CHAPTER 11

TECHNICAL REVIEWS AND AUDITS

11.1 PROGRESS MEASUREMENT

The Systems Engineer measures design progress and maturity by assessing its development at key event-driven points in the development schedule. The design is compared to pre-established exit criteria for the particular event to determine if the appropriate level of maturity has been achieved. These key events are generally known as Technical Reviews and Audits.

A system in development proceeds through a sequence of stages as it proceeds from concept to finished product. These are referred to as "levels of development." Technical Reviews are done after each level of development to check design maturity, review technical risk, and determines whether to proceed to the next level of development. Technical Reviews reduce program risk and ease the transition to production by:

- Assessing the maturity of the design/development effort,
- Clarifying design requirements,
- Challenging the design and related processes,
- Checking proposed design configuration against technical requirements, customer needs, and system requirements,
- Evaluating the system configuration at different stages,
- Providing a forum for communication, coordination, and integration across all disciplines and IPTs,
- Establishing a common configuration baseline from which to proceed to the next level of design, and
- Recording design decision rationale in the decision database.

Formal technical reviews are preceded by a series of technical interchange meetings where issues, problems and concerns are surfaced and addressed. The formal technical review is NOT the place for problem solving, but to verify problem solving has been done; it is a process rather than an event!

Planning

Planning for Technical Reviews must be extensive and up-front-and-early. Important considerations for planning include the following:

- Timely and effective attention and visibility into the activities preparing for the review,
- Identification and allocation of resources necessary to accomplish the total review effort,
- Tailoring consistent with program risk levels,
- Scheduling consistent with availability of appropriate data,
- Establishing event-driven entry and exit criteria,
- Where appropriate, conduct of incremental reviews,
- Implementation by IPTs,

- Review of all system functions, and
- Confirmation that all system elements are integrated and balanced.

The maturity of enabling products are reviewed with their associated end product. Reviews should consider the testability, producibility, training, and supportability for the system, subsystem or configuration item being addressed.

The depth of the review is a function of the complexity of the system, subsystem, or configuration item being reviewed. Where design is pushing state-of-the-art technology the review will require a greater depth than if it is for a commercial off-the-shelf item. Items, which are complex or an application of new technology, will require a more detailed scrutiny.

Planning Tip: Develop a check list of pre-review, review, and post-review activities required. Develop check lists for exit criteria and required level of detail in design documentation. Include key questions to be answered and what information must be available to facilitate the review process. Figure 11-1 shows the review process with key activities identified.

11.2 TECHNICAL REVIEWS

Technical reviews are conducted at both the system level and at lower levels (e.g., sub-system). This discussion will focus on the primary system-level reviews. Lower-level reviews may be thought of as events that support and prepare for the system-level events. The names used in reference to

