CHAPTER 3
INTRODUCTION FOR DESIGN CRITICAL PATH TEMPLATES

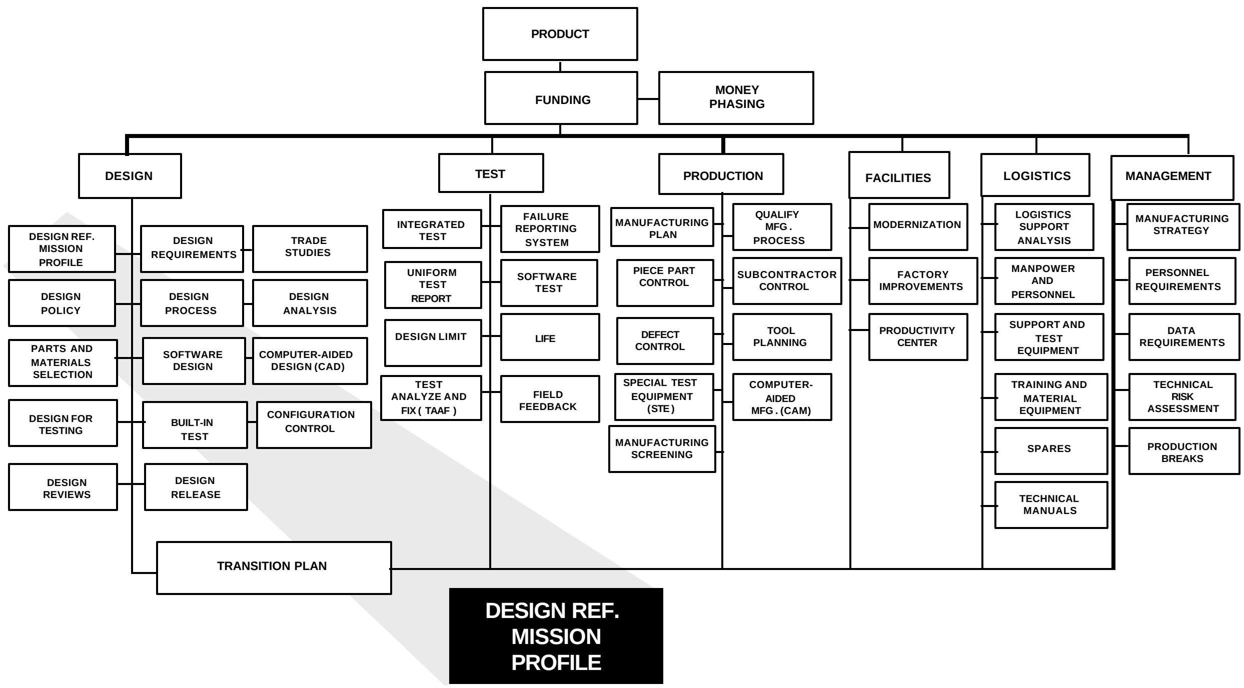
High risk of failure of Government material acquisition programs occurs at the outset of the design process. While some level of risk associated with a new technical concept may be unavoidable, historically this risk has been magnified by the misunderstanding of the industrial design disciplines necessary to turn the concept into a mature product. The Government and its contractors must share equal responsibility for this misunderstanding. The industrial proposal and Government source selection process provide the last cost-effective opportunity to ensure application of critical disciplines during design and therefore the ultimate achievement of design maturity. The application of these disciplines is the source of the requirement for "up front funding" to minimize material acquisition program risk.

What is design maturity? It is defined easily in the operational environment. A mature design meets operational requirements without additional Government or contractor intervention—no further field modifications or additional equipment and spares are required to overcome design shortfalls. In the factory, design maturity might be indicated by the tapering off of engineering change proposal (ECP) traffic, once the test phase is underway, if it can be assumed that contract requirements are being met. But what constitutes design maturity at the conclusion of the design effort before entering the formal test phase? This is the question faced at the critical design review (CDR), when a decision to proceed with fabrication of formal test articles must be made, a decision on which hangs this matter of risk.

Among the many engineering disciplines that must be applied to arrive at a product design are several, bearing directly on risk, that have been underemphasized by the Government and underutilized by its defense contractors. These disciplines share a common thread—all serve to reduce stress in the broadest sense. At the micro-level, parts age at a rate dependent on the stress they must endure. A design can be said to be mature when it meets its functional performance requirements and the applied stresses are well-known, and the ability of every part to endure those stresses can be ensured for the required life of the product. The engineering disciplines that determine stress and ensure the ability of the parts to endure stress are those that have received the least attention in defense system acquisition.

The templates in this section address those neglected engineering design disciplines. The Government and its contractors bear equal responsibility to address the issues in all material acquisition programs. The outlines for reducing risk will serve to guide the Government both in the preparation of requests for proposals and in proposal evaluation during source selection. They also will serve to guide program managers in the conduct of formal design reviews; and the outlines will serve notice to Government contractors of the unclaimed risk issues on which the Government intends to take action, as a guide to ordering their internal policies and procedures.

TEMPLATE



AREA OF RISK

Accurate and complete specification of the design reference mission profile is required in order to support the entire acquisition process: design definition, stress analysis, test design, logistic support analysis, et. al. The degree to which the specified mission profile corresponds to ultimate service use directly determines the degree of risk. Conversely, this degree of correspondence also affects progress toward design maturity, which is ultimately decided by service use, not development and operational testing. Yet the mission profile is often left to the contractor’s discretion, based on a board definition of the Government’s intended use of the product.

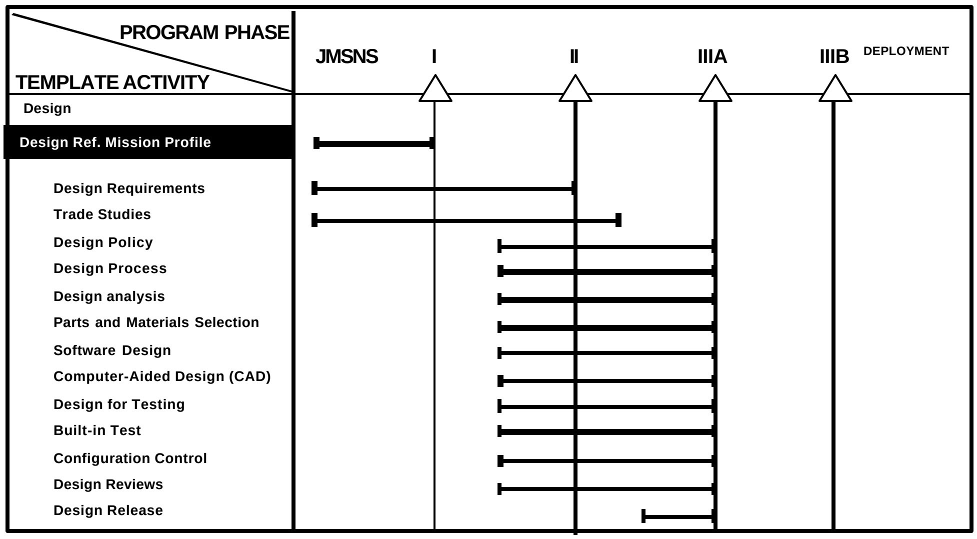
OUTLINE FOR REDUCING RISK

- A functional mission profile is prepared that shows on a time scale all the functions that must be performed by the system to accomplish the mission. The functional mission profile of a system having multiple or variable missions is defined by a hypothetical design reference mission profile that contains a comprehensive listing of all functions expected in every potential mission.
- An environmental mission profile is prepared that shows on a time scale the significant properties of the surroundings (and their limits) that are likely to have an effect on the operation or survival of the system. It defines the total envelope of environments in which the weapon system must perform, including conditions of storage, maintenance, transportation, and operational use.
- Mission functional and environmental profiles are prepared by the Government and included in requests for proposals, forming a basis for proposals, source selection, and contracts.
- System functional and environmental profiles are prepared by the contractor on the basis of the total envelope of external environments given by the mission profile, to

define the functional requirements and induced environmental conditions for the system and its component parts. These become the design requirements for the component parts of the system.

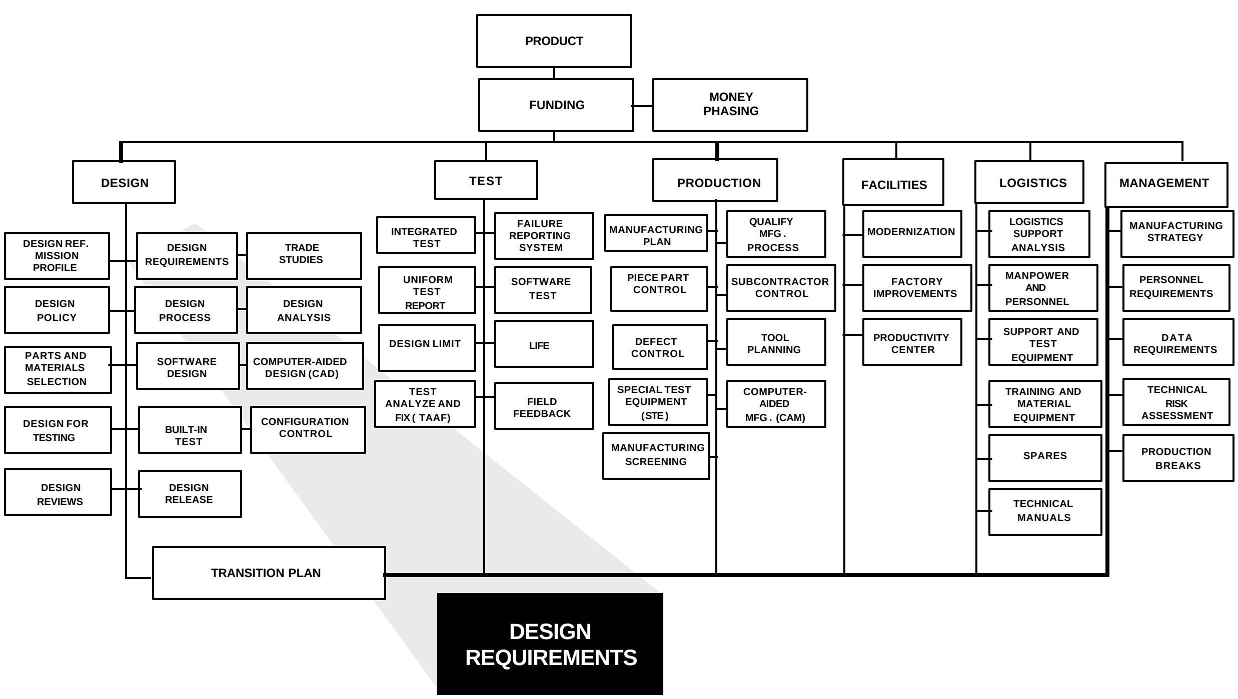
- The design requirements and concept should include a determination of support and operability factors such as the need to interoperate with other Military Service and allied systems.

TIMELINE



System functional and environmental profiles are prepared by the contractor during the early stages of concept development.

