subsection should list and describe any other operational constraints that govern or limit operations (e.g., personnel availability, acceptable weather, etc.).

4.1.1.4 Existing Operational Environment

This subsection should describe the existing physical operational environment, if any, in terms of facilities, equipment, computing hardware and software.

4.1.1.5 Existing Support Environment

This subsection should make reference to the existing physical support environment by W to paragraph xxx.

4.1.2 Mission Operations Personnel

4.1.2.1 Personnel Profile

This subsection should identify the various types of personnel involved in the mission.

4.1.2.1.x Personnel Type

For each type, this subsection should describe necessary educational and training background and skill levels.

4.1.2.2 Organizational Structure

This subsection should identify and describe the organizational structure(s) of the personnel. It should state the charter of each organizational element and describe any reporting relationships.

4.1.2.3 Personnel Interactions

This section should describe the interactions of personnel, within the organizational boundaries and between organizations. Both formal and informal interactions should be identified.

4.1.2.4 Personnel Activities

This section should discuss the activities of each type of personnel in fulfilling the mission.

4.1.2.4.x Personnel Type

For each type, this subsection should describe the various roles that may be assumed as well as the duties and activities performed within each role.

4.1.3 Operational Processes

This subsection should discuss the operational processes used to accomplish the mission. Process models should be provided that illustrate the operational flow and sequence of operations. Processes may be decomposed from high level to lower level processes.

4.1.3.x Process

This subsection should describe a model for each process. The process, including its sequence and interrelationships with other processes should be described. Inputs and outputs for each process should be stated. Methods and techniques employed should be described, as well as traceability to strategies and tactics.

4.2 Needs That Drive the System

This section should provide a transition from the description of operations (Section 4 above) to the system overview, Section x, stating the mission and personnel needs that drive the requirements for the system.

4.2.1 Mission Needs

This subsection should describe the mission needs that the system will seek to satisfy.

4.2.2 Personnel Needs

4.2.2.x Personnel Type

For each type, this subsection should describe the personnel needs that the system will seek to satisfy.

4.3 System Overview

This section should provide an overview of the system requirements and, where applicable, the system architecture.

4.3.1 System Scope

This subsection should describe the scope of the system within the context of the mission. It should describe the primary use(s) of the system within the context of the user's environment.

4.3.2 Users

This subsection should identify the various users of the system, relating them to the personnel described above.

It is important to clearly describe the difference between the "user" and the "operator" of the system. Both points of view, while potentially very difference, are needed to ensure a well-designed system.

4.3.3 System Interfaces

This subsection should identify and overview the various external interfaces of the system.

4.3.4 System States and Modes

This subsection should describe the operational states and modes and relate the various operational processes and user activities.

4.3.5 System Capabilities

This subsection should identify and describe the system's functional requirements to be implemented by the system as a whole. It should also correlate system capabilities and characteristics to specific mission and personnel needs.

4.3.6 System Goals and Objectives

This subsection should describe the system's goals and the objectives and expectations for it, including the system "-ileitis", e.g., reliability, maintainability, transportability, flexibility and expansion, etc.

4.3.7 System Architecture

This subsection should overview the system architecture, identifying the various system elements (hardware configuration items (HWCIs), computer software configuration items (CSCIs)) and their interrelationships.

4.4 Operational Environment

This section should describe the required physical operational environment, if known, in terms of facilities, equipment, computing hardware, software, personnel, operational procedures and support necessary to operate the deployed system. The availability of information on the computing hardware and software will depend on the approach taken for system development (i.e., "software first", "hardware first", or "concurrent") and the timeframe, in relation to the system life cycle, during which this O&SCD is prepared.

4.5 System Operational Scenarios

This section should describe, for each identified operational process, how the system is used in terms of and related to the elements defined in Section 4 through 6 above, it should provide typical usage scenarios for each of the operational processes served by the system. Scenarios describe typical detailed sequences of user, system and environment events. Based on the motivations for preparing an O&SCD, this section is by far the most important and should receive substantial emphasis.

This section of O&SCD describes the operations from a time-oriented perspective in terms of sequences of environment, user and system events.

4.5.x Process

This subsection should describe the operational process(s) that are supported by the system.

4.5.x.y Scenario

This subsection should provide, for each process, the scenario(s) of the sequence of user and system operations. Each scenario should be related to specific users and system elements.

Several different types of scenarios should be considered, including those which address normal mission modes, anomaly/exception handling, mission critical activities, safety critical modes/activities, maintenance modes, etc.

