LCSIS®

Life Cycle Support
Information System

Training Guide

Visible
SYSTEMS CORPORATION

This manual is intended for both the end user and the administrator of the LCSIS tool suite.

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Welcome to LCSIS

LCSIS is a product data management software application developed to support and enhance product design and development, manufacturing, and in-service life cycle support. LCSIS was designed from conception to support sound configuration management principles and associated change control as well as to provide rapid retrieval and viewing of vaulted digital objects that identify and define configuration items. Through its graphical user interface design, LCSIS has the feel and look of the Windows environment while offering all of the advantages of client/server technology and relational database architecture.

LCSIS was designed to create product baselines during initial product development and, at the same time, provide a means for the permanent storage of digital data in predefined folders tied to each configuration item created in the design. This product-centered design approach separates LCSIS from the majority of document management products offered today that are unable to create meaningful relationships between their product structures and their associated documentation. LCSIS is able to create and modify multiple baseline variants through a product's life cycle and still maintain its relation ship to its documentation. As new baselines are added to create variants of existing products or modifications are made to existing life cycle baselines, documentation associated with configuration items is carried forward and maintained as revisions to existing documents. New reference documents can be added to enhance each configuration item's library of documents or deleted if they become obsolete.

LCSIS offers users the ability to create four basic product baselines that are both relevant and meaningful during a product's life cycle. These baselines, defined by the Configuration Management Institute of America in conjunction with the University of Arizona are: 1) the Bill of Material (BOM); 2) the As-Planned; 3) the As-Built; and 4) the As-Modified. Each baseline is extremely important because it establishes benchmarks in a product's life cycle. The benchmarks are used to coordinate such activities as long lead time procurements; baseline documentation requirements; defining the product to be built, and tracking the deployed product to support both out-year product liability issues and product upgrades.

LCSIS allows multiple users to access data simultaneously without affecting performance. Additionally, LCSIS provides full system metrics for every action initiated by an author-

ized user. By simply defining a given period of performance, the system administrator can generate a summary of actions undertaken for a particular time period. LCSIS also monitors all action undertaken by the system administrator by automatically notifying each individual program manager, with a warning message, of every change action to the database that is initiated to his product by the system administrator. In essence LCSIS is on guard twenty four hours a day, to ensure the validity, integrity, and accessibility of product data required to design, manufacture, and support a product throughout its life cycle.

1 ....Configuration Management (CM)

CM is the process of managing physical configurations and their supporting processes through documents, records, and data.

Objectives

Configuration Management was created as the result of tragedy and first formalized in the Defense and Space communities. Most CM Procedures have been implemented by contractors doing business with government agencies and commercial industries.

What is CM?

CM

"A Management Process

for establishing and maintaining consistency of a product's physical and functional attributes

with its design and operational information

throughout its life,

using disciplined change management."

EIA STANDARD 649

Configuration Management:

- is applied over the life cycle of a product,
- provides visibility and control of its performance, functional, and physical attributes,
- verifies that a product performs as intended, and is identified and documented in sufficient detail to support its projected life cycle, and
- corrects defects.

The CM process facilitates orderly management of product in order to revise capability; improve performance, reliability, or maintainability; extend life; and/or reduce cost

The lack of CM, or its ineffectual implementation, can be very expensive and can result in failure of equipment or loss of life.

Why CM?

- Increase Profits
- Reduce Time to Market
- Expedite Change Process
- Expedite Response to Queries
- Support ISO 9000 Certification
- Control Documentation
- Provide Traceability

The purpose and benefits of CM include the following:

- Product attributes are defined.
- Product configuration is documented and a basis for change established.
- Products are labeled and correlated with required information.
- Proposed changes are identified and evaluated for impact prior to making change decisions.
- Change activity is managed using a defined process.
- Configuration information is organized for retrieval.
- Actual product configuration is verified against the required attributes.

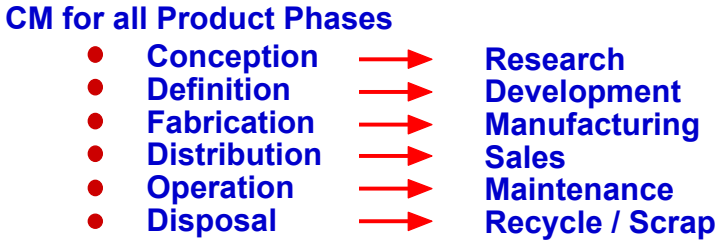
For example, software developers practice configuration management to identify and control versions of their product. The automotive industry practices CM to support the spare parts market, to track warranties, and to be able to effect recalls, when necessary. The nuclear power and armament production industries use CM to maintain both products and facilities.

CM Standards & Specifications
MIL-STD-973 (Military Standard for CM)
MIL-STD-2549 (DoD Interface Standard)
EIA-649 (Commercial Standard for CM)
ISO 10007 (International Standard for CM)

CM Course of Instruction
Institution for Configuration Management
Sponsored by
Arizona State University
The University of Tennessee

The emphasis placed on various CM principles and practices differs in each phase of the product life cycle:

- Conception
- Definition
- Fabrication
- Distribution
- Operation
- Disposal.



The basic principles of CM come into play in varying degrees in each phase. To tailor CM for a given product:

- identify the applicable phase(s),
- select the appropriate CM principles that apply, and
- determine the degree to which they apply during each phase.
- CM principles underlie sound business practices:
- The orderly establishment, documentation, and maintenance of a product's functional, performance and physical attributes.
- Management of changes to those attributes.
- Access to accurate information essential to the product's development, fabrication, production, use, maintenance, procurement, and eventual disposal.

CM practices are employed because they make good business sense rather than because requirements are imposed by an external customer. All of the CM principles are applicable to a product environment in which a robust CM approach is necessary. A risk vs. benefit assessment should be conducted before discarding principles which, although desirable, appear to be too costly. All too often the "best practices" associated with a principle are equated with "most costly" when in fact they represent "best investment." In the long run, these investments, like insurance, may prove to be the "least costly" alternative.

