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Implementation Guide for Configuration Management

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References

The publications listed below are related to this handbook:

A. ANSI/IEEE Standard 1042-1987, “Guide to Software Configuration Management”

B. ANSI/IEEE Standard 610.12-1990, “Standard Glossary of Software Engineering Terminology”

C. ANSI/IEEE Standard 830-1994, “Software Requirements Specification, Guide to”

D. ASME Y14.100M, “Engineering Drawing Practices”

E. ASME Y14.24, “Engineering Drawing Types”

F. ASME Y14.34M, “Associated Lists”

G. ASME Y14.35M, “Revisions to Engineering drawings”

H. EIA 632, “Processes for Engineering a System”

I. EIA 836, “Consensus Standards for Configuration Management Data Exchange”

J. ANSI/EIA 859, “Data Management”

K. IEEE[1] /EIA 12207.0, 12207.1 & 12207.2, “Industry Implementation of International Standard ISO/IEC 12207: 1995 (ISO/IEC 12207) Standard for information Technology - Software Life Cycle Processes - Life Cycle Data”

L. IEEE Standard 828-1990, “Software Configuration Management Plans”

M. ISO 10007 “Quality management – Guidelines for configuration management”

N. ISO/IEC 6523-1 "Information Technology - Structure for the Identification of Organizations and Organization Parts - Part 1: Identification of Organization Identification Schemes"

O. ISO 9000 Series Standards and their ASQ[2] equivalents

P. ISO 9000-3, “Quality Program Standard for Software Development"

Q. ISO/DIS 13584-26 - "Parts Library: Logical Structure: Supplier Identification"

R. MIL-HDBK-505, “Definition of Item Levels, Item Exchangeability, Models, and Related Terms”

S. Military Handbook 61 (MIL-HDBK-61A(SE))

T. SEI-93-TR-024, “The Software Engineering Institute’s Software Development Capability Maturity Model (SEI/CMM)“

U. ANSI/EIA-649, “National Consensus Standard for Configuration Management”

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[1] Institute of Electrical and Electronics Engineers

[2] American Society of Quality Control

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V. Capability Maturity Model® Integration (CMMI℠), "CMMI℠ for Systems Engineering, Software, Engineering, Integrated Product and Process Development, and Supplier Sourcing, Continuous Representation," Carnegie Mellon Software Engineering Institute

W. GEIA-HB-859, "Implementation Guide for Data Management."

X. MIL-STD-130, "Identification Marking of U.S. Military Property"

Y. ATA-2000, "E-Business Specification for Materials Management"

Z. ISO/IED 15434, "Information Technology — Syntax for High-Capacity Automatic Data Capture (ADC) Media"

Foreword

ANSI/EIA-649, National Consensus Standard for Configuration Management, published in June, 1998, became an internationally recognized, award-winning canonical basis for CM practice. Revision A, developed in a concerted effort between the DoD and industry, was released in April, 2004 to update and improve the standard. A major objective accomplished by the revision was to limit the standard to the normative principles by which an effective CM program should operate. An outcome of the revision was a decision to create a companion handbook to expand the informative data. The handbook also provides implementation guidelines for a variety of techniques and examples that may be selected for tailoring and use. Thus the GEIA project to produce GEIA HB-649 was launched in January, 2003.This handbook will be periodically revised to incorporate new ideas, examples and improvements as requested/identified by the using community. User input is expressly requested. Input/requests can be submitted to GEIA at www.geia.org.

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1 Introduction

This handbook is intended to assist the user in interpreting ANSI/EIA 649, National Consensus Standard for Configuration Management, and in the planning and implementation of effective CM. The handbook provides a framework for making prudent and cost-effective choices regardless of CM requirements, project or product size and complexity, customer, or business objectives.

CM implementation requires the balanced and consistent application or tailoring of the product-appropriate mix of CM functions, principles, and practices throughout the product life cycle. CM as a discipline improves the capabilities, performance, reliability, and maintainability of the product by identifying attributes and by controlling information and changes.

2 Scope

This handbook provides guidance about the use of CM and about CM's interface with other management systems and procedures. The paragraph numbers in this handbook map directly to the paragraph numbers in ANSI/EIA-649. It is applicable to the support of projects throughout all phases of a product's life cycle. Generic CM examples are included which may be tailored, taking into account the complexity and nature of the work and the product. It is applicable to the support of projects throughout all phases of a products life cycle. Generic CM examples are included and may be tailored to suit the complexity and nature of the work and the product.

This handbook establishes a common framework for generic product life cycle CM. It addresses tailored implementation based on differences that may exist in organization policies and procedures, in the phase of the product life cycle, in the acquisition method, in the project size and complexity, and in the system requirements and development. A characterization of these differences will aid in the determination of the extent of the required CM process. A CM process should be tailored to the context and environment to which it is applied.

Tailoring for a specific product may involve:

– more or less stringent criteria,

– implementing only some of the functions and principles, or

– implementing to a lesser or greater degree of complexity.

The attributes of the context and environment will dictate which of these individual tailoring approaches will be used for each of the CM functions in the CM Plan; see Section 5 for CM functions.

3 Definitions

See ANSI/EIA-649 for definitions.

4 Symbols and Abbreviations

See ANSI/EIA-649 for symbols and abbreviations.

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5 Functions and Principles

The CM process described in ANSI/EIA-649 is comprised of five CM functions and the underlying CM principles that together provide a flexible implementation structure. The CM process provides consistency among the various elements of product configuration information. See Table 5 in Section 5.2.

The five CM functions are

1) CM Planning and Management,
2) Configuration Identification,
3) Configuration Change Management,
4) Configuration Status Accounting, and
5) Configuration Verification and Audit.

The underlying principles are explained in detail to illustrate how they might be implemented. Examples are provided for most principles illustrating specific levels of implementation for that principle. The CM practitioner should determine the appropriate level.

In ANSI/EIA-649, "product" is the key word used to designate documents, facilities, firmware, hardware, materials, processes, services, software, and systems. Most of the CM activity is focused on the products; i.e., hardware and software, and their related product configuration information. However, CM and CM metrics should also focus on the CM processes related to those products. Almost all of the discussion and examples in this handbook relate to the hardware and software products and their product configuration information.

In this handbook, the term "project" will be used to define a series of activities which result in the availability of a product, or the simultaneous availability of a number of products working as an integrated and co-functioning whole. However, the deliverable product of many enterprises is a document or service for which the configuration management process is directly applicable, so all of the following CM activities also need to be applied. To understand how to apply the best practices discussed in this handbook to the document and service products, the examples will need to be interpreted or adapted in the context of those "products."

The CM discipline for the enterprise is defined by its CM planning, which may be documented through high-level business policy statements, CM plans, or other documents that apply requirements, policies and procedures to the principles in each of the CM functions.

In this handbook, a generic reference to the CM function or principle may also be referring to the corresponding CM process used in implementing the CM function or principle. For example, the CM planning and management function is implemented using a CM planning and management process that include policies, procedures, and a CM plan; the configuration change management function is implemented using a change management process with supporting detailed procedures.

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5.1. Configuration Management Planning and Management

QUESTIONS THIS SECTION WILL ANSWER	Section
1. What activities comprise the CM Process; how are they related?	5.1.1
2. What information is prerequisite to effective planning?	5.1.1
3. What should be considered in the planning for each phase?	5.1.2
4. What is appropriate content for CM plans?	5.1.2 Annex 1
5. What are the resources needed to carry out CM during the product life cycle? What skills are needed to perform the CM tasks?	5.1.3
6. How will each of the CM functions and principles be implemented?	5.1.4
7. Are the personnel trained for the tasks required?	5.1.5
8. What additional or new training is required?	5.1.5
9. What are the appropriate CM activities, and actions to be performed in each phase? What are the criteria for performing them? What are the objectives and benefits?	5.1.6
10. What are appropriate metrics for the project?	5.1.6 Annex 2
11. What are the methods that can be used to assure that suppliers apply an effective CM process?	5.1.7
12. Is it necessary to establish status level for product configuration information?	5.1.8A
13. How are criteria established to assure that the overall intent of ANSI/EIA 649 is met?	5.1.2 5.1.3 5.1.4 5.1.5 5.1.6 5.1.7 Annex 3
14. How can CM performance be evaluated? What is CMMI℠ performance implementation and assessment?	5.1.6 Annex 5
15. Are methods in place to ensure that transmitted data is usable by the receiving party?	5.1.8B
16. Is there a plan for long term recovery of product configuration information and status?	5.1.9
17. How can a CM Planning and Management process be evaluated?	Annex 3 Annex 4, A4-1

Planning involves providing for adequate resources and putting procedures in place to accomplish CM process implementation and tasks. Management involves the monitoring of

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the CM process as it is being implemented and the development and incorporation of CM process improvements as they mature. Continuous CM planning and management over the product life cycle will result in CM functions tailored to the needs of the product.

CM planning and management for products includes:

- selection and application of the appropriate level of CM functions throughout the product life cycle,
- integration of the organization's product configuration information processes, and
- planning for the life cycle management and preservation of data.

CM planning and management for CM process includes:

- assignment of organizational responsibilities for CM functions and placement of procedures,
- training of CM practitioners and of those who provide CM support or who have CM responsibilities,
- recognition and application of adequate resources and facilities for process implementation,
- measurements as a basis for continuous improvement,
- performance of adequate CM by suppliers and subcontractors, and
- protection of the intellectual capital of the organization (reference Section 6.0 in GEIA HB-859).

CM functions focus on the product, enterprise, customer, and regulatory requirements that are the basis of policies, procedures, processes and tools that result in effective product configuration information management, cost avoidance, and product consistency and support.

A given level of CM implementation may represent a best practice for one product environment while being excessive for another. If appropriate to the product environment, each element of product or application complexity requires an investment in time and money which usually results in reduced recurring costs. However, if a highly complex CM implementation is inappropriate to the product environment, it may drive unnecessary cost into the process.

The planning of CM implementation should focus on its appropriateness and effectiveness to the given environment, the rigor with which the selected processes are applied, and the results in terms of final product cost and stability. Table 1 identifies the sample practices and characteristics of several levels of increasingly more rigorous CM implementation.

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Table 1 — Sample Characteristics of CM Implementation Levels

Implementation Level	Characteristics	Sample Practices
1. Planned	• Necessary CM process elements are identified • Planning is based on the CM principles deemed applicable using the tailoring guidelines in this handbook • Resources and facilities needs are based on planning/requirements • Automated configuration management tool requirements are defined and made available consistent with need or planning	• CM policy is documented at organization level • CM Planning information is made readily available • CM tools are identified • CM plan is documented • Resources are identified and allocated • Training needs identified
2. Functional	• Initial Configuration Identification baseline achieved • Configuration Change Management implemented	• Processes are deployed for establishing baselines, version control, issue/problem tracking, change coordination/approval/implementation, and requirements management • Processes are reviewed to ensure reproducibility
3. Integrated	• Processes, procedures, tools and repositories are coordinated, validated and approved • Processes and tools are reliable, and provide repeatable results • Roles, responsibilities, authorities and accountability for interacting functions are well communicated	• Roles and communication responsibilities, such as required sign-offs, are codified in systems. • Various CM processes, such as requirements management, establishing baselines, version control, defect tracking, and change management, are secure and integrated. • Scope of CM process includes traceability, repeatability, verification, validation, and recovery.
4. Rule or workflow based	• Processes are measurable; i.e., metrics based • Life cycle workflows are defined • CM process is integrated with other processes such as program management, engineering, fabrication, manufacturing, operations, product support • Information sources; e.g., customer, performing activity, subordinate supplier, are shared. • Common data directory/dictionary is implemented	• Processes and systems encourage reuse of components. • CM functions are common among all organizations including partners and suppliers. • Interfacing systems; i.e., tools, are fully compatible.
5. Flexible, Measured, Transparent	• Incremental increase or decrease is allowed in the rigor of the CM process appropriate to changes in the requirements. • Metrics are used for determining the health of processes and for continuous improvement of processes and products • CM is integrated into daily operations to a degree where CM activity is relatively invisible.	• Metrics are established and used for continuous improvement. • Process rigor requirements are understood and applied as necessary to meet program/enterprise priorities.