TEMPLATE



AREA OF RISK

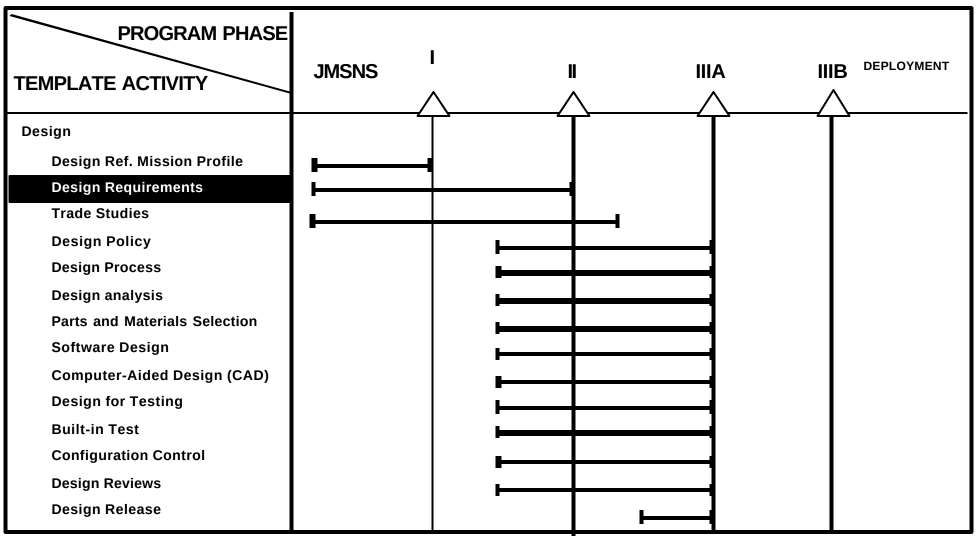
Design requirements are translated from operational requirements, stated by the “user” activity, and frequently negotiated or evolved during the course of design. They may include design requirements that are not measurable directly during the design process, but only can be verified by extended formal tests. Such intangible design requirements are a common cause of high risk.

OUTLINE FOR REDUCING RISK

- Design requirements are developed in parallel with the development of the design reference mission profile. They are defined completely in the requests for proposals, in order that one basis for source selection may be the offeror’s approach to satisfying those requirements, including Government evaluation of corporate design policy bearing on product risk. The complete design reference mission profile, including support-related “design to” requirements, is specified in these design requirements.
- Primary design requirements are stated in terms of parameters that can be measured during the design process, by breadboard testing or analogous design action. Probabilistic specifications that would require extended system level testing to verify compliance cannot be used by the design engineer for real time design decision making, and are therefore considered secondary, to be used for planning purposes only.

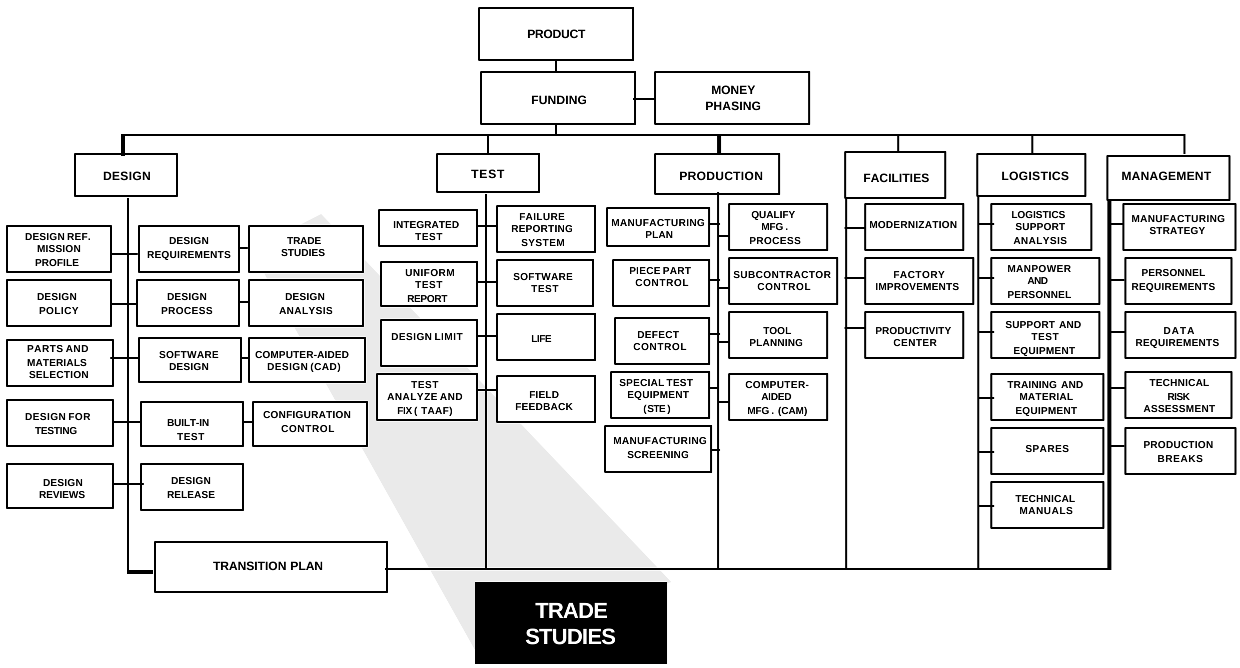
- When the achievement of specific quantitative system requirements is conditional upon the performance of a set of predefined tasks, the contract establishes the requirements for development of approved program plans for the accomplishment of these tasks. This will apply to such disciplines as structural analysis, weight control, reliability, maintainability, systems safety, survivability, corrosion prevention, parts standardization, and similar activities.
- Contractors are responsible for ensuring that subcontractors and suppliers have complete and definitive design requirements that flow down Government requirements such as measurable parameters and performance of predefined tasks.

TIMELINE



Design requirements are established early in the conceptual phase and may be altered during validation as well as increased in level of detail and specificity. The design reference mission profile influences the design requirements for the component parts of the system. The contract for validation should be structured to require contractor recommendations for selection and tailoring of the optimum specifications and standards for application before the start of FSD.

TEMPLATE



AREA OF RISK

Trade studies are essential elements of material acquisition programs, not only in defining concepts that best meet mission needs, but also in fine-tuning selected concepts during the design process. Concept validation may not be complete at the beginning of full-scale development, however, there is the expectation that significant conceptual problems can be resolved during the design process. In addition, reducing production risk frequently is not a trade study criterion.

OUTLINE FOR REDUCING RISK

- Concepts representing new technology untested in the production environment are validated fully before FSD.
- Trade studies during the design process are oriented towards reducing product risk, by such means as design simplification, design for compatibility with production processes, design for ease of both factory testing and built-in test, and design for supportability and readiness.
- Early in the design phase, full consideration is given to standard components that have been developed and can meet the mission requirements (such as standard avionics, egress seats, etc.).
- A quantitative trade parameters list is developed and standardized across all design, manufacturing, and quality disciplines as a priority task early in the RDT&E program.

- Trade study alternatives are documented and preserved formally in design review documentation to ensure system engineering traceability to design characteristics downstream.
- Production transition trade studies are based on design and performance criteria as weight factors for trade study decisions.
- Product quality and reliability are not trade study parameters to be sacrificed for cost, schedule, or performance gains.

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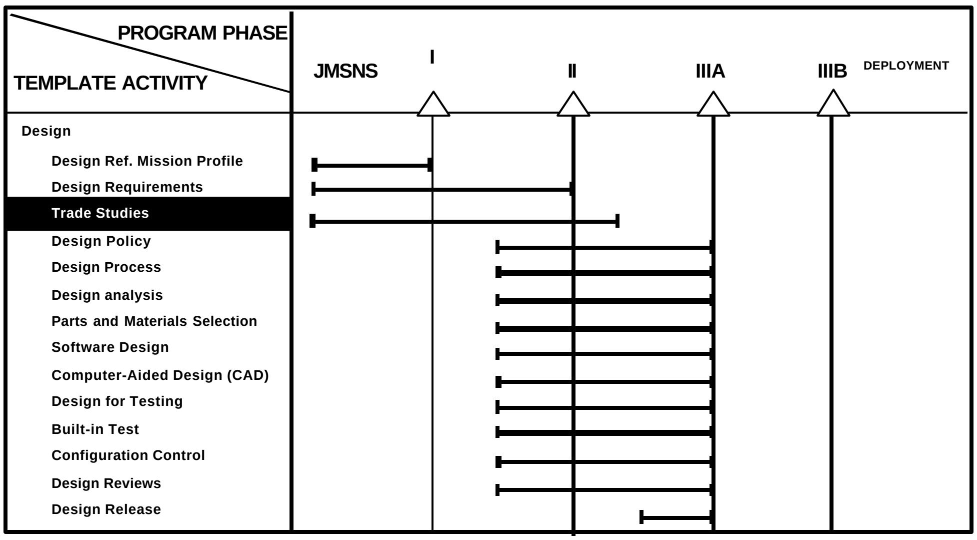
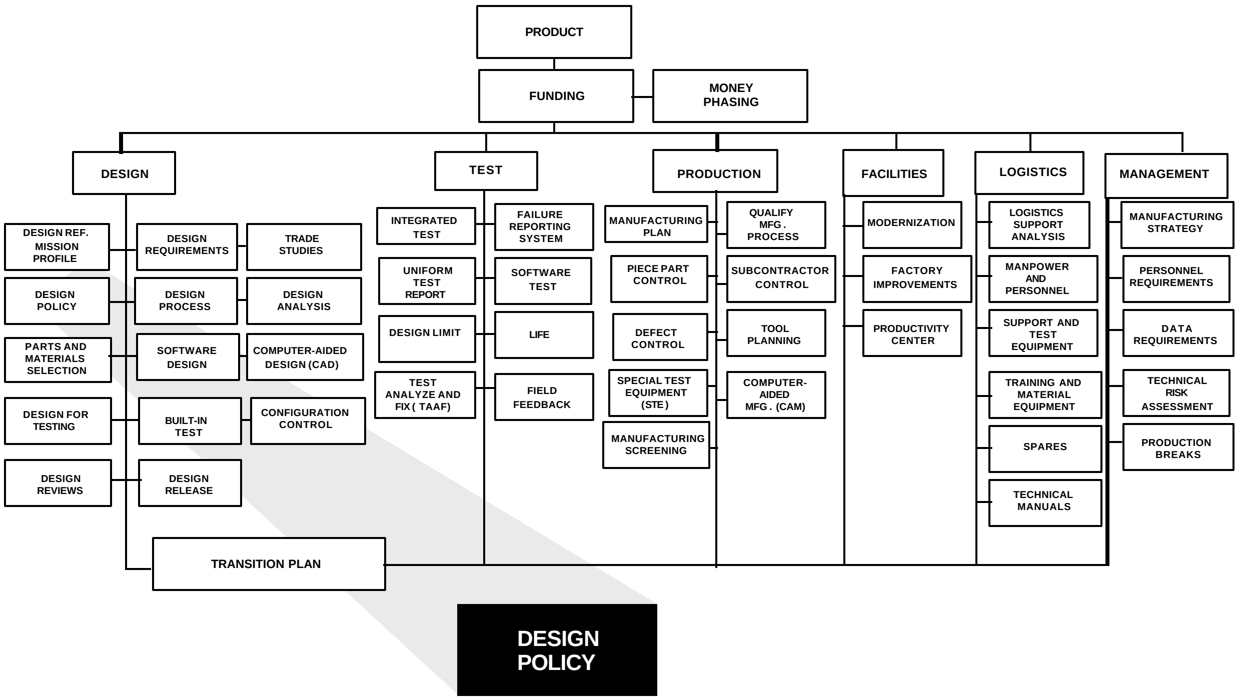


A broad spectrum of trade studies is initiated during the concept exploration phase. These trade studies continue on into FSD as a logical approach to selecting the best design once the mission profile and design requirements have been specified. The final selection and fine turning of the design approach must consider such factors as producibility and operational suitability as well as performance, cost, and schedule.