CM is a PROCESS -- a DISCIPLINE
for Managing Documents Records & Data

The CM Process must
accommodate change
and provide
CLEAR CONCISE VALID
Documents Records Data

Disciplined Consistent Conformance
to the PROCESS is a Prerequisite
(Computerizing a Poor PROCESS is a Step Backward)

The CM process addresses the composition of a product, configuration documentation defining the product, and other data concerning products that support it. CM provides tailored methods and procedures for effectively planning, recording, controlling, and validating product requirements along with the data containing the requirements. Where applicable, the CM process also addresses the document representations and associated digital data files that may be accessible on physical media or from on-line information services.

Software configuration management (SCM or SWCM) is integral to the configuration management process for a program or project which includes software development or maintenance. The same objectives, purpose, and benefits of CM apply to software as to any other product. SCM is also integral to a modern, automated, tool-driven software engineering process. Preferably, SCM is automated using tools within the software engineering environment.

Interrelated CM Processes

The CM process may be related to a single product or to an associated collection of products (sometimes referred to as a system or subsystem) and described in terms of the following interrelated processes:

- Configuration identification
- Configuration change management

- Configuration status accounting (CSA)
- Configuration audit
- CM of digital data
- CM planning and management.

Interrelated CM Processes:

- Configuration Identification
- Configuration Change Management
- Configuration Status Accounting (CSA)
- Configuration Audits (Verifications)
- CM of Digital Data (Software CM)
- CM Planning & Management

Configuration Identification

The purpose and benefits of configuration identification include:

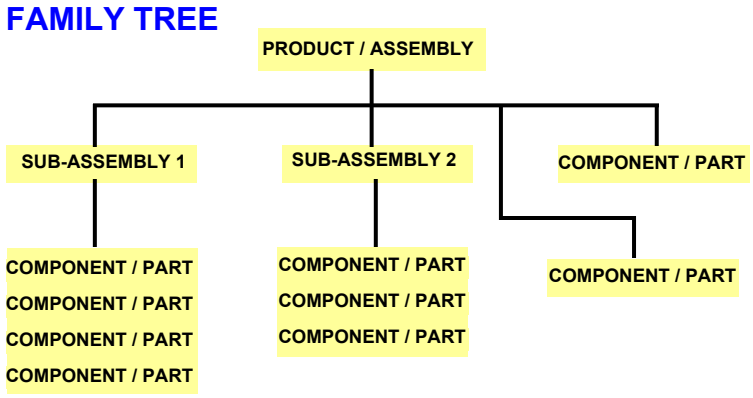
- Determining the structure (hierarchy) of a product
- Documenting the performance, interface and other attributes
- Determining the appropriate level of identification marking
- Providing unique identity to a product or to a component
- Providing unique identity to associated technical documents
- Modifying identification to reflect incorporation of major changes
- Maintaining release control of documents for baseline management
- Enabling a user to distinguish between product versions
- Enabling a user to correlate a product to related instructions

- Facilitating management of information
- Correlating individual product units to warranties and service life obligations
- Enabling correlation of document revision level to product version/configuration
- Providing a reference point for defining changes and corrective actions

These benefits are realized only if there is consistency between a product itself and the information about the product. To achieve consistency of the product attributes and the information about them, the performance, functional and physical attributes are first defined in configuration. documentation. Consistency is maintained throughout the product life cycle by identifying and evaluating the impact of all proposed changes.

Product Structure

A product structure is a common technique for organizing the composition of a product. It is a representation of the breakdown hierarchy (i.e., product tree, "family tree", or pyramid) of a complex product, from the top down to the lowest level. Each level makes reference to associated configuration documentation (e.g., engineering drawings, bills of material, specifications, processes and procedures).

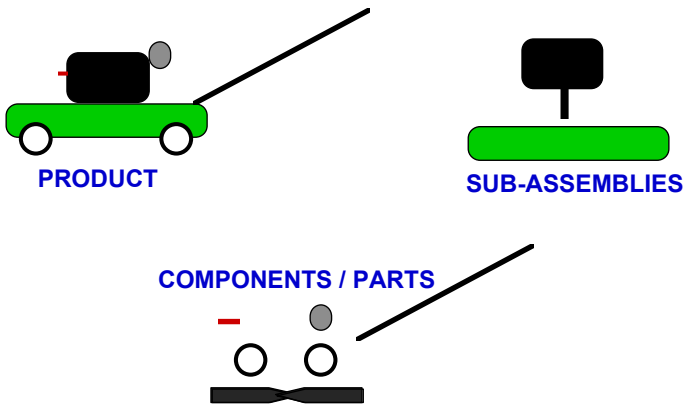


The product structure shows the top-down relationships among the various parts that make up the product and the quantity of each. The product structure is complete when all parts are included.

Product Identifiers

There are two general levels of product and document identifiers:

- (1) the identifier level that is visible to an external customer or user of the product during the operational period, and
- (2) the level of identifiers of the product and its component parts that is internally necessary for the developing and manufacturing activity to manage the configuration during the definition, build, and operation phases .



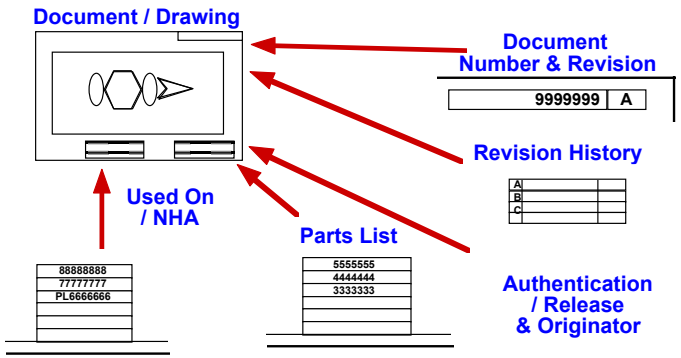
The customer requires identifiers of the product and all parts that can be ordered as spare, replacement, or accessory parts, and of any parts that have specific service life attributes (such as shelf life or limited period of operation) or specific warranties. The customer also requires unique identifiers for documents which reflect the configuration of the product to the same level. The developer needs all of that information plus the complete set of identifiers for all parts comprising the product, and their associated documents.