Reference Section 5.3.4 of the Guidelines for how to develop an appropriate and quality set of scenarios.

5. SUPPORT CONCEPT

5.1 Support Operations

This section should be written from a support operations point of view, describing the support operations as they currently exist or are envisioned to exist, related to the operational mission and without reference to the proposed system, in order to provide a clear context for its support.

This section summarizes, in prose style, information regarding the support of the system, the support environment and a characterization of the support personnel. It also includes:

a. support strategies, tactics, policies and constraints that describe *how* the support is to be accomplished;
b. support personnel organization, activities and interactions that describe *who* the support personnel are and *what* the support personnel do in providing the support; and
b. support processes that provide a process model describing *when* and in *what* order support operations take place, including such things as dependencies and concurrences.

Subparagraphs of this section are as follows.

5.1.1 Support Operational Overview

5.1.1.1 Support Objectives

This subsection should describe the applicable support objectives in terms related to the operational mission. It should state the overall purpose and intent of support and should describe, if applicable, such things as threats, geography of support operations, strategies used to provide the support, and specific tactics, methods or techniques employed to provide the support.

5.1.1.2 Support Policies

This subsection should reference the policies and standards governing the support.

5.1.1.3 Support Constraints

This subsection should list and describe any other support constraints that govern or limit support (e.g., personnel availability, acceptable weather, etc.).

5.1.1.4 Existing Support Environment

This subsection should describe the existing physical support environment, if any, in terms of facilities, equipment, computing hardware and software.

5.1.2 Support Personnel

5.1.2.1 Personnel Profile

This subsection should identify the various types of personnel involved in the mission.

5.1.2.1.x Personnel Type

For each type, this subsection should describe necessary educational and training background and skill levels.

5.1.2.2 Organizational Structure

This subsection should identify and describe the organizational structure(s) of the personnel. It should state the charter of each organizational element and describe any reporting relationships.

5.1.2.3 Personnel Interactions

This section should describe the interactions of personnel, within the organizational boundaries and between organizations. Both formal and informal interactions should be identified.

5.1.2.4 Personnel Activities

This section should discuss the activities of each type of personnel in fulfilling the mission.

5.1.2.4.x Personnel Type

For each type, this subsection should describe the various roles that may be assumed as well as the duties and activities performed within each role.

5.1.3 Support Processes

This subsection should discuss the operational processes used to accomplish the mission. Process models should be provided that illustrate the operational flow and sequence of operations. Processes may be decomposed from high level to lower level processes.

5.1.3.x Process

This subsection should describe a model for each process. The process, including its sequence and interrelationships with other processes should be described. Inputs and outputs for each process should be stated. Methods and techniques employed should be described, as well as traceability to strategies and tactics.

5.2 Needs That Drive Support Requirements

This section should provide a transition from the description of support operations (Section x above) to the support system overview Section x, stating the mission and personnel needs that drive the requirements for the support system.

5.3 Support System Overview

This section should provide an overview of the support system requirements and the support system architecture.

5.3.1 Support System Scope

This subsection should describe the scope of the system within the context of the mission. It should differentiate between different support system elements such as support personnel, support equipment, spare parts, facilities and support publications.

5.3.2 Support System Interfaces

This subsection should identify and overview the various external interfaces of the support system.

5.3.3 Support System Modes

This subsection should describe any support system modes of operation and relate these as applicable to system operational processes and user activities.

5.3.4 Support System Capabilities

This subsection should identify and describe the tasks to be performed by the support system. It should also correlate support system capabilities and characteristics to specific mission and personnel needs.

5.3.5 Support System Goals and Objectives

This subsection should describe the objectives and expectations for the support system, including the "-ileitis", e.g., reliability, maintainability, transportability, flexibility and expansion, etc. of the *support* system.

5.3.6 Support System Architecture

This subsection should overview the support system architecture, describing the various support system elements and their interrelationships.

5.4 Support Environment

This section should describe the required physical support environment, if known, in terms of equipment, computing hardware, software, personnel, operational procedures and support necessary to maintain the deployed system. The availability of information on the computing hardware and software will depend on the approach taken for system development (i.e., "software first", "hardware first", or "concurrent") and the timeframe, in relation to the system life cycle, during which this O&SCD is prepared.

This section should also describe the support concept for the deployed system (e.g., use of automated test equipment, repair vs replacement criteria, maintenance levels and cycles, government vs contractor support, etc.), required facilities, requirements/impacts on the supply system, and identification of organisations involved in the system's development, support and use.

