Information Technology Support for Software Engineering

Guide to Selection and Application of Software Engineering Standards

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Defense Information Systems Agency
Joint Interoperability and Engineering Organization
Center for Information Technology Standards
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EXECUTIVE SUMMARY

The Defense Information Systems Agency (DISA) Center for Information Technology Standards (CFITS) is responsible for identifying standards suitable for use by the Department of Defense (DOD). In accordance with DOD policy, emphasis is placed on the selection of national, international, and de facto commercial standards in lieu of unique military standards (MIL-STD).

As part of this effort, the DISA CFITS has initiated the Software Engineering Standards Working Group (SESWG) to identify the standards needed by the software engineering community and to develop mechanisms addressing specific software engineering standards issues. The SESWG will assist the DOD regarding the reduction and/or elimination of unique military standards/specifications by assessing all existing and emerging military software engineering standards and providing the focal point for determining the feasibility of adopting appropriate de jure and de facto commercial standards or submitting selected military specifications/standards to national and international Standards Development Organizations (SDO) for consideration.

This guide, developed with the support of the SESWG, addresses concerns raised by the SESWG. This document provides guidance on the selection and application of standards in the software engineering process. It is to be used by program managers and contractors tasked to select, evaluate, and/or apply software engineering standards to their software effort.

This document presents information on sources of standards and guidance for assessing standards for DOD programs. It also contains sources of assistance in software engineering methods and recommendations on how to address deficiencies or gaps found in standards as they apply to particular programs or DOD needs.

1.0 INTRODUCTION

1.1 Background

The DISA CFITS is responsible for identifying standards suitable for use by DOD. In accordance with DOD policy, emphasis is placed on the selection of national, international, and de facto commercial standards in lieu of unique MIL-STD.

As part of this effort, the DISA CFITS has initiated the SESWG to identify the standards needed by the software engineering community and to develop mechanisms addressing specific software engineering standards issues. The SESWG will assist DOD regarding the reduction and/or elimination of unique military standards/specifications by assessing all existing and emerging military software engineering standards, and providing recommendations for determining the feasibility of either adopting appropriate de jure and de facto commercial standards, or submitting selected military specifications/standards to national and international SDO for consideration.

1.2 Purpose

The *Institute of Electrical and Electronic Engineers (IEEE) Standard Glossary of Software Engineering Terminology* (IEEE Std. 610.12-1990) defines *software engineering* as "the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software" [Reference 19].

This document provides guidance on the selection and application of standards in the software engineering process. It is to be used by program managers and contractors tasked to select, evaluate, and/or apply software engineering standards to their software effort

1.3 Scope

The "Guide to Selection and Application of Software Engineering Standards" presents information on sources of standards and guidance for assessing standards for DOD programs. It also contains sources of assistance in software engineering methods and recommendations on how to address deficiencies or gaps found in standards as they apply to particular programs or DOD needs.

2.0 SELECTING STANDARDS FOR DOD PROGRAMS

Today's standards selection process is based on the DOD Specifications and Standards Reform, which began in June 1994 when the Secretary of Defense, William Perry, issued his memorandum entitled "Specifications and Standards - A New Way of Doing Business" [Reference 14]. That memorandum established the Defense Standardization Improvement Council (DSIC) as the primary coordinating body for the specification and standards program in DOD. The memorandum, together with the mandated DOD Directive (DODD) 5000.1 [Reference 4], and DOD 5000.2-R [Reference 5] direct that performance-based specifications and standards or nationally-recognized private sector standards be used in future acquisitions unless there is a DOD unique need or there is no adequate non-government standard (NGS).[1]

2.1 Sources of Software Engineering Standards

Standards used in DOD include both government and NGS (or commercial standards). Government standards include MIL-STD, military specifications (MIL-SPEC), and military handbooks (MIL-HDBK) developed by DOD organizations, and Federal Information Processing Standards (FIPS) Publications (PUB) developed by the National Institute of Standards and Technology (NIST). NGS include standardization documents developed by a private sector organization, association, or technical society that plans, develops, establishes, or coordinates standards, specifications, handbooks, or related documents. These non-government standards bodies (NGSB) include international, non-government U.S. national, and consortia standards organizations.

The following sections discuss how standards are maintained, the major standards organizations that develop standards related to software engineering, sources of guidance for software engineering standards, and some standards selection references available to DOD.

2.1.1 Standards Development

Standards are normally developed by committees. Committee members are professionals with relevant experience and an interest in the particular issue. Members of NGSB typically serve without compensation. Where DOD interests are affected, DISA CFITS tries to participate on the committee. Standards are developed by consensus among the committee members. There is

[1]The DSIC has approved the following definition of a performance specification: "A performance specification states requirements in terms of the required results with criteria for verifying compliance, but without stating the methods for achieving the required results. A performance specification defines the functional requirements for the item, the environment in which it must operate, and interface and interchangeability characteristics." [Reference 14]

usually a period during which a new standard is made available to industry and other interested parties for review and comment before formal approval. After review and approval, a standard is issued under the banner of some sponsoring organization such as IEEE or the International Organization for Standardization (ISO). The use of a standard is not enforced by the sponsoring organization. The use of standards may be voluntary or may be made part of a contract or development agreement.

2.1.2 Standards Organizations

There are several NGSB whose work relates to software engineering. The major NGSB that develop or facilitate the development of software engineering standards of interest to DOD include: ISO, American National Standards Institute (ANSI), IEEE, and Electronic Industries Association (EIA). Appendix B provides the addresses and World Wide Web (WWW) locations for these organizations.

2.1.2.1 International Organization for Standardization

ISO is composed of national standards bodies from approximately 100 countries, one member body from each country. The U.S. member body to ISO is ANSI. ISO is a non-governmental organization whose purpose is to promote the development of standardization in order to facilitate international trade and technology transfer; its activities culminate in published international standards. ISO addresses all fields except electrical and electronic engineering; standardization efforts in those fields are accomplished by the International Electrotechnical Commission (IEC). However, joint ISO/IEC working groups or technical committees may be formed; for example, ISO/IEC Joint Technical Committee 1 (JTC 1) addresses the field of information technology [Reference 21]. ISO/IEC developed ISO/IEC 12207: 1995, *Information Technology - Software Life Cycle Processes* [Reference 23].