TEMPLATE



AREA OF RISK

The implementation of the engineering design disciplines involved in reducing product risk is the responsibility of Government contractors. The existence or absence of documented corporate policies, backed up by controlled engineering manuals to the necessary degree of detail, has a direct bearing on the degree of product risk associated with material acquisition. Many Government contractors do not have such corporate policies, and when these policies do exist, they often lack implementation at the operating level and often lack substantive direction on design for low risk.

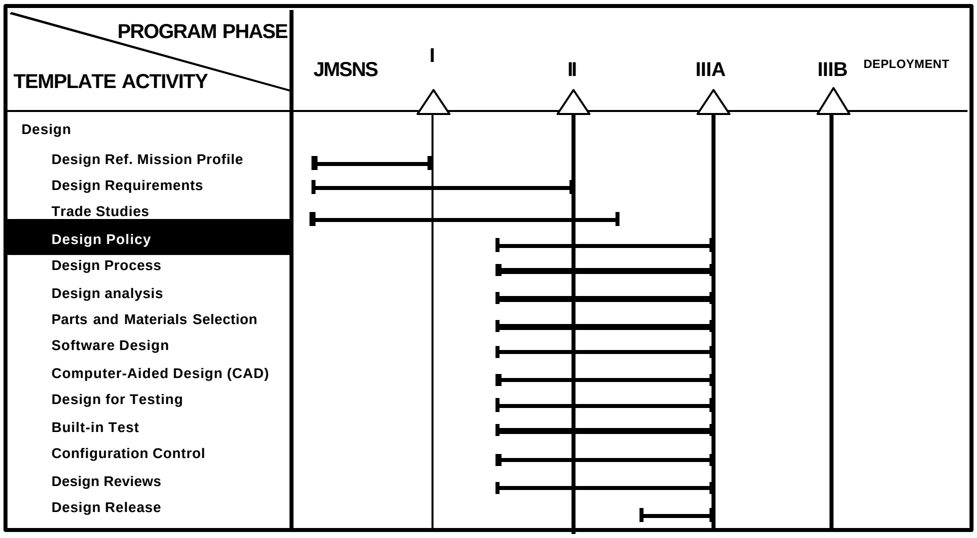
OUTLINE FOR REDUCING RISK

- Documented design policies and comprehensive engineering documents implementing these policies are visible and adhered to in design, test, and manufacturing practices.
  - Policies and practices are sensitive to “lessons learned” on past programs.
  - Abundant evidence is available that engineering practices are tailored to product lines.
  - Policies and practices reflect the importance of designing for supportability as an integral part of all design efforts.
- Engineering design has the documented responsibility not only for development of a low risk design but also for specification of test requirements and design for production and support.
- Engineering practices in the form of criteria and standards are included in an integrated data base accessible by design, test, production, and logistics engineering personnel.
- Established design review criteria are available and are used by an expert design review team. These criteria, along with specific means of assessing maturity, are tailored

specifically to product lines.

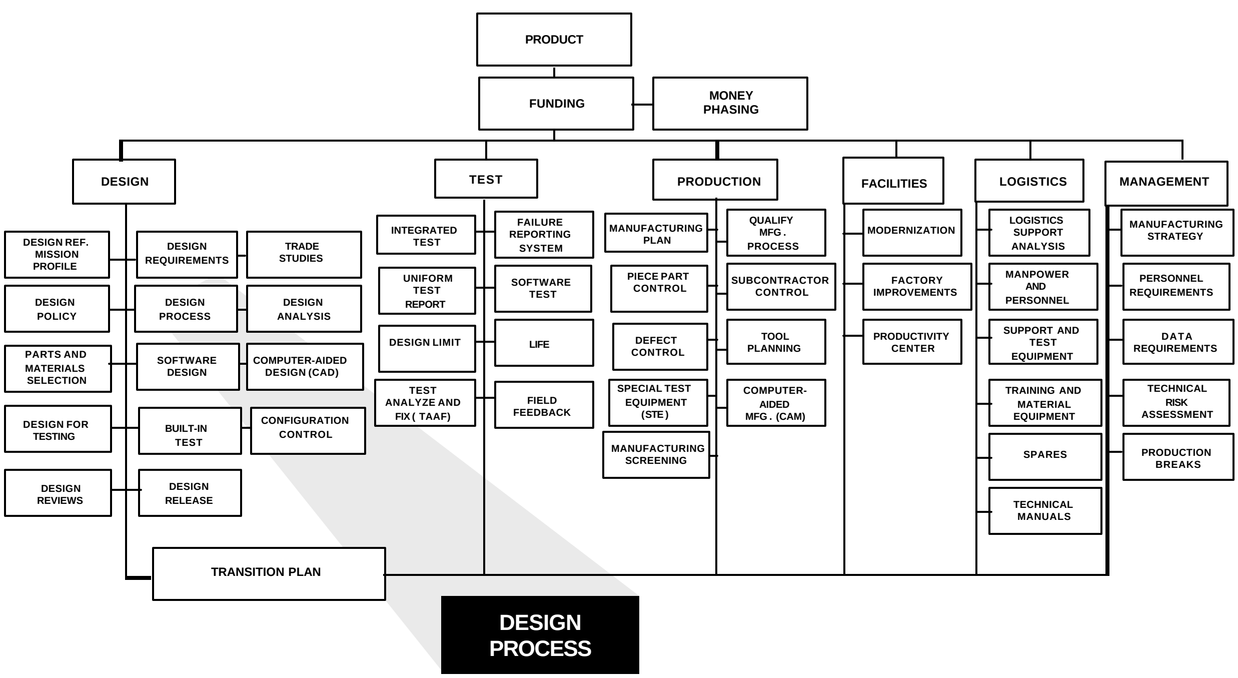
- Design emphasis is placed on implementation of design fundamentals, disciplines, and practices that are known to produce a low risk design and that ensure design maturity before design release.

TIMELINE



The implementation of best practices in engineering design is the responsibility of contractors. The existence or absence of documented corporate policy has a direct bearing on the degree of product risk associated with material acquisition. Appropriate design policies are developed and proven before FSD, and they may be updated and otherwise refined as experience is gained during development.

TEMPLATE



AREA OF RISK

The design process ought to reflect a sound design policy and proper engineering disciplines and practices—an integration of factors that influence the production, operations, and support of a system throughout its life cycle. Nevertheless, concepts are often selected, demonstrated, and validated with little thought given to the feasibility of producing a system employing those concepts. This omission is then carried forward into design, with voids appearing in manufacturing technology and absence of proven manufacturing methods and processes to produce the system within affordable cost. One of the most common sources of risk in the transition from development to production is failure to design for production. Some design engineers do not consider in their design the limitations in manufacturing personnel and processes. The predictable result is that an apparently successful design, assembled by engineers and highly skilled model shop technicians, goes to pieces in the factory environment when subjected to rate production. A design should not be produced if it cannot survive rate production without degradation.

OUTLINE FOR REDUCING RISK

- The potential to produce a system is investigated carefully during the demonstration and validation phase by means of appropriate producibility analyses. Voids in manufacturing technology projects and manufacturing methods and processes peculiar to the design of the specific system, subsystems, and components are addressed during engineering development. These methods and processes are proven by pilot lines and pilot quantities, when necessary.

- The design avoids reliance on a single unproven manufacturing technology for system critical performance characteristics. Alternative technologies and design approaches are carried through Milestone II and into engineering development, when warranted.

- Producibility engineering and planning is an integral element of the design process. Close coordination between production and design engineering is established from the outset. Integration of life cycle factors in the design is fostered by forming design teams with production engineering and support area representatives. Manufacturing coordination is part of production drawing release. Production engineers participate in design concept development and design engineers participate in production planning to ensure design compatibility with production.

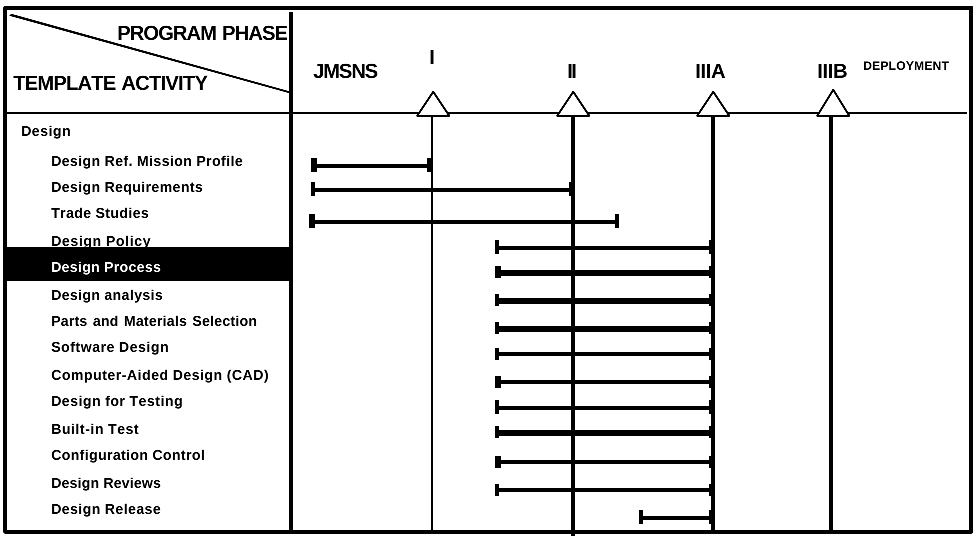
- The design process specifically ensures both performance and producibility considerations for packaging of electronic components. Factors such as envelope clearance, package density, predicted versus actual weight, tooling, and power access are equally as important as component and circuit design considerations in reducing transition and production risk.

- The design is evaluated to ensure that the producibility and supportability factors are being incorporated. Producibility and supportability design changes are expedited and incorporated as early as possible to reduce cost and are not resisted automatically. These changes are substantiated promptly by necessary testing.

- A task analysis approach, as called out in Military Handbook 46855B (reference (c)), is used to divide tasks among hardware, software, and operators. System design then proceeds with this partitioning in mind, thus reducing the risk of complex tasks being "dumped" on operators when they are better performed by software. This partitioning also helps to bound and define the entire design effort.

