CHAPTER 10

CONFIGURATION MANAGEMENT

10.1 FOUNDATIONS

Configuration Defined

A "configuration" consists of the functional, physical, and interface characteristics of existing or planned hardware, firmware, software or a combination thereof as set forth in technical documentation and ultimately achieved in a product. The configuration is formally expressed in relation to a Functional, Allocated, or Product configuration baseline as described in Chapter 8.

Configuration Management

Configuration management permits the orderly development of a system, subsystem, or configuration item. A good configuration management program ensures that designs are traceable to requirements, that change is controlled and documented, that interfaces are defined and understood, and that there is consistency between the product and its supporting documentation. Configuration management provides documentation that describes what is supposed to be produced, what is being produced, what has been produced, and what modifications have been made to what was produced.

Configuration management is performed on baselines, and the approval level for configuration modification can change with each baseline. In a typical system development, customers or user representatives control the operational requirements and usually the system concept. The developing agency program office normally controls the functional baseline. Allocated and product baselines can be controlled by the program office, the producer, or a logistics agent depending on the life cycle management strategy. This sets up a hierarchy of configuration control authority corresponding to the baseline structure. Since lower level baselines have to conform to a higher-level baseline, changes at the lower levels must be examined to assure they do not impact a higher-level baseline. If they do, they must be approved at the highest level impacted. For example, suppose the only engine turbine assembly affordably available for an engine development cannot provide the continuous operating temperature required by the allocated baseline. Then not only must the impact of the change at the lower level (turbine) be examined, but the change should also be reviewed for possible impact on the functional baseline, where requirements such as engine power and thrust might reside.

Configuration management is supported and performed by integrated teams in an Integrated Product and Process Development (IPPD) environment. Configuration management is closely associated with technical data management and interface management. Data and interface management is essential for proper configuration management, and the configuration management effort has to include them.

DoD Application of Configuration Management

During the development contract, the Government should maintain configuration control of the functional and performance requirements only, giving contractors responsibility for the detailed design. (SECDEF Memo of 29 Jun 94.) This implies government control of the Functional (system requirements) Baseline. Decisions regarding whether or not the government will take control of the lower-level baselines (allocated and product baselines), and when ultimately depends on the

requirements and strategies needed for the particular program. In general, government control of lower-level baselines, if exercised, will take place late in the development program after design has stabilized.

Configuration Management Planning

When planning a configuration management effort you should consider the basics: what has to be done, how should it be done, who should do it, when should it be done, and what resources are required. Planning should include the organizational and functional structure that will define the methods and procedures to manage functional and physical characteristics, interfaces, and documents of the system component. It should also include statements of responsibility and authority, methods of control, methods of audit or verification, milestones, and schedules. EIA IS-649, National Consensus Standard for Configuration Management, and MIL-HDBK-61 can be used as planning guidance.

Configuration Item (CI)

A key concept that affects planning is the configuration item (CI). CI decisions will determine what configurations will be managed. CIs are an aggregation of hardware, firmware, or computer software, or any of their discrete portions, which satisfies an end-use function and is designated for separate configuration management. Any item required for logistic support and designated for separate procurement is generally identified as CI. Components can be designated CIs because of crucial interfaces or the need to be integrated with operation with other components within or outside of the system. An item can be designated CI if it is developed wholly or partially with government funds, including nondevelopmental items (NDI) if additional development of technical data is required. All CIs are directly traceable to the WBS.

Impact of CI Designation

CI designation requires a separate configuration management effort for the CI, or groupings of related CIs. The decision to place an item, or items, under formal configuration control results in:

- Separate specifications,
- Formal approval of changes,
- Discrete records for configuration status accounting,
- Individual design reviews and configuration audits,
- Discrete identifiers and name plates,
- Separate qualification testing, and
- Separate operating and user manuals.

10.2 CONFIGURATION MANAGEMENT STRUCTURE

Configuration management comprises four interrelated efforts:

- Identification,
- Control,
- Status Accounting, and
- Audits.

Also directly associated with configuration management are data management and interface management. Any configuration management planning effort must consider all six elements.

Identification

Configuration Identification consists of documentation of formally approved baselines and specifications, including:

- Selection of the CIs,
- Determination of the types of configuration documentation required for each CI,

- Documenting the functional and physical characteristics of each CI,
- Establishing interface management procedures, organization, and documentation,
- Issuance of numbers and other identifiers associated with the system/CI configuration structure, including internal and external interfaces, and
- Distribution of CI identification and related configuration documentation.