The most commonly used identifier for a part, consists of a part number and a code representing the design activity/manufacturer/supplier. These elements are necessary for auto-

mated systems. A widely accepted practice is for the design document (engineering drawing) number to be the same as, or included within, the part number. The code and/or the supplier's name and logo may appear.

A product and each of its component parts are assigned unique identifiers as follows:

- Part numbers (and in some cases, names such as "nylon") are assigned for all new products down to the lowest level in each branch of the product structure for which that activity has development responsibility.
- Already developed products used as components of the product retain their existing identifiers (part numbers), unless modified to the extent that interchangeability is affected
- Parts of the product developed by, or acquired from, suppliers retain the unique identifiers assigned by the supplier. If the acquiring activity has special requirements, it may choose to provide a unique identifier in addition to the supplier's identifier, to correlate the part to its specification document. The additional identifier distinguishes the part meeting special requirements, such as additional test or parts screening, from like parts that do not.



When a change is applied to a product (or component of a product), its descriptive configuration documentation (engineering drawing, product model) is updated to reflect the change. The unique identifier assigned to a product, or part, and the marking on the part itself, are changed to distinguish one configuration of the product from another, when:

- The new or updated part is no longer interchangeable functionally and physically with the previous part
- The new part requires new or revised testing, maintenance, repair, training, operating procedures, equipment, or software
- The part is altered, selected or is a source controlled item
- The updated part has different application, use, safety, or other restrictions.

When a repair part within a product is changed so that it is no longer interchangeable with its previous version (it does not match in form, fit and function), it must be assigned a new identifier. The standard rule is to re-identify the next higher assembly and all subsequent higher assemblies up to and including the level at which interchangeability is re-established, because you cannot have two different configurations with the same CI.

Software identifiers are assigned for each software product and for each element of the software engineering and test environments. The software identifier includes the version of the entity (typically, a dash number or decimal is used to separate the version number from the root software number). Software units are assigned a name or number that is unique within the software product.

The most widely accepted method of identifying an individual unit within a series of like units is by assigning a unique serial number to each unit. Some illustrative examples of when product units should be serialized are:

- When products with the same basic identifying number can be provided with customer options (e.g., paint color), serialization (such as the vehicle identification number on a car) provides the means to direct the customization and to maintain appropriate records.
- When products have warranties, the serial number is used to correlate information concerning dates of manufacture and sale and the warranty period for each individual unit. In effect, the serial number fixes the part number in time.
- Whenever each unit must be subject to individual functional and performance testing or screening, such as acceptance testing, serialization provides the means to correlate each unit to its test records.
- When products are modified, they retain their original serial number, even though their part identifying number is altered to reflect a new configuration.

All documents which include information related to the product (such as maintenance records, reports, letters, and memoranda), are uniquely identified so that they may be referred to precisely and retrieved when necessary. Configuration documents and other

product related documentation cite, or are linked (in a data base or other cross-reference) to the product identifier and revision with which they associate.

Baselines

BASELINE:
A Heirarchy of Subordinate Level Configurations

- **As - Planned (Design of Record)**
- **As - Built (Production Baseline)**
  (Maybe Several)
- **As - Modified (Serialized Components)**
  (End Result of Production)

Baselines are the fundamental foundation of CM. Baselines provide an assurance of the stability and consistency of information needed for subsequent activities. They provide a common communication of product definition and also a vehicle permitting transfer of authority over all or a portion of a product' s definition. The requirements definition established before beginning a product' s design represents a baseline; the completed detailed drawings, as production begins, represents another.

The As-Planned Baseline (sometimes referred to as the Design Baseline) represents the CI as approved for future contracts. It includes all approved changes, even those which may never be included in a production for any of a variety of reasons. The As-Built Baseline (sometimes termed the Production Baseline) reflects the design approved for production. The As-Modified Baseline reflects the CI as actually built, including serialization, and Variances (Waivers/Deviations), if any.

The current approved configuration defines the baseline and becomes the basis for the next change. Baselines are normally established within the enterprise developing and manufacturing a product. The baselines frequently become formalized at the interface between customer and supplier, depending on the practices of the industry and the contractual involvement of the customer in the product change process.

Identified baselines are often categorized by the degree of detail defined (e.g., requirements, design release, and product configuration baselines) or by the placement of authority for change approval (e.g., external customer baseline, program baseline, engineering baseline).

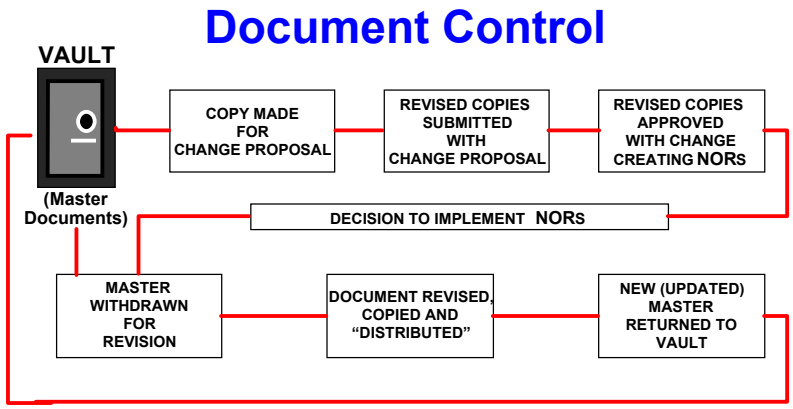
To provide a consistent reference when describing the principles of configuration management, the baseline terminology and protocol, described below are used in some disciplines. They overlap the more common definitions above:

- Requirements Baseline - The customer baseline established for a product represents firm performance (functional) requirements For new development, the requirements baseline is often a product of the conception phase
- Design Release Baseline - Design information is normally created, reviewed, and incrementally released over a period of time during the definition phase of a product's life cycle. Once design information is released, it becomes part of the design release baseline controlled by the developing activity.
- Product Configuration Baseline - A baseline is normally established for a product at the end of the definition phase, when the detailed design of the product is "frozen" and the Build phase begins. It is defined by the complete set of current product configuration documentation constituting the current design release baseline. Once the product configuration baseline is fixed, it is changed only through appropriate configuration change management action.