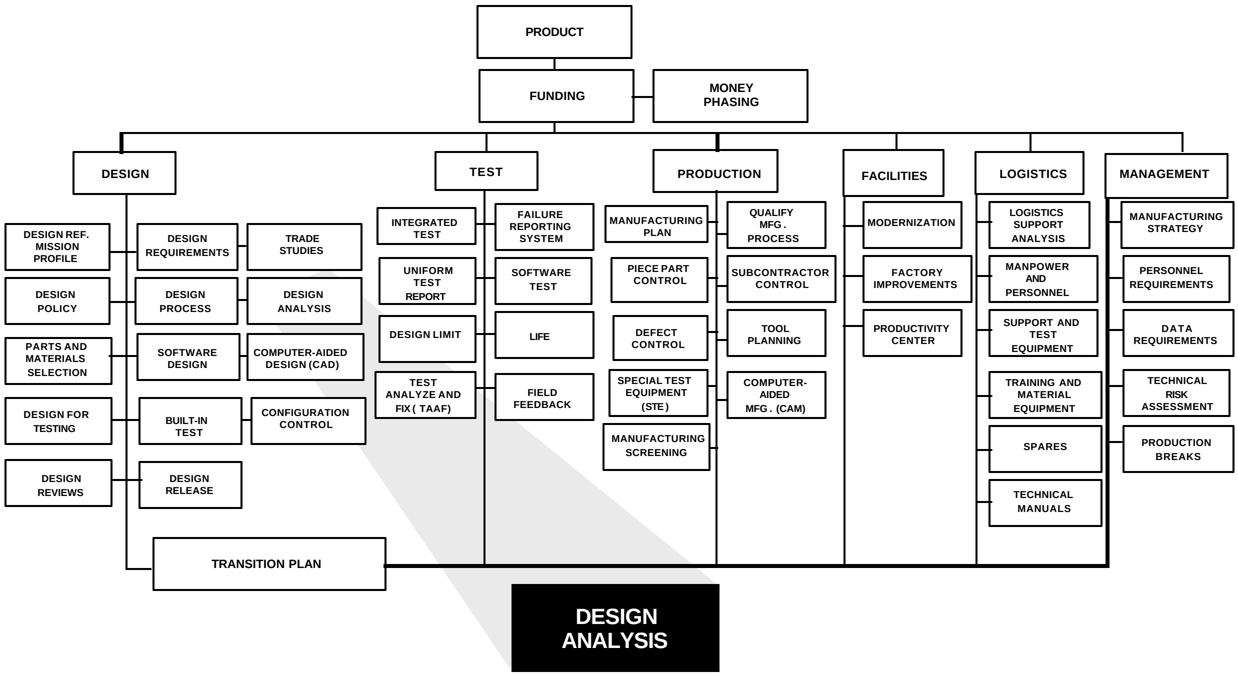
- Cross training of engineers in design and manufacturing disciplines actively is supported. Design engineers stay abreast of developments in manufacturing technology that would affect the design.

TIMELINE



The design process describes all the actions taken that culminate in a set of drawings or a data base from which a model can be constructed for testing to verify specification compliance. Design criteria are developed and proven before FSD, and may be updated and otherwise refined as experience is gained during development. Production design occurs concurrently with the other elements of the design process. Much useful information guidance technology on obtaining a producible design is in Military Handbook 727 (reference (d)).

TEMPLATE



AREA OF RISK

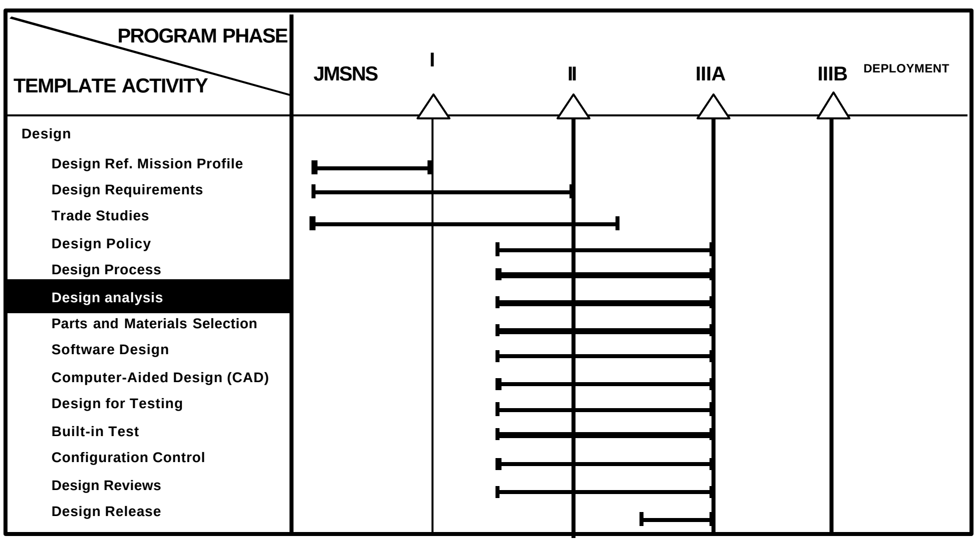
Engineering design involves many specialized analyses, most of which are oriented towards meeting desired performance specifications. There also are specialized analyses oriented towards proofing design risk but they are not practiced widely. When they are completed, it is often by personnel other than the design engineers most familiar with the product design. These analyses are critical to ensuring a low risk design.

OUTLINE FOR REDUCING RISK

- Stress and stress/strength analyses are performed to ensure that applied values of all parameters specified in the derating, margin of safety, and safety factor criteria for all component parts and materials meet those criteria.
- “Worst case” tolerance analyses are performed to ensure that the system design performance remains within specified limits for any combination of component part parameters within the limits of their own allowable tolerances.
- Sneak circuit analyses are performed to detect such unexpected failure modes as latent circuit paths, timing errors, or obscure “cause and effect” relations that may trigger unintended actions or block desired ones without any part failures having occurred.
- Failure modes and effects analyses are performed in order to understand the effect of each component part failure on overall design performance, and system and equipment supportability. Each component part is analyzed for the purpose of reducing these effects to a minimum through design changes.

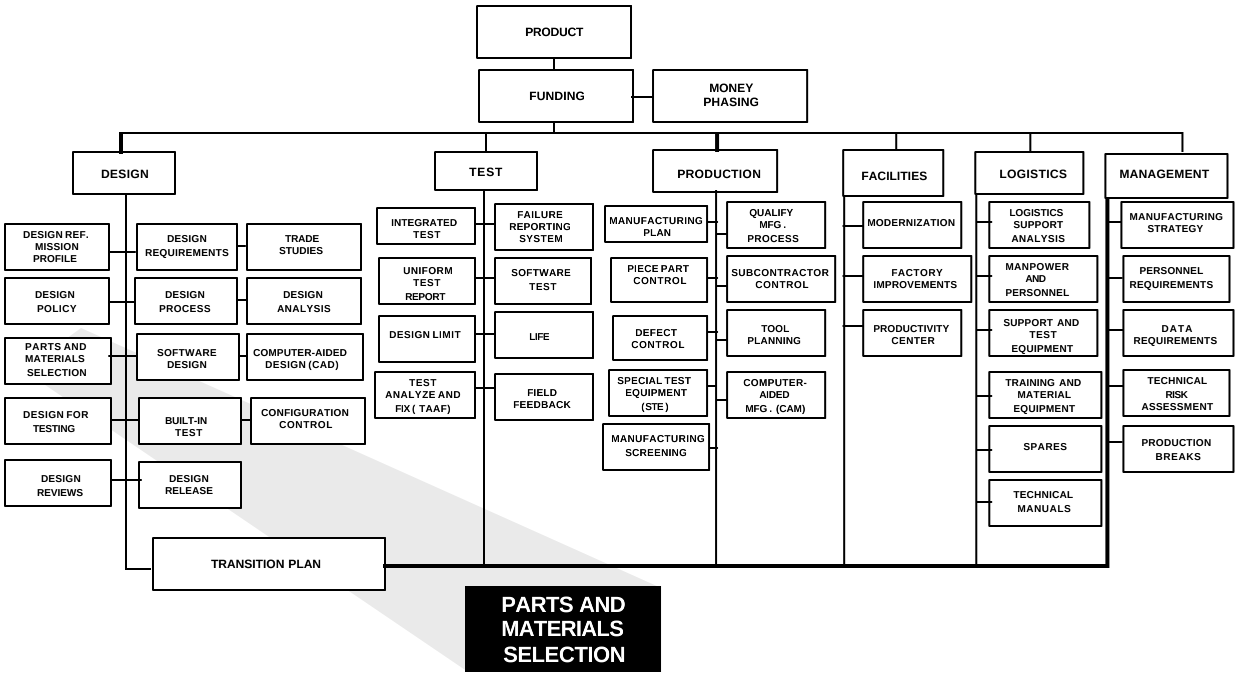
- A thermal survey is conducted on electronic systems to validate the accuracy of the thermal stress analysis, which is then revised as indicated by the survey to yield more accurate results.
- Other analyses that may be applied effectively are fault tree, mass property, system safety, maintainability, life cycle cost, fault isolation, redundancy management, and vibration survey.
- The results of these analyses are used to revise the design, as necessary, to reduce design risk, and the analyses are update, as necessary, for changes in design. Design risk analyses are not performed simply for the sake of meeting contract data requirements.
- CAD techniques are developed or acquired, as necessary, to conduct these analyses to the maximum extent possible, both as a potential savings in engineering time and cost, and in the interest of improved and more consistent analytical accuracy.
- Integrated logistics support analyses are performed to understand and determine the effects of a design on supportability and logistics resources requirements for the purpose of reducing any adverse effects.

TIMELINE



Design analysis policies are developed and proven before FSD, but shall be updated and otherwise refined as experience is gained during development. Their use is completed largely, except for engineering changes to correct failures, at the conclusion of the design process.

TEMPLATE



AREA OF RISK

Low risk designs allow parts and materials to operate well below their maximum allowable stress levels. Performance-oriented military programs often attempt to use these same parts and materials at much higher stress levels. Pursuit of interoperability and parts standardization also may introduce similar risks. These choices often are made by using mathematical models and generic handbook data that are imprecise. The resultant high risk may not be discovered except by testing, often operational testing, which is too late to avoid extensive corrective action.

OUTLINE FOR REDUCING RISK

- The following design criteria are used for part operating temperatures (except semiconductors and integrated circuits). These criteria apply to case and hotspot temperatures.

≤ 3 watts:	40^0C rise from the part ambient with a maximum absolute temperature of $+110^0$C
> 3 watts:	55^0C rise from the part ambient with a maximum absolute temperature of $+125^0$C
Transformers:	30^0C rise from the part ambient with a maximum absolute temperature of $+100^0$C for MIL-T-27 class S insulation
Capacitors:	10^0C rise from the part ambient with a maximum absolute temperature of $+85^0$C

Of all the forms of stress to which electronic parts are susceptible, thermal stress is the most common source of failures. The thermal stress guidelines that are highlighted have been instrumental in reducing the failure rate of electronic equipment by up to a factor of 10 over traditional handbook design criteria.

- The junction temperatures of semiconductors and integrated circuits normally should not exceed +110^{0}C, regardless of power rating. The failure rates of semiconductors decrease by as much as a factor of two for each 10^{0}C by which their junction temperatures can be lowered. In modern electronic systems having high semiconductor populations, this translates to an approximately equal decrease in the overall system failure rate when instituted as design policy. In one program involving 200 aircraft, each 5^{0}C reduction in cooling air temperature was estimated to save $10 million in electronic system maintenance costs by reducing failure rates.

- The absolute values of operating temperatures for all electronic parts in a design are determined both by analysis and by measurement.