Configuration Documentation

Configuration documentation is technical documentation that identifies and defines the item's functional and physical characteristics. It is developed, approved, and maintained through three distinct evolutionary increasing levels of detail. The three levels of configuration documentation form the three baselines and are referred to as functional, allocated, and product configuration documentation. These provide the specific technical description of a system or its components at any point in time.

Configuration Control

Configuration Control is the systematic proposal, justification, prioritization, evaluation, coordination, approval or disapproval, and implementation of all approved changes in the configuration of a system/CI after formal establishment of its baseline. In other words, it is how a system (and its CIs) change control process is executed and managed.

Configuration Control provides management visibility, ensures all factors associated with a proposed change are evaluated, prevents unnecessary or marginal changes, and establishes change priorities. In DoD it consists primarily of a change process that formalizes documentation and provides a management structure for change approval.

Change Documents Used for Government Controlled Baselines

There are three types of change documents used to control baselines associated with government configuration management: Engineering Change Proposal, Request for Deviation, and Request for Waivers.

- Engineering Change Proposals (ECP) identify need for a permanent configuration change. Upon approval of an ECP a new configuration is established.
- Requests for Deviation or Waiver propose a temporary departure from the baseline. They allow for acceptance of non-conforming material. After acceptance of a deviation or waiver the documented configuration remains unchanged.

Engineering Change Proposal (ECP)

An ECP is documentation that describes and suggests a change to a configuration baseline. Separate ECPs are submitted for each change that has a distinct objective. To provide advanced notice and reduce paperwork, Preliminary ECPs or Advance Change/Study Notices can be used preparatory to issue of a formal ECP. Time and effort for the approval process can be further reduced through use of joint government and contractor integrated teams to review and edit preliminary change proposals.

ECPs are identified as Class I or Class II. Class I changes require government approval before changing the configuration. These changes can result from problems with the baseline requirement, safety, interfaces, operating/servicing capability, preset adjustments, human interface including skill level, or training. Class I changes can also be used to upgrade already delivered systems to the new configuration through use of retrofit, mod kits, and the like. Class I ECPs are also used to change contractual provisions that do not directly impact the configuration baseline; for example, changes affecting cost, warranties, deliveries, or

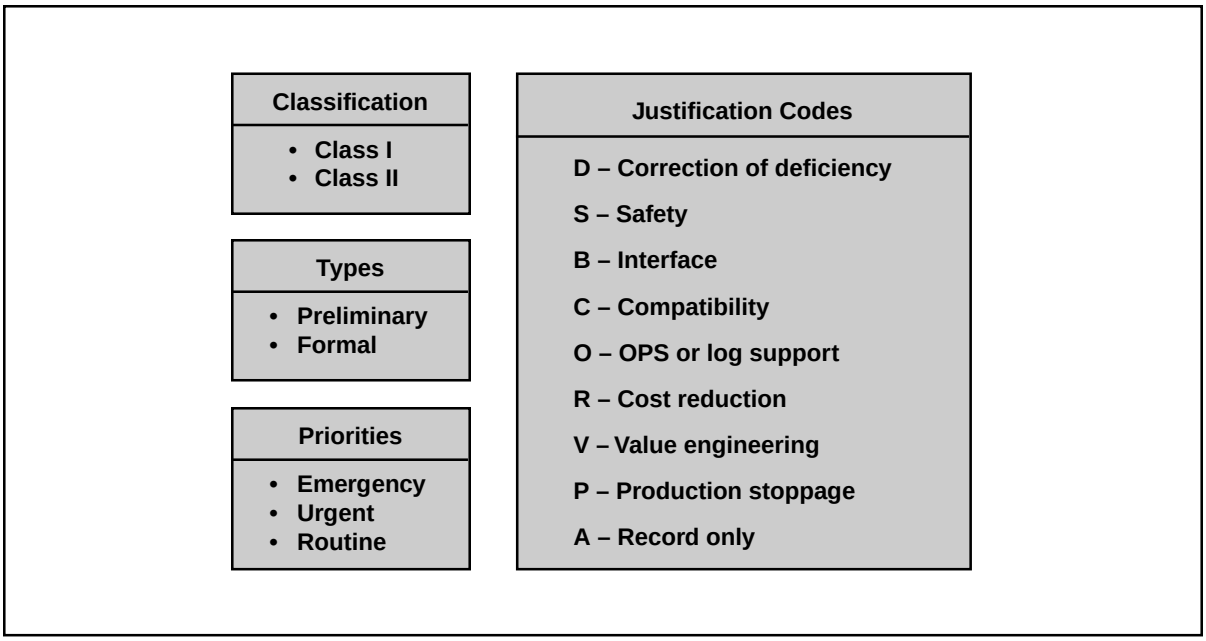

Figure 10-1. ECP Designators

data requirements. Class I ECPs require program office approval, which is usually handled through a formal Configuration Control Board, chaired by the government program manager or delegated representative.