5.5 Support Scenarios

This section should describe, for each identified support process, how the support system is used in terms of and related to the elements defined in Section 5.1 through 5.4 above. It should provide typical scenarios for each of the operational processes served by the support system. Scenarios describe typical detailed sequences of user, system, support system and environmental events. Based on the motivations for preparing an O&SCD, this section is by far the most important and should receive substantial emphasis.

This section of O&SCD describes the support operations from a time-oriented perspective in terms of sequences of environment, user, system and support events. The section may refer to an integrated model of operational and support scenarios if desired. In this case, the information would be contained within an annex.

5.5.x Process

This subsection should describe the support process(s) that are supported by the support system.

5.5.x.y Scenario

This subsection should provide, for each support process, the scenario(s) of the sequence of user, system and support system operations. Each scenario should be related to specific users, system elements and support system elements.

Several different types of scenarios should be considered, including those which address normal support modes, anomaly/exception handling, mission critical activities, safety critical modes/activities, maintenance modes, etc.

Reference Section 5.3.4 of the Guidelines for how to develop an appropriate and quality set of scenarios.

A. ANNEXES

Annexes may be used to provide information published separately for convenience in document maintenance or use (e.g., charts, databases). As applicable, each annex should be referenced in the main body of the document where the data would normally have been provided. Annexes may be bound or prepared digitally as separate documents for ease in use. Annexes should be lettered alphabetically (A, B, etc.).

Appendices may be used to annexes. Appendices should be numbered numerically (1, 2, etc.).

ANNEX A

1. EXAMPLE SCENARIO DEVELOPMENT

1.1 Overview

The following example shows how engineers and scientists used the operational concept approach and a set of operational scenarios. They were used to support the development of a spacecraft capable of "flying" a group of instruments on an interplanetary mission to collect scientific data about a body in our solar system. The example, based upon an actual situation, is somewhat atypical in that the operational concept activity was initiated much later in the life cycle than is recommended by this technical practice document. It does, however, indicate the benefits of the approach and implies how its earlier application could have helped focus more attention on some important user-related design attributes.

While this example indicates the value of initiating the operational concept work early, it makes the point that even if initiated later than recommended, it can still be a significant benefit to the system development. In this example, the spacecraft system design had been going on for some time before the operational concept work was initiated. The spacecraft system design was based heavily upon that of previous similar missions and the specific science instrument complement for this mission had been selected. This had been accomplished in an atmosphere of severe budget and schedule constraints. Instrument selection was done based upon the data provided in a formal "Announcement of Opportunity" (AO). The AO is an initial high-level description of the type of mission to be flown, including things such as the trajectory from earth to the body, the general approach to encountering the body, and various general assumptions regarding the capabilities of the spacecraft system. Typical of these are the pointing accuracy of the platform on which remote sensing instruments will be mounted, available data transmission bandwidth, capacity of on-board data storage, etc. Since these were all predefined, they had to be considered as constraints. Furthermore, several physical constraints limited the designers in virtually every dimension. The amount of available spacecraft mass, power, volume, computer processing speed, and memory capacity were also predefined. This mission was to be based upon the experience of similar missions. During the pre-project phase, initial operations discussions with scientists, mission operations personnel and spacecraft operators were conducted to establish a basis for initial spacecraft user-related design requirements definition. Since this input was felt to be adequate, a formal operational concept activity was not conducted during the early development phases.

Later in the spacecraft system design phase, as the spacecraft engineers began to firm up the spacecraft system design, the engineers and managers responsible for the mission operations design began to interact more heavily. It then becomes evident that the spacecraft system design had evolved to a point where a more detailed understanding of its operational capabilities and constraints had been gained. From this understanding, it also became clear that some elements of the current design implied potentially significant operational difficulties if implemented in the manner specified.

Consequently, an interdisciplinary team was formed to do operational concept studies to gain more in-depth understanding of the user-oriented aspects of the evolving spacecraft system design. This team searched for potential major problem areas and constraints, which were then further analyzed to determine what solutions could be implemented to ease perceived operational difficulties. The following narrative describes the operational concept study approach, which was taken and indicates the benefits of such an activity.