When an already developed product is purchased by a customer, the current product configuration baseline defines the configuration of the product supplied, unless a configuration change is approved. The unit(s) of product delivered in the current product baseline configuration may differ from the configuration of earlier units, delivered to a previous baseline configuration.

Configuration Control

Before any document or data set is considered part of a baseline, it must be reviewed to ensure that the document is complete, valid and suitable for use. A release system/process is employed to validate the document and file integrity. The set of master documents must be carefully controlled.



Configuration change management is essentially a process for managing baselines. Baselines are tools to match the need for consistency with the authority to approve changes. A configuration management system or plan must recognize:

- What baselines are to be established
- When and how they will be defined
- The process for assuring document and file integrity
- The authority to approve baseline changes
- If and when change authority will transfer
- The process by which proposed changes will be dispositioned.

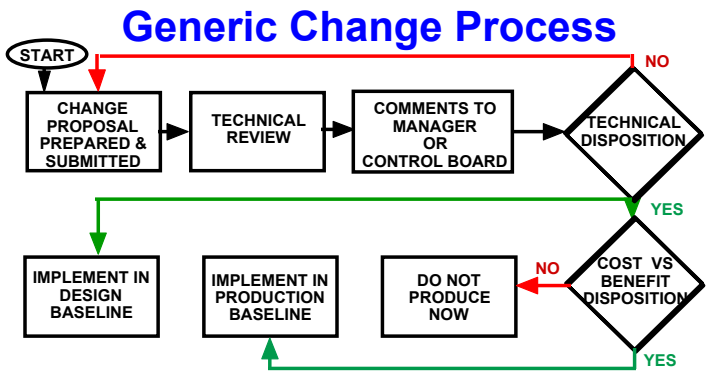
Configuration Change Management

Change Vehicles / Documentation:

- **ECP - Engineering Change Proposal**
- **NOR - Notice of Revision**
- **EO - Engineering Order**
- **RDW (RFD/RFW) - Request for Deviation/Waiver**

Changes to a product are accomplished using a systematic, measurable change process. The purpose and benefits of the change management process include :

- Enable change decisions to be based on knowledge of complete impact
- Limit changes to those which are necessary or offer significant benefit
- Facilitate evaluation of cost, savings, and trade-offs
- Ensure customer interests are considered
- Provide orderly communication of change information
- Preserve configuration control at product interfaces
- Maintain and control a current configuration baseline
- Maintain consistency between product and documentation
- Document and limit variances
- Facilitate continued supportability of the product after change



The process includes:

- Identifying the need for a change
- Documenting change impact
- Evaluating and coordinating the proposed change
- Incorporating the approved change in the product and its related configuration documents; and
- Verifying consistency of the product definition

The process also encompasses the identification, documentation approval, and implementation of variances from configuration baseline requirements

The initial baseline for change management consists of the configuration documentation defining the requirements that the performing activity (i.e., the product developer or product supplier) has agreed to meet. The "approved" change then becomes part of the current baseline.

The design release baseline for change management consists of the detail design documentation used to manufacture, construct, build, or code the product. The design release baseline incrementally defines the design that is developed to meet the customer's performance requirements. Internal configuration control measures are applied to the configuration documentation constituting the design release baseline for a product, during the definition phase.

The product configuration baseline for change management consists of the detailed design documentation from the design release baseline which defines the product configuration that has been proven to meet the requirements for the product.

Documenting Requests for Changes

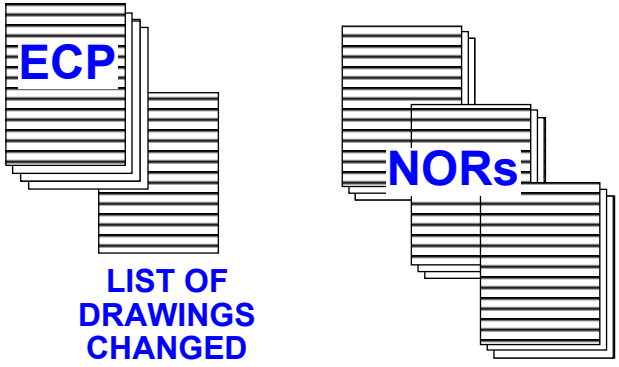
Documentation of major changes includes the following information that is required to make an informed evaluation of the change and to clearly define the change:

- Unique change identifier
- Originator organization and responsible individual
- Class of change
- Product(s), major components, interfacing products affected
- Contract and configuration documents affected
- Scope and description of change, including work efforts
- Effects on specified performance, operation, maintenance, servicing, operation and maintenance training, spare and repair parts, support and test equipment, catalogs, marketing literature, etc.
- Reason and justification for the change; consequences of not doing the change
- Priority/urgency of the change
- Proposed change effectivity
- Requested approval date
- Change implementation and delivery schedules
- Estimated cost increase or savings
- Alternatives

Minor changes are documented in the format used to release and communicate design changes. As a minimum, the following information is necessary:

- Unique change identifier
- Originator organization and responsible individual
- Class of change

- Product, assemblies, and components affected
- Configuration documents affected
- Description of change
- Reason for the change
- Proposed change effectivity.



In DoD application practice, a minor change that requires government review (or sometimes only concurrence) is designated as a Class II change.

Requesting Changes

Changes may be initiated for a variety of reasons, to include:

- To provide new capabilities desired by a customer(s)
- To enhance product support
- To insert new technology
- To effect product improvements
- To correct product defects or deficiencies
- To correct problems and prevent recurrence

- To eliminate safety hazard conditions
- To implement pre-planned product improvement
- To reduce production costs/ improve production efficiency
- To prevent schedule slippage.

Requests for change are documented either by the requester directly or by the sponsor after communication with the requester. The originator and sponsor make preliminary judgments to identify the proper change authority and to determine the processing method and document format that are most appropriate. These judgments concern:

- The need for the requested change
- The basic scope and description of the requested change
- The definition of its impacts
- The desired effectivity
- Its urgency and importance.

