MN 3221 Principles of Systems Acquisition and Program Management

Systems Engineering Process
Outputs

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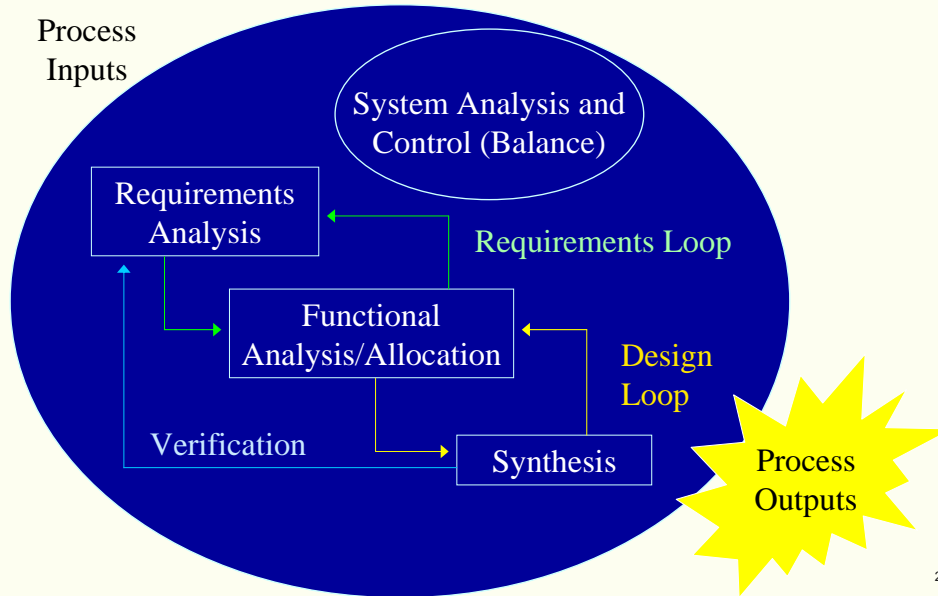**Jdillard@nps.edu**
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No notes on this slide.

Systems Engineering Process

Process Inputs

System Analysis and Control (Balance)

Requirements Analysis

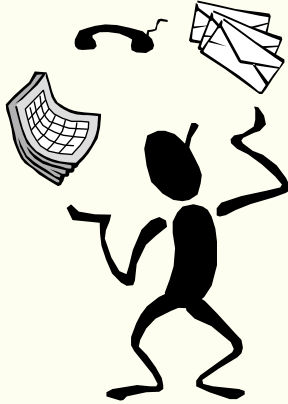Requirements Loop

Functional Analysis/Allocation

Design Loop

Verification

Synthesis

Process Outputs

We're still discussing SEP outputs and it's time to focus on baselines.

Systems Engineering Process Outputs

- **Output Varies Depending on Stage of Development**
  - **Decision Data**
  - **System Architecture**
  - **Performance Specifications and Baselines**

- **Process Outputs from one SEP Iteration may be Process Inputs for the next Iteration**

We've said before that system development is iterative and divided into phases, with many outputs from one phase feeding directly into another.

Specification Definitions

- **Specification: Document that describes the essential technical requirements for materiel and the criteria for determining whether those requirements are met.**
  - **Military Specification: Technical requirements that are military unique.**

  - **Performance Specification: In terms of required results without stating methods for achieving required results.**

  - **Detail Specification: Specifies design requirements, such as materials to be used, how a requirement is to be achieved, or how an item is to be fabricated or constructed.**

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The materiel developer, user, and contractor get a clear picture of the system from specifications – our expert technical translation of user requirements.

It is DoD policy to give first preference to developing and using performance specifications, which describe what function will be performed without necessarily describing how it will be performed.

We feel this gives latitude for innovative solutions that we might not have thought of.

If it is not practical or effective to use a performance specification, a non-government standard should be used. If it is not practical or effective to develop and use a performance specification or non-government standard, a detail or military specification may be developed or used.

We had actually held a moratorium on the use of MILSPECS for about 10 years, because they were being used indiscriminately and presumably driving up cost.

You have seen the policy memo that lifted this "ban," but we should still be judicious in what we specify.

We should not "over-specify" what we want, and neither should we fail to be specific about what we do and don't want the system to do.

The term "military specification" was largely eliminated and replaced by either "Performance Specification" or "Detail Specification."