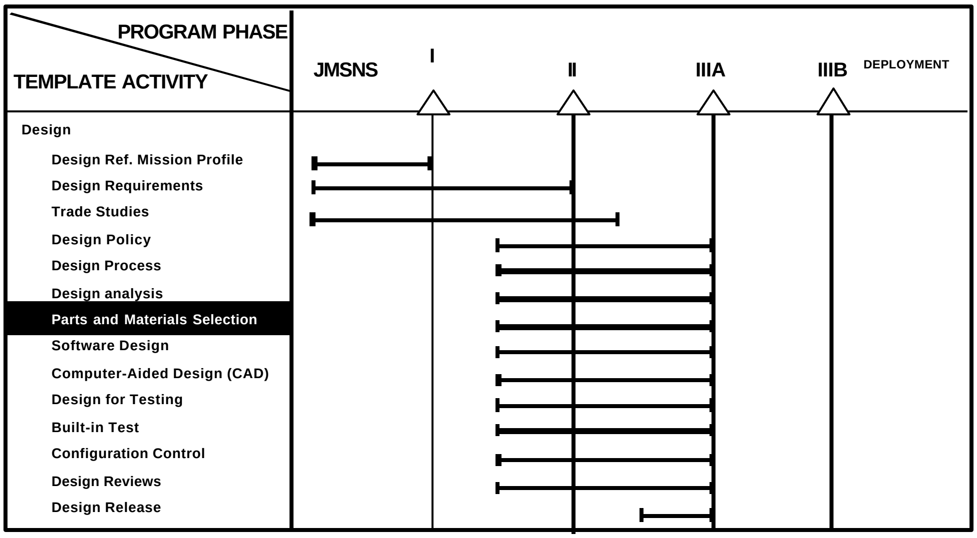
  Equipment used to perform thermal surveys on electronic systems and components now is available readily. This equipment usually is based on infrared scanning techniques, and now is capable of measuring even the junction temperatures of integrated circuits under development.

- Government contractors include in their design policies and their parts and materials programs the derating criteria for all classes of parts and materials to be used in their products, specifying absolute limits on all parameters to which reliability is sensitive. This policy is subject to review and approval by the Government before contract award.

  Stress derating practice ranks with mission profiles as the most critical design factors associated with low risk products.

- Program-peculiar approved parts lists (APL), in general a sub-set of the Military Specification (MIL-SPEC) lists, are issued at the start of FSD. The APL shall inform all designers of the program’s standardization decisions—on resistors, capacitors, other electronic parts, fasteners, connectors, wire, epoxies, and so forth. Designers must use the selected standard parts when they meet system requirements or justify use of nonstandard parts.

TIMELINE



Parts and materials selection and stress derating policies must be in place at the start of hardware development. The contractor design review process is the primary mechanism to ensure compliance with these policies.

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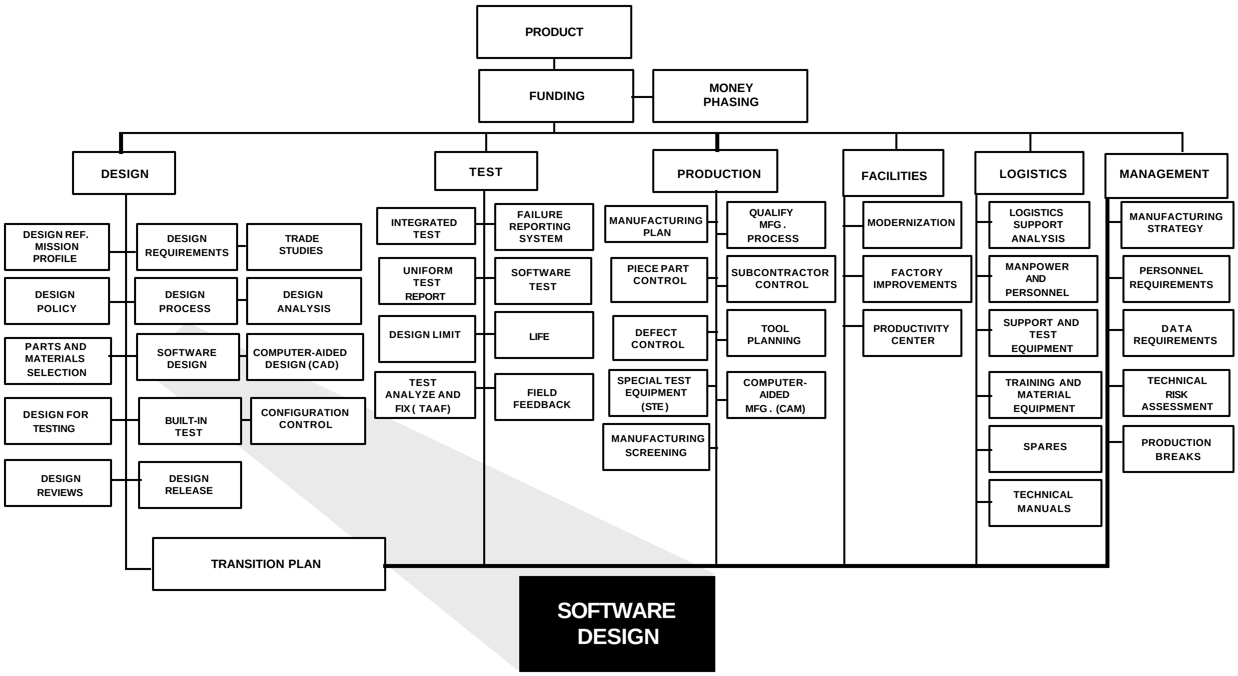


AREA OF RISK

Many weapon systems now depend upon software for their operations and maintenance. Whether the software is embedded ("tactical" or "firmware") or loaded into main memory from peripheral storage devices, the problems are the same—the weapon systems cannot be qualification tested and they can't function, in most cases, without proper software. A software error can cause a weapon system failure. Nevertheless, software frequently fails to receive the same degree of discipline as hardware early in FSD. Failure to allocate system requirements clearly between hardware and software greatly increases the difficulty of isolating and correcting design problems. Industry experience shows that 64 percent of all software errors are traceable to functional or logical design, with the remaining 36 percent due to coding.

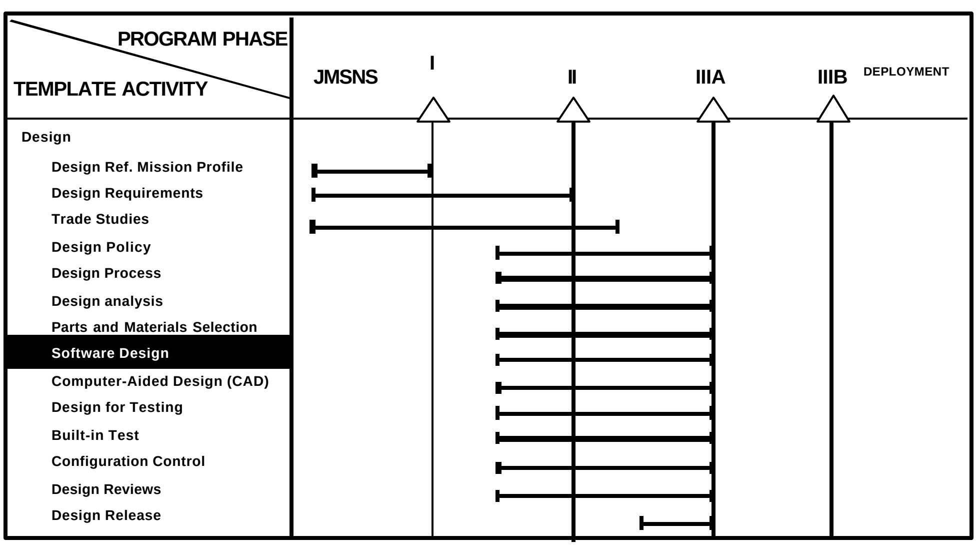
OUTLINE FOR REDUCING RISK

- The applicability to software in the outline for reducing risk of every design template is considered. Most templates are as applicable to software as to hardware, especially design process and design analysis.
- Functional requirements are allocated either to hardware or to software, as appropriate, at design start. These allocations usually are trade study topics, since it often is not clear initially which functions should be implemented in hardware, and which in software. Hardware and software responsibilities reside with one individual.
- Proven design policies, processes, and analyses governing software design are employed, including, but not limited to the following:
  - Rigorous configuration control.

- Chief programmer/designer teams and modular construction.
- Structured programming and top-down design.
- Structured walkthroughs.
- Good documentation.
- Traceability of all design and programming steps back to top level requirements.
- Independent review of requirements analyses and design process.
- Thorough test plan developed and utilized from design start.
- Compliance with standards.
- Structured flowcharting.

- Computer software developers are accountable for their work quality, and are subject to both incentives and penalties during all phases of the system life cycle.
- A uniform computer software error data collection and analysis capability is established to provide insights into reliability problems, leading to clear definitions and measures of computer software reliability.
- A software simulator is developed and maintained to test and maintain software before, during and after field testing.
- Security requirements are considered during the software design process.

TIMELINE



It is essential that software design practices follow a disciplined process similar to proven hardware design practices. Design schedule for software coincide with the hardware schedule.

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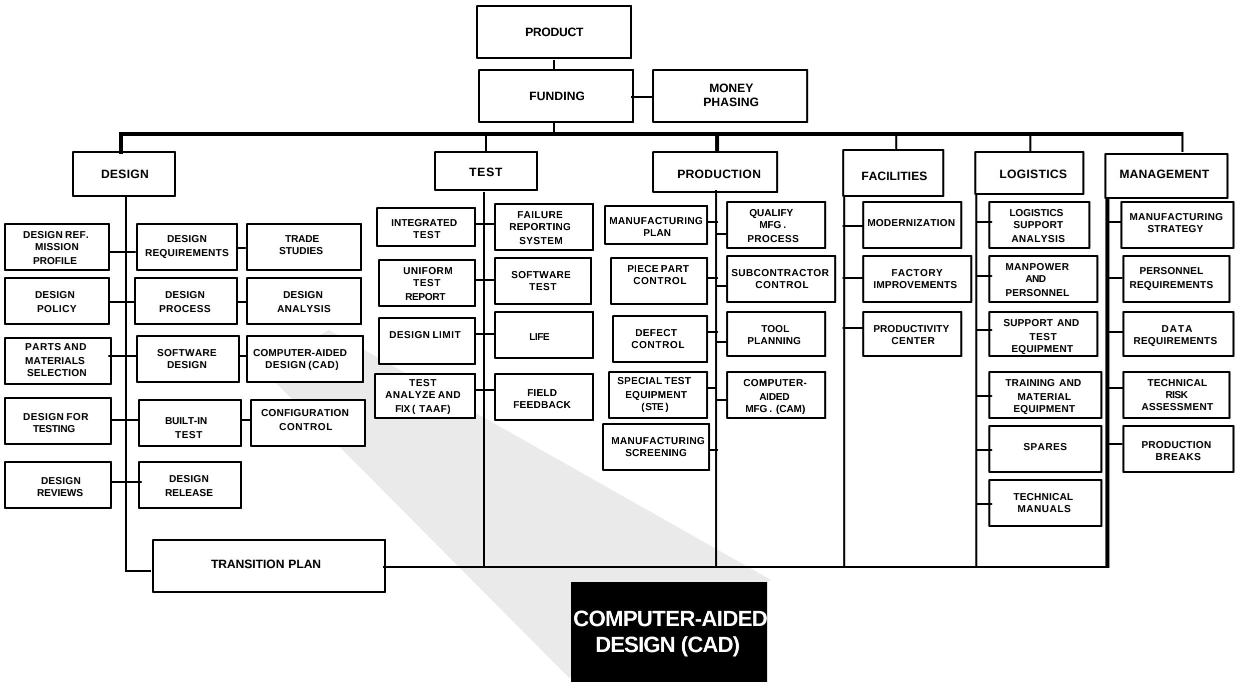


AREA OF RISK

Many design tools and analysis techniques required to achieve a mature design are not used or performed at all because they are time consuming and costly. Engineers don't always follow the design rules that their companies require. Producibility and testability of the design is often lacking due to lack of communications with and knowledge of manufacturing processes. Obtaining a good understanding of the design before it is built and tested is often lacking, increasing the length and cost of test and fix periods, increasing cost of redesigning tooling and test equipment, and increasing support costs and the risk during the transition to production and early deployment. Obtaining information on part and material parameter limitations and availability, as technology produces new items, is time consuming when available only in printed form.