Change Approval Authority

The approval authority for a change can be delegated depending upon the classification of the change. As the life cycle progresses, the change authority often transitions to individuals with greater management and fiscal responsibility, because the effect of a change can be more widespread and, as a result, the cost impact of change decisions are normally greater.

The simplest, most informal level of configuration control is practiced by an individual authoring initial drafts of a document. The individual controls the document's content and may unilaterally change it. If generation of the complete document is a group effort, each author working on his assigned portion also has unilateral control until such time as the individual portions are consolidated into a common draft. The initial consolidated draft then becomes the governing revision. Responsibility for its management passes to a lead individual. If work in process, or even scheduled future work, is impacted by the document change, control rises to a level of management with the authority to approve the work scope changes The process for obtaining approval may be relatively informal, or more structured, depending on the organizational interfaces and customer impact. The most complex multi-level configuration control is practiced on projects in which authority for making change decisions is structured around tiered "Change Boards."

Planning for, and implementing, a change can be very simple or can involve many complex and inter-related considerations. The basic planning for implementation of the change is accomplished during the engineering change evaluation before the change is approved. Once the change is approved, detailed implementation planning which expands but remains consistent with the basic planning is normally required.

Implementation of a change involves the release of new or revised configuration documentation including requirements and design information. It may involve changes to operation and maintenance information, build and test information, and sales information (such as catalogs, marketing literature). The new or revised information is identified and released.

CHANGE PROPOSAL ACTION:

- **Disapprove**
- **Return for Rewrite / Resubmit**
- **Approve (after Revision or Correction if necessary)**
  - **For Design Only**
  - **For Production**
  - **For Retrofit**

Change Management Process applied to Variances

Products that incorporate a known departure from requirements (even if the requirements are internally specified) should not be delivered to a customer unless a variance has been documented and authorized. Authorized variances are temporary departures from requirements and do not constitute a change to the configuration documentation.

If it is decided that a departure will be permanent, an engineering change is processed. Similarly, unless unusual circumstances exist, a variance should not be processed if it would affect operation, support, or maintenance, or if it would include the entire remaining number of deliverable units of the product. Rather, an engineering change should be proposed. In some programs the approval of a variance is required to be temporary and the requester is required to forward an ECP in the near future.

Requests for variances should always be documented in writing, either by the requester, or by the sponsor after verbal communication with the requester. Requests for variances should include the following information:

- Unique identifier for the variance
- Originator organization and responsible individual
- Category of variance, if applicable (Deviation or Waiver)
- Identifiers of the product(s) and components affected
- Description of variance including (if any) impacts to performance, operation, maintenance, servicing, operation and maintenance training, spare and repair parts, support and test equipment, catalogs. marketing literature, etc.
- Reason/justification for the variance
- Priority/Urgency
- Proposed effectivity of the variance (limited quantity or time period)
- Corrective action to prevent recurrence and/or to eliminate the variance
- Consideration, if any, for accepting variant products
- Alternatives.

After approval of a variance, there is normally a corrective action to prevent recurrence of the variance or to eliminate it completely as, for example, with an engineering change.

In DoD application practice, variances are called deviations (formerly deviations and waivers) and are classified as Critical, Major and Minor.

Change Impact Assessment

Change Boards are a common means of achieving the coordination necessary to evaluate a change and assess its impact. Change boards go by many aliases, but whether it is a committee, team, program review board, configuration control board, change review board, or some other name, it should have the following characteristics:

- A change board should be chaired by someone with the authority to commit the resources of the enterprise to implementing the change
- Members of the board should represent the functional activities or product development teams impacted by the proposed changes and have the authority to commit the group they represent to the implementation actions required for the changes

- Review agendas and documents should be provided to board members prior to the meeting
- Board direction and decisions should be documented and disseminated all affected activities.

Change Effectivity Determination

Lack of timely and concurrent support was one of the primary factors leading to the formulation of the configuration management discipline. Therefore, choosing an effectivity requires knowledge not only of the lead times associated with changing the product (whether in production or by retrofit, recall or other means), but of the actions and lead times necessary to effect the associated change in all impacted support areas (such as the update of support software, availability of spare and repair parts, or revision to operating and maintenance instructions). In addition, effectivity determination typically requires the balancing of a number of other considerations, such as:

- Urgency of the change, e.g., is safety involved
- Parts and materials on hand (can implementation be delayed until they are depleted, can they be modified, or do they need to be scrapped?)
- The need to support multiple configurations because all existing units of the product will not be updated, or will not be updated at the same time
- Timing of the introduction of the changed product with respect to customer preferences and needs, competition, marketing strategies, etc.

Effectivity is expressed in different ways depending on product type and quantity or rate of production. Two common means of expressing effectivity are by product unit identifying number (e.g., serial number) and by date code (e.g., date of manufacture). Other examples of effectivity expression are by model year, model designation, version number, and by product group identification number (e.g., lot number, batch number). All of the methods of expression are intended to delineate, as clearly and precisely as practicable, which unit(s) of the product are and are not to be changed.

Change Cost/Price Determination

Determining change costs (or savings) is usually one of the most critical factors that must be addressed in making a decision about a change. The decision should be based on a cost/benefit analysis covering the remaining product life cycle. Cost estimating and pricing of a change cannot be effectively accomplished without the knowledge resulting from the impact assessment and effectivity determination. That knowledge facilitates determi-

nation of not only the immediate cost of making the change but also the expected costs that will be incurred in the future because the change is made.

Configuration Status Accounting (CSA)

CSA:

- Correlates, stores, maintains and provides readily available views of this organized collection of information
- Provides access to accurate, timely information about a product and its documentation throughout the product life cycle.

CSA involves:

- The storage and maintenance of the configuration documentation
- Information about the configuration documentation (such as document identifiers and effective dates)
- Information about the product's configuration (such as part numbers or changes installed in a given unit)
- Information about the product's operational and maintenance documentation (such as the documents affected by each change and their update status), and
- Information about the CM process (such as the status of change requests.)