2. EXAMPLE OPERATIONAL CONCEPT STUDY

2.1 Defined Purpose of the Study

The purpose of this operational concept study was to:

a. describe the current spacecraft system design from several perspectives (e.g., the scientists who want to operate their instruments to collect data, navigation system engineers who determine the spacecraft operations necessary to maneuver the spacecraft to the areas in space where the science data can be obtained, and mission sequence system engineers who coordinate the instrument operations activities with all of the other activities, the spacecraft subsystem engineers who analyze and maintain the spacecraft health and predict the capabilities available to conduct the desired operations [e.g., telecommunications bandwidth, spacecraft power utilization, thermal balance, etc., versus time and operational modes]);

b. describe the intended scientific observations for each instrument necessary to meet the individual and coordinated scientific mission objectives;

c. describe the currently planned process for defining spacecraft sequences of events, generating and validating the spacecraft command sequences necessary to implement those events, and scheduling the facilities to transmit those commands; and

d. describe the currently planned operational teams, interfaces and interactions necessary to coordinate all of the above activities into a feasible, cost-effective mission operations entity.

2.2 Interdisciplinary Team Composition

Given the nature of the mission and system, the interdisciplinary team was composed of engineers and scientists with the range of expertise indicated in Table 2.2-1 below.

This table provides examples of the types of expertise which were deemed to be necessary on the interdisciplinary team for the deep space scientific mission. Indicated, for each type of expertise, are the perspectives (either user or developer) from which that person would participate. In cases where an individual would represent both views, they are listed highest priority first. In addition, an asterisk (*) following an entry indicates a person that is also involved in post-launch support of the mission (maintenance).

System Manager (developer)
Project System Engineer (developer)
Spacecraft System Engineer (developer)
Flight Operations Engineer (user, developer)*
Mission Design Specialist (user, developer)
Science Investigator (user)
Science Data Processing Engineer (user, developer)*
Instrument Designer (developer, user)*
Celestial Navigation Engineer (user, developer)
Guidance & Control Engineer (user, developer)
Information System Engineer (developer, user)*
Software System Engineer (developer, user)*
Deep Space Telecommunications Engineer (developer, user)*
Spacecraft Power System Engineer (developer, user)*
Spacecraft Mechanical, Structural & Thermal Specialist (developer, user)*
System Integration & Test Engineer (developer)

Table 2.2-1 Team Composition

2.3 The Approach

It was a requirement that the interdisciplinary team members participate in all working sessions to ensure that each gained an understanding of the overall context plus the expectations, points of view, biases, etc., of the other members. As a result, a significant amount of clarification of issues was accomplished in real-time at each session, enabling the team to distil the essence of many issues relatively quickly.

The team leader established a series of working sessions to determine the "what", "when", "where", "who", "why" and "how" of the currently planned or expected elements of the end-to-end system (i.e., instrument sensor through spacecraft and ground systems to end user output products) that were perceived to be necessary to accomplish the mission objectives. This was accomplished through the development of various scenarios which are discussed below (note: the following are typical items and are not complete lists):

a. science "scenarios" wherein the operational needs and science data acquisition and handling expectations of the scientists and instrument engineers were established:
   i. what parameters are involved in typical sensor data collection sequences for your instrument and what is involved in controlling them?
   ii. what parameters of your instrument require calibrations? How often, what ground-based operations are necessary, etc.?
   iii. what information do you need prior to determine the values of the above parameters?
   iv. what are the characteristics of the data received from your instrument during the above operations (e.g., data rate, number of observations mode changes required, etc.)?

   v. what data from other spacecraft elements are required to support your observation data (e.g., platform position data, spacecraft time, data from other instruments)?
   vi. How soon after the observations do you need the data, in what form, and what do you do with that data? Particularly, what do you need from the data which influences what you do on subsequent observations?

b. spacecraft engineering "scenarios" wherein a similar set of items were defined by the engineers responsible for the operation of the spacecraft engineering subsystems which support the instruments (e.g., telecommunications, power, guidance and control, command and data handling, etc.):
   i. what standard sequences must be run on your subsystem during flight for either operational verification or calibration? How often must they be run, what are typical verification activities, how much time is required, what support from other subsystems is required, etc.?
   ii. what subsystem analyst visibility into your subsystem's operation is required during normal flight operations (low activity and high activity) periods?
   iii. what is done with the data from a sequence? What form is expected, how soon after execution, etc.?
   iv. what closed-loop or autonomous functions does your subsystem perform or depend upon some other subsystem for?
   v. what role does your subsystem play in navigation maneuver and what data is required for you to prepare for a maneuver?