OUTLINE FOR REDUCING RISK

- Computer-aided design (CAD) is carried out in the factory as part of a thorough modernization strategy.
- Each design engineer is provided the use of an alphanumeric computer terminal.
- An interactive graphics terminal is provided for each group of four to six design engineers.
- These graphics terminals have user-friendly access to a data base that contains the following:
  - Parts and materials data.
  - Design rules (both corporate policy and product specified).
  - Design specifications (mission profile, performance and reliability requirements,

supportability design-to requirements, limits, and boundaries).

– Manufacturing rules (special processes, testability, and estimated quantity).

– File and retrieve capability, including design data and analysis results.

- Terminals have user-friendly access to special computer software (programs) that provide a capability to accomplish the following:

  – Perform modeling and prototyping.

  – Perform simulation and performance analyses.

  – Perform special analyses such as the following:

    - Electrical stress.
    - Thermal stress.
    - Vibration stress.
    - Sneak circuit.
    - Failure modes and effects.
    - "Worst case" tolerance.
    - Reliability prediction and allocation.

  – Maintain configuration and design release control.

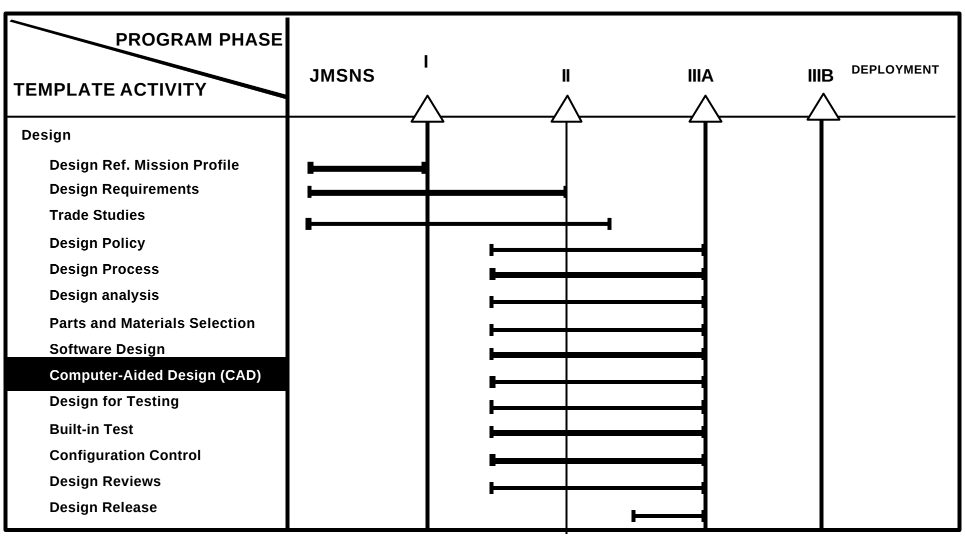
  – Help design product tests.

  – Manage test and failure analysis data.

- A common data base is in place to integrate CAD and computer-aided manufacturing (CAM) functions (see template on CAM) to achieve significant cost, schedule, quality, supportability, and performance benefits.

- An aggressive employee retraining program is in place to provide for orderly introduction of new skills.

TIME LINE



Through the use of CAD equipment, a full complement of design tools is available to facilitate the design process and satisfy producibility objectives.

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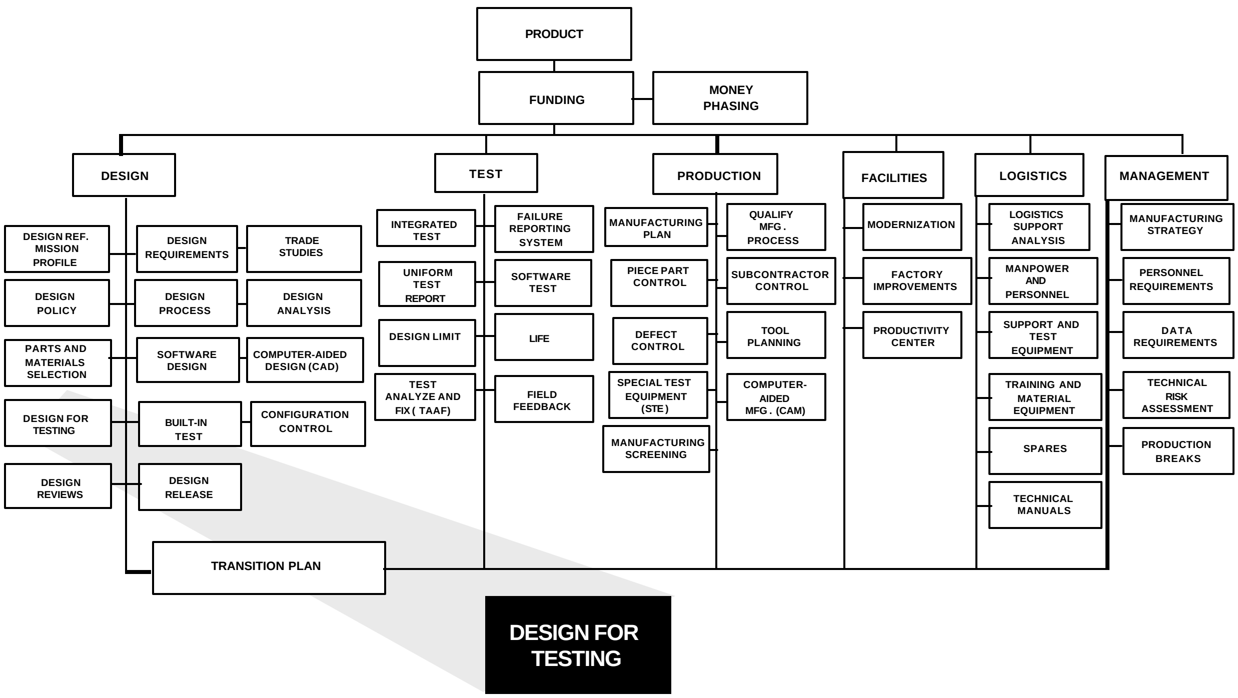


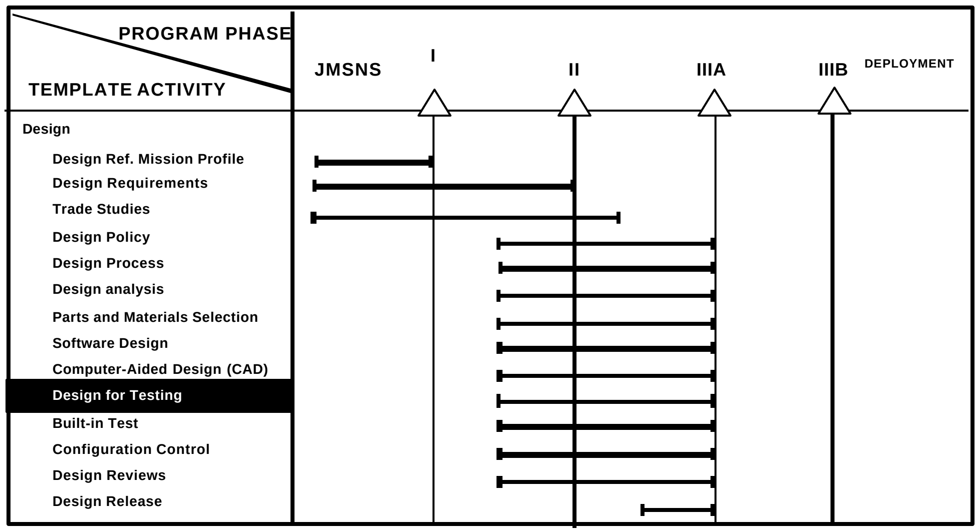
AREA OF RISK

Test and inspection are integral functions of the production and operational environment. To survive the production process without degradation, a design must allow for access by both inspectors and various types of automatic testing approaches.

OUTLINE FOR REDUCING RISK

- Design criteria are provided for partitioning, initialization, functional compatibility with automatic test equipment (ATE), functional coverage, modularization, and visual and physical accessibility.
- Trade studies are conducted for integrated application of built-in test (BIT), ATE, and manual testing to support fault detection and isolation.
- Production design studies are conducted to define inspection, test, and evaluation requirements; to maximize inspectability; and to minimize the need for special manufacturing tests and special factory or field test equipment.
- Classification of characteristics are noted on drawings.
- Test and evaluation (T&E) are planned and coordinated to minimize the need for subjective interpretation of a system's performance design requirements.
- Factory test consumes no more than 10 percent of expected product life.
- System level functional testing is conducted at a level that meets but does not exceed operational use requirements.

TIMELINE



To provide for efficient and economical manufacture, consideration must be given to providing the proper test and inspection capabilities in the basic equipment design. Policies governing design for testing are established before FSD, and such design is completed largely at the conclusion of the design process.

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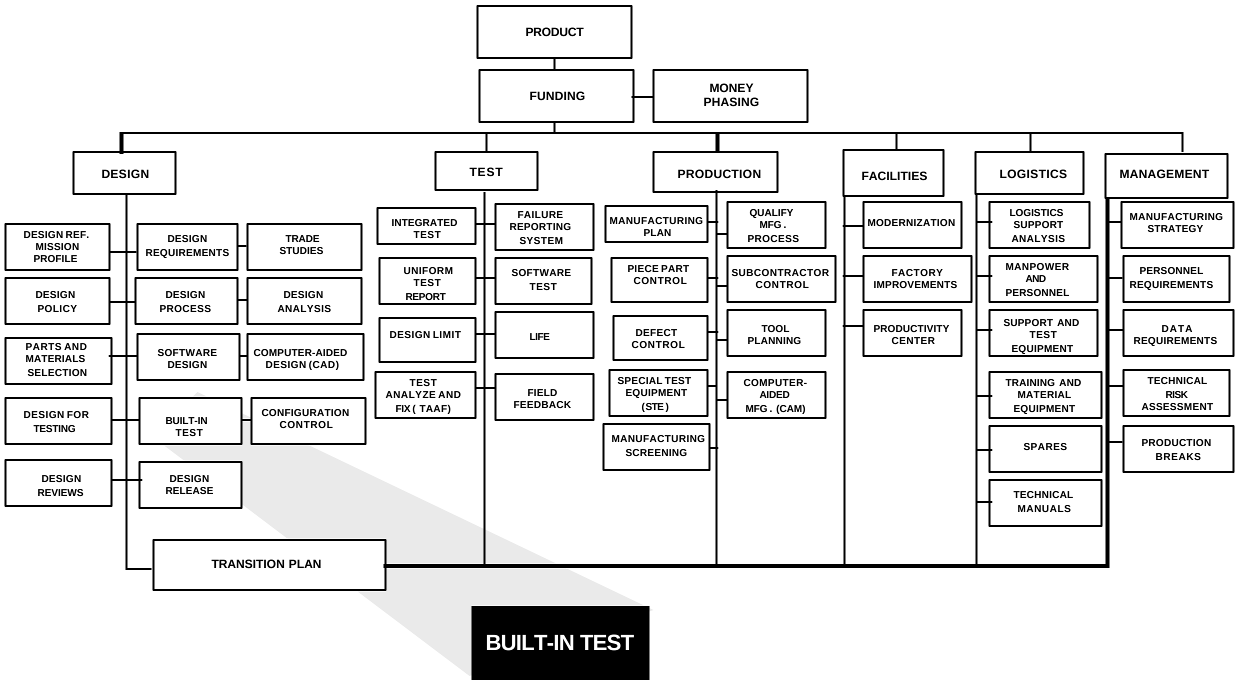