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5.1.1 Identify Context and Environment

PRINCIPLE 1-1: IDENTIFY THE CONTEXT AND ENVIRONMENT FOR A PRODUCT TO WHICH CM IS TO BE APPLIED TO DETERMINE THE SPECIFIC CM APPLICATION METHODS AND LEVELS OF EMPHASIS.

Principle 1-1 says that, when planning for the CM processes to be used for the product, it is important to tailor the application of the CM functions to be appropriate to the level of product complexity and requirements, and to both the product and CM process environments and requirements. See Figures 1 and 4. Many different factors influence the tailoring of the CM processes, including but not limited to:

- the attributes of the product and the environment(s) in which it is developed, produced, used, sustained, and disposed. Environmental attributes include legal/legislative, manufacturing, meteorological, operational, functional, and those associated with the product industry itself. The various environment(s) require different degrees of CM process application. The complexity of the product will also affect the degree of CM process implementation within each product environment. Attributes can be found in specifications, statements of work and objectives, contracting vehicles, and other requirements documents.
- the types of administrative and technical support that CM requires. Types of support may include, but are not limited to, generation of design information, establishment of product development time lines or schedules, generation of requirements specifications, and manufacturing specifications, preparation of test procedures and conduct of tests, number of designers.
- the type of maintenance, repair, and parts support to be provided for the product(s). The means to be utilized to maintain and repair the product will dictate the types of CM processes to be used and the records to be maintained for each product, model, delivered unit, and/or product component. For example, non-repairable products require no tracking beyond the delivered configuration for product deficiency correction and liability issues. Repairable products may require tracking of the configuration of each replaceable component. Products that are repaired only at the manufacturing facility require updates by enterprise personnel about actions accomplished on each product/unit/component. Products repaired by an independent repair facility, including the customer, often require a record of actions completed on each product/unit/component.
- product evaluation for the complete set of functionalities developed in one or more organization sites. All the interfaces existing between the several organizations should be considered and addressed in the CM planning; examples include structure of Control Board, request for change (RFC), request for variance (RFV), software library for planning the development and the releasing of the product code and documentation.
- the types of support that CM will provide. Types of support may include, but are not limited to, configuration change management board; current status information that depicts the current content of, and changes to, products such as information listings; examples include software libraries, drawings, specifications, maintenance manuals.

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- the life cycle phases and the level to which CM is applied to the product as it passes through each life cycle phase. Phases can include Conception, Definition, Build, Distribution, Operation, and Disposal. See ANSI/EIA-649. Levels might include, but are not limited to, the use of more rigorous performance measurement, control of more detailed information, implementation of specific automated tools, quality requirements, higher-level decision-makers chairing change boards, more formal and detailed change documentation.
- definition of the configuration change management authority over each product and it's associated intellectual property rights. Configuration change management authority is defined as the group or individual authorized to disposition any requested change to baselines, including any changes that affect intellectual property rights. For example, a change board is generally authorized to dispose, approve, or disapprove of a change request as part of the configuration change management process.

It may be appropriate to periodically review and further tailor the actual workforce practices used to implement the CM process which was selected during the initial tailoring action. These practices can range from very basic process oversight with manual information records to the use of complex management hierarchies using automatic information inputs and interactive databases. Regardless of the size and complexity of the product, considerations about the product environment and the CM process environment are provided in Figure 1.

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Product environment considerations include:

- integration of other products
- the performance requirements of the product
- the operating requirements of the product
- the environment the product will be used in
- the environmental extremes expected to be encountered by the product
- operational limitations expected at environmental extremes
- the expected life of the product
- the maintenance/support requirements of the product
- maintenance procedures change for operation in extreme environments or when the product is operated at or near operational design limits for extended periods
- product-related standards/specifications/requirements
    - Government/regulatory
    - International, Federal, State or local
    - Industry specific
    - Design
    - Performance
    - Statutory constraints

CM process environment considerations include:

- the work on the product may be accomplished at one or more enterprise locations
- definition of organizational interfaces and hierarchies
- related process support requirements
- number of outside suppliers expected to provide compatible component products
- suppliers from other countries
- the product may be marketed in more than one country
- applicable CM process standards/specifications/requirements
    - Government/regulatory
    - International, Federal, State or local
    - Industry specific
    - CM specific
    - Interface control
    - Statutory constraints
    - De facto standards such as items from community websites or products

Figure 1 — Considerations for Determining CM Context and Environment

It is important to reevaluate the CM planning as documented in the CM plan whenever significant changes are made to the context and environment since the tailoring of the CM process elements is based on those requirements. Significant changes might include changes:

– in the vendors or the suppliers

– to the vendor or supplier responsibilities,

– in resource availability,

– in the maintenance approach for the product, or

– in the product itself.

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Tables 2 and 3 provide insights about some of the more significant aspects of the product and process environments that are driven by the level of complexity of the product(s) involved; the tables address three different levels of product complexity. They provide guidelines that will aid in the determination of the levels of CM process effort required to be included in a CM Plan based on these environmental issues.

Table 2 addresses the environmental issues that focus on the nature of the product, including how it will be used and supported. In turn, these product factors will dictate the amount of CM process effort required to adequately manage the product at each of the three levels of product complexity. Requirements related to that level of CM process effort should then be incorporated into the applicable sections of the CM Plan.

Table 2 — CM Product Attribute Considerations

Environment	Simple Product Sample: Sports equipment Hand-held calculator Fuel pump O-ring	Complex Product Sample: Desktop/Laptop computer Home theater sound system Motorcycle	Very Complex Product Sample: Automobile Airliner Fighter/attack aircraft Intercontinental air traffic control system Information Technology (IT) Network
Where used	Normal environment	Normal or extreme environment	Normal or extreme environment
Define and control interfaces	Little if any impact	Define and control numerous external interfaces among already-developed components	Define and control many external interfaces in many technical areas
Amount of Expected Product Support After Delivery	Little, if any, (throwaway)	Factory service or factory-authorized service facilities	Factory service or factory-authorized service facilities - Train customer personnel to analyze and fix product units - Dedicated service force working for customer (on-site or on-call/rapid response)
Amount of Embedded Software	None to large	Little to large	Large to very large
Number of Delivered Units or Production Rate	Higher quantities or production rate mean increased surveillance may be required as workers accomplish process from memory and fail to regularly check for process changes. Lower quantities or production rate mean increased costs through loss of "efficiency of scale". Increased surveillance may be required. Workers do not get enough repetition to become familiar with process.		
Developmental Aspects	Simple development	Complex development primarily consisting of product integration	Complex development consisting of generation of new component product designs and of integration of existing and new components

For example, in Table 2, the "Where Used" aspect of the product environment would affect the planning for monitoring and accomplishing the implementation of approved Requests for Change. The planning would be much different if the implementation had to be accomplished on a product that is to be located in an extreme environment, such as 22,000 miles out in space or inside a nuclear reactor, than on a product that can be accessed in a normal atmospheric environment. Similarly, the "Expected Product Support" aspect of the product environment would dictate a much less comprehensive configuration status accounting database to be maintained if the product were a "throwaway" than if it were to be subject to regular maintenance events such as the periodic replacement of life-limited components.

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Table 3 addresses the environmental issues that focus on the nature of the CM process and the level of CM process effort required to adequately manage the product at each of the three levels of product complexity. Requirements related to that level of CM process effort should then be incorporated into the applicable sections of the CM Plan.

Table 3 — CM Process Attribute Considerations

Environment	Simple Product Sample: Sports equipment Hand-held calculator Fuel pump O-ring	Complex Product Sample: Desktop/Laptop computer Home theater sound system Motorcycle	Very Complex Product Sample: Automobile Airliner Fighter/attack aircraft Intercontinental air traffic control system Information Technology (IT) Network
CM Planning and Management	Use the standard enterprise CM plan for all such products	Use the standard enterprise CM plan for assemblies of existing products	May use standard enterprise CM plan; more likely to use Product CM plan due to special cases in development of component products
Configuration Identification	Simple identification effort is required.	Simple to complex identification effort is required.	Complex identification effort is required.
- Number of Specifications	One or few. A requirements or performance definition document may suffice.	Few to many for primary enterprise. Suppliers of component products maintain specification(s) for their product(s).	Many specifications required to provide the basis for the development of the product and the component products. Very high number of specifications required for the development and production of the product.
- Number of Drawings	Only a few drawings required to define the detail design of the product.	Moderate number of drawings for prime enterprise. Each supplier maintains moderate number of drawings.	Moderate number of drawings for each of many different products. Myriad of drawings for many different products involved in the system.
- Number of Interface Definitions	Few, if any, required	Moderate quantity of interface definitions required to provide top-level control of changes to interfaces otherwise controlled by suppliers	Significant quantity of interface definitions required to provide top-level control of changes to interfaces otherwise controlled by various suppliers
- Number of Identifiers	Very low	Moderate number of enterprise-issued identifiers. Suppliers will also have a moderate number of identifiers for their products.	Moderate-to-high number of enterprise-issued identifiers for newly-developed products. Component-product suppliers, where applicable, will also have a moderate number of identifiers for their products.
Configuration Change Management	The phase of product life cycle and the degree of complexity of the product, affect the level of change control.		
- Potential for changes	Low to medium	Medium	High
Configuration Status Accounting	Paper or electronic database maintaining information related to delivered configurations	Moderate-sized database, most likely to be electronic, maintaining information related to delivered configurations of groups of units or individual units of each product model.	Very large database, most likely to be electronic, maintaining information related to delivered configurations of individual units (and sometimes of groups of units) of each product model
Configuration Verifications and Audits	Inspection and verification of interface and operating compatibility	Some specialized testing, simulations, and inspections and verification of successful integration and compatibility	Significant amount of specialized testing, simulations, and inspections and verification of successful integration and compatibility

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Reevaluating the CM planning is important whenever significant changes are made to the product and/or the CM process context and environment since the tailoring of the CM process elements is based on those. Significant changes might include changes in vendors/suppliers or vendor/supplier responsibilities, changes in resource availability, changes in the maintenance approach for the product, or changes in the capabilities of the product itself.

It may be appropriate periodically to review and further tailor the actual workforce practices used to implement the CM processes which were selected during the initial tailoring action. This should be done continuously, but it is especially important to review and adjust the practices as the product proceeds from phase to phase in its life cycle. These practices can range from very basic process oversight with manual information records to the use of complex management hierarchies using automatic information inputs and interactive databases.

For example, in Table 3, CM workforce planning for "configuration identification" of a very complex product involving both supplier and enterprise documentation identifiers would dictate that the CM Planning identify the need for more personnel with greater expertise than for a product that is a simple design item. Similarly, the "configuration verifications and audits" aspect of the CM process environment would dictate that the CM Plan address the need for more verification and audit activities with a complex product than for a simple product.