A **performance specification** defines the functional requirements for the item, the environment in which it must operate, and interface and interchange characteristics. Requirements in the performance specification shall describe what is required or the item's form, fit, or function. The performance specification shall not describe how a requirement is to be achieved, require the use of specific materials or parts, or give detailed design or construction requirements beyond those needed to ensure interchangeability with existing items.

The definition for a **detail specification** is also taken from MILSTD 961D. A specification that contains both performance and detail requirements is still considered a detail specification, unless the detail information applies only to interface requirements. Detail specifications shall specify materials, design or construction requirements, or "how to" requirements only to the extent necessary to ensure the adequacy, safety, and interchangeability of the item being acquired

Specification Hierarchy

Tech & Mission Rqmts for a system/segment eg. MILSTAR-System Space/Ground Segments. Initial version based on CE studies; finalized in PDRR

Complex item, such as aircraft, missile, launcher, radar set, etc. Some features:
- Formally accept on DD250
- Qual conf insp on each item vice sampling

State Rqmts for design or eng dev of a product during devel period. Finalized during EMD.

Sometimes called: Procurement Spec Applic to any CI below syst level to be procured thru spec of fnl or fab rqmts. Finalized after PCA.

Below compl level of prime item, but warrants spec due to tech or log criticality

A relatively simple CI. Why designate as CI? -Impact on other items. Eg. Special tools, work stands. Cannot be S/W Acc Testg not req'd to verify perf.

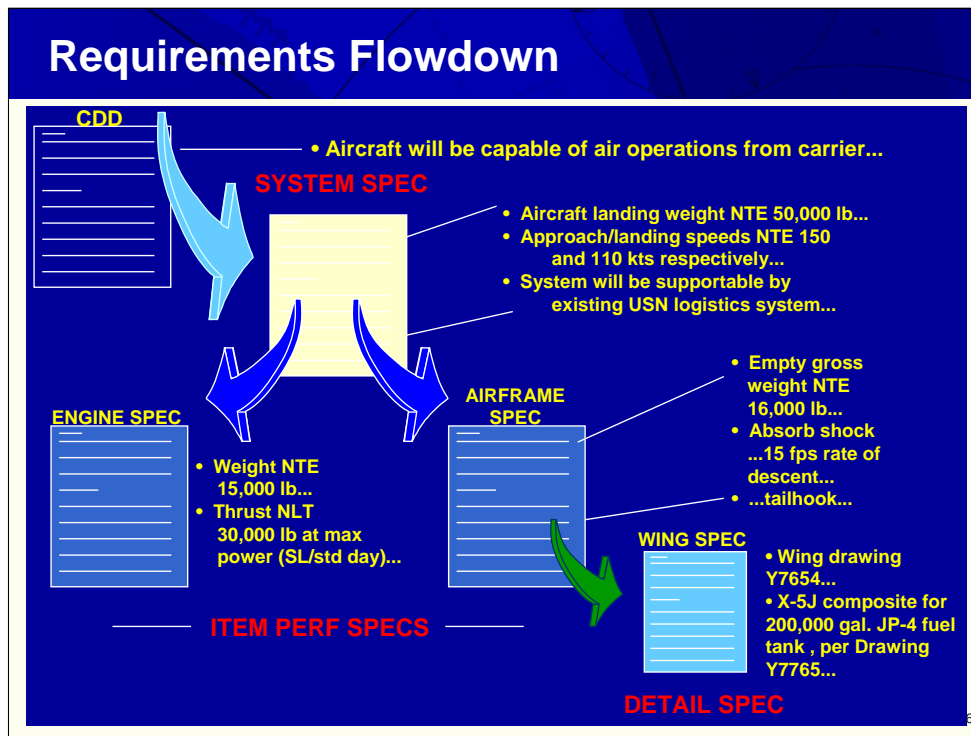*Complete perf rqmts of the product*

SYSTEM SPEC (OLD "A")

Software Performance Spec

Item Performance Spec (OLD "B")

Software Detail Spec

Detail Spec (OLD "C")

Process Spec (OLD "D")

Material Spec (OLD "E")

> The old MIL-STD 490 designations may still be found in older programs but are rapidly fading away in usage.