ISO developed the 9000 series of standards for quality management and quality assurance (including software quality), and offers the ISO 9000 News Service to give the facts on ISO 9000. More information on this subject and ISO standards can be found at the ISO WWW home page. (See Appendix B.)

2.1.2.2 American National Standards Institute

ANSI is a private, nonprofit organization that is supported by both private and public sector organizations. ANSI's objective is to improve the level of professionalism and U.S. business competitiveness at the global level by promoting standards and conformity assessment systems. ANSI facilitates the development of American National Standards and represents the interests of company, government agency, institutional, and international members. ANSI is the U.S. member body to ISO, and is a permanent member of the governing ISO Council. ANSI also

represents the U.S. in the IEC via the U.S. National Committee [Reference 2]. More information can be found at the ANSI WWW home page. (See Appendix B.)

2.1.2.3 Institute of Electrical and Electronics Engineers

The IEEE is an accredited standards body whose members represent users, vendors, and engineering professionals. IEEE standards are developed by the technical committees of IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Each IEEE standard is reviewed at least once every five years [Reference 22].

The IEEE Computer Society Software Engineering Standards Committee (SESC) develops and maintains a collection of approximately 50 standards which grows at the rate of about 5 standards a year. Information on these standards has been included in this revision of this document. More information on the IEEE SESC software engineering standards collection can be found in the book, *Software Engineering Standards: A User's Road Map*, by James W. Moore [Reference 20].

The IEEE produces a number of journals and periodicals relating to software engineering, including the following: *IEEE Transactions on Software Engineering*, *Software Engineering Notes*, *IEEE Computer*, and *IEEE Software*. More information can be found at the IEEE WWW home page. (See Appendix B.)

2.1.2.4 Electronic Industries Association

EIA is an accredited standards organization that develops standards in a number of areas, including software. The EIA Software Committee, G-34, "prepares and coordinates positions on policies, practices, standards, and specifications dealing with the life cycle of software from conceptualization through retirement" [Reference 18]. The Software Committee serves as the EIA's focus for monitoring industry and government activities relating to software. More information can be found at the EIA Engineering and Operations Council WWW home page. (See Appendix B.)

2.1.3 Other Sources of Guidance

Standards do not cover every software engineering contingency. Guidebooks and training courses are available to address many topics essential to successful software engineering programs. Some of the key sources for software engineering technology are described below using information from their Internet WWW home pages. Appendix C provides the WWW locations for the sources of guidance discussed in this section.

2.1.3.1 Association for Computing Machinery

The Association for Computing Machinery (ACM) publishes numerous journals and periodicals on computer-related issues including one devoted exclusively to software engineering: ACM *Transactions on Software Engineering and Methodology* (TOSEM). Other ACM journals and periodicals related to software engineering include: *Communications of the ACM*, *Transactions on Programming Languages and Systems*, *Transactions on Computer Systems*, *Transactions on Information Systems*, *Journal of Experimental Algorithms*, *Transactions on Modeling and Computer Simulation*, and *Ada Letters*. More information can be found at the ACM WWW home page. (See Appendix C.)

2.1.3.2 Software Technology Support Center

The U. S. Air Force (USAF) Software Technology Support Center (STSC) helps USAF and other DOD organizations identify, evaluate, and adopt technologies that improve software product quality, production efficiency, and predictability.

The STSC uses the term "technology" in its broadest sense to include processes, methods, practices, techniques, and tools that enhance human capability. The focus is on field-proven technologies that will benefit the USAF mission. The STSC goes beyond identification and evaluation of technologies by providing hands-on help in exploiting and incorporating these technologies.

The STSC provides five main services to its customers:

a. Software Technology Conference (STC). Held annually in Salt Lake City, Utah, this forum for over 3,000 software professionals shares lessons learned in acquiring, developing, and supporting software-intensive systems.

b. *CrossTalk – The Journal of Defense Software Engineering*. This official DOD publication features articles, reports, and opinions from the software community that instruct, inform, and educate its readers. The journal is free upon request and has a monthly circulation of over 19,000. It is designed for professionals who develop or maintain defense software, manage defense software, create tools used in software production, or educate software practitioners. Each issue contains:

    - New ideas on software improvement.
    - Lessons learned on adopting technology.

- The latest high level policy decisions.
- Authors from all branches of the DOD.
- Authors from academia and industry.

c. Software Technology On-Line. This one-stop WWW page [Reference 34] on the Internet provides access to meaningful software information. In addition to electronic access to STSC information, it provides pointers to resources across the nation designed to increase customer awareness and enhance understanding of software practices.

d. Technical Evaluation Services. The STSC provides experienced resources to help identify, pare down, evaluate, and select proven technologies that improve software production. These services are available on a cost-recovery basis and take the form of research, validation, demonstration, evaluation, comparison, analysis, and recommendations. The STSC specializes in Ada, configuration management, documentation, formal inspections, project management, process definition, reengineering, requirements engineering, reuse, software design, software estimation, software measurement and metrics, software quality engineering, software testing, and software acquisition.

e. Technical Consulting Services. The STSC provides experienced software engineers to help customers assess, prepare, plan, apply, and effectively use software technologies. These services are available on a cost-recovery basis and take the form of assessments, workshops, counseling, or application projects. The STSC offers this service for the technologies mentioned in the Technology Evaluation Services discussion above.

More information can be found at the USAF STSC WWW homepage. (See Appendix C.)

2.1.3.3 Software Productivity Consortium

The Software Productivity Consortium (SPC), a nonprofit organization of industry, government, and academia, develops processes, methods, tools, and services that significantly improve the ability of its members and affiliates to build high-integrity, software-intensive systems. The SPC helps its more than 60 members rapidly implement the processes, methods, and technologies needed for the entire life cycle of software and systems development. The SPC technical program offers an integrated approach to systems and software process improvement, rapid application development, product line engineering (including software reuse), requirements analysis, and systems and software design, development, and measurement. The consortium also publishes guidebooks and conducts training classes [Reference 31]. More information can be found at the SPC WWW home page. (See Appendix C.)