Tables 2 and 3 describe various considerations about the product environment and the CM process environment that need to be addressed as the CM planning for the enterprise or for the product is accomplished. The CM Plan will be used throughout the product life cycle for one, or many, product(s), sometimes with updates as the product transitions from phase to phase of the life cycle. However, these same factors need to be considered, and a CM Plan prepared or revised, to address the development of the new configuration that will result from an approved change, see Section 5.3, that has a significant impact on the performance and design of the product. For each new or significantly redesigned product, or product component, that will result from the approved change, the approval of the change marks the "start" of the development of a "new" product. The CM processes and resources required for that development need to be identified in a CM Plan as the basis for managing the development of the change, just as this section has been discussing the CM planning for the development of a completely new product. An adequate CM process needs to be planned to support the development and integration of the changed design into the existing product. The degree of complexity of this CM planning will be determined by the complexity of the approved change; it would be relatively trivial for a simple change to one of the "simple products" defined in Tables 2 and 3, but it would be highly complex and extensive for a major change or addition to a complex product as defined in that table.

All of the environmental factors in those tables need to be addressed in generating the CM planning information. The change will require new product definition information to describe the functional and physical attributes of the changed product; they could be as simple as a few wording changes to an existing specification and a revision to an existing drawing or as complex as generating several new specifications and a complete set of detail design information. The changes to the product definition information will normally be approved by the Change Board, as it approves the change, see Section 5.3, to provide the

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basis for the development of the revised or new product, including the testing and verification and audit activities. The verification and audit activity may be as simple as a few inspections or as complex as a months-long program similar to the one used for the original product.

5.1.2 Document Configuration Management Planning

PRINCIPLE 1-2:	DOCUMENT HOW THE ORGANIZATION WILL IMPLEMENT CM FUNCTIONS TO PROVIDE CONSISTENCY BETWEEN THE PRODUCT REQUIREMENTS, THE PRODUCT'S CONFIGURATION INFORMATION, AND THE PRODUCT THROUGHOUT THE APPLICABLE PHASES OF THE PRODUCT'S LIFE CYCLE.

Principle 1-2 says that the CM planning is very important, but to have value, the planning must be documented so that all personnel in the organization understand how they interact with, and apply CM. In general, there are two levels of CM planning that are accomplished within an organization:

- organizational -- A comprehensive set of standard CM practices and procedures that apply to the entire organization and which are applied to the extent necessary to all programs, projects, or products, and
- programmatic/product -- A selected set of CM practices and procedures based on the organizational practices and procedures that are applied to a specific program, project, or product.

The CM planning information can be documented in a product CM Plan or enterprise-equivalent standards or procedures. However, it can be included in other program or project-planning document such as a Project Management Plan. For example, a corporation may have a CM Plan that documents high level, corporate-wide, requirements. Individual projects within that corporation may have their own CM Plans that detail how that project meets the corporate CM requirements. The document format is not as crucial as the content.

The CM Plan encompasses all work related to the development of required processes, procedures, tools, and training material. The CM Plan must address the five functions of CM: CM Planning and Management, Configuration Identification, Configuration Change Management, Configuration Status Accounting, and Configuration Verification and Audits. Each of the functions is described in further detail later in this handbook. Annex 1 of this handbook provides a sample CM Plan template, based on the Principles in this handbook, for use in generating a CM Plan.

5.1.3 Assign Responsibility and Apply Adequate Configuration Management Resources

PRINCIPLE 1-3:	IDENTIFY RESOURCES REQUIRED TO IMPLEMENT THE CM FUNCTIONS AND ENSURE THEY ARE APPLIED THROUGHOUT THE PRODUCT'S LIFE CYCLE.

Principle 1-3 says that the context and environment factors such as the complexity of the project, the interfaces required with customers and suppliers, and other aspects of the projects, all influence the number and types of roles and resources required to implement the CM functions.

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The CM Plan identifies the skills and level of effort required to conduct CM activities. The CM Plan should clearly define the necessary CM roles, including the responsibilities, authority, and accountability for each role. There may be instances in an enterprise, especially for relatively small, simple products, where many CM roles are assigned to a single individual while in another enterprise, especially for very large, complex products, there could be many individuals assigned to perform a single CM role.

Figure 2 provides some examples of the program-specific CM activities or responsibilities that are accomplished on most programs:

Function	Sample CM Activities
Configuration Management Planning and Management	• establish, document, and maintain plans to address the five functions and implement CM activities for the enterprise and/or the product • establish and maintain a verification and audit plan • approve the use of standard CM procedures, tools and resources for the product • coordinate and integrate the CM infrastructure with the supporting organizations • identify and conduct CM training and mentoring programs • plan and secure the CM library; i.e., library environment, accounts, access, privileges, backups. • establish requirements for supplier delivery of specific data products; i.e., identifiers, change information packages, drawings, processes.
Configuration Identification	• issue and revise identifiers for product and product configuration information. See Table 5 • establish product hierarchy • establish and define baselines • establish and maintain design activities that generate CM baseline information
Configuration Change Management	• establish and maintain Change Board (CB) Operating procedures including schedule dates and facilities • participate, as a CB member or authorized decision maker for the CB, in generation and review of Requests for Change (RFC) and Requests for Variance (RFV) • ensure that an approval signature is provided before baselining or releasing product definition information identify the change approval designee as the change approval authority(s) for changes to each product • obtain the appointment of change approval authority (s) for changes to each product record discussions and decisions at board meetings and publish official results of meetings

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Function	Sample CM Activities
Configuration Status Accounting	• set up an overall, integrated database system and establish protocols for access control and use of CM database and product configuration information and provide data to approved users • secure baseline documents to control issuance and maintenance of work copies • document and monitor timely receipt of data products and assess data acceptability; i.e., record required CM product configuration information into the database • maintain records that provide complete historical evidence of changes to the baseline • verify and validate change implementation • generate backup copies of database for remote storage on periodic basis
Configuration Verification and Audit	• execute to the Audit Plan, gather Audit Documentation per the CM planning, perform Audit and record action items for disposition, verify completion of action items, and close-out the Audit • perform periodic CM review and assessment, identify problems and potential "cures," and implement improvements into policy and procedure documentation • verify that the CM process provides traceability of requirements to the product for the product life cycle • define, establish and maintain the configuration change life cycle for each product

Figure 2 — Example CM Activities/responsibilities

Examples of the types of resources commonly needed for the CM process are:

- personnel -- includes numbers of full-time/part-time personnel or numbers of man-years for specific CM skills.
- facilities -- includes office space, meeting rooms, records storage areas, furniture, computers, and communications equipment.
- information systems -- includes sufficient file servers to support the user base, on-line access, adequate back-up systems, and secure remote storage facilities.
- CM tools -- includes Product Data Management (PDM) applications, software development tools, product life cycle management applications, software for authoring drawings/specifications/text documents/changes.

Figure 3 is a case study of CM resource planning based on context and environment factors for a hypothetical program that identifies the CM roles for the hypothetical product. Annex 5 of this handbook provides a CM process self-assessment tool based on the Integrated Capability Maturity Model. As the allocation of personnel, responsibilities, and resources is being finalized, this tool can be helpful in affirming many of the allocations made.

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Company Y is a small enterprise supplying electronic communications components with embedded software to the airline industry. In a company of approximately 300 workers and managers, the entire CM organization consists of five CM personnel and one CM supervisor.

The company has developed a new product directed by national security authorities to be installed in numerous models of existing airliners on the production line. The secure communications downlink equipment provides assured communication between flight crews and airline company headquarters which, once armed by an intrusion detection device, cannot be disabled in the cockpit. The product also has other classified capabilities.

With the development of the product complete, the CM level of effort for production of the product had been planned at one-half man-year distributed among several CM personnel skilled in library administration (~ 10%), document identifier control (~ 5%), change coordination (~ 30%), change board administration (~ 20%), CM database management (~ 20%), and CM metrics review (~ 15%). These CM roles will be implemented according to standard company CM procedures.

The company has now won a contract to install the product in already-delivered airliners, with the installations to be completed on the flight line at a customer's facility. Because of the added workload to keep track of the specialized hardware, software, and data provided by the aircraft manufacturers to facilitate the installation of the product components, the CM supervisor has also recommended to the product manager that an additional quarter man-year of CM effort be added. This effort would be focused on CM roles in document identifier control (~ 20%), library administration (~ 30%), and CM database management (~ 50%) to ensure that updates are incorporated into these specialized resources and that only the current approved resources are utilized during the product installations.

The CM database effort must also address information security requirements and access limitations for proprietary information from each airplane manufacturer. Because of the uniqueness of these particular CM database activities at Company Y, a new company procedure will be generated defining the activities required for this contract effort.

Figure 3 — Case Study of CM Resource Planning

5.1.4 Implementation Procedures

PRINCIPLE 1-4: ESTABLISH PROCEDURES TO DEFINE HOW EACH CM FUNCTION WILL BE ACCOMPLISHED.

Principle 1-4 says that procedures must be documented to consistently implement the CM process. When the organization does not have a process for documenting procedures, a process must be established. Procedures to support the five CM functions should be unambiguous and written at a level of detail that is commensurate with the intended user skill level. Organizations with non-complex products might limit their procedures to one for each of the CM functions or even one procedure for all of CM. On the other hand, an organization with a very complex product line might have an extensive procedural library with one procedure for each CM function; e.g., configuration change management, supplemented by one or more lower level procedures for the important sub-functions of each CM function; e.g., Requests for Change, Requests for Variance, and change boards. As with planning, procedures may be applied to a range of products, or tailored for individual products. Procedures are intended to control implementation of CM functions and, therefore, must be carefully evaluated to ensure that they are consistent with CM planning.

Procedures should be documented in tiers or levels with expanding degrees of detail. The suggested format includes four (4) tiers with accompanying guidance material, standards and reference documentation. See Figure 4. This 4-tier structure provides many advantages; the top tiers can remain somewhat stable because, once established, policy and

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requirements usually remain somewhat static; as processes and tools to support these policies and requirements mature, only the affected work instruction(s) or process document are subject to change.