Class II changes correct minor conflicts, typos, and other "housekeeping" changes that basically correct the documentation to reflect the current configuration. Class II applies only if the configuration is not changed when the documentation is changed. Class II ECPs are usually handled by the in-plant government representative. Class II ECPs generally require only that the government concurs that the change is properly classified. Under an initiative by the Defense Contract Management Command (DCMC), contractors are increasingly delegated the authority to make ECP classification decisions.

Figure 10-1 shows the key attributes associated with ECPs. The preliminary ECP, mentioned in Figure 10-1, is a simplified version of a formal ECP that explains the proposed ECP, and establishes an approximate schedule and cost for the change. The expense of an ECP development is avoided if review of the Preliminary ECP indicates the change is not viable. The approach used for preliminary ECPs vary in their form and name. Both Preliminary ECPs and Advanced Change/Study Notices have been used to formalize this process, but forms tailored to specific programs have also been used.

Configuration Control Board (CCB)

A CCB is formed to review Class I ECPs for approval, and make a recommendation to approve or not approve the proposed change. The CCB chair, usually the program manager, makes the final decision. Members advise and recommend, but the authority for the decision rests with the chair. CCB membership should represent the eight primary functions with the addition of representation of the procurement office, program control (budget), and Configuration Control manager, who serves as the CCB secretariat.

The CCB process is shown in Figure 10-2. The process starts with the contractor. A request to the contractor for an ECP or Preliminary ECP is necessary to initiate a government identified configuration change. The secretariat's review process includes assuring appropriate government

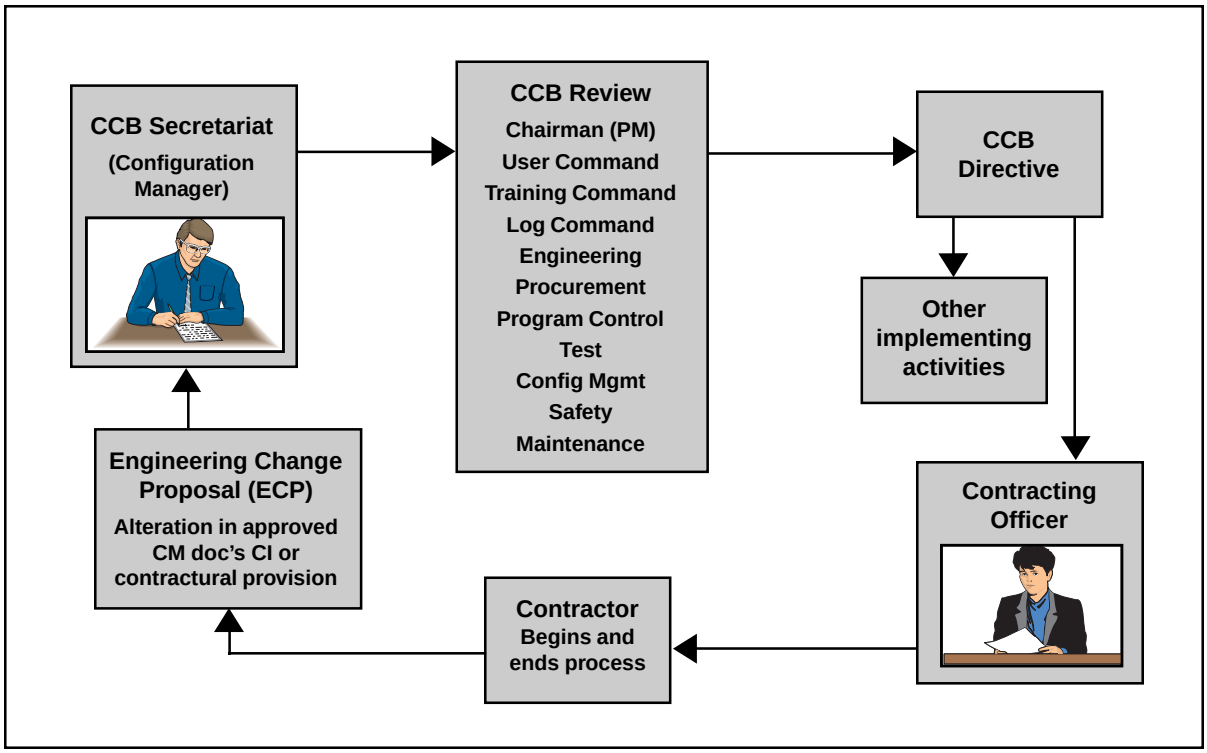

Figure 10-2. Configuration Control Board

contractual and engineering review is done prior to receipt by the CCB.