2.1.3.4 Software Engineering Institute

The Software Engineering Institute (SEI) is a Federally-Funded Research and Development Center (FFRDC) sponsored by the DOD and operated by Carnegie Mellon University. It develops models, frameworks, diagnostics, methods, standards, techniques, and architectures that help its customers to make measured improvements in their software engineering capability. It offers training classes and publishes reports and guidebooks, but no periodicals.

SEI and the software community developed the Capability Maturity Model (CMM) for Software, a model for judging the maturity of the organizational and managerial processes of an organization and for identifying the key practices that are required to increase the maturity of these processes. The CMM has become a standard for assessing and improving software processes. Through the CMM, the SEI and community have put in place an effective means for modeling, defining, and measuring the maturity of organizational and managerial processes used by software professionals [Reference 30]. The CMM, Version 1.1, includes the *Capability Maturity Model for Software, Version 1.1* [Reference 27] and *Key Practices of the Capability Maturity Model, Version 1.1* [Reference 28]. The SEI has begun work on CMM Version 2 and expects to release Version 2.1 in 1998 for full-scale transition from Version 1.1. The SEI has also developed the *People Capability Maturity* to provide guidance to organizations to improve the way they address the people-related issues involved in developing and maintaining software and information systems [Reference 29].

More information can be found at the SEI WWW home page. (See Appendix C.)

2.1.3.5 Software Program Managers Network and Best Practices Initiative

The Software Program Managers Network (SPMN), in which project offices from all services and Office of the Secretary of Defense (OSD) agencies participate, is a fundamental mechanism for improving the acquisition of large-scale software systems by identifying highly-effective practices from industry and government, and conveying those practices to software managers and practitioners. This effort is DOD's Best Practice Initiative (BPI). These best practices directly address the underlying cost and schedule drivers that cause software to be delivered over budget, late, and with diminished performance capability.

Culled from a nomination and review process, the best practices and lessons-learned are disseminated through Direct Satellite Broadcasts, the SPMN *NetFocus* newsletter, workshops, symposia, guidebooks, videotapes, audio tapes, and the SPMN web site [Reference 13].

More information on the SPMN and the related BPI can be found at the SPMN WWW home page. (See Appendix C.)

2.1.3.6 Defense Systems Management College

The Defense Systems Management College (DSMC) is a DOD educational institution. Its mission is to conduct advanced courses of study that prepare selected military officers and civilian personnel for program management assignments and to conduct research and disseminate information concerning new methods and practices in program management. The DSMC is part of a consortium of DOD acquisition schools comprising the Defense Acquisition University (DAU) [Reference 8]. More information can be found at the DSMC WWW home page. (See Appendix C.)

2.2 DOD Single Stock Point for Military Specifications and Standards Acquisition Streamlining and Standardization Information System Data Base

The DODSSP at the Defense Automated Printing Service, Philadelphia, PA, is the official DOD single stock point for military specifications, standards, and related documents. The ASSIST, an evolving database system for DOD-wide Standardization Program information management, is maintained by the DODSSP. ASSIST includes four parts: the DOD Index of Specifications and Standards (DODISS), the SD-1 Standardization Directory, the SD-4 Status of Standardization Projects, and the Acquisition Management Source Data List (AMSDL). The DODISS consists of the following parts:

- Part I: an alphabetic listing of all current standardization documents in order by document title, plus all standardization documents canceled since the last basic DODISS edition.
- Part II: a numerical listing of all current standardization documents in order by document identifier number, plus all standardization documents canceled since the last basic DODISS edition.
- Part III: a Federal Supply Class (FSC) listing of all current standardization documents in alphabetical order within each FSC, plus all standardization documents canceled since the last basic DODISS edition.
- Part IV: a numerical listing of all standardization documents canceled from 1964 to the date of the DODISS edition at hand. This part is a triennial publication.

The SD-1 indicates the responsibilities of all activities with an interest in the Defense Standardization Program. The SD-4 contains standardization project tracking data. The AMSDL is an index of all active and canceled Data Item Descriptions (DID) [Reference 7].

More information can be found at the DODSSP WWW home page. (See Appendix C.)**2.3**

2.3 Types of Software Standards

This section discusses the various types of standards related to software engineering.

2.3.1 Software Life Cycle Standards

MIL-STD-498**,** *Software Development and Documentation***,** was cancelled on 27 May 98 and has been replaced by IEEE/EIA 12207, *Industry Implementation of ISO/IEC 12207:1995* , "Information technology (IT)-Software life cycle processes".

EIA/IEEE J-STD-016-1995, Software Development Acquirer-Supplier Agreement (Issued for Trial Use) is available and can be used in its trial form until full use form is available.

A brief summary of the contents of these standards follows.

2.3.1.1 ISO/IEC 12207: 1995

ISO/IEC 12207: 1995, *Information Technology - Software Life Cycle Processes*, was prepared by the ISO/IEC JTC1, Information Technology, Subcommittee 7, Software Engineering. This international standard establishes a common framework for software life cycle processes, with well-defined terminology, that can be referenced by the software industry. It contains processes, activities, and tasks to be applied during the acquisition of a system containing software, a stand-alone software product, and software services. It also applies during the supply, development, operation, and maintenance of software products. Software includes the software portion of firmware. This standard also provides a process that can be employed for defining, controlling, and improving software life cycle processes [Reference 23]. The standard will be used with country-specific implementations such as IEEE/EIA 12207.

ISO/IEC groups the activities that may be performed during the life cycle of software into primary, supporting, and organizational life cycle processes. The five primary life cycle processes are acquisition, supply, development, operation, and maintenance. The eight supporting life cycle processes include documentation, configuration management, quality assurance, verification, validation, joint review, audit, and problem resolution. The four organizational life cycle processes are management, infrastructure, improvement, and training.