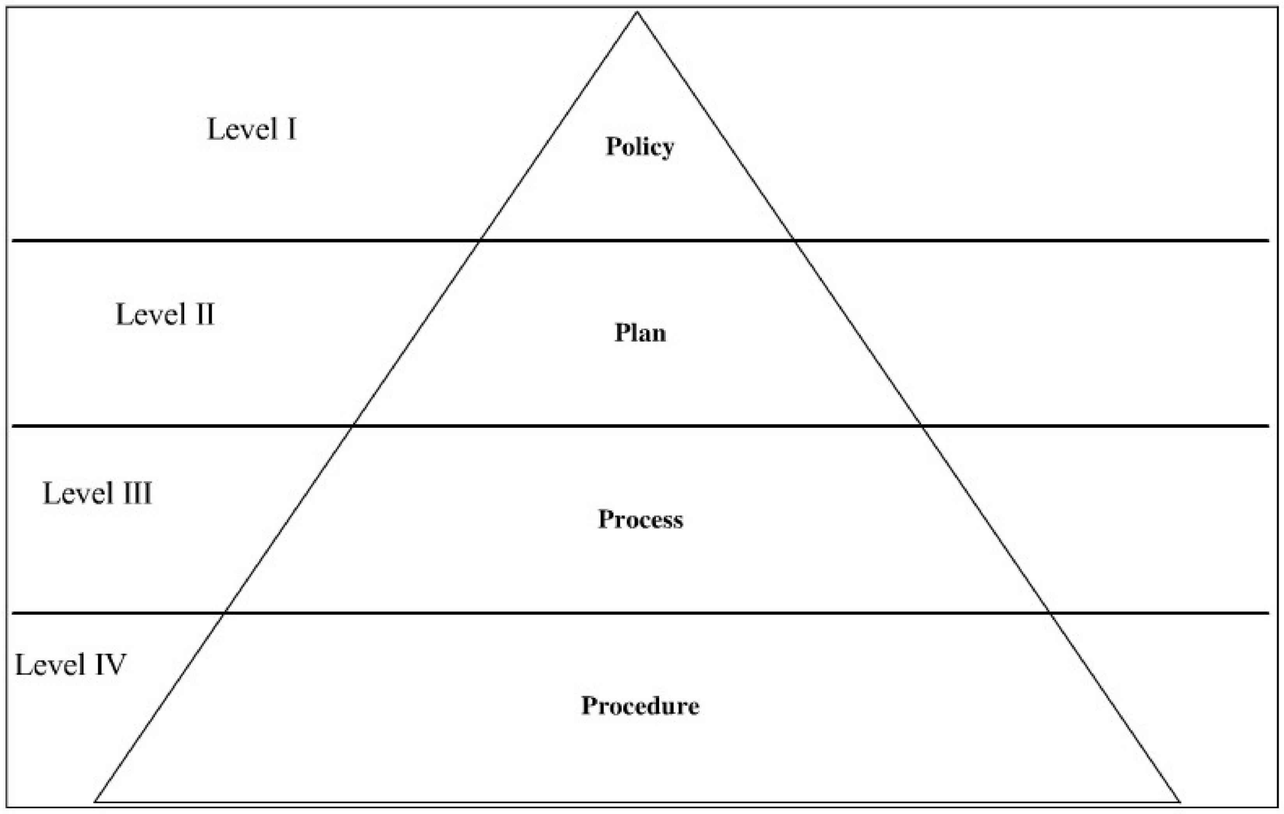


Figure 4 — Sample Document Hierarchy

CM and many other specialized management activities like Data Management, Systems Engineering, and Quality Control, are referred to as disciplines. A "discipline" is defined as, among other things, "a set of rules and methods, and a specified pattern of behavior that results from rigorous training and practice". However, each enterprise will implement the CM discipline utilizing Policies, Plans, Processes, and Procedures, as explained in Table 4. Those documents describe how CM and its five functions (CM Planning and Management, Configuration Identification, Configuration Change Management, Configuration Status Accounting, and Configuration Verification and Audits) are to be accomplished for each product and/or for the whole enterprise.

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Table 4 — Sample Document Hierarchy Description

Type of Document	Type of Information Provided	Identified Documentation Types Separate Documents (Level III may be multiples)	CM Topic Examples Separate Documents at this Level
Policy **(Level I)**	Enterprise focus on various aspects of a high-quality set of management processes to provide quality products and customer service	- administrative - cost - management - manufacturing - marketing - quality - service/maintenance - technical - test	CM usually not in separate document at this level. Top-level policy for application of CM discipline included in one of these documents
Plan **(Level II)**	Tailored application of specific functions within the various disciplines comprising each of the above policy areas	(using technical area) - configuration mgt - design - design media library - development - system engineering - certification	All configuration management functions would be spelled out in one enterprise CM Plan. It is also possible that separate Product CM Plans would be created for certain high-value, high-complexity products.
Process **(Level III)**	Description of who, what, and when various activities will be accomplished for the functions within the disciplines listed above	- approvals of design and changes - product identification - change management - status accounting - verification and audit - supplier management - interface management	Configuration Mgt plus - CM Planning/Mgt - Config Identification - Config Change Mgt - Config Status Acctg - Config Verif/Audit
Procedure **(Level IV)**	Detailed (often step-by-step) description of how an important part of one of the above processes should be accomplished, including filling out certain forms and acquiring and analyzing metrics.	- drawing/part identification - document identification - revision control - Request For Change content - conformance of products	Config Change Mgt plus - Change Review - Change Coordination - Change Boards - Chg Implementation - Request for Change - Request for Variance - Change Metrics

As noted in Table 4, the CM policy is usually embedded in a single Level I policy document for the "umbrella" management specialty that includes the CM discipline. Similarly, there is usually only one Level II "CM Plan" that applies to a particular product within the enterprise, either as an enterprise-wide CM Plan for all products or a product-specific CM Plan for that particular product. That CM Plan defines the tailored capabilities which each of the five CM functions should achieve. To achieve these capabilities, a Level III process document would be written for Configuration Management and for at least each of the five

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CM functions. Finally, Level IV procedures are written to inform the practitioners of the details of how to accomplish the specific parts of each of the CM functions described in the process documents.

Terminology-wise, the enterprise Policy for the CM discipline is defined using a CM Plan(s). The CM Plan is then implemented using a CM Process, a CM Planning and Management Process, a Configuration Identification Process(es), a Configuration Change Management Process(es), a Configuration Status Accounting Process(es), and a Configuration Verification and Audits Process(es). Even though the processes for the five functions are really sub-processes, each is defined in one or more Process documents, and so each of the five CM functions will be referred to, in this Handbook, as either a function or as a "process," since the one implements the other.

Associated with the entire tree would be guidance documentation such as regulatory documents, standards and handbooks which are used as the basis for much of the enterprise documentation. This could include ANSI/EIA-649 as the basis for the CM Requirements document in Level II and GEIA-HB-649 and/or MIL-HDBK-61 as the basis for many of the writings in Levels III and IV.

5.1.5 Configuration Management Training

PRINCIPLE 1-5:	CONDUCT TRAINING SO THAT INDIVIDUALS UNDERSTAND THEIR RESPONSIBILITY, AUTHORITY, ACCOUNTABILITY, AND THE PROCEDURES FOR PERFORMING SPECIFIED CM TASKS.

Principle 1-5 says that Configuration Management training should be conducted to provide each employee involved with the CM process an understanding of the fundamentals of CM and the use of CM tools, procedures, and practices. An organizational training plan should be developed that is consistent with the training policies of the organization and which addresses the tools and processes unique to a specific project. The CM training plan may be included in the CM Plan or may exist as a separate document based on the complexity or size of the project.

Personnel from many organizations within the enterprise may have CM roles to perform. Training should address both performance of assigned CM tasks and cross-training to provide awareness of relationships and interactions with other functions having CM-related responsibilities. CM training should be tailored to address the needs of the individual based on the individual's position, experience level, and/or responsibility. For example, a Design or System Engineer would need an overview of the various CM functions, whereas an individual assigned to maintain a CSA database requires an in-depth training on status accounting tools being used by the enterprise. Training should not be a one-time event; it should be continuous as processes change, personal skills evolve, and new tools are introduced. In addition, for each new worker assigned to CM, an experienced mentor should be assigned to aid their transition into the CM procedures used by the enterprise.

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5.1.6 Performance Measurement

PRINCIPLE 1-6: USE PERFORMANCE MEASURES TO ASSESS THE CM PLAN IN TERMS OF IMPLEMENTATION AND THE EFFECTIVE PERFORMANCE OF CM FUNCTIONS.

Principle 1-6 says that it is important to develop performance measures (metrics) for use in evaluating the effectiveness of CM tools, processes and procedures. Metrics are key to continuous process improvement. They enable problems that need attention to be quantified, stratified, and prioritized and also provide a basis for assessing the improvements and evaluating trends. Prioritizing metrics is a subjective process; a simple rating of high, medium and low importance is usually sufficient; see Annex 2 for a sample of a prioritization schema. In doing such a rating, some consideration should be given to whether either a simple status mechanism is sufficient, or a quantitative approach is value added, in addressing a given need or measurement during a products life cycle. Metrics should be designed to positively motivate, rather than keep score, and should be forward-focused rather than a compilation of past history.

The information derived from the evaluation of performance data is used to identify problems and inefficiencies, to provide insight to support planning and evaluation of corrective actions or improvements, and to maintain a high level of efficiency. Improvements are implemented by revisions to the CM policy, plans, processes and procedures. CM performance measures are developed and adjusted as appropriate for the organization and product life cycle phase.

An effective metric has the following attributes:

- it is meaningful in terms of customer relationships, where the "customer" is any user of information provided,
- it relates to an organization's goals and objectives and tells how well the process meets those goal and objectives, and
- it is timely, simple, logical, repeatable, unambiguously defined, and economical to collect.

Metrics serve the organization when they present a complete picture of the performance of the CM process or activity under evaluation. A complete picture of performance is comprised of several metrics, that are repeated at specific intervals, at specific measuring points, and are reported to responsible management who have the authority to instigate and implement improvements to the process or activity. It is important that organizations use several metrics to provide a complete picture. Examples of metrics include change request process throughput time; number of configuration audits planned, held, and successfully completed; change incorporation rate; and approved engineering changes incorporated into drawings. Several examples of CM metrics are found in Annex 2 and in GEIA HB-859.

Figure 5 provides a view of several points at which metrics can be collected in a given process flow. The collected metrics can provide insight into how well or how poorly the process is being managed. Or these metrics may simply be a counter for throughput at certain points in the process.

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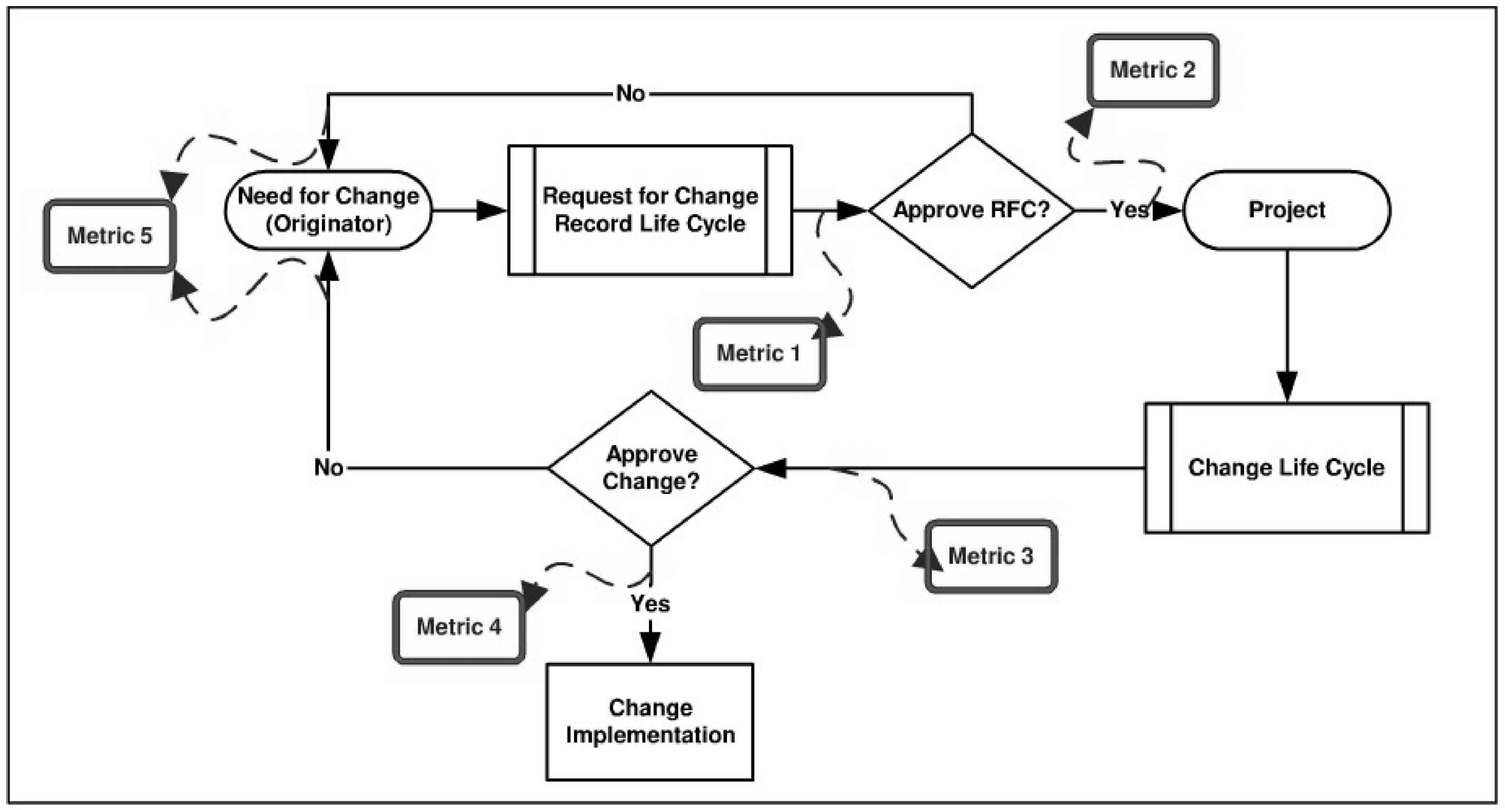


Figure 5 — Sample Metric Collection Points

5.1.7 Supplier Configuration Management

PRINCIPLE 1-7: DELEGATE APPROPRIATE CM REQUIREMENTS TO SUPPLIERS AND MONITOR FOR CM FUNCTIONAL PERFORMANCE.