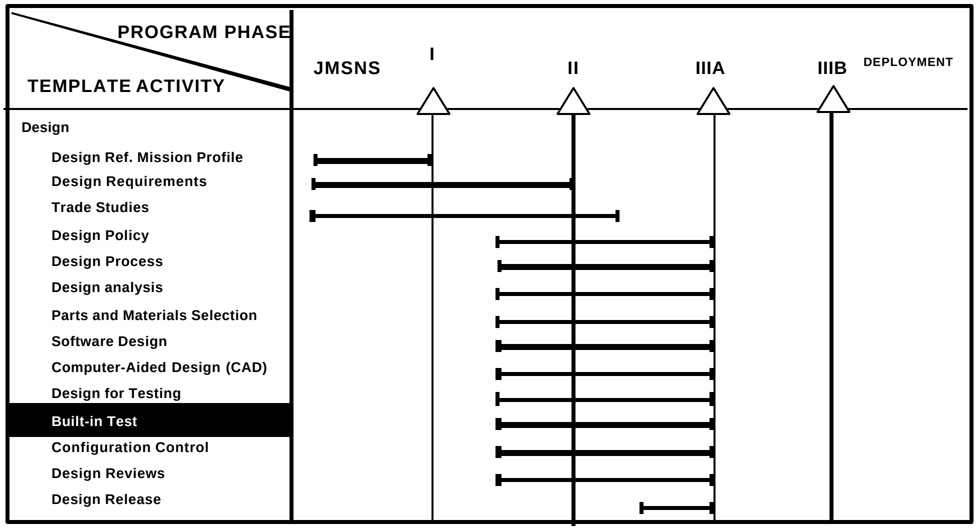
AREA OF RISK

Built-in test (BIT) circuitry offers not only ease of maintenance in the field but also more rapid troubleshooting during factory test and production. Many designs do not include sufficient BIT capability to isolate failures to the single faulty line-replaceable or weapon-replaceable assembly, much less the shop-replaceable assembly or component part. One of the more common results is the line removal of functional assemblies along with the nonfunctional one, increasing downtime and causing unnecessary backlogs in logistic support. The argument is heard frequently that additional BIT equipment itself adds to product risk beyond the value it might have in maintenance. This argument may have had validity in an earlier era, but not with today's complex yet low risk integrated circuitry.

OUTLINE FOR REDUCING RISK

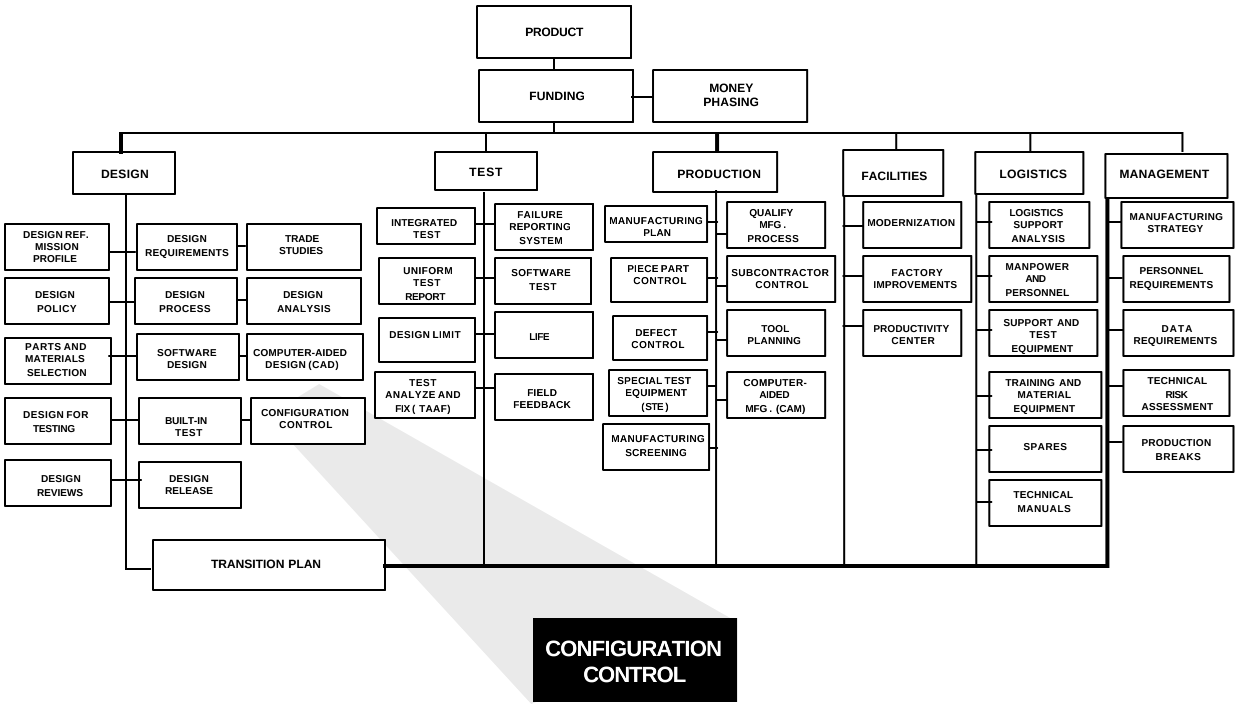
- Maintenance and support requirements are defined before initiation of BIT design.
- Design criteria are provided for the contribution of BIT circuitry to product risk, weight, volume, and power consumption. These criteria are established by Milestone II.
- Trade studies are conducted for each maintenance level on the interaction of BIT, automatic test equipment, and manual test in support of fault detection and isolation; and to optimize BIT allocation in hardware, software, and firmware.
- Production design studies are conducted to define the use of BIT in manufacturing inspection, test, and evaluation.
- BIT criteria, at a minimum, detect all mission compromising failures, and validate all redundant functions.

TIMELINE



BIT is a significant factor in the initial design planning and tradeoff analyses and must be evaluated in subsequent design reviews. Concepts for BIT that are validated during the normal program validation phase may be adopted for the final design. BIT design is completed and validated during full-scale development.

TEMPLATE



AREA OF RISK

A common source of risk in the transition from development into production is failure to establish and maintain a strong configuration control system. Direct application of boilerplate policies and/or invoking MIL-SPECs leads to ineffective control or overly complex and costly approaches to managing configuration. In a loosely implemented control system, design changes can occur without proper maintenance of the configuration change documentation after the design freeze is established. Lack of a good configuration control system leads to many pitfalls, including an unknown design baseline, excessive production rework, poor spares effort, stock purging rather than stock control, and an inability to resolve field problems. Poor configuration control is a leading cause of increasing program costs and lengthening procurement schedules.

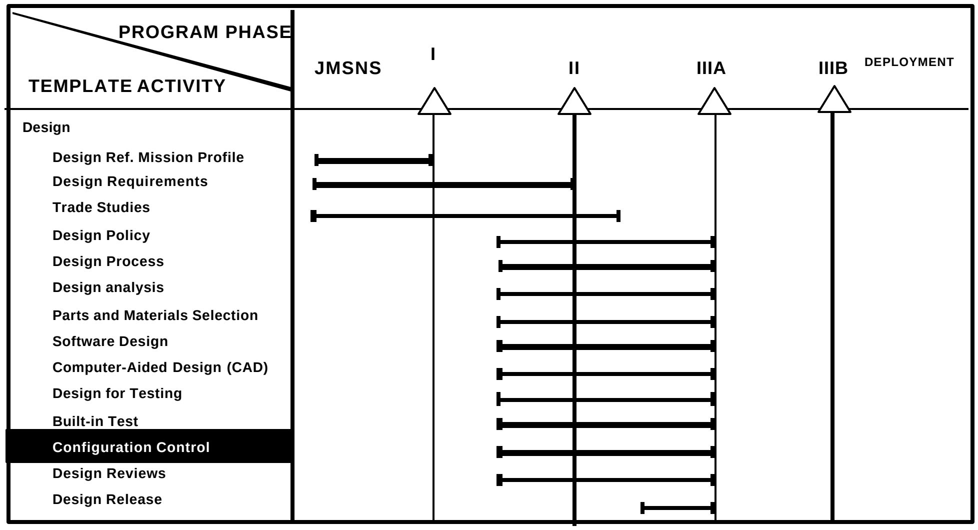
OUTLINE FOR REDUCING RISK

- An effective configuration control system contains the following features:
  - It is tailored from an effective set of guidelines and standards to fit the nature of the program including hardware and logistics support elements.
  - Corporate or division policy recognizes the importance of proper configuration management in the development of a new program, and emphasizes the need to generate an adequate plan for implementation.
  - A configuration management plan is streamlined, yet adequately encompasses the entire life cycle of the program, recognizing the requirements of each phase of the life cycle and the complexity of the system configuration.

- The configuration management plan establishes the mode of operation and interface relationship among vendors, subcontractors, contractor, and customer.

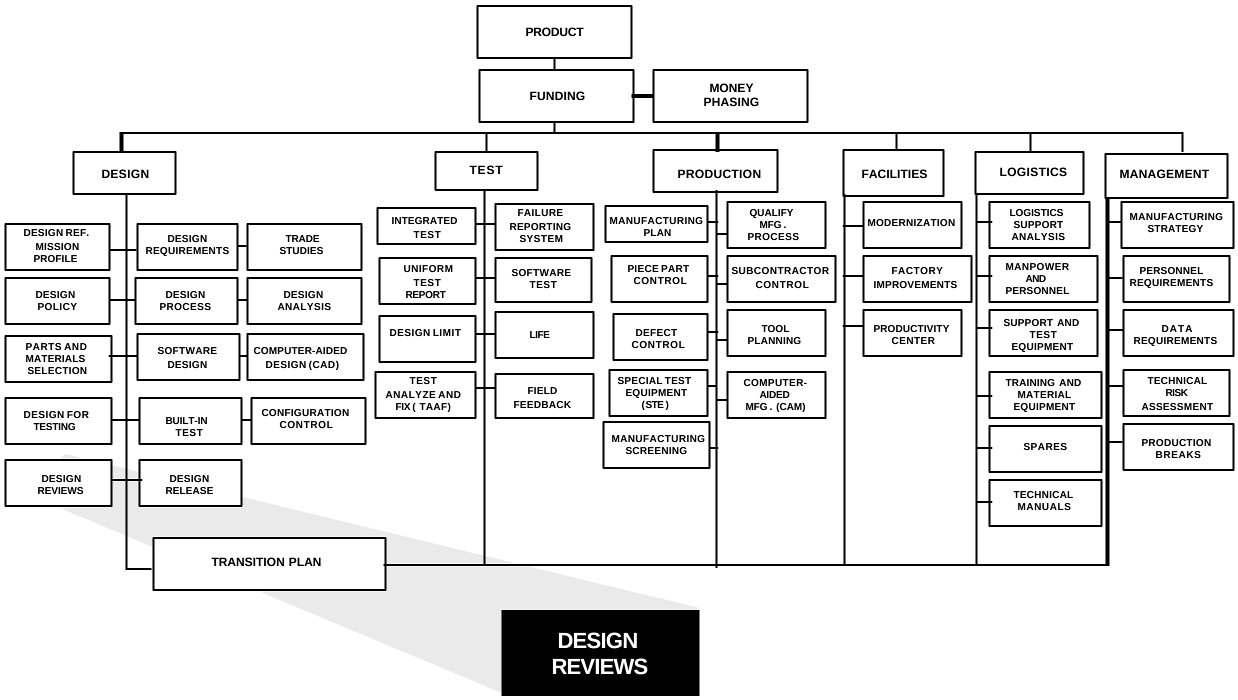
- Proper staffing and authority commensurate with responsibility are essential to the success of a configuration management organization.
- The specification tree, engineering release, and drawing discipline are managed by documentation requirements that have been established through the configuration management plan.
- Training in the established configuration management system is essential for a smooth configuration management program.
- A sound configuration management system recognizes that strict discipline is necessary to organize and implement, in a systematic fashion, the process of documenting and controlling configuration.
- Dynamic change control boards and status accounting systems that are updated frequently by timely feedback from user activities are indicative of effective configuration management.
- Good configuration control procedures ensure the establishment and maintenance of design integrity.
- Configuration audits are performed to establish the design baseline and to validate the drawing package before production release.
- Manufacturing engineering interfaces with configuration control of work instruction planning.
- The transition from contractor to Government responsibility is made when the design is largely mature and when field support will be enhanced.