2.3.1.2 IEEE/EIA 12207

IEEE/EIA 12207 is the United States implementation of ISO/IEC 12207 approved by IEEE 9 Dec 98. It consists of three parts:

- IEEE/EIA 12207.0, *Industry Implementation of ISO/IEC 12207:1995, Standard for IT-Software life cycle processes*,
- IEEE/EIA 12207.1, *Industry Implementation of ISO/IEC 12207:1995, Standard for IT-Software life cycle processes-Life cycle data*,

- IEEE/EIA 12207.2, *Industry Implementation of ISO/IEC 12207:1995, Standard for IT-Software life cycle processes-Implementation considerations.*

IEEE/EIA 12207.0 contains ISO/IEC 12207 in its original form and six additional annexes: Basic concepts, Compliance, Life cycle process objectives, Life Cycle data objectives, Relationships, and Errata. IEEE/EIA 12207.0 consists of the clarifications, additions, and changes accepted by IEEE and EIA and contains concepts and guidelines to foster better understanding and application of ISO/IEC 12207.

IEEE/EIA 12207.1 provides guidance on life cycle data resulting from the processes of IEEE/EIA 12207.0. It describes the relationship among the following: the content of the life cycle data information items, references to documentation of life cycle data in IEEE/EIA 12207.0, and sources of detailed software product information.

IEEE/EIA 12207.2 provides guidance in implementing the process requirements of IEEE/EIA 12207.0. The guidance is intended to summarize the best practices of the software industry in the context of the process structure provided by ISO/IEC 12207.

2.3.1.3 EIA/IEEE J-STD-016

This standard is best regarded as a “demilitarized” version of MIL-STD-498. It describes a set of software development activities and related products performed in the context of a two-party agreement. EIA/IEEE J-Std-016 -1995 is being revised to incorporate the harmonization recommendations and trial use experience and to promote it from its current status as an EIA Interim Standard to the status of a full-use standard.

2.3.2 Data Element Standards

FIPS PUB 184, *Integration Definition for Information Modeling (IDEFIX)* [Reference 24], and DOD 8320.1-M-1," DOD Data Standardization Procedures" [Reference 6], provide procedures for data modeling. DOD 8320.1-M-1 also contains procedures for data definitions for the Defense Data Dictionary System (DDDS).

2.3.3 Modeling and Simulation Standards

2.3.3.1 High-Level Architecture for Simulations

The DOD High-Level Architecture (HLA) for Simulations is a common high-level simulation architecture to which models and simulations must conform. The HLA baseline was completed on August 21, 1996. It was approved by the Under Secretary of Defense for Acquisitions and Technology as the standard for DOD simulations on September 10, 1996. More information can be found at the Defense Modeling and Simulation Office (DMSO) WWW home page. (See

Appendix C.) HLA was adopted as the Facility for Distributed Simulation Systems 1.0 by the Object Management Group (OMG) in November 1998 and is in the process of becoming an open standard , IEEE P1516.

2.3.3.2 IDEF (Integrated Definition)

IDEF is a modeling language, combining graphics and text, used to analyze and define functions and requirements of a system. Three IDEF notations were developed:

- IDEF 0 for function models
- IDEF 1 for information models
- IDEF 2 for dynamics models

FIPS PUB 183, *Integration Definition for Function Modeling (IDEF 0)*, 1993, describes the IDEF 0 modeling language, and associated rules and techniques, for developing structured graphical representations of a system or enterprise. Use of this standard permits the construction of models comprising systems functions, functional relationships, and data that supports systems integration.

FIPS PUB 184, *Integration Definition for Information Modeling (IDEF1x)*, 1993, describes the IDEF1X modeling language and associated rules and techniques, for developing a logical model of data. IDEF1X is used to produce a graphical information model which represents the structure and semantics of information within an environment or system.

IEEE 1320.1-1998, *Standard for Functional Modeling Language, Syntax and Semantics for IDEF 0*, (1998), describes the syntax and semantics of the IDEF 0 language that are required to draw the physical diagrams of a specific IDEF 0 model.

IEEE 1320.2-1998, *Standard for Conceptual Modeling Language Syntax and Semantics for IDEF1X*, (1998), defines the semantics and syntax of IDEF1X.

2.3.4 Interface Standards

ISO/IEC 12227: 1995, *Information Technology - Programming Languages - SQL/Ada Module Description Language (SAMeDL)*, specifies a standards interface between the Ada programming language and Structured Query Language (SQL)-compliant database management systems.

FIPS PUB 151-2 and the ISO/IEC 9945/IEEE 1003.1 series provide system interface extensions for Portable Operating System Interface (POSIX).

2.3.5 Data Interchange Standards

Data interchange services provide specialized support for representing, storing, accessing, and transmitting data. The lessons learned in the recent conflicts of Desert Shield/Desert Storm have resulted in DOD efforts to establish the capability to readily exchange information throughout current systems and new acquisitions. Joint and interoperable systems are part of the new doctrine. A piece of the puzzle is to develop a standardized approach to data (such as files, images, graphics, etc.) among all tactical, strategic, and sustaining base systems that produce, use, or exchange information electronically. The JTA, AITS, and ITSG discuss various data interchange standards and provide a number of references to standards that support this requirement. More information on this subject can be found in those documents at the DISA CFITS WWW home page. (See Appendix C.)

Continuous Acquisition and Life-Cycle Support (CALS) is a core strategy for sharing integrated digital product data through a set of standards to achieve efficiencies in business and operational mission areas. Within DOD, the CALS objectives are to:

a. Reduce process cycle times and the cost of operations by accelerating and maximizing the use of shared digital product data.

b. Achieve business process improvements by acquiring, managing, and using product data in standard digital forms and working toward paperless operations.

c. Implement a shared infrastructure by developing a common operating environment and fostering interoperability among DOD, industry, and international partners.

More information can be found at the OSD CALS WWW home page. (See Appendix C.)

2.3.6 Software Metrics Standards

Software metrics are a means of obtaining insight into project status and risks. The following are examples of core metrics:

- Size
- Effort
- Schedule
- Software quality
- Rework

IEEE Standard 1061, *Standard for a Software Quality Metrics Methodology*, 1998, provides a methodology for establishing quality requirements and identifying, implementing, analyzing, and validating process and product software quality metrics. This methodology applies to all

software at all phases of any software life cycle. This standard does not prescribe specific metrics. The following are approaches to metrics used by the DOD:

The SEI established a framework for software measurement. More information can be found at the SEI WWW home page. (See Appendix C.)