Principle 1-7 says that it is incumbent upon any organization acquiring a product from a supplier to invoke appropriate requirements for the CM process. Each organization must evaluate its CM process, decide which requirements should be levied on suppliers or subcontractors, and determine to what extent the CM process should be tailored to accommodate the context and environment of the supplier's part/product. Each organization passes requirements appropriate to the product being acquired down to the subcontractors, suppliers, and team partners via a purchase order or other contractual agreement/instrument.

Each organization takes on the role of customer to the supplier. Because of this role, the customer organization must address an initial validation process to determine that the supplier has adequate CM processes documented. A periodic inspection process ensures that the supplier continues to effectively implement the documented CM processes. When doing business with product suppliers, the customer organization may not have control over the supplier's CM process. The following case study in Figure 6 shows how an organization would institute the CM processes within their supplier chain.

The organization working on Project X utilizes a standard set of CM process to be used for all of the internal and supplied Project X products. The CM process is provided to their suppliers of complex products without change, along with a set of criteria that the supplier's CM plan/practices will be evaluated against. The CM personnel from the buying organization will initially validate the plan and practices based on their criteria and then, on a semi-annual basis, will check to make sure that the documented practices are being accomplished.

Figure 6 — CM Process Case Study

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See Annex 3 for information about CM process assessment that might be used with suppliers.

5.1.8 Information Management, Interoperability and Exchange Planning

PRINCIPLE 1-8A: ESTABLISH PRODUCT CONFIGURATION INFORMATION STATUS LEVELS

Principle 1-8A says that product configuration information must be assigned status levels as it is updated continuously throughout the product life cycle. Product configuration information and, specifically, the product definition information part of product configuration information is updated continuously throughout the product life cycle. See Table 5 in Section 5.2. As part of this continual update and approval or baselining process, product definition information repeatedly flows through various status levels that can be generically defined as pending, current, and historical. While these status levels are important relative to the product definition information, it is also important for enterprises to track the related product operational information by these status levels as those information elements go through an approval and revision process. This is true even though the product operational information is not always placed under configuration control.

It is important to note that, when defining product configuration information status levels and the product definition information approval workflow, the CM plan should take into consideration the organization's structure and business processes. The product configuration information status levels and approval process should be designed in concert with other members of the organization who will participate in product evaluation. This ensures that the product configuration information status levels and workflow meet the organization's needs, are fully and clearly defined, and are easily understood by all. Figure 7 illustrates a sample product definition information life-cycle model with status levels.

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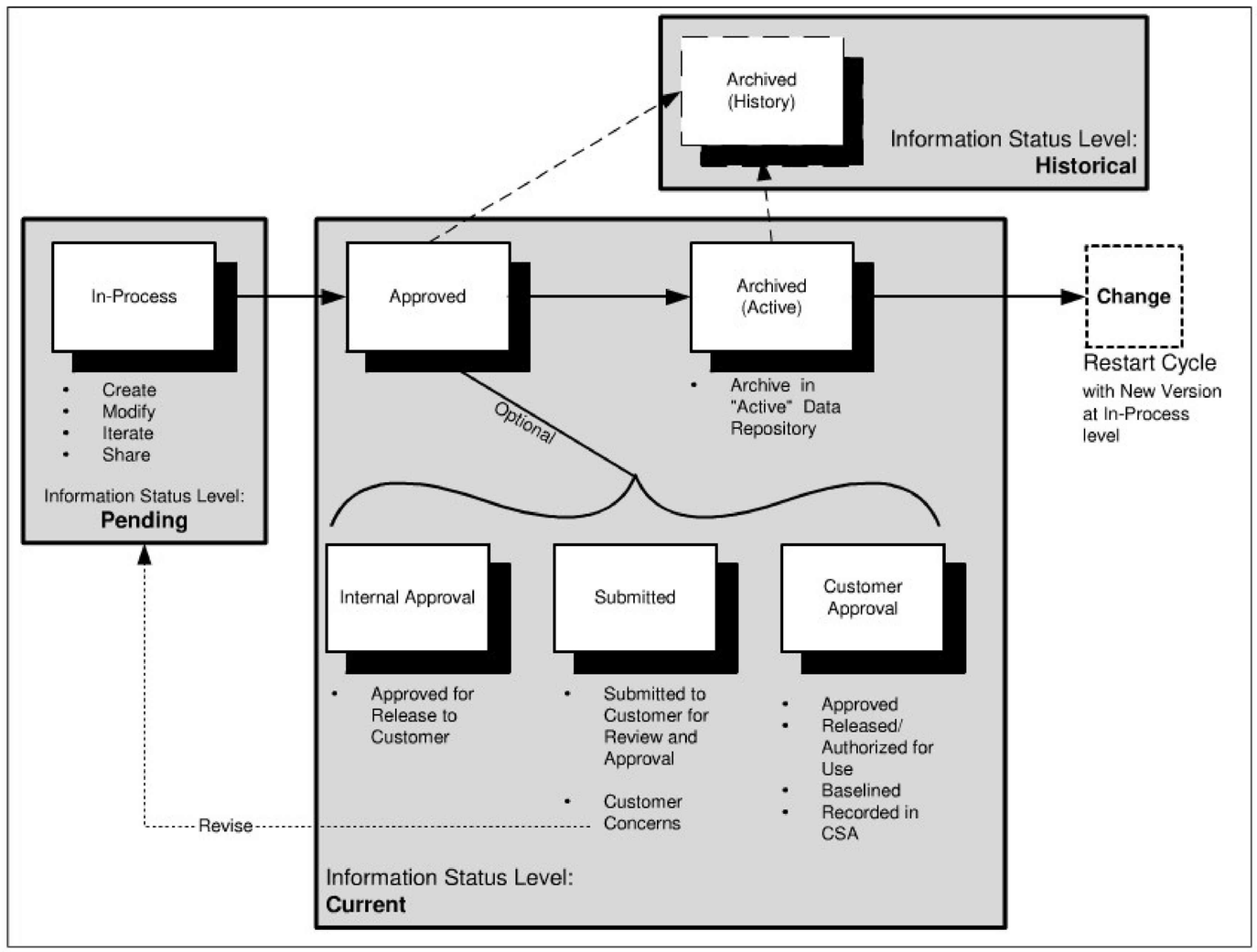


Figure 7 — Product Definition Information Life Cycle Model Example

The product configuration information status level identifiers given below are common terms that are often used for products and will be used throughout this handbook. Information status levels could include:

– In-process product definition information -- In-process product definition information represents "work-in-progress," which is subject to change without notice and without the requirement to be passed through a configuration change management board. Most original design/development work exists in this status level prior to establishment of controlled baselines. Sub-levels may be defined for in-process product definition information to distinguish information that is in various status' such as draft status or review status. In-process product configuration information may be created, reviewed and modified several times before it reaches a point where it is ready to be released, baselined, and subject to change management. During this in-process period, the information is usually subject to informal document management and configuration change management procedures, as defined by the local work group. The final step for in-process product definition information is its submission to the formal change management authority for approval and baselining and "release." Any revision of released product definition information initially starts with the status of in-process product definition information.

– Approved product definition information -- Approved product definition information has been reviewed and authorized for use. At this point the product definition information becomes part of a controlled product baseline and is recorded within the Configuration

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Status Accounting (CSA) system. Changes to approved product definition information are authorized by the appropriate configuration change management authority in accordance with documented configuration change management rules.

The following three status sub-levels apply only to product definition information that requires customer action. In these cases, a business process sub-loop accommodates two levels of approval, an internal enterprise approval and an external customer approval. The sub-levels indicate that the internally approved product definition information was promoted, without change, to another status level.

- Internally approved product definition information – Internally approved product definition information is enterprise-approved and validated as being sufficiently mature to be submitted to the customer for their review and approval. This information should not be released for use until customer approval has been obtained.
  - submitted product definition information – Submitted product definition information is version-controlled, internally-approved product definition information that has been submitted to the customer for review and approval. When submitted product definition information is commented on, or disapproved, a new version should be started in the "in-process" status and the process repeated until customer approval is achieved.
  - customer approved product definition information – Once the customer has accepted the submitted product definition information it becomes "approved product definition information." Usually this also means that any subsequent changes also require approval/authorization by that customer.
- Archived active product definition information -- Archived active product definition information is retained and made available for current use by all authorized personnel. The archived file of this information serves as the "master copy" of the product definition information and is the source from which all other copies are generated. This information is also officially recorded in the CSA system. Information is kept in the active archive as long as it is currently in use.
- Archived historical product definition information -- Archived historical product definition information has been retained for historical records, can be retrieved within a reasonable time, and is maintained in usable condition (see Section 5.1.9) over the time designated for retention. Some active data may also be duplicated in the historical archives based on organizational rules for historical archiving.

See Section 5.2.4 of this handbook for more information about configuration baselines.

PRINCIPLE 1-8B: ENSURE THAT A TRANSMITTED DATA PRODUCT IS USABLE.

Principle 1-8B says that the tools and processes implemented to provide access, sharing, or exchange of data must be compatible and the data be accurately translated from one computer system, tool, or process to another. This is true for transmittal between internal computer systems, tools, and processes as well as with and between customer, partner, and supplier computer systems, tools, and processes.

Effective access, sharing, and exchange between the heterogeneous data environments in various participating enterprises depends upon consistent, standardized CM data definitions

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and relationships consistent with the CM principles in this handbook and the ANSI/EIA-649 standard. EIA-836, "Configuration Management Data Interoperability and Exchange" is an extension of ANSI/EIA-649 and provides a comprehensive data dictionary of CM data elements. It defines the structure, properties and definition of the data elements, and explains how identified CM objects and their data elements may be used to form information exchange sets, referred to as "business objects" for exchanging CM information. The use of the EIA-836 reference schema to define business objects allows "intelligent" transfer of CM data between different databases that can be mapped to the reference model.