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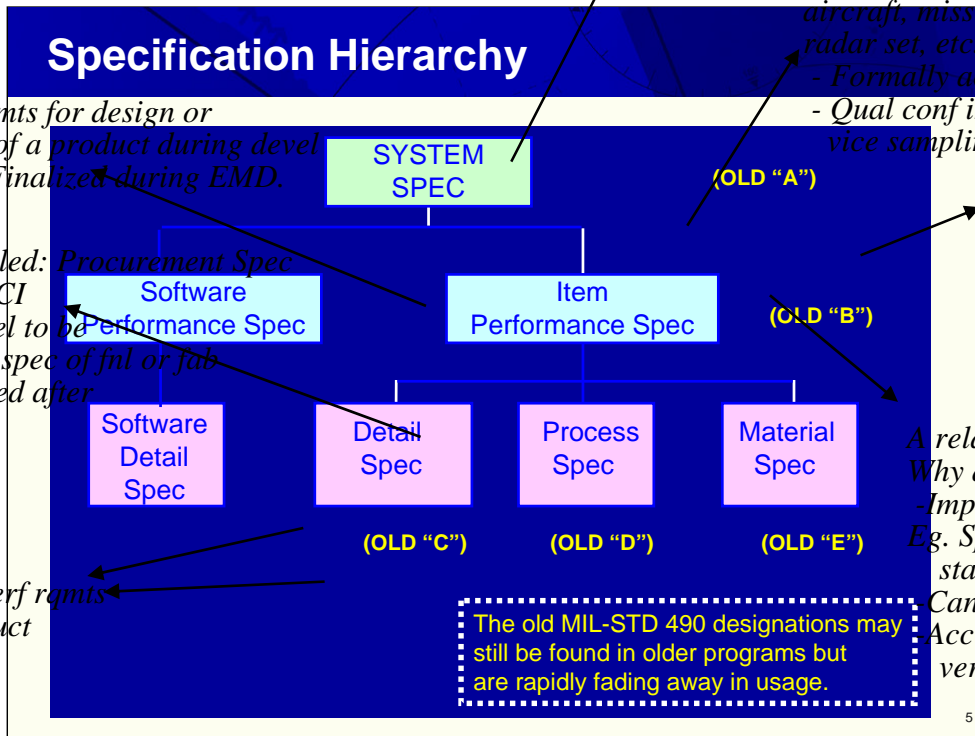
The Specification Hierarchy provides more detail on the types of specifications. Note the change to "name" specs and elimination of the "A, B, C, D, E" and their numbers, i.e., no more B-2, C-1 specs for new programs, although you may still find this convention on existing programs initiated prior to 1994.
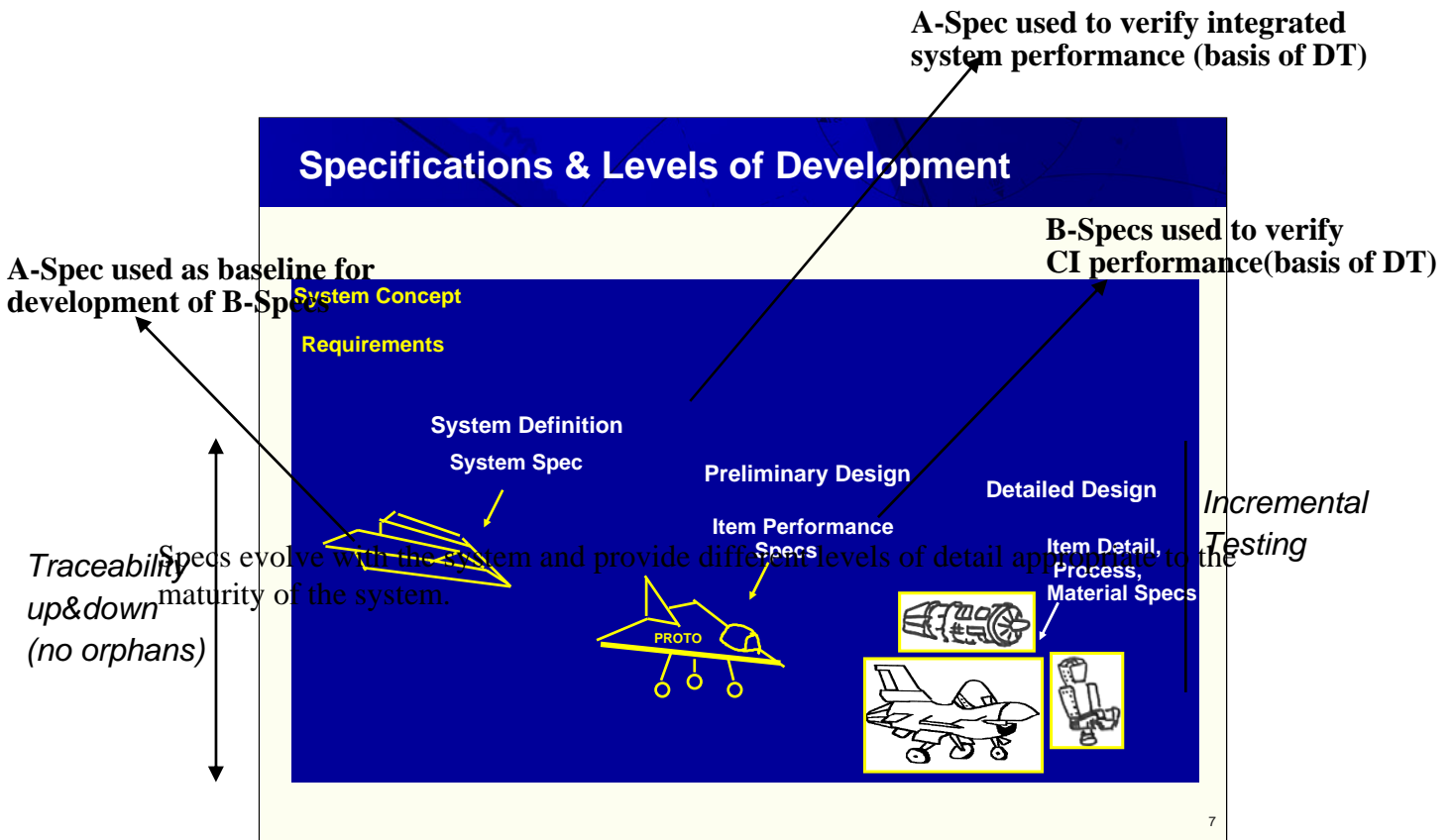
Type of Specs selected are driven by things like:
  - Level of control over design that is needed
  - Technical or Log criticality of the item(s)
  - Requirement for training documentation, etc.