The USAF STSC developed the *Software Metrics Capability Evaluation Guide*, Version 2.0, October 1995 [Reference 33], which documents the STSC approach for assessing an organization's software metrics capability. The STSC approach uses metrics-related themes to address software development, measurement, and project control. More information can be found at the USAF STSC WWW home page. (See Appendix C.)

In addition, the Joint Logistics Commanders Joint Group on Systems Engineering developed *Practical Software Measurement, A Guide to Objective Program Insight*, Version 2.1, March 27, 1996 [Reference 10]. More information can be found at the Joint Logistics Commanders Joint Group on Systems Engineering WWW home page. (See Appendix C.)

2.3.7 Configuration Management Standards

Configuration management is the process of applying administrative and technical procedures throughout the software life cycle to identify, define, and baseline configuration items for software in a system; controlling modifications and releases of the items; recording and reporting the status of the items and modification requests; ensuring the completeness and correctness of the items; and controlling the storage, handling, and delivery of items. MIL-STD-973, *Configuration Management*, will most likely be canceled once a plan to transition to the use of an NGS is in place. The ITSG recommends EIA 649, *National Consensus Standard for Configuration Management*. More information can be found in the ITSG at the DISA CFITS and at the Aerospace Industries Association (AIA) Early Warning Project Group WWW home pages. (See Appendix C.) IEEE Std 828-1998, *Standard for Software Configuration Plans*, prescribes the minimum required contents of a software configuration management plan. IEEE Std 1042-1993, *Guide to Software Configuration Management*, provides a technical and philosophical overview of the software configuration management planning process.

2.3.8 Quality Assurance Standards

Software quality assurance standards provide a planned and systematic pattern of all actions necessary to provide adequate confidence that a software work product conforms to established technical requirements. The ITSG recommends ISO 9001, ISO 9000-3, IEEE 1298, and ANSI/IEEE 730. More information can be found in the ITSG at the DISA CFITS WWW home page. (See Appendix C.) IEEE Std 730-1998 provides minimum requirements for the content and preparation of a Software Quality Assurance plan for the development and maintenance of software.

2.3.9 System Testing Standards

The ability to validate conformance of an implementation with the specified standard may be crucial to the attainment of the required capabilities. This is especially important for those implementations with interoperability requirements. The NIST Information Technology Laboratory (ITL) maintains a Validated Products List (VPL) that identifies information technology products that have been tested for conformance to FIPS PUB in accordance with ITL testing procedures, and have a current validation certificate or registered report. The VPL includes conformance testing information for programming languages (Ada, COBOL, Fortran, Pascal, C, and MUMPS), SQL, and POSIX. More information can be found at the NIST VPL WWW home page. (See Appendix C.)

IEEE 829--1998, *Standard for Software Test Documentation*, IEEE 1008-1993, *Standard for Software Unit Testing*, IEEE 1012-1998, *Standard for Software Verification and Validation*, and IEEE Std 1044-1993, *Standard for Classification of Software Anomalies*, are standards related to software testing and evaluation.

2.3.10 Program Management Standards

Integrated Product Process Development (IPPD) is a management technique that simultaneously integrates all essential acquisition activities through the use of multi-disciplinary teams to optimize the design, manufacturing, and supportability processes. A key tenet of IPPD is multi-disciplinary teamwork through integrated product teams. Guidance on IPPD and other project management issues can be found in the Defense Acquisition Deskbook. (See Appendix C.) IEEE 1058-1998, *Standard for Software Project Management Plans*, describes the format and content of software project management plans. It is intended to be applicable to software projects of any size or type.

2.3.11 Risk Management Standards

Risk management consists of the following activities:

- Identification, analysis, and prioritization of the areas of a software development project involving potential technical, cost, or schedule risks.
- Development of strategies for managing those risks.
- Recording the risks and strategies.
- Implementing the strategies.

Risk management is vital to the success of any software engineering effort. The risk management process requires corporate acceptance of risk as a major consideration for software program management, commitment of program resources, and formal methods for identifying, monitoring, and managing risk. More information can be found at the DOD SPMN, SEI, and the USAF STSC WWW home pages. (See Appendix C.)

2.3.11.1 Software Reliability Standards

AIAA R-013, which is a recommended practice for software reliability, particularly within the context of aerospace systems, defines software reliability engineering as the application of statistical techniques to data collected during system development and operation to specify, predict, estimate, and asses the reliability of software-based systems. IEEE Std 982.1-1988, *Standard Dictionary of Measures to Produce Reliable Software*, is a dictionary of measures for the production of reliable software. IEEE Std 982.2-1998, provides guidance on how the measures in IEEE Std 982.1 can be applied as a part of a software reliability engineering program.

2.3.11.2 Software Safety Standards

Software safety is a discipline different from software reliability. While reliability deals with all possible software errors, the safety discipline concerns itself with those errors that cause or fail to mitigate system hazards. IEEE Std 1228-1993, *Standard for Software Safety Plans*, establishes minimum acceptable requirements for the content of a Software Safety Plan.

2.3.12 Acquisition Standards

DODD 5000.1 provides the policies and the broad management principles for DOD acquisition programs. The directive applies to all elements of DOD. It requires that performance specifications be used when purchasing new systems, major modifications, and commercial and nondevelopmental items. Performance specifications include DOD performance specifications, commercial item descriptions, and performance-based NGS. If use of a performance specification is not practicable, an NGS shall be used. The directive notes that there may be cases where military specifications are needed to define an exact design solution because there is no acceptable NGS or because the use of a performance specification or NGS is not cost effective, not practical, or does not meet the user's needs. In those cases, the directive authorizes, as a last resort, the use of military specifications and standards with an appropriate waiver or exception from the Milestone Decision Authority.

DOD 5000.2-R implements the policies and principles of DODD 5000.1, the guidelines of OMB Circular 109 and current statutes.

In May of 1995, the Secretary of Defense directed acquisition programs to apply the Integrated Product and Process Development concept of using Integrated Product Teams (IPTs) for as many acquisition functions as possible, including oversight and review. The IPT supports the Major Automated Information Systems Review Council (MAISRC) process. The IPT process simultaneously takes advantage of all members' expertise as a basis for detailed insight into project progress and risks and allows the MAISRC to focus on project specific critical areas and other issues requiring high level decisions.