In a simple example, transmitting information about an engineering change using EIA-836 methods allows the receiving system to identify and access the basic Change Proposal, the associated affected documents, the affected product parts, the configuration change management authority, and possibly the final decision. All of the above occurs without the need for human interpretation. EIA-836 can be used as a reference source for developing and mapping, CM related tools, systems and databases.

Other issues that affect the usability of transmitted/delivered data include:

- Exchange Medium -- The chosen exchange medium; i.e., physical media, electronic data interchange (EDI), web access, or other means, must be selected to maximize accessibility by the customer or partner, withstand time and the environment, and maximize potential for forward compatibility with new technology.
- Language or Format -- To ensure usability, the sender should coordinate with the receiver to ensure that the transmitted or delivered data is compatible with their computing environment. Backwards compatibility with earlier versions of the authoring or viewing application should also be considered.
- Security -- Information and media security are of the highest importance, and security precautions such as data encryption are often used. In those cases, care should be taken to ensure the supplier, the customer and their partner have compatible standards as well as encryption and decryption devices. In addition, review contract or business rules that may affect security.
- Distribution Limitations -- Factors such as intellectual property rights, export control regulations, or security classification place limitations upon the distribution of the data. Distribution limitations dictate who has access to the media and the data on the media. The organization is responsible for ensuring that the appropriate distribution limitations and use constraints are researched, mutually agreed to, and marked on all exchanged data. Two examples of a distribution limitation statement could read: "Approved for public release." or "Approved for limited use."

When CM provides information on floppy disks, tapes, CD-ROM, or other physical media, an appropriate release or identification label must be affixed to the media to clearly identify the configuration of its contents. When it is not practical to include all of the file identifications on the label, include a reference to an accompanying list or file included as part of the media.

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5.1.9 Planning for Data Preservation

PRINCIPLE 1-9: PLAN FOR LONG-TERM DATA PRESERVATION BY ADDRESSING THE INFORMATION TECHNOLOGIES USED TO STORE, RETRIEVE, AND INTERPRET DATA.

Principle 1-9 says that the enterprise must consider long-term preservation of the product data including consideration of the life cycle of the product; the information technology applications used to retrieve, interpret, host the data; and the storage media. As the product matures and is planned for use over a number of years, the enterprise should consider the length of time that the associated product configuration information, both archived active files and archived historical files, will retain value. This consideration should include the length of time that information needs to be stored and available for access. It should also be understood that the technologies associated with storing and accessing this data will change over time. Changing technologies can potentially render certain types of data unusable unless provision is made for periodic assessment and appropriate update of the technologies and media formats. The information may be presented on any medium or in any format and may include, but not be limited to, paperwork, digital media, blueprints, computer-aided designs, spreadsheets, photographs, and e-mail; each of which is subject to its own storage, maintenance, retrieval, and retention considerations.

This principle also addresses the need to back up current "active" data repositories and historical data archives to protect against damage to, or destruction of, the primary data repository. The backup copies of electronic files should be generated at specific time intervals; e.g., hourly, daily, weekly, or monthly, depending on the importance and volatility of the content of the files. The frequency of the backups will normally be much greater for active data than for data in historical archives. A specific number of these backup copies should be retained in a safe storage area remote from the location where the master files are retained.

Additional important factors to consider in data preservation decisions are the applicable laws and requirements. To ensure that the product configuration information will continue to be accessible and usable, the planning needs to address a variety of national and international standards and regulations. There are a number of laws that dictate what information the enterprise must keep and for how long, such as tax codes. Governmental regulations also dictate document retention policies in many industries. For instance, commercial aircraft manufacturers must consider FAA regulations, and the medical industry is subject to regulations governing record keeping pertaining to the prescription and handling of drugs, the medical condition of patients, and cost analysis for Medicare and Medicaid reporting. Other factors, such as purchase orders or contracts, may also provide information retention requirements that must be adhered to. See Figure 8 for a sample data preservation model; see also GEIA-859 for Data Preservation.

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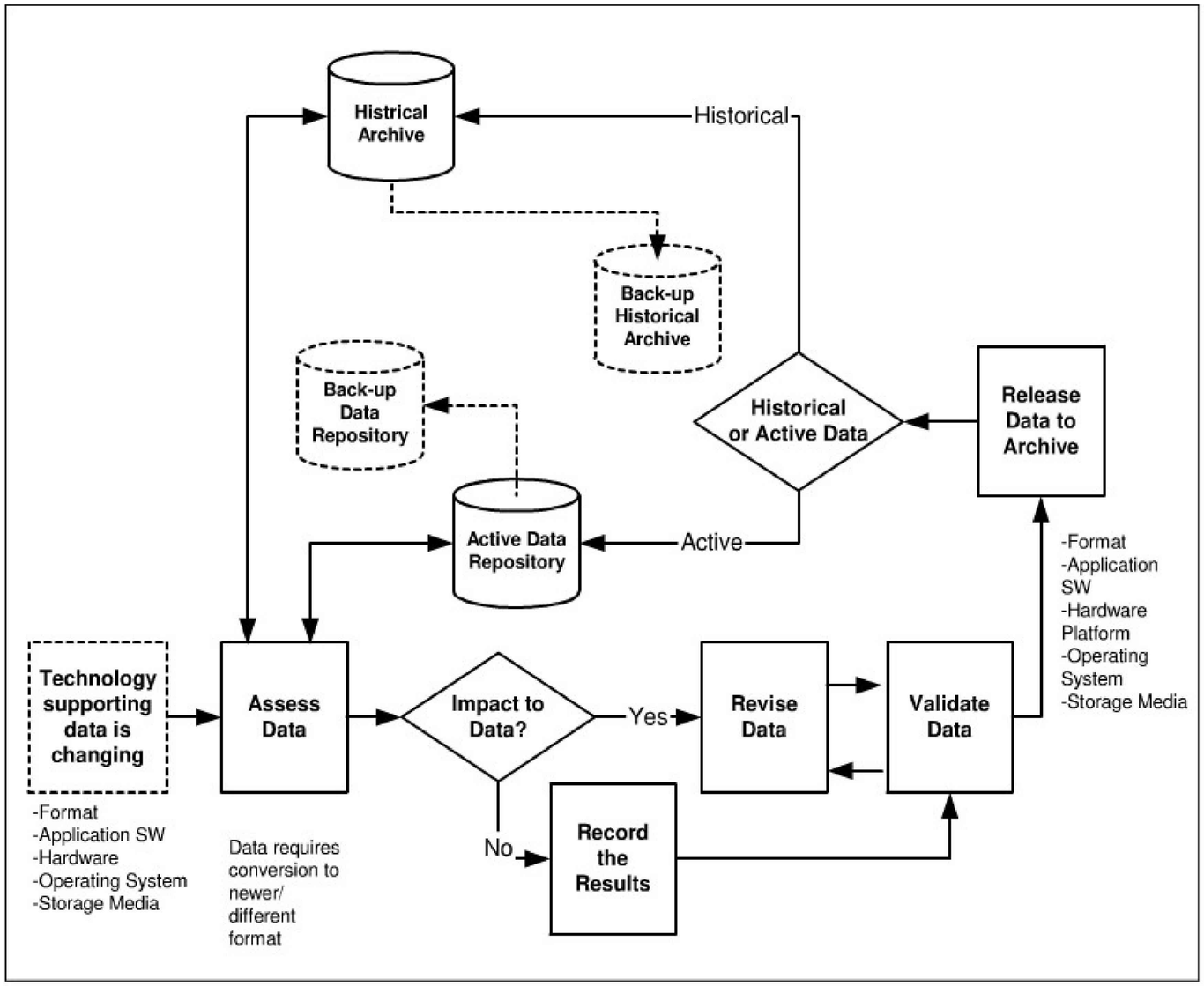


Figure 8 — Data Preservation Model

5.1.9.1 Product and Product Life Cycle

The complexity of the product and its associated life cycle will guide the selection of the data that needs to be retained and will guide the determination of how long the data might need to be available to be accessed and used. Some of the data will be very transitory and only be retained for a brief period; for example, initial analyses and sketches outlining the product design are superseded by more formally generated product definition information, so such preliminary data might only be retained until the end of the development of the product.

The CM discipline depends on accurate and current product configuration information to define, manage, and control the configuration of the product throughout the Product Life Cycle. That information needs to be recorded, and those records need to be preserved for historical purposes. Most of the performance and design requirements in the product definition information need to be retained for many decades until all produced units have been disposed of at the end of the Disposal phase and there is no probability of future use. If CM is to be successful for complex products, it is especially important that long-term data preservation be planned for data and files that:

– define and control performance and interface requirements,

– define and control product design,

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- define and document processes,
- define proposed changes, including records of the change review and change implementation,
- maintain traceability of modification(s) incorporated into the product, and
- document product conformance activities, including configuration verifications and audits

5.1.9.2 Technology Life Cycle

The life cycles of the technology applications required to interpret the data and accurately present it in human readable form are often overlooked until it's too late. The inability to interpret information is usually not realized until the information is needed. Systems used to create and/or interpret design data often support the ability to read data created in earlier versions of the system. Generally, the more iterations there are between the application version used to store the data and the current version used to interpret that data, the less likely it is that the data will be displayed as it was originally intended. The risk of losing access to older data should be addressed when making the decision to upgrade, or replace, a system used to create or interpret data.

Data preservation should also be addressed when it becomes apparent that the software system supplier will no longer support the older information technology being used to store the data. Data may be altered during the conversion process when upgrading to a newer application version or a different compatible application. Unintended data may be added or original data may be removed. An example of this would be using a current version of Microsoft Word™ to read a file originally created in an older version of Word Perfect™.

An alternative, but usually less acceptable approach may be for the organization to consider maintaining the original application and related equipment, or maintaining the information in hardcopy, microfilm or more archaic formats.

5.1.9.3 Storage Technology

The life cycles of storage technologies are usually addressed for data required to support products currently in production or service, but are often overlooked in the case of archived historical data. Lost data is often not detected until it is needed. The media on which data is stored ages and can fail. Therefore, archived historical data should be stored in a repository for which there is a backup. When problems are encountered, the data should be migrated to new media as required. The type of media and the environment in which it is stored affect the period between audits.

Technologies required to retrieve data from media, as well as the media itself, will eventually become obsolete and unsupportable. Data custodians should monitor the ongoing level of industry support available for various technologies. A reduction or loss of support may impact the ability to use stored data and thus should trigger consideration for refresh or change to an archive format; e.g., .PDF files created in Adobe Acrobat™. Figure 9 illustrates a generic update process that can be used when information technology or storage media require change.