CCB Management Philosophy

The CCB process is a configuration control process, but it is also a contractual control process. Decisions made by the CCB chair affects the contractual agreement and program baseline as well as the configuration baseline. Concerns over contractual policy, program schedule, and budget can easily come into conflict with concerns relating to configuration management, technical issues, and technical activity scheduling. The CCB technical membership and CCB secretariat is responsible to provide a clear view of the technical need and the impact of alternate solutions to these conflicts. The CCB secretariat is further responsible to see that the CCB is fully informed and prepared, including ensuring that:

- A government/contractor engineering working group has analyzed the ECP and supporting data, prepared comments for CCB consideration, and is available to support the CCB;
- All pertinent information is available for review;
- The ECP has been reviewed by appropriate functional activities; and
- Issues have been identified and addressed.

CCB Documentation

Once the CCB chair makes a decision concerning an ECP, the CCB issues a Configuration Control Board Directive that distributes the decision and identifies key information relating to the implementation of the change:

- Implementation plan (who does what when);
- Contracts affected (prime and secondary);
- Dates of incorporation into contracts;
- Documentation affected (drawings, specifications, technical manuals, etc.), associated cost, and schedule completion date; and

- Identification of any orders or directives needed to be drafted and issued.

Request for Deviation or Waiver

A deviation is a specific written authorization, granted prior to manufacture of an item, to depart from a performance or design requirement for a specific number of units or a specific period of time.

A waiver is a written authorization to accept a CI that departs from specified requirements, but is suitable for use "as is" or after repair.

Requests for deviation and waivers relate to a temporary baseline departure that can affect system design and/or performance. The baseline remains unchanged and the government makes a determination whether the alternative "non-conforming" configuration results in an acceptable substitute. Acceptable substitute usually implies that there will be no impact on support elements, systems affected can operate effectively, and no follow-up or correction is required. The Federal Acquisition Regulations (FAR) requires "consideration" on government contracts when the Government accepts a "non-conforming" unit.

The distinction between Request for Deviation and Request for a Waiver is that a deviation is used *before* final assembly of the affected unit, and a waiver is used *after* final assembly or acceptance testing of the affected unit.

Status Accounting

Configuration Status Accounting is the recording and reporting of the information that is needed to manage the configuration effectively, including:

- A listing of the approved configuration documentation,
- The status of proposed changes, waivers and deviations to the configuration identification,
- The implementation status of approved changes, and
- The configuration of all units, including those in the operational inventory.

Purpose of Configuration Status Accounting

Configuration Status Accounting provides information required for configuration management by:

- Collecting and recording data concerning:
  - Baseline configurations,
  - Proposed changes, and
  - Approved changes.
- Disseminating information concerning:
  - Approved configurations,
  - Status and impact of proposed changes,
  - Requirements, schedules, impact and status of approved changes, and
  - Current configurations of delivered items.

Audits

Configuration Audits are used to verify a system and its components' conformance to their configuration documentation. Audits are key milestones in the development of the system and do not stand alone. The next chapter will show how they fit in the overall process of assessing design maturity.

Functional Configuration Audits (FCA) and the System Verification Review (SVR) are performed in the Production Readiness and LRIP stage of the Production and Development Phase. FCA is used to verify that actual performance of the configuration item meets specification requirements. The SVR serves as system-level audit after FCAs have been conducted.

The Physical Configuration Audit (PCA) is normally held during Rate Production and Development stage as a formal examination of a production representative unit against the draft technical data package (product baseline documentation).

Most audits, whether FCA or PCA, are today approached as a series of "rolling" reviews in which items are progressively audited as they are produced such that the final FCA or PCA becomes

significantly less oppressive and disruptive to the normal flow of program development.

10.3 INTERFACE MANAGEMENT

Interface Management consists of identifying the interfaces, establishing working groups to manage the interfaces, and the group's development of interface control documentation. Interface Management identifies, develops, and maintains the external and internal interfaces necessary for system operation. It supports the configuration management effort by ensuring that configuration decisions are made with full understanding of their impact outside of the area of the change.