IEEE 1062-1993, *Recommended Practice for Software Acquisition*, is the key IEEE standard for the software acquisition process. It provides a set of practices that are useful in the management and execution of software acquisition. The practices encompass nine steps covering a broad scope ranging from planning the overall strategy through follow-up on the use of the acquired software. This document includes an annex with software acquisition checklists.

2.3.13 Programming Language Standards

Certification of conformance to the source language specification results in a higher degree of portability across platforms for programming languages. Public Law 102-172 requires that all DOD software be written in Ada, unless a waiver is granted. The Assistant Secretary of Defense for Command, Control, Communications, and Intelligence is the designated DOD Ada waiver review authority. ANSI/ISO/IEC 8652, *Ada*, is adopted by FIPS PUB 119-1. More information can be found in the ITSG at the DISA CFITS WWW home page. (See Appendix C.)

2.3.14 Language Bindings Standards

Language bindings are interfaces to operating systems, network software, graphical user interfaces, database management systems, and other system software specific to a programming language. IEEE 1003.5: 1992, *POSIX Ada Language Interfaces, Part 1: Binding for System API*, and IEEE 1003.9, *POSIX Fortran 77 Language Interfaces, Part 1: Binding for System API*, are two important standards in this area. More information can be found in the ITSG at the DISA CFITS WWW home page. (See Appendix C.)

3.0 ASSESSING ADEQUACY OF STANDARDS FOR DOD PROGRAMS

Commercial standards must be assessed to ensure that they fulfill DOD requirements for a given contract. This should be done as early in the acquisition process as possible. It is also necessary to evaluate products that claim conformance to a standard. This can be done through branding and validation programs.

Acquisition Reform policy promotes the use of commercial standards and contractor selection of an approach to software development based on their choice of standards and practices. Although Requests for Proposals (RFP) can require the use of specific commercial standards, the government acquirer is encouraged to provide guidance but allow the contractor to make the choice, even including their own proprietary standards and practices. Even if the acquirer specifies the standards to be used, or agrees to standards before signing the contract, the contractor can change their software process later and request modifications of their contract, under the Single Process Initiative[2]. Thus, the acquirer needs to be knowledgeable about available standards and practices, the purpose they serve, and their evaluation. The acquirer initially should provide guidance about preferred standards, then evaluate the approach in an offer's proposal and negotiate improvements within the tight window of source selection and contract finalization. Finally, the acquirer should evaluate proposed changes under the Single Process Initiative, where there is again an unreasonably tight window for evaluation by software engineering experts.

Although DOD relies on NGS and developer practices, DOD has some specialized needs as well as a vested interest in the use of effective, mature software practices. Compliance/competence in relevant Key Practice Areas of the Capability Maturity Model should be required. When NGS are used as a basis for the government acquisition of mission-critical, complex, unprecedented software, contract language will have to be used to ensure compliance with critical provisions of standards, to ensure the use of mature software practices, to place enforceable requirements on the developer's process, and to ensure that the acquirer has visibility into the development process. Those involved in source selection will need to be aware of compliance "loopholes," i.e., where standards provide guidance rather than requirements and how developers tailor those requirements that would be imposed by the standards.

3.1 DOD Acquisition Process

[2]The Single Process Initiative is a policy announced December 8, 1995, by then Secretary of Defense William Perry to implement the use of common processes and performance specifications on existing DOD contracts. It involves the consolidation or elimination of multiple processes, specifications, and standards in all contracts on a facility-wide basis, rather than on a contract-by-contract basis.

The DOD acquisition process is divided into several stages as defined in DODD 5000.1 and DOD 5000.2-R. These are:

- Preacquisition process: determination of mission needs and identification of deficiencies.
- Concept Exploration (phase 0).
- Program Definition and Risk Reduction (phase I).
- Engineering and Manufacturing Development (phase II).
- Production, Fielding/Deployment, and Operational Support (phase III).
- Demilitarization and Disposal.

The acquisition process can be tailored, subject to applicable statutes, "to minimize the time it takes to satisfy an identified need consistent with common sense and sound business practice" [Reference 5].

Standards which may apply to a given program should be identified by the program office before the RFP is written, preferably in phase 0 or earlier. There are also lists of mandated standards for each generic type of program which should be consulted. There are some mandated standards, but, in general, DOD's goal is to minimize specifying in RFP which standards a developer must use. In particular, the elimination of government-specific specifications and standards (such as MIL-STD) to the greatest degree possible is the desired goal. The program office can identify and require standards that are exempt from the requirements for a waiver. Waivers are required if non-exempt government standards are specified. Offer's should be requested to describe how their software process meets the objective of a consistent, comprehensive standard or set of standards, so that government persons performing source selection have a useable basis for the comparison of proposals. The developers must specify their approach to using standards and practices. In evaluating the developers' proposals, the government must determine gaps and conflicts in the proposed standards and practices. The program office can contact DISA CFITS for guidance in this evaluation.

The developer will review the standards identified in the RFP while preparing the proposal and, after contract award, while preparing the software development plan (SDP). If the developer finds gaps or conflicts, or wants to propose its own software process within the proposal, the developer may request a clarification from the program office or propose an alternate approach, citing the differences, "risks" and improvements in the alternative. After contract award, the developer can propose an alternate process under the Single Process Initiative.

Furthermore, the program office, the developer, or some other party may find gaps or conflicts in standards at any point in the acquisition and development cycle. The program office should contact its standards representatives who will then coordinate with DISA CFITS and process the recommendations through working groups to the standards bodies.

Solutions may already exist for some problems, and the originator or the program office should check for them. Standards bodies publish statements in response to requests for the clarification or interpretation of standards. One of these may answer the problem at hand. There are also FIPS PUB which may help explain how to use or apply specific standards.

If none of these sources provide a resolution of the problem, it is recommended that it be forwarded to DISA CFITS as discussed in section 4.0. DISA CFITS may be able to provide short term solutions or will forward the problem to an appropriate technical working group.