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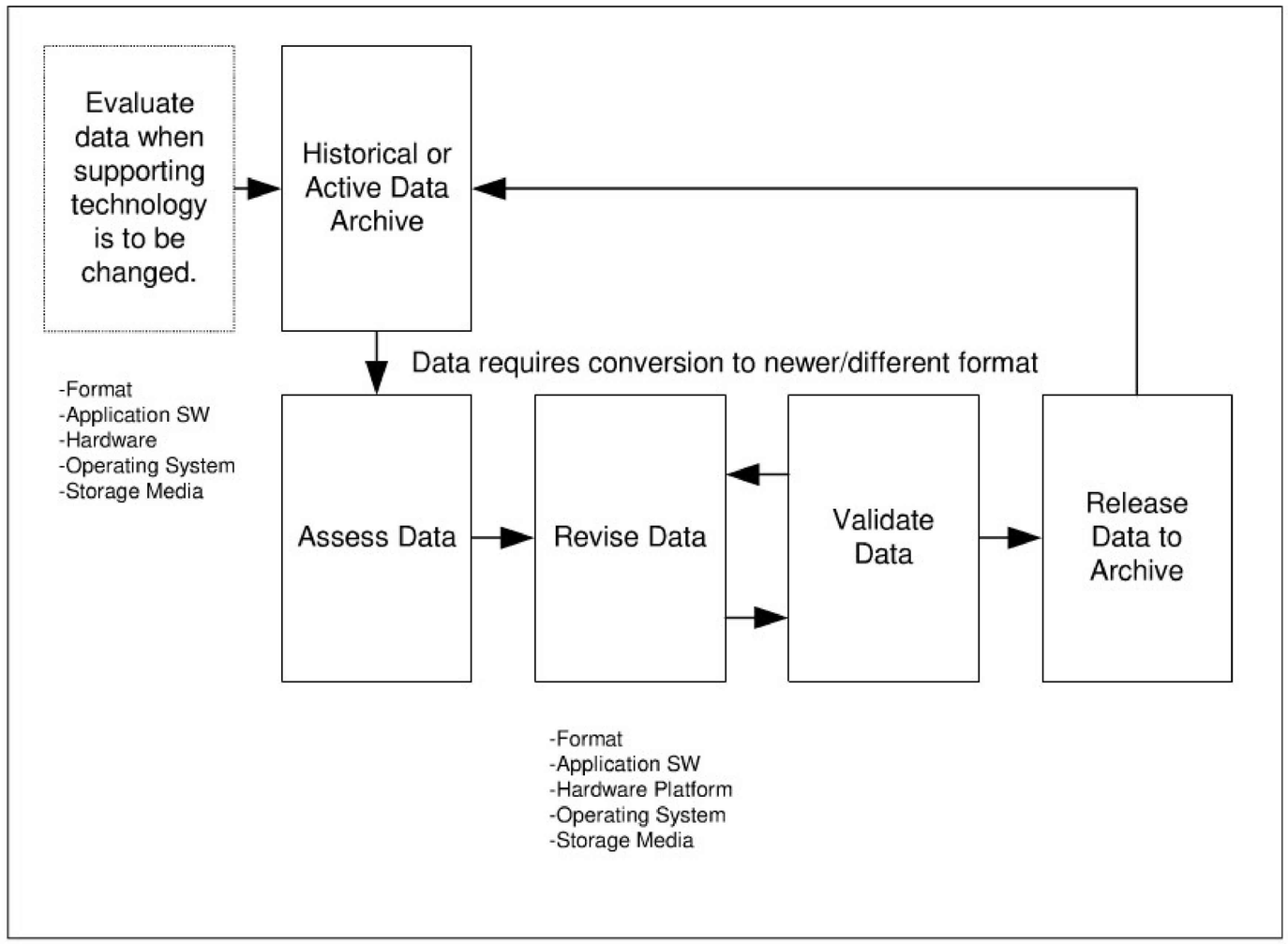


Figure 9 — Archived Data Preservation Model

For more information on data retention and preservation see GEIA-859 and GEIA-HB-859.

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5.2 Configuration Identification

QUESTIONS THIS SECTION WILL ANSWER	Section
1. What is the configuration identification process and why is it necessary?	5.2
2. What are the attributes of the configuration identification process?	5.2
3. What is product configuration information? What is product definition information? What is product operational information?	5.2.1
4. What is a product structure? How is it determined and used?	5.2.2
5. How should configuration information files and their media be identified? When and how should these identifiers be changed?	5.2.3.1 5.2.3.3
6. How should products be physically identified? When and how should the product identifiers be changed?	5.2.3.1 5.2.3.2
7. How should individual produced units and groups of produced units be identified? When and how should these identifiers be changed? What is a UID?	5.2.3.2.2 5.2.3.2.3
8. What is a configuration baseline? What types of baselines are used?	5.2.4
9. How is a configuration baseline established? Changed?	5.2.4 5.2.4.1 5.2.4.2
10. How are interfaces defined?	5.2.5
11. What is the relationship between interface control documents/drawings and product configuration information?	5.2.5
12. Why aren't there any guidelines about configuration items?	See ANSI/EIA-649, Table 2, Product
13. How can a Configuration Identification process be evaluated?	Annex 3 Annex 4, A4-2

The configuration identification process ensures that all affected organizations have common sets of product configuration information as the basis for activities; for example developing a new product, modifying an existing product or component, buying a product for operational use, or providing support for a product and its components. The configuration identification process also includes the issuance of identifiers for the products and their product configuration information.

The configuration identification process for the life cycle of a product includes:

– determining the types of product definition information required for each product to identify its performance, functional and physical attributes, including internal and external interfaces,

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- identifying the types of product operational information required for each product for inspection, testing, operation and maintenance,
- insuring that each element of product configuration information is assigned a responsible owner/decision maker at an appropriate level consistent with the product and with the customer/manufacturer relationship. That owner is responsible for the content and control of the information, providing configuration control authority for that product configuration information,
- issuing identifiers for products and the product configuration information to facilitate the establishment of configuration baselines and the management of configuration changes, and
- maintaining the product configuration information and the identifiers of the products to facilitate manufacturing and logistics support of items in service.

The configuration identification function is the foundation of and the prerequisite for the configuration change management, configuration status accounting, and configuration verification and audit functions which all use the outputs of the configuration identification process. When products and their associated product configuration information are not properly identified and documented, it is difficult to control changes to the product's configuration, to establish accurate records and reports, or to validate the configuration through audit.

Inaccurate or incomplete product configuration information may result in defective products, schedule delays, and higher maintenance costs after delivery.

The continuous integrity of the product configuration identification is dependent on good change management procedures. See Section 5.3.

5.2.1 Product Configuration Information

PRINCIPLE 2-1: DEFINE THE ATTRIBUTES OF A PRODUCT AND ITS INTERFACES IN THE PRODUCT DEFINITION INFORMATION AND USE IT AS THE BASIS FOR PRODUCT OPERATIONAL INFORMATION.

Principle 2-1 says that product configuration information consists of product definition information and product operational information which is derived from the product definition information as described in ANSI/EIA-649.

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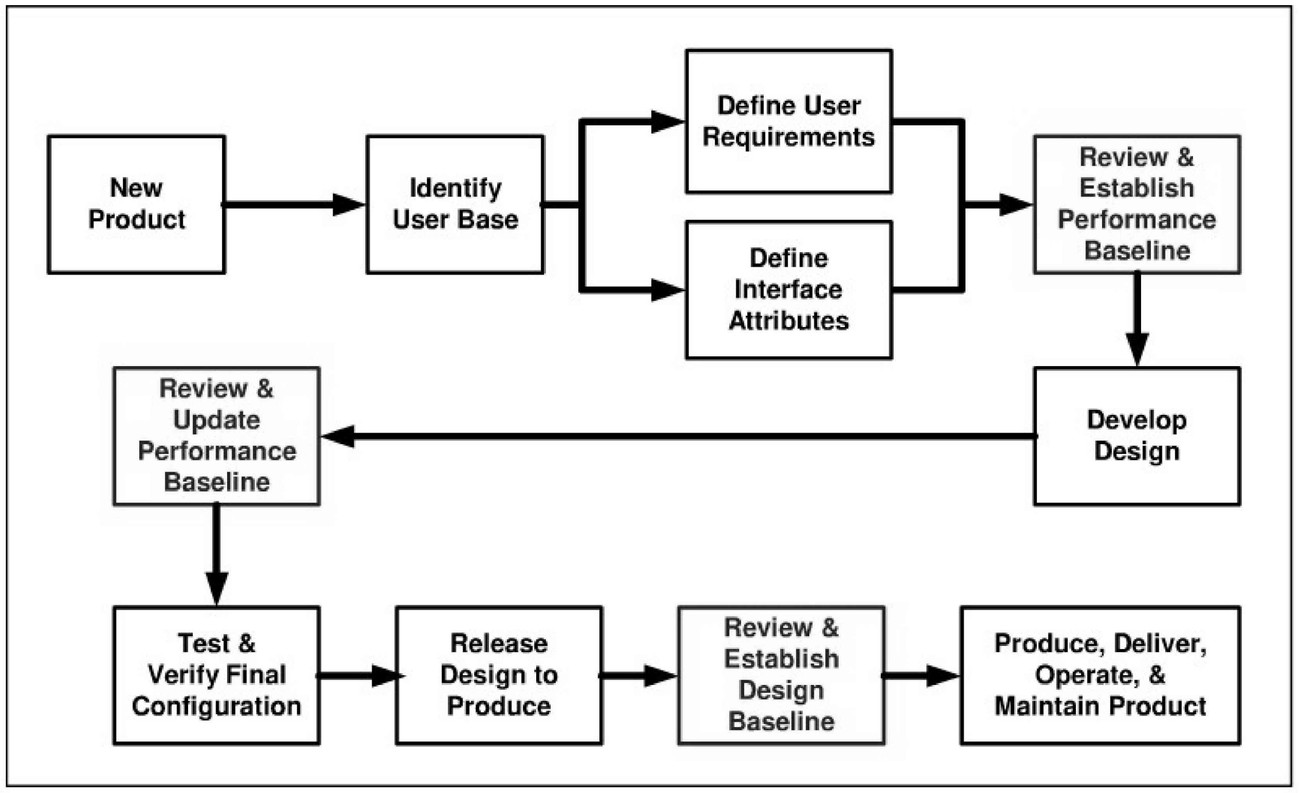


Figure 10 — Sample Evolution of Product

Figure 10 provides a simplistic depiction of the evolution of a product. A decision must first be made to allocate resources to the assessment of the viability of developing a new product, usually based on the availability of a new technology or the identification of an emerging need for a new capability. Before developing the new product, the user base must be assessed to determine whether there is a sufficiently broad market for the new product to warrant the "expenditure" of resources in its development. If so, the potential users will be queried or modeled to determine the attributes and capabilities that the product would need to have, and the interfaces it must match, to meet the needs of the potential users.

These attributes would then be incorporated into appropriate product definition information, which would be reviewed by the product's manager, and sometimes by the users. The product definition information would be approved as the baseline for development of the new product. Resources would be allocated to the product's development based on the attributes defined in the performance baseline. That baseline would then be used as a benchmark as the product is developed and designed. Once the product is stable enough to be tested, the performance baseline should be reviewed and updated.

Updating of the performance baseline marks the beginning of the product test and verification phase. This performance baseline will be used as a reference to evaluate any performance deficiencies reported during testing of the product. In the event the product is developed and released in modules, the performance baseline should be updated before the test and verification phase for each module. Before being released for production, a final audit is conducted to ensure that the attributes defined in the performance baseline for the product were achieved and that they were accurately recorded in the design baseline. See Section 5.5. The product operational information is derived from the product definition information for the product that will be delivered.

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Table 5 shows examples of what types of information comprise the product configuration information. These examples are not all inclusive.

Table 5 — Product Configuration Information Examples

Product Configuration Information		
Product Definition Information		**Product Operational Information**
Specifications	← **Associated Information** →	Maintenance Manuals/Procedures
Drawings/Datasets	Distribution Information	Users Manuals
Software Listings	Request For Changes (RFCs) and Request For Variances (RFVs)*	Checkout Procedures
Interface Control Drawings/Documents	Analysis Documents*	Test Procedures
Requirements Documents/Databases	Test Reports*	Diagnostic Procedures
Parts Lists/Bills of Materials	Functional Verification Procedures*	Calibration Procedures
Standards (Internal and External)	Test Plan*	Training Manuals
Processes (Internal and External)	Test Equipment Operating Procedures*	Operational Procedures
Models and Simulations	* Note: some organizations include these types of information as part of either product definition information or product operational information	Spare Parts Lists
System architecture		Disposal Methods
Other Associated Lists		Security Procedures
Design Descriptions		Operational/Support Data
		Repair Manuals/Procedures

Product definition information -- provides the baseline information that describes the product's performance, functional, and physical attributes. See ANSI/EIA-649 for baseline information requirements. Product definition information provides the technical basis for product verification activities, including audits in Section 5.5, and for change actions taken during all product life cycle phases.