The purposes and benefits of CSA include the following:

- Enables retrieval of information concerning change decisions
- Supports inquiries concerning future planning of design changes, investigations of design problems, warranties, shelf and operating life calculations, etc.
- Provides access to complete configuration information on a product, any individual product unit, or group of product units
- Provides access to accurate identification of the configuration of each delivered product unit (or batch/lot of product units)
- Improves capabilities to identify, produce, inspect, deliver, operate, maintain, repair, and refurbish products

- Enhances availability of accurate information on spare parts and maintenance support
- Provides a source for configuration history of a product and all of its configuration documentation

As an example of CSA, the critical nature of military aircraft escape systems containing explosive devices with limited life, makes accurate complete and traceable change history records for each serial numbered unit essential so that future inquiries and investigations can be supported. As another example, the nature of liability and warranty obligations on a commercial vehicle make it necessary to capture the dates of manufacture and sale, as well as the installation dates of changes.

Configuration records must be generated and maintained by an effective and timely CSA information management system. Most information resulting from such CM activities as release, change evaluation, change approval and change verification, are collected, correlated and maintained in a database. The extent, complexity, and interrelationships of product information to be managed typically requires the use of information systems products such as a product data manager (PDM), and a work flow manager. The supporting information system must also provide storage and security of product information and traceability of product history.

Configuration Verification and Audit

Configuration verification and audit actions establish that the performance and functional requirements as defined in the documentation have been achieved by the design and that the design has been accurately documented. The purpose and benefits of the process include:

- Ensuring that the product design provides the agreed capabilities
- Validating the integrity of the documentation
- Verifying the consistency between a product and its documentation
- Determining that an adequate process is in place to provide continuing control
- Providing confidence in establishing a product baseline
- Ensuring a known configuration as the basis for operation and for maintenance instructions, training, spare and repair parts, etc.

An effective configuration audit, typically performed at the conclusion of the definition phase or at the start of the build phase, includes performance verification (the functional configuration audit) and design verification (the physical configuration audit). As appro-

priate, ongoing production and processes are audited, tested or inspected to determine continued suitability and consistency of the product or process with its documentation.

Operation of products or facilities are periodically reviewed to identify and monitor changes or degradation of performance, or to compare existing elements with new criteria or requirements. Associated documentation is changed or updated to maintain consistency between the product and its definition.

Configuration Management Planning and Management

CM planning and management over the life cycle of a product are essential to achieve effective, predictable and repeatable control in each phase. CM activities focus on the product and on the customer and shape the application of solid, practical procedures which result in cost avoidance and product stability.

Once effective CM processes are implemented, existing plans and procedures normally require relatively minimal fine tuning to suit specific aided tools and methodologies, product, market, or customer needs; or to incorporate improved computer-aided tools and methodologies.

An Optimal CM Process Depends Upon:

- Adherence to procedures
- Attention to detail
- Ability to accomodate change
- Clear, concise & valid
  - measurements
  - documentation
  - records
  - data
- Discipline

The CM Plan must cover these requirements.

The sophistication of CM implementation can range from elementary paper and pencil methods to the use of highly sophisticated, interactive, shared databases. The degree of sophistication may represent the best practice for a given application environment.

Each element of increased sophistication requires an investment in time and money to establish, but usually results in reduced recurring costs if appropriate to the application environment. In many instances, a highly sophisticated system is totally inappropriate.

The purposes and benefits of CM planning and management include:

- Ensuring that the appropriate CM processes are applied
- Establishing organizational responsibilities for CM activities
- Determining the necessary resources and facilities
- Providing a basis for continuous improvement

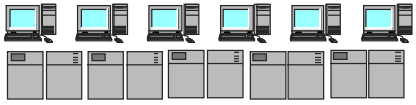
The CM Plan is driven by:

- External constraints (such as product scope, product importance and complexity, production quantity, quality needs, number and size of organizations involved, budgets, and schedules)
- The application environment (such as defense energy, automotive, building construction, or consumer products), and
- The life cycle phases (such as definition, build, distribution, operations, and disposal)

CM Plan & Processes :

As Simple as Possible

As Sophisticated as Required



Typical questions relating to these topics include:

- Who is/are the customer(s)?
- What are the attributes of the customer's and the end user's environments that need to be addressed by CM?
- What role will the customer play in decisions about changes?
- What is the current phase of the life cycle
- What are the anticipated future phases?
- What is the technical complexity of the product?
- Are there product components requiring separate management attention?
- Is the product, a new design, an existing design, or a modification to an existing design?
- How complex a documentation package is necessary?
- If in the operational phase, what documentation is available, and does it reflect the current product?
- What level of change activity, if any, is anticipated?
- Are changes expected to be requested by customers/users?
- What is the anticipated operational life of the product?
- What, if any, are the required attributes related to disposal; are environmental issues involved?
- What specific information will be required by users, maintenance activities, or others?

A new CM Plan is necessary only when an established CM Plan and well established CM processes are not in place. With a plan and processes in place, the plan may be supplemented or used as "boilerplate" for new, but similar, products. The minimum information for the new product is a milestone chart and schedule of resources.

Product Data Management (PDM)

PDM had its origin as a convenient system to handle Computer Assisted Drawing (CAD) files. It was later expanded to control and manage other types of documentation. PDM now manages a broad range of product-related technical information, including:

- Design Geometry
- Project Plans
- Assembly Diagrams
- Correspondence
- Bills of Materials
- Engineering Drawings
- Parts Files
- Analysis Results
- Software
- Design Configurations

Attempts have been made to adapt computer PDM systems to handle the more demanding discipline of Configuration Management. These attempts have met with only limited success.

TheVisible Systems Corporation solution to Product Data Management has been to build from extensive experience in CM and design a PDM system that would meet all requirements.