The Defense Acquisition Deskbook is an automated acquisition reference tool sponsored by the Deputy Under Secretary of Defense for Acquisition Reform (DUSD(AR)) and the DUSD for Acquisition and Technology (A&T) that provides DOD acquisition information for all services across all functional disciplines. The Defense Acquisition Deskbook concept provides the opportunity to support a basic change in the acquisition culture. It provides an easy-to-use, automated information retrieval system and real-time access to the most current acquisition information. It is a primary acquisition reference tool for the entire DOD acquisition workforce, a means to integrate disciplines and a vehicle to communicate acquisition reform. The system includes DOD directives appropriate to the Air Force, Army, Navy, Marine Corps, Defense Logistics Agency (DLA), and Special Operations Command (SOCOM). The Defense Acquisition Deskbook is a Windows 3.1/Windows 95 program. The user may run Deskbook on either a CD-ROM drive or a local drive (120MB). New versions are released quarterly and can be obtained by order form or by downloading from the Deskbook distribution home page (http://129.48.195.226/deskdist.html). Deskbook is updated quarterly. For additional information, call the Customer Support Desk at (513) 255-0423 or DSN 785-0423. (There is no cost to federal government organizations.) More information can be found at the Defense Acquisition Deskbook WWW home page. (See Appendix C.)

3.2 Validation and Branding

In addition to selecting open, approved standards, it is important to ensure that there are products available conforming to the standard. It does no good to specify a standard in a procurement document if no one builds products to meet the specifications. The best way to be sure products meet all the requirements of a specification is to buy products that are validated or branded by a standards organization.

The *Federal ADP and Telecommunications Standards Index* [Reference 36] describes the validation process. The three validation methods recognized by NIST are formal validation, offer certification, and capability demonstration. Each method has benefits and limitations.

3.2.1 Formal Validation

Formal validation requires four components: a standard, a test or test method, a test procedure, and formal controlled conditions for conducting the test. The NIST ITL conducts a validation program to determine the degree in which information technology products conform to specific FIPS. Ada products are validated by the Ada Joint Program Office. Products that pass the validation process are listed in the VPL. More information can be found on the NIST ITL VPL WWW home page. (See Appendix C.)

The formal validation process can save money and time because the costs of validation are borne by the vendor, and offerors can submit their VPL registrations with their proposals. On the other hand, not all standards have formal validations, and there may be a lead time for the validation of products, which may delay the procurement process.

3.2.2 Offerors Certification

The offerors certification method of validation requires the offerors to certify in writing that the products offered conform with the referenced standard. This method is quick and inexpensive; however, there is no assurance that the offeror has not misrepresented conformance to the standard.

3.2.3 Capability Demonstrations

Capability demonstrations may be used as part of an agency's evaluation strategy to verify proposals. They are conducted during live test demonstrations or operational capability benchmark demonstrations. Capability demonstrations may be used in conjunction with offeror certifications to determine the level of compliance of products. These demonstrations are intended to provide verification of feasibility of design, manufacturing, or compliance with system requirements.

3.2.4 Branding

X/Open Company Limited, which combined with the Open Software Foundation to form The Open Group (TOG), conducts an extensive product branding program. When a vendor receives an X/Open brand on a product, it guarantees three things to the buyer: that the product conforms to the TOG specification, that it will continue to conform as the product is revised, and that any non-conformance that may occur will be fixed. This guarantee simplifies the procurement process by reducing or eliminating the need for testing and by making it easier to prepare procurement documents and compare bids.

3.3 Process Validation

Process validation assesses the likelihood of an offerors software process to produce quality products. Two areas of process validation are the software process assessment of the offerors software process, based on the CMM, and the examination of the offerors compliance with ISO 9000-3: 1991.

3.3.1 Software Process Assessment

The set of products based on the SEI-developed CMM "includes diagnostic tools, which are used by software process assessment and software capability evaluation teams to identify strengths, weaknesses, and risks of an organization's software process" [Reference 27]. "A software process assessment is an appraisal by a trained team of software professionals to determine the state of an organization's current software process, to determine the high priority software process-related issues facing an organization, and to obtain the organizational support for software process improvement" [Reference 27]. A software capability evaluation consists of "an appraisal by a trained team of professionals to identify contractors who are qualified to perform the software work or to monitor the state of the software process used on an existing software effort" [Reference 27]. More information can be found at the SEI WWW home page. (See Appendix C.)

3.3.2 ISO 9000-3 Certification

ISO 9000-3: 1991, *Quality Management and Quality Assurance Standards - Part 3: Guidelines for the Application of ISO 9001 to the Development, Supply, and Maintenance of Software*, amplifies (for the software life cycle process) the generic quality process discussed in ISO 9001: 1987, *Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing* [Reference 22]. ISO 9000-3: 1991 deals primarily with situations where specific software is developed as part of a contract according to the purchaser's specifications. At present, DOD does not require third party registration or certification of DOD contractors using ISO 9000-3. This is because there are no nationally accredited certification bodies for ISO 9000-3, and the expense does not justify the effort required for registration or

certification. More information can be found in *Crosstalk* articles on the USAF STSC home page. (See Appendix C.)

4.0 ADDRESSING DEFICIENCIES

The maintenance of standards is a complex process involving the experts who sit on the standard setting committees, the technicians who implement them, and all those in between. This section provides a brief discussion of how standards are maintained and how deficiencies encountered on DOD programs should be reported.

Organizations such as IEEE welcome recommendations for revision of their standards from any interested party. However, where DOD development programs are concerned, the DUSD(A&T) has responsibility for system engineering issues. It is recommended that any problems or change recommendations concerning information processing standards issues be worked in conjunction with the Software Support Agencies (SSA) and submitted through the individual services standards offices. The individual service standards representatives will coordinate with DISA CFITS and process the recommendations through appropriate working groups to the standards bodies.

A deficiency report or change request should include the following information:

- Statement of problem addressed - Describe the problem identified and why a change is needed.
- Suggested change - Recommend specific wording to replace the affected sections of the current standard.
- Point of contact - Provide the name, phone number, e-mail, and postal address of the individual recommending the change.