TIME LINE



The application of configuration control on a program is essential. For effective utilization, it should be tailored to fit the nature of the program. Configuration control policies are established early in the development and the design baseline configuration is stabilized before production.

TEMPLATE



AREA OF RISK

While defense contracts usually require formal design reviews, they often lack specific direction and discipline in the design review requirement, resulting in an unstructured review process that fails to fulfill either of the two main purposes of design review, which are: (1) to bring to bear additional knowledge to the design process to augment the basic program design and analytical activity; and (2) to challenge the satisfactory accomplishment of specified design and analytical tasks needed for approval to proceed with the next step in the material acquisition process.

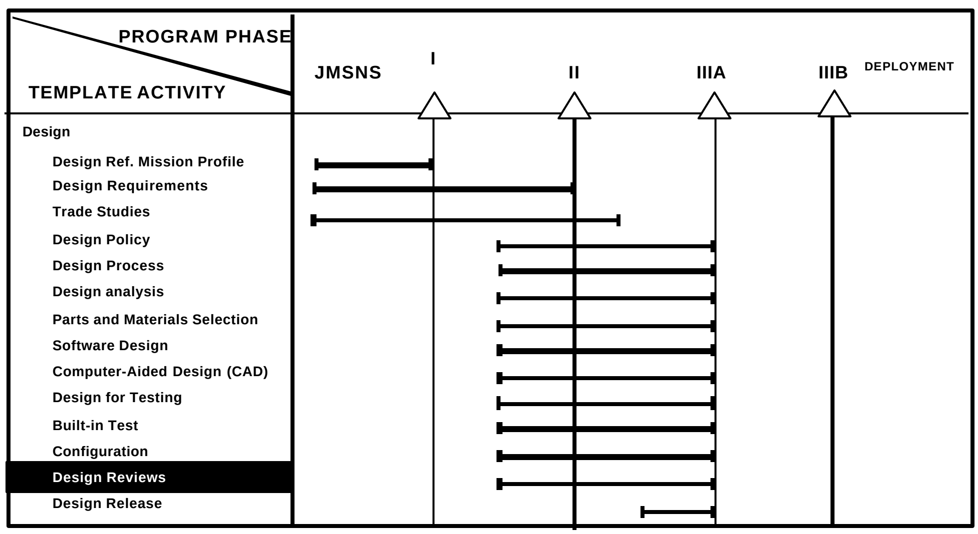
OUTLINE FOR REDUCING RISK

- The Government and its contractors recognize that design reviews represent the “front line” where readiness for transition from development to production is decided ultimately. Design review policy, schedule, budget, agenda, participants, actions, and follow up are decided in view of this foremost need.
- Design reviews are included in all material acquisition programs in accordance with existing Government requirements. A design review plan is developed by the contractor and approved by the Government. The design review plan provides for both Government design reviews and internal contractor design reviews and inspections.
- Design review requirements flow down to subcontractors and suppliers to ensure proper subcontractor internal design review practices and to provide timely opportunities for both the contractor and the Government to challenge subcontracted material design.
- Government and contractor design review participants are selected or recruited from outside the program to be reviewed, on the basis of experience and expertise in challenging the design, and have a collective technical competence greater than or equal to that of the

designers responsible for the design under review.

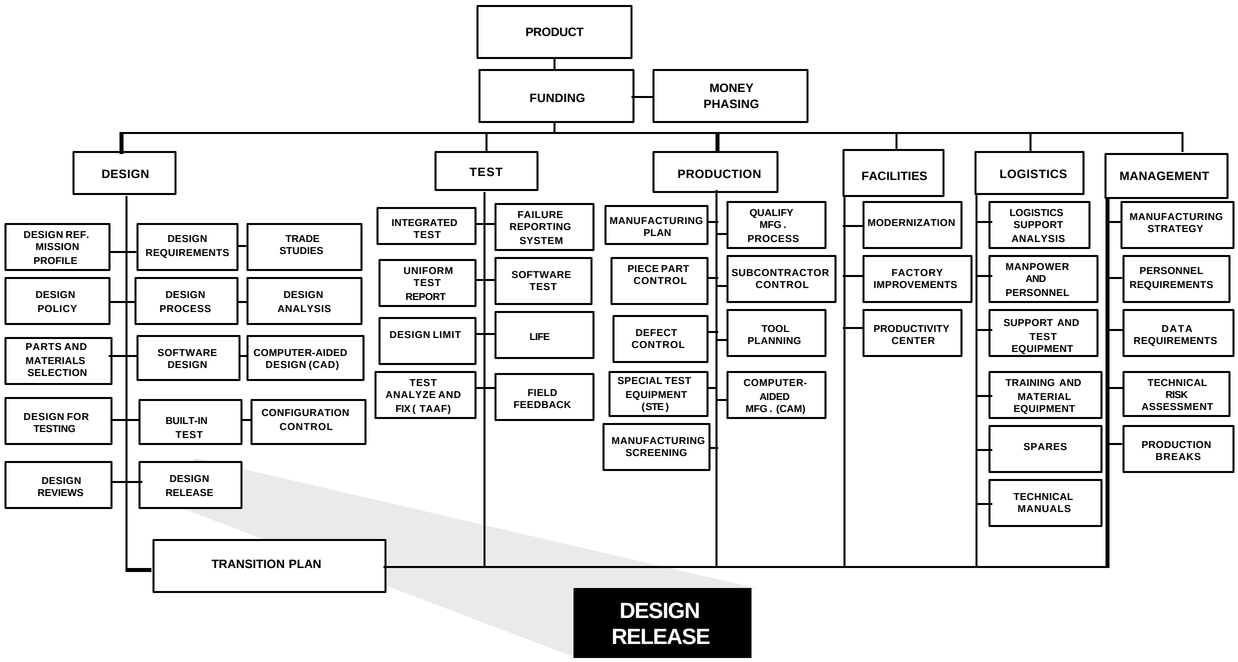
- Manufacturing, product assurance, and logistics engineering functions are represented and have authority equal to engineering in challenging design maturity.
- Design reviews use computer-aided design analyses, whenever available, and include review of production tooling required at the specific program milestone.

TIMELINE



Design review must be performed by technically competent personnel in order to review design analysis results and design maturity, and to assess the technical risk of proceeding to the next phase of the development process. Design review policies are established before FSD, and the design reviews are completed by the conclusion of FSD.

TEMPLATE



AREA OF RISK

One of the most critical concerns in the transition from development to production is the risk associated with the timing of design release. On many programs, design release schedules are established by “back planning” from manufacturing schedules or ambitious marketing considerations. As a result, the design engineer is expected to meet unrealistic milestones forcing him or her to deviate from standard design practices. The results are predictable: design solutions are not the most beneficial to the overall design, interface considerations are glossed over, costly redesigns occur, and necessary documentation is sketchy. Expedited and advanced design releases generally create the need for second and third generation effort. On the other extreme, when a design release is scheduled beyond the normal period required to complete the design, the designer is tempted to add undue complexity to the basic design rather than improve inherent reliability or maintainability or reduce costs.

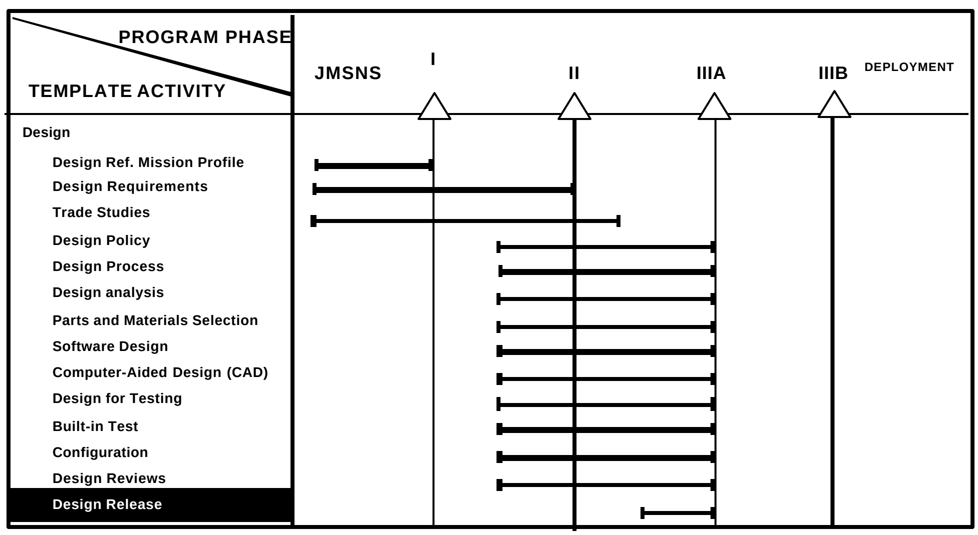
OUTLINE FOR REDUCING RISK

- Documented corporate policy clearly identifies practices and procedures for design drawing releases to facilitate transition and reduce production risk.
- The design release disciplines practiced by the contractor are flowed down to subcontractors and suppliers.
- By applying uniform practices and procedures dealing with technical requirements and evaluating current manufacturing capability, realistic design release dates can be established.
- In areas of high manufacturing risk, alternate design approaches are planned and evaluated to ensure that the design release schedule is maintained.
- Complex designs are validated before design release by fabricating preproduction manufacturing models and feeding results back to design for corrective action. This step

increases the assurance that the design release documentation will support full-scale production.

- The design release documentation includes all necessary information required for an orderly transition from design to production.
- A formal review of the design release documentation is conducted at the critical design review (CDR).
- The design baseline is established and validated as part of the design release.
- All design-related testing, including qualification testing, is completed before design release, to ensure that the design has reached acceptable maturity.

TIMELINE



Integral to the development process are the facts that at some point, creative design must then be released to manufacturing. Design release is completed with the acceptance of the design through the CDR and qualification test process.