Appendix A
The Principles of Configuration Management (from EIA Standard 649)

- Plan CM processes for the context and environment in which they are to be performed and manage in accordance with the planning: assign responsibilities; train personnel; measure performance; and assess measurements/trends to effect process improvements.
- To determine the specific CM value adding functions and levels of emphasis for a particular product, identify the context and environment in which CM is to be implemented.
- A configuration management plan describes how configuration management is accomplished and how consistency between the product definition, the product's configuration, and the configuration management records is achieved and maintained throughout the applicable phases of the product's life cycle.
- Prepare procedures to define how each configuration management process will be accomplished.
- Conduct training so that all responsible individuals understand their roles and responsibilities and the procedures for implementing configuration management processes.
- Assess the effectiveness of CM plan implementation and performance of the configuration management discipline with defined metrics (performance indicators).
- Performing configuration management includes responsibility for the configuration management performance of subordinate activities (e.g., subcontractors and vendors).

- Configuration identification is the basis from which the configuration of products are defined and verified; products and documents are labeled; changes are managed; and accountability is maintained.
- Configuration documentation defines the functional, performance, and physical attributes of a product. Other product information is derived from configuration documentation.
- The product composition (i.e., relationship and quantity of parts that comprise the product is determinable from its configuration documentation.
- All products are assigned unique identifiers so that one product can be distinguished from other products; one configuration of a product can be distinguished from another; the source of a product can be determined; and the correct product information can be retrieved.
- Individual units of a product are assigned a unique product unit identifier when there is a need to distinguish one unit of the product from another unit of the product.
- When a product is modified, it retains its original product unit identifier even though its part identifying number is altered to reflect a new configuration.
- A series of like units of a product is assigned a unique product group identifier when it is unnecessary or impracticable to identify individual units but nonetheless necessary to correlate units to a process, date, event, or test.
- All documents reflecting product performance, functional, or physical requirements and other product information are uniquely identified so that they can be correctly associated with the applicable configuration of the product.
- A baseline identifies an agreed-to description of the attributes of a product at a point in time and provides a known configuration to which changes are addressed.
- Baselines are established by agreeing to the stated definition of a product's attributes.
- The Configuration of any product, or any document, plus the approved changes to be incorporated is the current baseline.
- Recover of product information may be necessary in cases where models of operational units of a product do not match the actual units (as reported by maintenance activities) or where such records do not exist.
- For product interfaces external to the enterprise, establish an interface agreement and a mutually agreed to documentation of common attributes.

- Changes to a product are accomplished using a systematic, measurable change process.
- Each change is uniquely identified.
- Changes represent opportunities for improvement.
- Classify requested changes to aid in determining the appropriate levels of review and approval
- Change requests must be clearly documented.
- Consider the technical, support, schedule, and cost impacts of a requested change before making a judgment as to whether the change should be approved for implementation and incorporation in the product and its documentation.
- Determine all potential effects of a change and coordinate potential impacts with the areas of responsibility.
- Change documentation delineates which unit(s) of the product are to be changed. Change effectivity includes both production break-in and retrofit/recall, as applicable.
- A changed product should not be distributed until support and service areas are able to support it.
- The decision maker is aware of all cost factors in making the decision.
- Change approval decisions are made by an appropriate authority who can commit resources to implement the change.
- Implement an approved change in accordance with documented direction approved by the appropriate level of authority.
- Verify implementation of a change to ensure consistency between the product, its documentation and its support elements.
- If it is considered necessary to temporarily depart from specified baseline requirements, a variance is documented and authorized by the appropriate level of authority.
- An accurate, timely information base concerning a product and its associated product information is required throughout the product life cycle.
- Configuration information, appropriate to the product, is systematically recorded, safeguarded, validated, and disseminated.
- Configuration information content evolves and is captured over the product life cycle as tasks occur.

- Data collection and information processing system requirements are determined by the need for configuration information.
- Verification that a product's requirement attributes have been met and the product design meeting those attributes has been accurately documented is required to baseline the product configuration.
- Verification that a design achieves its goals is accomplished by a systematic comparison of requirements with the results of tests, analyses or inspections.
- Documentation of a product's definition must be complete and accurate enough to permit reproduction of the product without further design effort.
- Where necessary, verification is accomplished by configuration audit.
- Periodic reviews verify continued achievement of requirements, identify and document changes in performance, and ensure consistency with documentation.
- Apply configuration management principles to ensure the integrity of digital representations of product information and other data.
- Apply digital data identification rules to maintain document, document representation, and file version relationships.
- Apply business rules using data status levels for access, change management, and archiving of digital data documents.
- Maintain relationships between digital data, data requirements, and the related product configuration to ensure accurate data access.
- Apply disciplined version control to manage document review electronically.
- Ensure that a transmitted digital data product is usable.
- Effective digital data access fulfills requirements, preserves rights, and provides users with data they are entitled to in the correct version.

Appendix B
CM Definitions (from EIA Standard 649)

approval

The agreement that an item is complete and suitable for its intended use.

approved data

Data that has been approved by an appropriate authority and is the official (identified) version of the data until replaced by another approved version. Archived data: Released or approved data that is to be retained for historical purposes. Attributes: Performance, functional and physical characteristics of a product.

baseline

(1) An agreed-to description of the attributes of a product, at a point in time, which serves as a basis for defining change.

(2) An approved and released document, or a set of documents, each of a specific revision: the purpose of which is to provide a defined basis for managing change.

(3) The currently approved and released configuration documentation.

(4) A released set of files consisting of a software version and associated configuration documentation.

computer software documentation

Technical data or information, including computer listings, regardless of media, which document the requirements, design, or details of computer software; explain the capabilities and limitations of the software; or provide operating instructions for using or supporting computer software.

configuration

(1) The performance, functional, and physical attributes of an existing or planned product, or a combination of products.