Requirements Flowdown

CDD

• Aircraft will be capable of air operations from carrier...

SYSTEM SPEC

• Aircraft landing weight NTE 50,000 lb...
• Approach/landing speeds NTE 150 and 110 kts respectively...
• System will be supportable by existing USN logistics system...

ENGINE SPEC

• Weight NTE 15,000 lb...
• Thrust NLT 30,000 lb at max power (SL/std day)...

AIRFRAME SPEC

• Empty gross weight NTE 16,000 lb...
• Absorb shock ...15 fps rate of descent...
• ...tailhook...

WING SPEC

• Wing drawing Y7654...
• X-5J composite for 200,000 gal. JP-4 fuel tank , per Drawing Y7765...

ITEM PERF SPECS

DETAIL SPEC

This shows a sample flow-down of the type of information from the CDD to the item detail spec of a typical system.

Many of us may have heard the different spec terms, but still don't understand how the SE process goes from initial system concept to great detail at the end of the SDD phase.

A-Spec used to verify integrated system performance (basis of DT)

Specifications & Levels of Development

B-Specs used to verify CI performance(basis of DT)

A-Spec used as baseline for development of B-Specs

System Concept

Requirements

System Definition

System Spec

Preliminary Design

Detailed Design

Incremental Testing

Item Performance Specs

Item Detail, Process, Material Specs

Traceability up&down (no orphans)

Specs evolve with the system and provide different levels of detail appropriate to the maturity of the system.

PROTO

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Specs and Levels of Development shows the relationship between the types of specifications and the levels of development of the system. The key point here is that they need to be traceable between levels. In the preliminary design phase when we are developing prototypes, we are also developing "Item Performance" , SW or old B Specs for the Configuration Items.

Configuration Baselines

- **Three DoD Types....**
    - Functional - Sets the System Baseline
    - Allocated – The "Design To" Baseline
    - Product - The "Build To" Configuration

- **VPM suggests a fourth baseline: "As-built"**

These are the three types of system configuration baselines most commonly referred to.

Note that these are all different from the Acquisition Program Baseline, or APB, which is our top level programmatic baseline of cost, schedule, and performance goals.