The product definition information includes:

- requirements information; e.g., specifications, requirements documents, and
- design information; e.g., drawings, part models, software listings and design descriptions.

Product operational information -- consists of procedures and technical information needed by operators and support personnel to operate, maintain and dispose of the product; including, operating procedures, security procedures, maintenance procedures, spare parts lists, and disposal methods. Product operational information is derived from the product definition information.

Product operational information also includes:

- actual configuration of the delivered units of the product, and information from the status accounting database,
- customer feedback data and other data can be incorporated into the product operational information via the RFC process – see Section 5.3.

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Associated information -- consists of information generated as a part of the CM process which are not clearly definable as either product definition information or product operational information.

Associated information includes:

- change information like the records for the RFC and RFV, distribution information, various analysis documents, test plans, functional verification procedures, test equipment operating procedures, and test reports.
- some or all of these elements of associated information may be included by organizations as a part of either their product definition information or product operational information.

5.2.2 Product Structure

PRINCIPLE 2-2: DEFINE A PRODUCT COMPOSITION WHICH MATCHES ITS PRODUCT CONFIGURATION INFORMATION.

Principle 2-2 says the product structure should be defined that provides the composition of the product and provides a basis for identifying products, component products and product configuration information. The product structure shows the relationships among the various parts that make up the product and among the product configuration information describing those parts.

One of the common approaches for illustrating product structure includes using a hierarchical diagram similar to the structure illustrated in Figure 11.

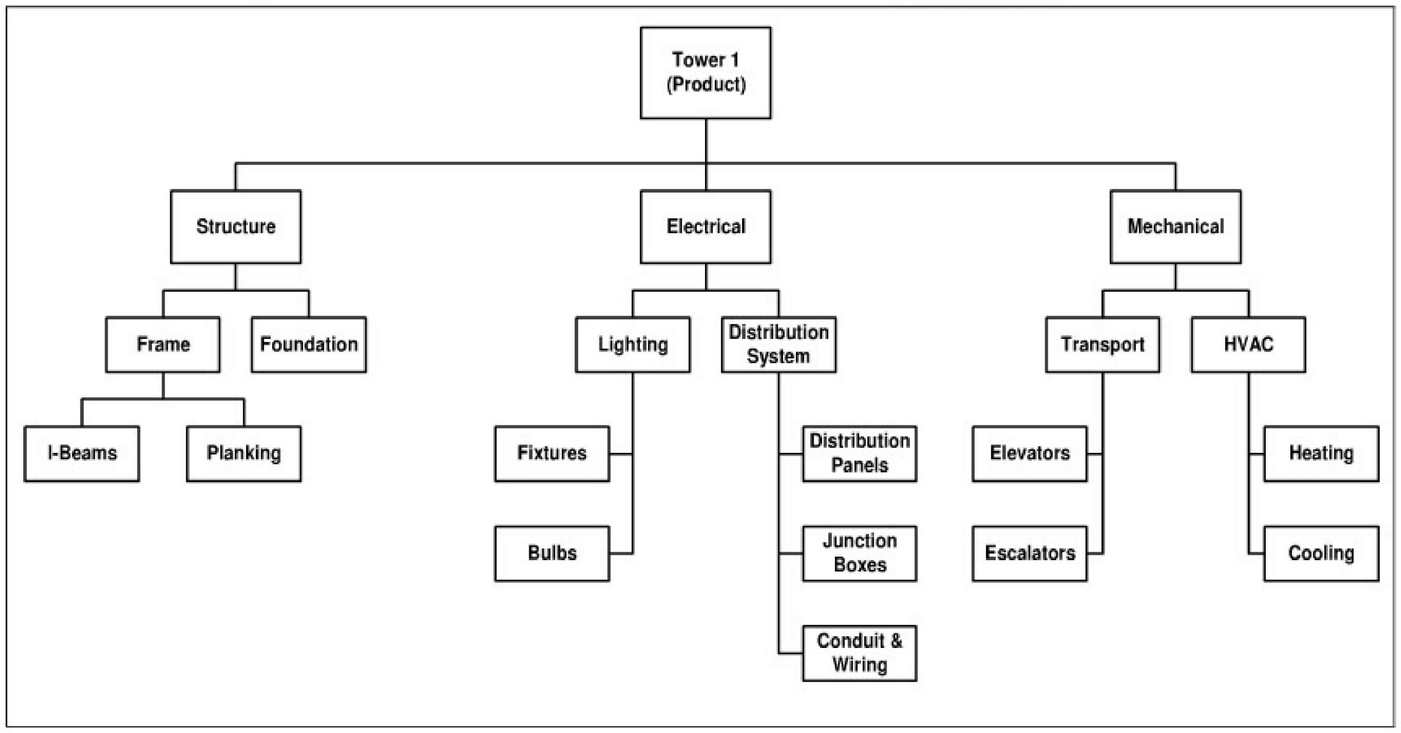


Figure 11 — Sample Product Structure in Hierarchical Diagram

Other methods of illustrating this structure include specification trees as illustrated in Figure 12, drawing trees, and work breakdown structures. In either approach of the two figures, the product is decomposed in recognizable levels of sub-tiered products, also known as assemblies, components, and parts. Product structure refers to the identifiers, internal

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structure, and relationship of product components and associated product configuration information.

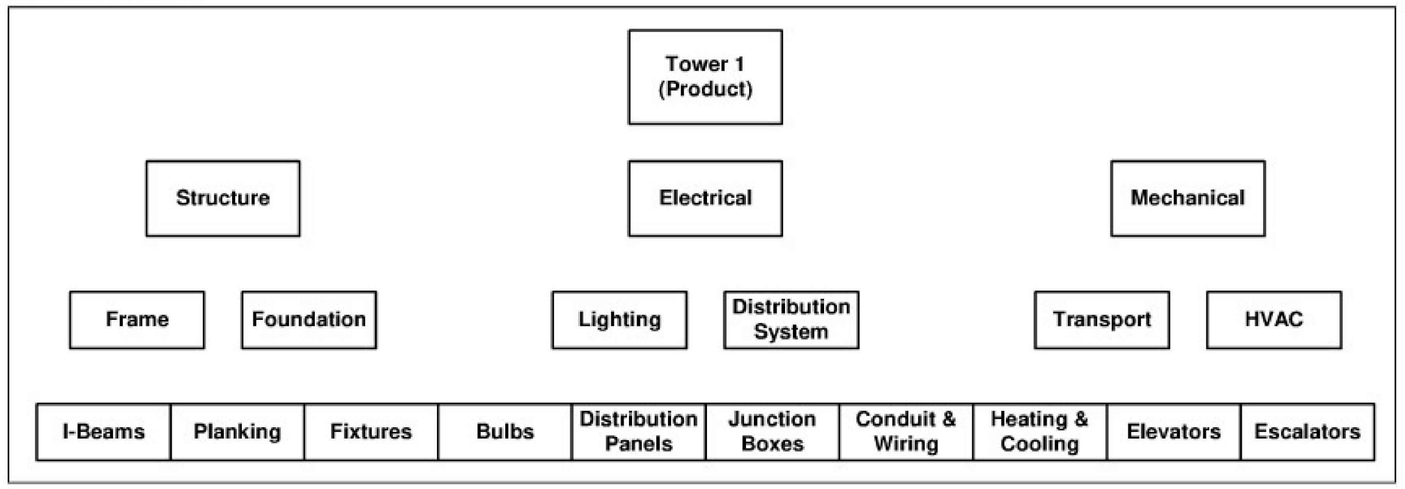


Figure 12 — Sample Product Structure in Specification Tree

Another common approach for illustrating product structure includes using an indentured listing as illustrated in Figure 13.

Tower 1	**TW1-50000**
Structural Assembly	**TW1-51000**
Frame	**TW1-51100**
I-Beams	**TW1-51110**
Planking	**TW1-51120**
Foundation	**TW1-51200**
Electrical System	**TW1-52000**
Electrical Distribution	**TW1-52100**
Distribution Panel	**TW1-52110**
Junction Box	**TW1-52120**
Conduit/Wiring Installation	**TW1-52130**
Lighting Installation	**TW1-52200**
Fixtures	**TW1-52210**
Bulbs	**TW1-52220**
Mechanical System	**TW1-53000**
HVAC Installation	**TW1-53100**
Heating	**TW1-53110**
Cooling	**TW1-53120**
Transport Installation	**TW1-53200**
Elevators	**TW1-53210**
Escalators	**TW1-53220**

Figure 13 — Sample Product Structure in Indentured Drawing List

These three figures provide views of the product structure that are directly traceable to all levels of the product.

5.2.3 Identifying Products and Product Configuration Information

This section describes the concepts for the assignment of identifiers to products, assemblies, components, and parts and their associated product configuration information. Products are

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marked or labeled with their applicable identifiers to enable correlation between the product, its product definition information and the associated product operational information for each unit of the product. Uniquely-identified products and documentation are essential to effective CM throughout the life cycle, particularly during the distribution, operation, and disposal product phases when the marking on a part is the key to installing a correct replacement part and finding the proper installation, operation and maintenance instructions.

5.2.3.1 Identify the Product Source and Product Configuration Information

PRINCIPLE 2-3A: USE ENTERPRISE IDENTIFIERS ON PRODUCTS AS WELL AS RELATED PRODUCT CONFIGURATION INFORMATION, TO DESIGNATE THE RESPONSIBLE DESIGNER OR MANUFACTURER.

Principle 2-3A says that Enterprise IDentifiers (EIDs) are a necessary part of the identification schema for the product. The EID is intended to be a unique identifier for the originator or design enterprise. Use of such an organizational identifier allows the differentiation between products and related product configuration information generated by a specific organization from all other products and information generated by all other organizations. It is advisable to utilize a standardized organization identification scheme to avoid duplication of enterprise identifiers.

Examples of such organization identification schemes include International Standards Organization (ISO) 13584-26, Information Supplier Identification along with ISO 6523-1, Identification of Organization Identification Schemes; the Data Universal Numbering System (DUNS) identifier system; the U.S. Government Commercial and Government Entity (CAGE) code; and the North Atlantic Treaty Organization (NATO) Supply Code for Manufacturers (NSCM) system. Table 6 lists examples of the existing EID schemes, identifies how to contact them for registration, and shows the identifier convention.

Table 6 — Major EID Issuing Registries Examples

EID Category	Internet Site	Numbering Convention	Issuing Entity
CAGE Code	http://www.dlis.dla.mil/cage_welcome.asp or http://www.ccr.gov/	5 alpha-numeric characters without any special characters or spaces	U.S. Government Issued
DUNS	www.dnb.com or http://www.ccr.gov/	9 digit identification sequence	Dunn & Bradstreet
ISO 13584-26	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=32856	4 numeric characters (Registration Authority) followed by up to 35 alphanumeric characters (organization code) plus optional fields.	ISO
NSCM	www.dlis.dla.mil/nato_poc.asp	5 alpha-numeric characters without any special characters or spaces	Issued by NATO

Often a small supplier will not have an EID from a registry such as those shown in Table 6. At these times, the purchasing enterprise may assign a derived EID to its supplier for

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