c. uplink process "scenarios" wherein the above information formed a framework in which the team could discuss the process and activities necessary to define operational sequences, generate and validate the necessary spacecraft command loads, and schedule their transmission and verification were defined next:
   i. how much sequence activity can be incorporated into a single spacecraft commanding session and how often can/should command loads be transmitted to the spacecraft?
   ii. how long is the sequence development and generation process?
   iii. how many sequence loads must be in some form of development concurrently?
   iv. what is the strategy for on-board sequence memory management?
   v. what is the process for validation of a sequence prior to transmission to the spacecraft, how long does it take, what tools are required, etc.?
   vi. what process is needed to review the proposed sequences, who is responsible for the approval, how long does this process take, how many levels of approval are needed, etc.?

d. downlink, process "scenarios" wherein the processes necessary to capture data transmitted by the spacecraft, process it, and route the output products to the end users were then defined:
   i. what types of spacecraft activities require on-line real-time analysis by what levels of analyst expertise?
   ii. how often are each of these expected?
   iii. what is the required minimum time from receipt of each type of data to distribution of processed output to each user?
   iv. what capacity of data storage is required and what safeguards are necessary to maintain data integrity after receipt?

e. spacecraft engineering subsystem and instrument performance analysis "scenarios" were discussed to establish the expectations and needs of analysts to ensure correct flight equipment operation and detect trends. It should be noted here that subsequent team activities are planned to address all of the above scenarios in the presence of flight and ground system anomalies or failures, including analysis of spacecraft autonomous fault tolerance functions:
   i. what data is required and how often to ensure continued, correct operations of all spacecraft elements?
   ii. what tools are necessary to perform this analysis?
   iii. what personnel with levels of expertise are required and what types of working shifts will be necessary?

2.4 Examples of Difficulties Uncovered By This Study

Following are a few representative examples of difficulties uncovered by the above operational concept study. These indicate the value of such an activity and emphasize the importance of performing operational concept development early in the system definition process. It also provides some insight into how operational scenarios can provide a framework upon which to base the analysis. Example difficulties uncovered were:

a. mismatch between available telemetry modes and target body encounter sequencing activities: The design of the spacecraft Command and Data Subsystem (CDS) had proceeded based upon the assumption that the maximum number of different telemetry formats needed during any major time period would not exceed ten. Analysis of the proposed instrument designs and the operational mode changes that would be required for each to acquire the optimum amount of science observations during a typical encounter time period resulted in significantly more mode changes and data rate changes. Because of the design approach already taken, there would be a major incompatibility between science observation needs and the on-board telemetry data mode capability. A spacecraft design team activity was defined to resolve this problem;

b. impact of small power margins on instrument operations: In the vicinity of the target body significant amounts of dust particle debris are expected to be encountered. To protect instrument sensors and optics from impact or becoming coated with dust, covers, which can be closed and opened, are included in the design. Unfortunately, these dust covers and the motors, which drive filter wheels, require a significant amount of power compared to the available power margin. In some spacecraft operational modes, the power margin is so small that many combinations of filter wheel and/or cover operations would require a peak power, which exceeds the available power. This could result in an autonomous response by the spacecraft fault protection system, which would sense this condition as a fault. Thus, the operational concepts discussions brought to light several individual instrument and system-level design and assumption inconsistencies. As above, now that these have been uncovered, they will be worked; and

c. the above item and several other similar issues brought into focus the fact that there had been no "operability" requirements defined or allocated to the instruments. What is needed is a set of system level requirements and constraints allocated to each instrument which relate to the operation of the instrument in the spacecraft system environment and in the mission operational sequencing area. Some examples of the types of requirements which need to be defined are:
    i. requirements to minimize the interactions necessary from other subsystems or ground operations personnel to initialize the instrument upon application of power. This is due to the fact that, because of limited spacecraft power margins, instruments may be required to be frequently power on and off during some periods;
    ii. requirements on the structure of command and telemetry messages which enable clear, unambiguous translation from human readable formats into mnemonics and command messages to be transmitted to or received form the instrument; and
    iii. requirements on the processes needed to calibrate the instrument or modify operational parameters which facilitate simple ground system operational procedures to implement them.

2.5 Summary

While the above example is very specific to a unique and narrow application, it is apparent that the approach described can be applied to the development of any system. The key elements are formulation of the interdisciplinary team with a range of expertise which covers all important aspects of the system; and involvement of these team members in analysis of system operational attributes through the generation of a set of operational scenarios.