Functional Baseline

- The approved configuration documentation describing a system's performance and the verification required to demonstrate those characteristics
    - Government Control
    - Functional Characteristics
    - Interface and Interoperability Characteristics
    - CI Integration and Interface
    - Design Constraints

- Government approves in System Integration phase

A functional baseline conveys our clear understanding of what our yet-to-be-designed system is supposed to do.

Allocated Baseline

- Composite of a series of CI allocated baselines

- Approved performance documentation required to develop CIs including....
  - Functional and interface characteristics allocated from the Functional Baseline
  - Verification methodology
  - Interface requirements with other CIs
  - Constraints

- Government can allow contractor configuration control of certain CI Allocated Baselines

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The allocated baseline conveys our understanding of what we are going to design, down to configuration item level, to fulfill all of our functional requirements

Product Baseline

- Approved technical documentation for production configurations including....
  - Necessary CI physical or Form, Fit & Function characteristics
  - Functional characteristics designated for production
  - Production Acceptance Testing (PAT) requirements
  - Technical Data designated for reprocurement

The product baseline conveys our understanding of what we are going to build in production.

Relationship of Baselines to Specs

- **Functional Baseline**
  - System Performance Spec
  - Govt approves at SFR

- **Allocated Baseline**
  - Item Performance Specs
  - Contractor sets NLT PDR; Govt approves at FCA /SVR

- **Product Baseline**
  - Item Detail Specs
  - Govt approves at PCA

As might be intuitive, there's a pretty direct relationship of baselines to specifications.

Relationship of Baselines to Reviews

- **Functional Baseline**
  - Draft established beginning at Alternative Systems Review
  - Set by contractor at System Requirements Review
  - Established by Govt at System Functional Review

- **Allocated Baseline**
  - Set by contractor NLT Preliminary Design Review
  - Govt control by Functional Configuration Audit or System Verification Review

- **Product Baseline**
  - Set by Contractor at Critical Design Review
  - Govt Control typically at Physical Configuration Audit

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And there's a pretty direct relationship of baselines to technical reviews.

Acquisition Framework-Reviews-Documents-Baselines
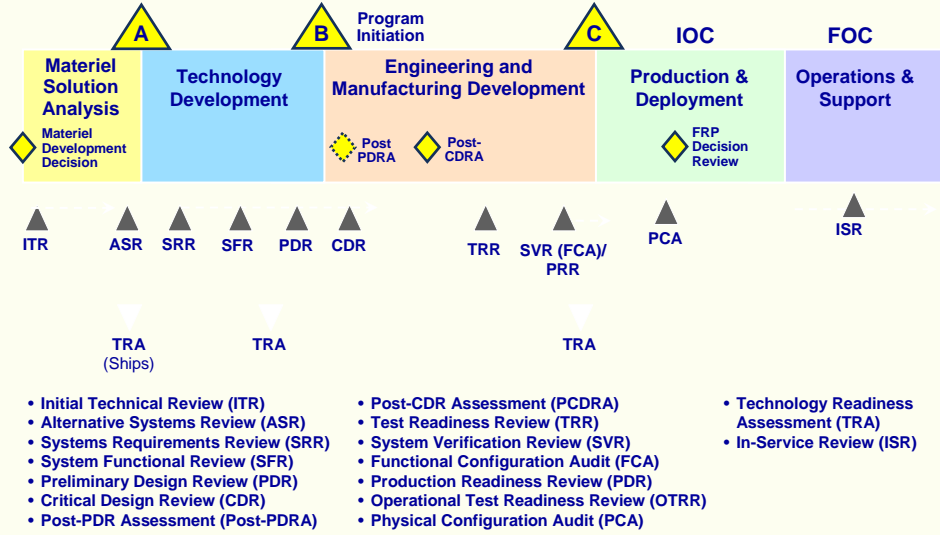
This graphic shows the approximate arrival of baselines against progress across our acquisition framework model.

Systems Engineering Summary

- Overarching process that a program team applies to transition from a stated capability need to an operationally effective and suitable system

- Systems engineering transforms needed operational capabilities into an integrated system design through concurrent consideration of *all* Lifecycle needs

- It is policy for all programs: "All programs responding to a capabilities or requirements document, regardless of acquisition category, shall apply a robust SE approach that balances total system performance and total ownership costs..."

- There is no prescribed format for the SE Plan.

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In summary, Systems Engineering is the process of how we technically describe the solution to the customers needs, and ultimately arrive at it.

We have flexibility in our policies for how we are to comply with the prescribed use of this approach, as long as we do indeed employ it.