(2) One of a series of sequentially-created variations of a product.

configuration audit

Product configuration verification accomplished by inspecting documents, products and records; and reviewing procedures, processes, and systems of operation to verify that the product has achieved its required attributes (performance requirements and functional constraints) and the product's design is accurately documented Sometimes divided into separate functional and physical configuration audits.

configuration change management:(control)

(1) A systematic process which ensures that changes to a baseline are properly identified, documented, evaluated for impact, approved by an appropriate level of authority, incorporated, and verified

(2) The configuration management activity concerning: the systematic proposal, justification, evaluation, coordination, and disposition of proposed changes; and the implementation of all approved and released changes into

(a) the applicable configurations of a product,

(b) associated product information, and

(c) supporting and interfacing products and their associated product information.

configuration documentation

Technical documentation the primary purpose of which is to identify and define a product's performance, functional, and physical attributes.

configuration identification / product definition

(1) The systematic process of selecting the product attributes, organizing associated information about the attributes, and stating the attributes

(2) Unique identifiers for a product and its configuration documents.

(3) The configuration management activity which encompasses the selecting configuration documents; assigning and applying unique identifiers to a product, its components, and associated documents; and maintaining document revision relationships to product configurations.

configuration management (CM)

A management process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design and operational information throughout its life.

configuration status accounting (CSA / product configuration information)

The configuration management activity concerning capture and storage of, and access to, configuration information needed to manage products and product information effectively.

configuration verification

To verify that the product has achieved its required attributes (performance requirements and functional constraints) and the product's design is accurately documented.

contract

The document (for example, contract, memorandum of agreement or understanding, purchase order) used to implement an agreement between a customer (buyer) and a seller (supplier)

data

Recorded information of any nature (including administrative, managerial, financial, and technical), regardless of medium or characteristics, document representation: A set of digital files which collectively represent a complete digital document.

design information

Technical information resulting from translating requirements for a product into a complete description of the product.

disapproval

Conclusion BV the appropriate authority that an item submitted for approval is either not complete or is not suitable for its intended use.

engineering change

Any alteration to a product or its released configuration documentation. Effecting an engineering change may involve modification of the product, product information and associated interfacing products.

effectivity

A designation defining the point in time, and event, or a product range (e.g., serial number, model, date) at which changes or variances to specific products are to be effected

firmware

The combination of a hardware device and computer instructions or computer data that reside as read-only software "burned into" the hardware device; various types of firmware include devices whose software code is erasable/reprogramable to some degree.

fit

The ability of a product to interface or interconnect with or become an integral part of another product.

form

The shape, size, dimensions, and other physically measurable parameters that uniquely characterize a product. For software, form denotes the language and media. function: The action or actions that a product is designed to perform.

functional attributes

Measurable performance parameters including reliability, maintainability, and safety

hardware

Products made of material and their components (mechanical, electrical, electronic, hydraulic, pneumatic). Computer software and technical documentation are excluded.

interchangeable

A product which possess such functional and physical attributes as to be equivalent in performance to another product of similar or identical purposes; and is capable of being exchanged for the other product without selection for fit or performance, and without alteration of the products themselves or of adjoining products, except for adjustment.

interface

The performance, functional, and physical attributes required to exist at a common boundary

interface control

The process of identifying, documenting, and controlling all performance, functional, and physical attributes relevant to the interfacing of two or more products provided by one or more organizations

interface control documentation (ICD)

Interface control drawing or other documentation that depicts physical, functional, and test interfaces of related or co-functioning products.

life cycle

A generic term relating to the entire period of conception, definition, build, distribution, operation and disposal of a product.

manufacturer's code

Designator for a specific organizational entity, e.g., Commercial and Government Entity (CAGE) code.

nomenclature

(1) Names assigned to kinds and groups of products.

(2) formal designations assigned to products by customer or supplier (such as model number, or model type, design differentiation, specific design series or configuration.)

non-conformance

The failure of a product to meet a specified requirement

operational information

Information that supports the use of a product. For example, operation maintenance and user's manuals/ instructions, procedures, and diagrams.

original

The current design activity s document or digital document representation and associated source data file(s) of record (i e., for legal purposes)

performance

A quantitative measure characterizing a physical or functional attribute relating to the execution of an operation or function (supportability parameters, manufacturing process variability, reliability and so forth, are all performance measures).

physical attributes

Quantitative and qualitative expressions of material features, such as composition, dimensions, finishes, form, fit, and their respective tolerances.

product

Anything that is used or produced to satisfy a need - for example, facilities, systems, hardware, software, firmware, data, processes, materials, or services.

product information

Information related to a product including configuration documentation and other information that is derived from configuration documentation (e.g., instruction manuals, manufacturing instructions, catalogs).

release

The designation by the originating activity that a document or software version is approved by an appropriate authority and is subject to configuration change management procedures.

released data

(1) Data that has been released after review and internal approvals.

(2) Data that has been provided to others outside the originating group or team for use (as opposed to for comment)

requirements

Specified essential attributes.

retrofit

The incorporation of new design parts or software code, resulting from an approved engineering change to a product's current approved product configuration documentation, into products already delivered to and accepted by customers.

rework

A procedure applied to a nonconformance that will completely eliminate it and result in a characteristic that conforms completely.

software

Computer programs and computer databases.

software unit

A logical element in the design of software which may occur at different levels of a hierarchy, and which may consist of other such logical elements in the design, and which may or may not be in a one-to-one relationship with the code and data entities that implement them, or with the computer files containing those entities.

specification

A document which explicitly states essential technical attributes/requirements for a product and procedures to determine that the product's performance meets its requirements / attributes.

submitted data

Released data that has been made available to customers.

support equipment

Equipment and computer soft-ware required to maintain, test, or operate a product or facility in its intended environment.

unit

One of a quantity of items (products, parts, etc.)

variance; deviation: waiver; departure:

A specific written authorization to depart from a particular requirement(s) of a product's current approved configuration documentation for a specific number of units or a specified period of time. (A variance differs from an engineering change in that an approved engineering change requires corresponding revision of the product's current approved configuration documentation, whereas a variance does not.).

verification

The act of assuring that a requirement has been fulfilled.

version

(1) A supplementary identifier used to distinguish a changed body or set of computer-based data (software) from the previous configuration with the same primary identifier. Version identifiers are usually associated with data (such as files, databases and software) used by, or maintained in, computers.

(2) One of several sequentially created configurations of a data product.

working data

Data that has not been reviewed or released; any data that is currently controlled solely by the originator including a new version of data that was released, submitted, or approved.