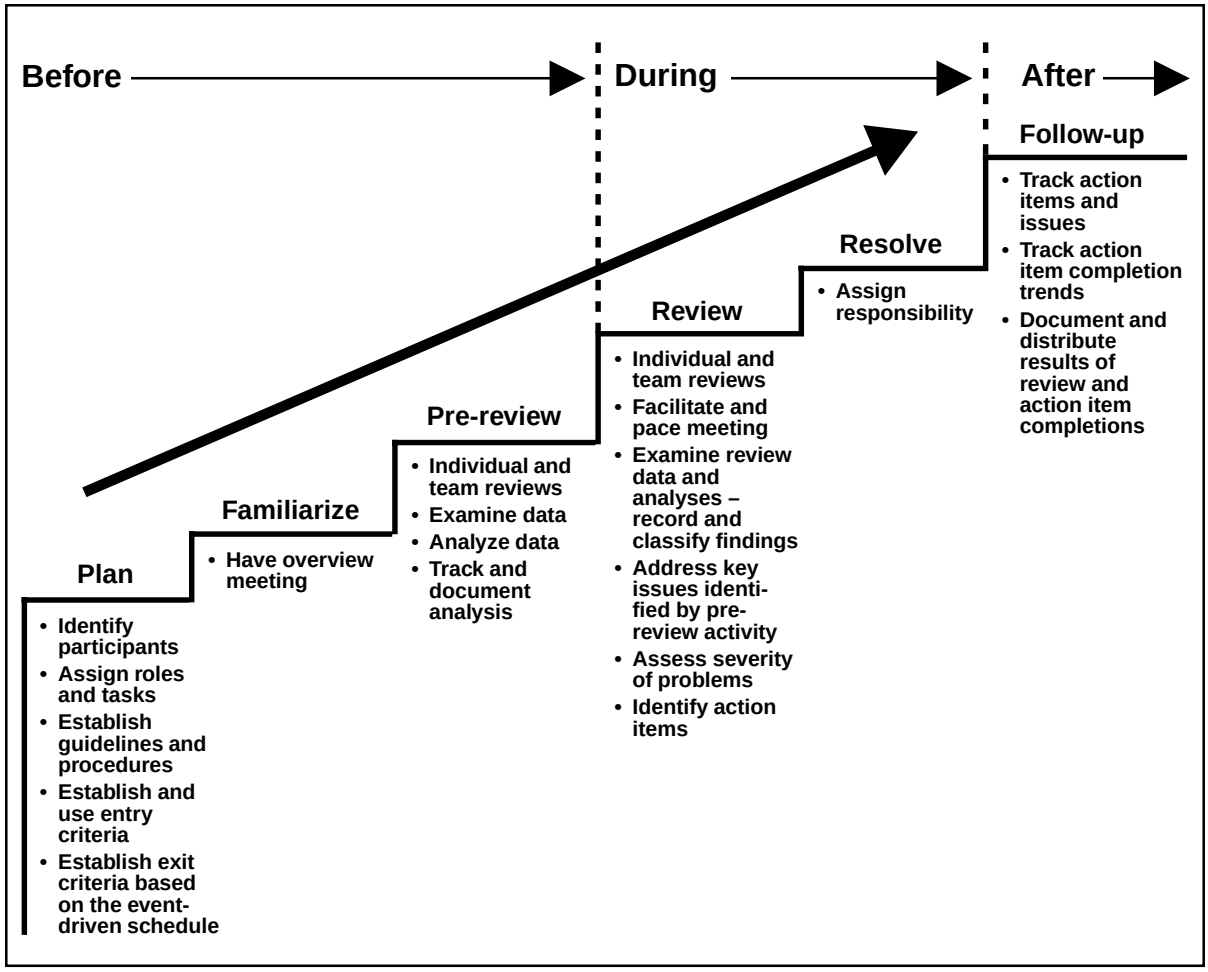

Figure 11-1. Technical Review Process

reviews is unimportant; however, it is important that reviews be held at appropriate points in program development and that both the contractor and government have common expectations regarding the content and outcomes.

Conducting Reviews

Reviews are event-driven, meaning that they are to be conducted when the progress of the product under development merits review. Forcing a review (simply based on the fact that a schedule developed earlier) projected the review at a point in time will jeopardize the review's legitimacy. Do the work ahead of the review event. Use the review event as a confirmation of completed effort. The data necessary to determine if the exit criteria are satisfied should be distributed, analyzed, and analysis coordinated prior to the review. The type of information needed for a technical review would include: specifications, drawings, manuals, schedules, design and test data, trade studies, risk analysis, effectiveness analyses, mock-ups, breadboards, in-process and finished hardware, test methods, technical plans (Manufacturing, Test, Support, Training), and trend (metrics) data. Reviews should be brief and follow a prepared agenda based on the pre-review analysis and assessment of where attention is needed.

Only designated participants should personally attend. These individuals should be those that were involved in the preparatory work for the review and members of the IPTs responsible for meeting the event exit criteria. Participants should include representation from all appropriate government activities, contractor, subcontractors, vendors and suppliers.