Mail the recommended change to:

Mr. James Barnette
DISA CFITS/JEBEA
10701 Parkridge
Reston, VA 20191-4357
barnettj@ncr.disa.mil

APPENDIX A - ACRONYMS

ACM	Association for Computing Machinery
AIA	Aerospace Industries Association
AITS	Adopted Information Technology Standards
AMSDL	Acquisition Management Source Data List
ANSI	American National Standards Institute
ASSIST	Acquisition Streamlining and Standardization Information System
BBS	Bulletin Board System
BPI	Business Process Improvement; Best Practices Initiative
BSA	Base Service Area
C4I	Command, Control, Communications, Computers, and Intelligence
CALS	Continuous Acquisition and Life-Cycle Support
CASE	Computer-Aided Software Engineering
CFITS	Center for Information Technology Standards
CMM	Capability Maturity Model
DAU	Defense Acquisition University
DDDS	Defense Data Dictionary System
DID	Data Item Description
DISA	Defense Information Systems Agency
DLA	Defense Logistics Agency
DMSO	Defense Modeling and Simulation Office
DOD	Department of Defense
DODD	DOD Directive
DODISS	DOD Index of Specifications and Standards
DODSSP	DOD Single Stock Point
DSIC	Defense Standards Improvement Council
DSMC	Defense Systems Management College
DSP	Defense Standardization Program
DUSD(AR)	Deputy Under Secretary of Defense for Acquisition Reform
DUSD(A&T)	Under Secretary of Defense (Acquisition and Technology)
ECMA	European Computer Manufacturers' Association
EIA	Electronic Industries Association
FFRDC	Federally Funded Research and Development Center

FIPS PUB Federal Information Processing Standards Publication
FSC Federal Supply Class

HLA High Level Architecture

IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers
IPPD Integrated Product and Process Development
IPSC Information Processing Standards for Computers
IPT Integrated Product Team
ISO International Organization for Standardization
IT Information Technology
ITL Information Technology Laboratory
ITSG Information Technology Standards Guidance

J-STD Joint Standard
JTA Joint Technical Architecture
JTC Joint Technical Committee

MAISRC Major Automated Information System Review Council
MIL-HDBK Military Handbook
MIL-SPEC Military Specification
MIL-STD Military Standard
MLSA Mid-Level Service Area
MSA Major Service Area

NGS Non-government standard
NGSB Non-government standards bodies
NIST National Institute of Standards and Technology

OSD Office of the Secretary of Defense
OSE Open System Environment

POSIX Portable Operating System Interface for Computing Environments
PUB Publication

RFP Request for Proposals

SDO Standards Development Organization
SDP Software Development Plan

SEE	Software Engineering Environments
SEI	Software Engineering Institute
SESWG	Software Engineering Standards Working Group
SOCOM	Special Operations Command
SPC	Software Productivity Consortium
SPMN	Software Program Managers Network
SQL	Structured Query Language
SSA	Software Support Agency
STC	Software Technology Conference
STSC	Software Technology Support Center
TAFIM	Technical Architecture Framework for Information Management
TOG	The Open Group
TOSEM	Transactions on Software Engineering and Methodology
USAF	U.S. Air Force
VPL	Validated Products List
WWW	World Wide Web

APPENDIX B - STANDARDS ORGANIZATIONS

Organization	Address	WWW ADDRESS
International Organization for Standardization (ISO)	Central Secretariat 1, rue de Varembe Case postale 56 CH-1211 Geneve 20 Switzerland Phone +41 22 749 01 11	http://www.iso.ch/
American National Standards Institute (ANSI)	11 West 42nd Street New York, NY 10036 Phone 212-642-4900	http://www.ansi.org/
Institute of Electrical and Electronics Engineers (IEEE)	445 Hoes Lane, P.O. Box 1331 Piscataway, NJ 08855-1331 Phone 800-678-4333	http://.stdsbbs.ieee.org/
Electronics Industries Association (EIA), Engineering and Operations Council	2500 Wilson Boulevard Arlington, VA 22201-3834	http://www.eia.org/eng/default.htm#g34

APPENDIX C - STANDARDS GUIDANCE SOURCES

ORGANIZATION	PUBLICATIONS	PHONE	WWW ADDRESS
AIA Early Warning Project Group	N/A		http://www.access.digex.net/~aia/ewpg.html/
ACM	Transactions on Software Engineering and Methodology; Communications of the ACM; Transactions on Programming Languages and Systems; Transactions on Computer Systems; Transactions on Information Systems; Journal of Experimental Algorithmics; Transactions on Modeling and Simulation, Ada Letters	212-869-7440	http://www.acm.org/
Defense Acquisition Deskbook	N/A	513-255-0423	http://www.deskbook.osd.mil/
Defense Standardization Program	The Standardization Newsletter	703-681-9339	http://www.acq.osd.mil/es/std/
DISA CFITS	Joint Technical Architecture; AITS; ITSG		http://www.itsi.disa.mil/
DMSO	N/A		http://www.dmso.mil/
DODSSP/ASSIST	DODISS; SD-1, Standardization Directory; SD-4, Status of Standardization Projects; Acquisition Management Source Data List	215-697-4742	http://www.dodssp.daps.mil/
DSMC	Acquisition Review Quarterly Program Manager	703-805-3734	http://www.dsmc.mil/
IEEE	IEEE Transactions on Software Engineering; Software Engineering Notes; IEEE Computer; IEEE Software	800-678-4333	http://www.ieee.org/
Joint Logistics Commanders, Joint Group on Systems Engineering	Practical Software Measurement		http://diamond.spawar.navy.mil/specs/jlc/psminfo.html/
NIST ITL	N/A		http://www.itl.nist.gov/dir897/
OSD CALS Office	N/A	703-681-3450	http://www.acq.osd.mil.cals/
SEI	N/A	412-268-5800	http://www.sei.cmu.edu/
SPC	Quarterly	703-742-7202	http://www.software.org/

ORGANIZATION	PUBLICATIONS	PHONE	WWW ADDRESS
SPMN	NetFocus	703-521-5231	http://www.spmn.com/
USAF STSC	Crosstalk	801-777-4435	http://www.stsc.hill.af.mil/

APPENDIX D - LIST OF REFERENCES

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