Interface Identification

An interface is a functional, physical, electrical, electronic, mechanical, hydraulic, pneumatic, optical, software, or similar characteristic required to exist at a common boundary between two or more systems, products, or components. Normally, in a contractual relationship the procuring agency identifies external interfaces, sets requirements for integrated teams, and provides appropriate personnel for the teams. The contracted design agent or manufacturer manages internal interfaces; plans, organizes, and leads design integrated teams; maintains internal and external interface requirements; and controls interfaces to ensure accountability and timely dissemination of changes.

Interface Control Working Group (ICWG)

The ICWG is the traditional forum to establish official communications link between those responsible for the design of interfacing systems or components. Within the IPPD framework ICWGs can be integrated teams that establish linkage between interfacing design IPTs, or could be integrated into a system-level engineering working group. Membership of ICWGs or comparable integrated teams should include membership from each contractor, significant vendors, and participating government agencies. The procuring program office (external and selected top-level interfaces) or prime contractor (internal interfaces) generally designates the chair.

Interface Control Documentation (ICD)

Interface Control Documentation includes Interface Control Drawings, Interface Requirements Specifications, and other documentation that depicts physical and functional interfaces of related or co-functioning systems or components. ICD is the product of ICWGs or comparable integrated teams, and their purpose is to establish and maintain compatibility between interfacing systems or components.

Open Systems Interface Standards

To minimize the impact of unique interface designs, improve interoperability, maximize the use of commercial components, and improve the capacity for future upgrade, an open-systems approach should be a significant part of interface control planning. The open-systems approach involves selecting industry-recognized specifications and standards to define system internal and external interfaces. An open system is characterized by:

- Increased use of functional partitioning and modular design to enhance flexibility of component choices without impact on interfaces,
- Use of well-defined, widely used, non-proprietary interfaces or protocols based on standards developed or adopted by industry recognized standards institutions or professional societies, and
- Explicit provision for expansion or upgrading through the incorporation of additional or higher performance elements with minimal impact on the system.

DoD mandatory guidance for information technology standards is in the Joint Technical Architecture.

10.4 DATA MANAGEMENT

Data management documents and maintains the database reflecting system life cycle decisions, methods, feedback, metrics, and configuration control. It directly supports the configuration status accounting process. Data Management governs and controls the selection, generation, preparation, acquisition, and use of data imposed on contractors.

Data Required By Contract

Data is defined as recorded information, regardless of form or characteristic, and includes all the administrative, management, financial, scientific, engineering, and logistics information and documentation required for delivery from the contractor. Contractually required data is classified as one of three types:

- Type I: Technical data
- Type II: Non-technical data
- Type III: One-time use data (technical or non-technical)

Data is acquired for two basic purposes:

- Information feedback from the contractor for program management control, and
- Decision making information needed to manage, operate, and support the system (e.g., specifications, technical manuals, engineering drawings, etc.).

Data analysis and management is expensive and time consuming. Present DoD philosophy requires that the contractor manage and maintain significant portions of the technical data, including the Technical Data Package (TDP). Note that this does *not* mean the government isn't paying for its development or shouldn't receive a copy for post-delivery use. Minimize the TDP cost by requesting the contractor's format (for example, accepting the same drawings they use for production), and asking only for details on items developed with government funds.

Data Call for Government Contracts

As part of the development of an Invitation for Bid or Request for Proposals, the program office issues a letter that describes the planned procurement and asks integrated team leaders and effected functional managers to identify and justify their data requirements for that contract. A description of each data item needed is then developed by the affected teams or functional offices, and reviewed by the program office. Data Item Descriptions, located in the Acquisition Management Systems Data List (AMSDL) (see Chapter 8) can be used for guidance in developing these descriptions.

Concurrent with the DoD policy on specifications and standards, there is a trend to avoid use of standard Data Item Descriptions on contracts, and specify the data item with a unique tailored data description referenced in the Contract Data Requirements List.

10.5 SUMMARY POINTS

- Configuration management is essential to control the system design throughout the life cycle.
- Use of integrated teams in an IPPD environment is necessary for disciplined configuration management of complex systems.
- Technical data management is essential to trace decisions and changes and to document designs, processes and procedures.
- Interface management is essential to ensure that system elements are compatible in terms of form, fit, and function.
- Three configuration baselines are managed:
  - Functional (System level)
  - Allocated (Design To)
  - Product (Build To/As Built)

Configuration management is a shared responsibility between the government and the contractor. Contract manager (CM) key elements are Identification, Control, Status Accounting, and Audits.