A review is the confirmation of a process. New items should not come up at the review. If significant items do emerge, it's a clear sign the review is

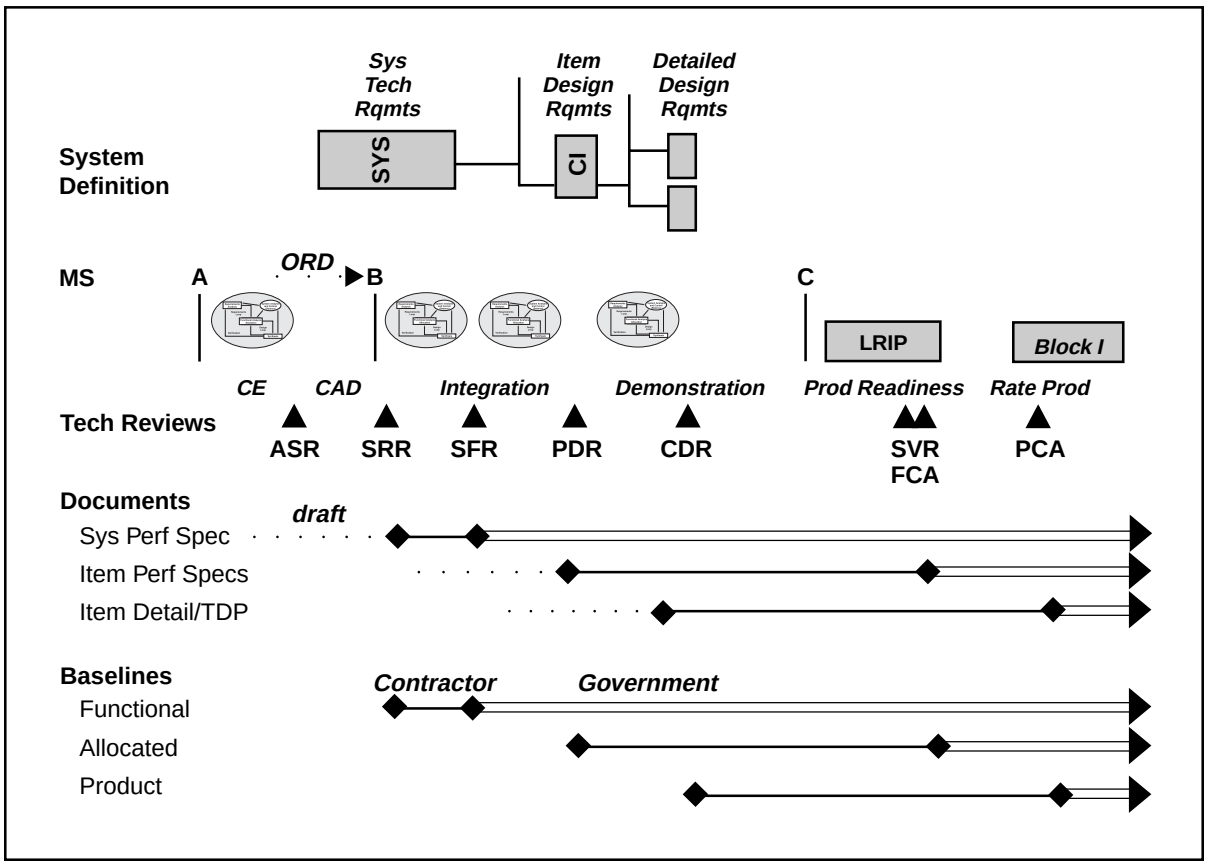

Figure 11-2. Phasing of Technical Reviews

being held prematurely, and project risk has just increased significantly. A poorly orchestrated and performed technical review is a significant indicator of management problems.

Action items resulting from the review are documented and tracked. These items, identified by specific nomenclature and due dates, are prepared and distributed as soon as possible after the review. The action taken is tracked and results distributed as items are completed.

Phasing of Technical Reviews

As a system progresses through design and development, it typically passes from a given level of development to another, more advanced level of development. For example, a typical system will pass from a stage where only the requirements are known, to another stage where a conceptual solution has been defined. Or it may pass from a stage where the design requirements for the primary subsystems are formalized, to a stage where the physical design solutions for those requirements are defined. (See Figure 11-2.)

These stages are the "levels of development" referred to in this chapter. System-level technical reviews are generally timed to correspond to the transition from one level of development to another. The technical review is the event at which the technical manager verifies that the technical maturity of the system or item under review is sufficient to justify passage into the subsequent phase of development, with the concomitant commitment of resources required.

As the system or product progresses through development, the focus of technical assessment takes different forms. Early in the process, the primary focus is on defining the requirements on which subsequent design and development activities will be based. Similarly, technical reviews conducted during the early stages of development are almost always focused on ensuring that the top-level concepts and system definitions reflect the requirements of the user. Once system-level definition is complete, the focus turns to design at sub-system levels and below. Technical reviews during these stages are typically design reviews that establish design requirements and then

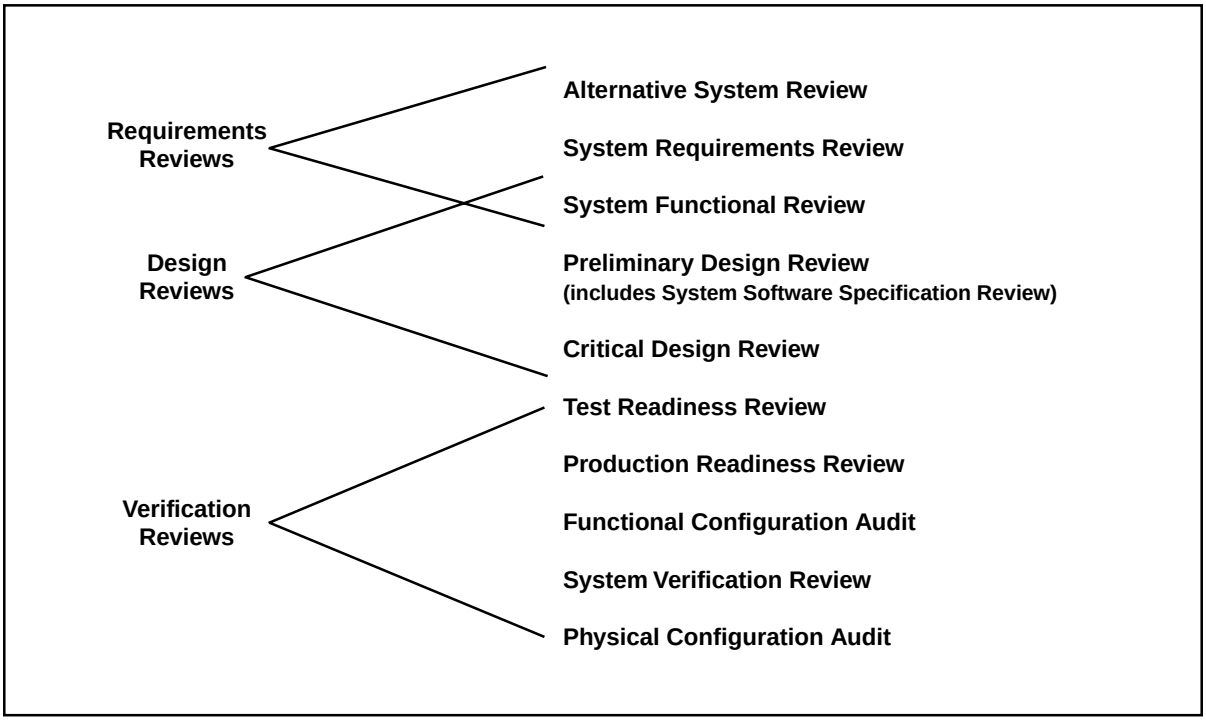

Figure 11-3. Typical System-Level Technical Reviews

verify that physical solutions are consistent with those requirements. In the final stages of development, technical reviews and audits are conducted to verify that the products produced meet the requirements on which the development is based. Figure 11-3 summarizes the typical schedule of system-level reviews by type and focus.

Another issue associated with technical reviews, as well as other key events normally associated with executing the systems engineering process, is when those events generally occur relative to the phases of the DoD acquisition life-cycle process. The timing of these events will vary somewhat from program to program, based upon the explicit and unique needs of the situation; however, Figure 11-4 shows a generalized concept of how the technical reviews normal to systems engineering might occur relative to the acquisition life-cycle phases.

Specific system-level technical reviews are known by many different names, and different engineering standards and documents often use different nomenclature when referring to the same review. The names used to refer to technical reviews are unimportant; however, it is important to have a grasp of the schedule of reviews that is normal to system development and to have an understanding of what is the focus and purpose of those reviews. The following paragraphs outline a schedule of reviews that is complete in terms of assessing technical progress from concept through production. The names used were chosen because they seemed to be descriptive of the focus of the activity. Of course, the array of reviews and the focus of individual reviews is to be tailored to the specific needs of the program under development, so not all programs should plan on conducting all of the following reviews.

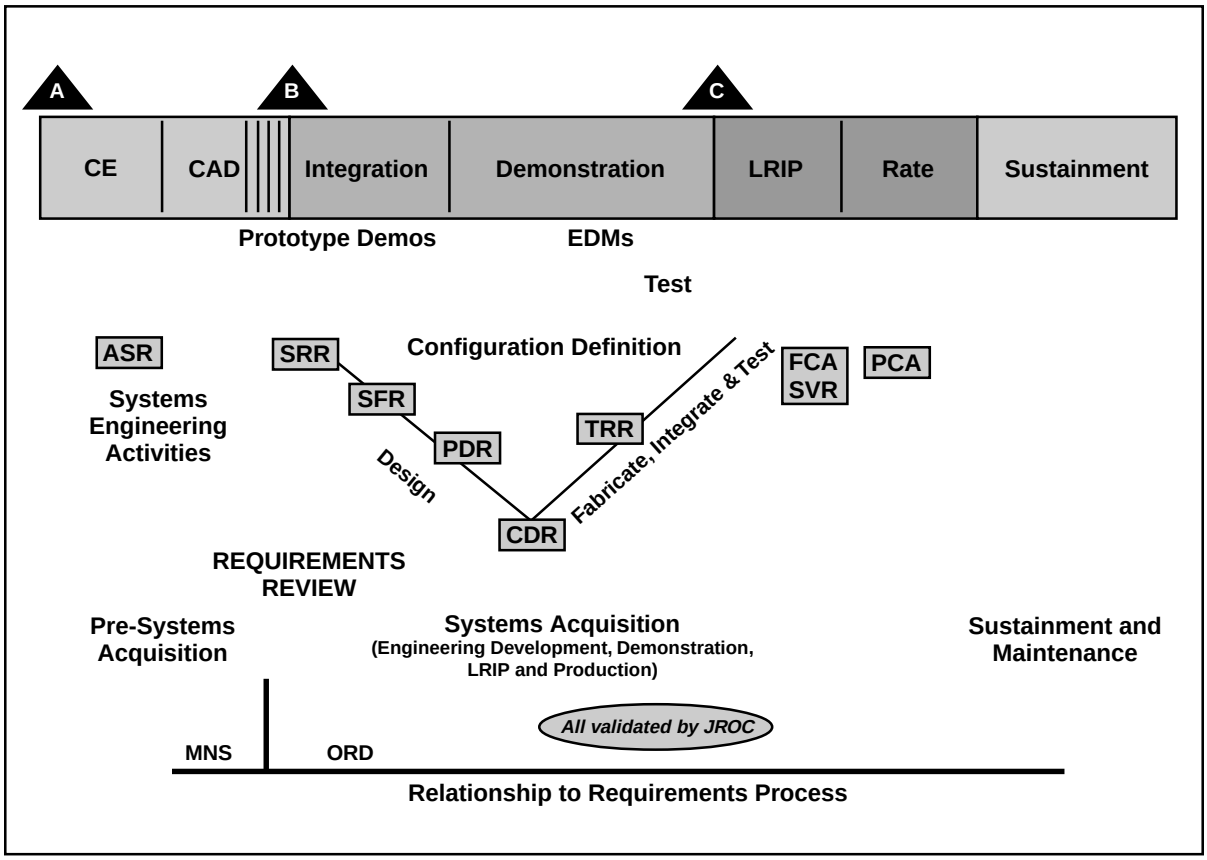

Figure 11-4. Relationship of Systems Engineering Events to Acquisition Life Cycle Phases

Alternative Systems Review (ASR)

After the concept studies are complete a preferred system concept is identified. The associated draft System Work Breakdown Structure, preliminary functional baseline, and draft system specification are reviewed to determine feasibility and risk. Technology dependencies are reviewed to ascertain the level of technology risk associated with the proposed concepts. This review is conducted late during the Concept Exploration stage of the Concept and Technology Development Phase of the acquisition process to verify that the preferred system concept:

- Provides a cost-effective, operationally-effective and suitable solution to identified needs,
- Meets established affordability criteria, and
- Can be developed to provide a timely solution to the need at an acceptable level of risk.

The findings of this review are a significant input to decision review conducted after Concept Exploration to determine where the system should enter in the life-cycle process to continue development. This determination is largely based on technology and system development maturity.

It is important to understand that the path of the system through the life-cycle process will be different for systems of different maturities. Consequently, the decision as whether or not to conduct the technical reviews that are briefly described in the following paragraphs is dependent on the extent of design and development required to bring the system to a level of maturity that justifies producing and fielding it.

System Requirements Review (SRR)

If a system architecture system must be developed and a top-down design elaborated, the system will pass through a number of well-defined levels of development, and that being the case, a well-planned schedule of technical reviews is imperative. The Component Advanced Development stage (the second stage of Concept and Technology Development in the revised acquisition life-cycle process) is the stage during which system-level architectures are defined and any necessary advanced development required to assess and control technical risk is conducted. As the system passes into the acquisition process, i.e., passes a Milestone B and enters System Development and Demonstration, it is appropriate to conduct a SRR. The SRR is intended to confirm that the user's requirements have been translated into system specific technical requirements, that critical technologies are identified and required technology demonstrations are planned, and that risks are well understood and mitigation plans are in place. The draft system specification is verified to reflect the operational requirements.

All relevant documentation should be reviewed, including:

- System Operational Requirements,
- Draft System Specification and any initial draft Performance Item Specifications,
- Functional Analysis (top level block diagrams),
- Feasibility Analysis (results of technology assessments and trade studies to justify system design approach),
- System Maintenance Concept,
- Significant system design criteria (reliability, maintainability, logistics requirements, etc.),
- System Engineering Planning,
- Test and Evaluation Master Plan,
- Draft top-level Technical Performance Measurement, and
- System design documentation (layout drawings, conceptual design drawings, selected supplier components data, etc.).

The SRR confirms that the system-level requirements are sufficiently well understood to permit

the developer (contractor) to establish an initial system level functional baseline. Once that baseline is established, the effort begins to define the functional, performance, and physical attributes of the items below system level and to allocate them to the physical elements that will perform the functions.

System Functional Review (SFR)

The process of defining the items or elements below system level involves substantial engineering effort. This design activity is accompanied by analysis, trade studies, modeling and simulation, as well as continuous developmental testing to achieve an optimum definition of the major elements that make up the system, with associated functionality and performance requirements. This activity results in two major systems engineering products: the final version of the system performance specification and draft versions of the performance specifications, which describe the items below system level (item performance specifications). These documents, in turn, define the system functional baseline and the draft allocated baseline. As this activity is completed, the system has passed from the level of a concept to a well-defined system design, and, as such, it is appropriate to conduct another in the series of technical reviews.

The SFR will typically include the tasks listed below. Most importantly, the system technical description (Functional Baseline) must be approved as the governing technical requirement before proceeding to further technical development. This sets the stage for engineering design and development at the lower levels in the system architecture. The government, as the customer, will normally take control of and manage the system functional baseline following successful completion of the SFR.

The review should include assessment of the following items. More complete lists are found in standards and texts on the subject.

- Verification that the system specification reflects requirements that will meet user expectations.
- Functional Analysis and Allocation of requirements to items below system level,
- Draft Item Performance and some Item Detail Specifications,
- Design data defining the overall system,
- Verification that the risks associated with the system design are at acceptable levels for engineering development,
- Verification that the design selections have been optimized through appropriate trade study analyses,
- Supporting analyses, e.g., logistics, human systems integration, etc., and plans are identified and complete where appropriate,
- Technical Performance Measurement data and analysis, and
- Plans for evolutionary design and development are in place and that the system design is modular and open.

Following the SFR, work proceeds to complete the definition of the design of the items below system level, in terms of function, performance, interface requirements for each item. These definitions are typically captured in item performance specifications, sometimes referred to as prime item development specifications. As these documents are finalized, reviews will normally be held to verify that the design requirements at the item level reflect the set of requirements that will result in an acceptable detailed design, because all design work from the item level to the lowest level in the system will be based on the requirements agreed upon at the item level. The establishment of a set of final item-level design requirements represents the definition of the allocated baseline for the system. There are two primary reviews normally associated with this event: the Software Specification Review (SSR), and the Preliminary Design Review (PDR).

Software Specification Review (SSR)

As system design decisions are made, typically some functions are allocated to hardware items, while others are allocated to software. A separate specification is developed for software items to describe the functions, performance, interfaces and other information that will guide the design and development of software items. In preparation for the system-level PDR, the system software specification is reviewed prior to establishing the Allocated Baseline. The review includes:

- Review and evaluate the maturity of software requirements,
- Validation that the software requirements specification and the interface requirements specification reflect the system-level requirements allocated to software,
- Evaluation of computer hardware and software compatibility,
- Evaluation of human interfaces, controls, and displays
- Assurance that software-related risks have been identified and mitigation plans established,
- Validation that software designs are consistent with the Operations Concept Document,
- Plans for testing, and
- Review of preliminary manuals.

Preliminary Design Review (PDR)

Using the Functional Baseline, especially the System Specification, as a governing requirement, a preliminary design is expressed in terms of design requirements for subsystems and configuration items. This preliminary design sets forth the functions, performance, and interface requirements that will govern design of the items below system level. Following the PDR, this preliminary design (Allocated Baseline) will be put under formal configuration control [usually] by the contractor. The Item Performance Specifications, including the system software specification, which form the core of the Allocated Baseline, will be confirmed to represent a design that meets the System Specification.

This review is performed during the System Development and Demonstration phase. Reviews are held for configuration items (CIs), or groups of related CIs, prior to a system-level PDR. Item Performance Specifications are put under configuration control (Current DoD practice is for contractors to maintain configuration control over Item Performance Specifications, while the government exercises requirements control at the system level). At a minimum, the review should include assessment of the following items:

- Item Performance Specifications,
- Draft Item Detail, Process, and Material Specifications,
- Design data defining major subsystems, equipment, software, and other system elements,
- Analyses, reports, “ility” analyses, trade studies, logistics support analysis data, and design documentation,
- Technical Performance Measurement data and analysis,
- Engineering breadboards, laboratory models, test models, mockups, and prototypes used to support the design, and
- Supplier data describing specific components.

[Rough Rule of Thumb: ~15% of production drawings are released by PDR. This rule is anecdotal and only guidance relating to an “average” defense hardware program.]

Critical Design Review (CDR)

Before starting to build the production line there needs to be verification and formalization of the

mutual understanding of the details of the item being produced. Performed during the System Development and Demonstration phase, this review evaluates the draft Production Baseline ("Build To" documentation) to determine if the system design documentation (Product Baseline, including Item Detail Specs, Material Specs, Process Specs) is satisfactory to start initial manufacturing. This review includes the evaluation of all CIs. It includes a series of reviews conducted for each hardware CI before release of design to fabrication, and each computer software CI before final coding and testing. Additionally, test plans are reviewed to assess if test efforts are developing sufficiently to indicate the Test Readiness Review will be successful. The approved detail design serves as the basis for final production planning and initiates the development of final software code.

[Rough Rule of Thumb: At CDR the design should be at least 85% complete. Many programs use drawing release as a metric for measuring design completion. This rule is anecdotal and only guidance relating to an "average" defense hardware program.]

Test Readiness Review (TRR)

Typically performed during the System Demonstration stage of the System Development and Demonstration phase (after CDR), the TRR assesses test objectives, procedures, and resources testing coordination. Originally developed as a software CI review, this review is increasingly applied to both hardware and software items. The TRR determines the completeness of test procedures and their compliance with test plans and descriptions. Completion coincides with the initiation of *formal* CI testing.

Production Readiness Reviews (PRR)

Performed incrementally during the System Development and Demonstration and during the Production Readiness stage of the Production and Deployment phase, this series of reviews is held to determine if production preparation for the system, subsystems, and configuration items is complete, comprehensive, and coordinated. PRRs are necessary to determine the readiness for production prior to executing a production go-ahead decision. They will formally examine the producibility of the production design, the control over the projected production processes, and adequacy of resources necessary to execute production. Manufacturing risk is evaluated in relationship to product and manufacturing process performance, cost, and schedule. These reviews support acquisition decisions to proceed to Low-Rate Initial Production (LRIP) or Full-Rate Production.

Functional Configuration Audit/ System Verification Review (FCA)/(SVR)

This series of audits and the consolidating SVR re-examines and verifies the customer's needs, and the relationship of these needs to the system and subsystem technical performance descriptions (Functional and Allocated Baselines). They determine if the system produced (including production representative prototypes or LRIP units) is capable of meeting the technical performance requirements established in the specifications, test plans, etc. The FCA verifies that all requirements established in the specifications, associated test plans, and related documents have been tested and that the item has passed the tests, or corrective action has been initiated. The technical assessments and decisions that are made in SVR will be presented to support the full-rate production go-ahead decision. Among the issues addressed:

- Readiness issues for continuing design, continuing verifications, production, training, deployment, operations, support, and disposal have been resolved,
- Verification is comprehensive and complete,
- Configuration audits, including completion of all change actions, have been completed for all CIs,
- Risk management planning has been updated for production,
- Systems Engineering planning is updated for production, and

- Critical achievements, success criteria and metrics have been established for production.

Physical Configuration Audit (PCA)

After full-rate production has been approved, follow-on independent verification (FOT&E) has identified the changes the user requires, and those changes have been corrected on the baseline documents and the production line, then it is time to assure that the product and the product baseline documentation are consistent. The PCA will formalize the Product Baseline, including specifications and the technical data package, so that future changes can only be made through full configuration management procedures. Fundamentally, the PCA verifies the product (as built) is consistent with the Technical Data Package which describes the Product Baseline. The final PCA confirms:

- The subsystem and CI PCAs have been successfully completed,
- The integrated decision database is valid and represents the product,
- All items have been baselined,
- Changes to previous baselines have been completed,
- Testing deficiencies have been resolved and appropriate changes implemented, and
- System processes are current and can be executed.

The PCA is a configuration management activity and is conducted following procedures established in the Configuration Management Plan.

11.3 TAILORING

The reviews described above are based on a complex system development project requiring significant technical evaluation. There are also cases where system technical maturity is more advanced than normal for the phase, for example, where a previous program or an Advanced Technical Concept Demonstration (ACTD) has provided a significant level of technical development applicable to the current program. In some cases this will precipitate the merging or even elimination of acquisition phases. This does not justify elimination of the technical management activities grouped under the general heading of systems analysis and control, nor does it relieve the government program manager of the responsibility to see that these disciplines are enforced. It does, however, highlight the need for flexibility and tailoring to the specific needs of the program under development.

For example, a DoD acquisition strategy that proposes that a system proceed directly into the demonstration stage may skip a stage of the complete acquisition process, but it must not skip the formulation of an appropriate Functional Baseline and the equivalent of an SFR to support the development. Nor should it skip the formulation of the Allocated Baseline and the equivalent of a PDR, and the formulation of the Product Baseline and the equivalent of a CDR. Baselines must be developed sequentially because they document different levels of design requirements and must build on each other. However, the assessment of design and development maturity can be tailored as appropriate for the particular system. Tailored efforts still have to deal with the problem of determining when the design maturity should be assessed, and how these assessments will support the formulation and control of baselines, which document the design requirements as the system matures.

In tailoring efforts, be extremely careful determining the level of system complexity. The system integration effort, the development of a single advanced technology or complex sub-component, or the need for intensive software development may be sufficient to establish the total system as a complex project, even though it appears simple because most subsystems are simple or off-the-shelf.

11.4 SUMMARY POINTS

- Each level of product development is evaluated and progress is controlled by specification development (System, Item Performance, Item Detail, Process, and Material specifications) and technical reviews and audits (ASR, SRR, SDR, SSR, PDR, CDR, TRR, PRR, FCA, SVR, PCA).

- Technical reviews assess development maturity, risk, and cost/schedule effectiveness to determine readiness to proceed.

- Reviews must be planned, managed, and followed up to be effective as an analysis and control tool.

- As the system progresses through the development effort, the nature of design reviews and audits will parallel the technical effort. Initially they will focus on requirements and functions, and later become very product focused.

- After system level reviews establish the Functional Baseline, technical reviews tend to be subsystem and CI focused until late in development when the focus again turns to the system level to determine the system's readiness for production.