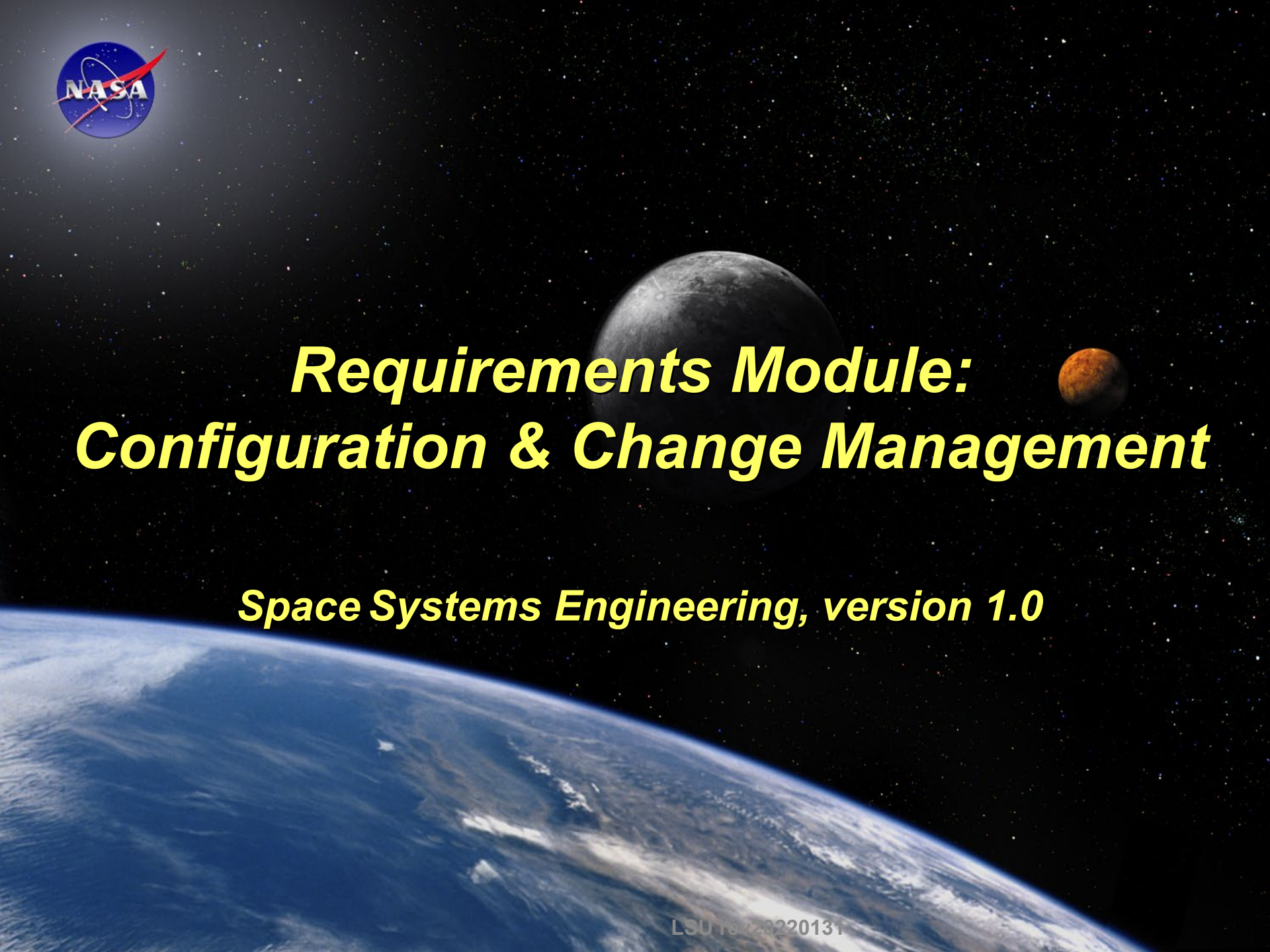


Requirements Module: Configuration & Change Management

Space Systems Engineering, version 1.0

Module Purpose: Configuration and Change Management

- *Define system baselines and when they are updated.*
- *Describe why system baselines are useful.*
- *Define requirements and configuration management and why they are necessary.*
- *Discuss the fact that changes are inevitable.*
- *Describe a typical management process for considering and assessing the impact of requirements and configuration changes.*

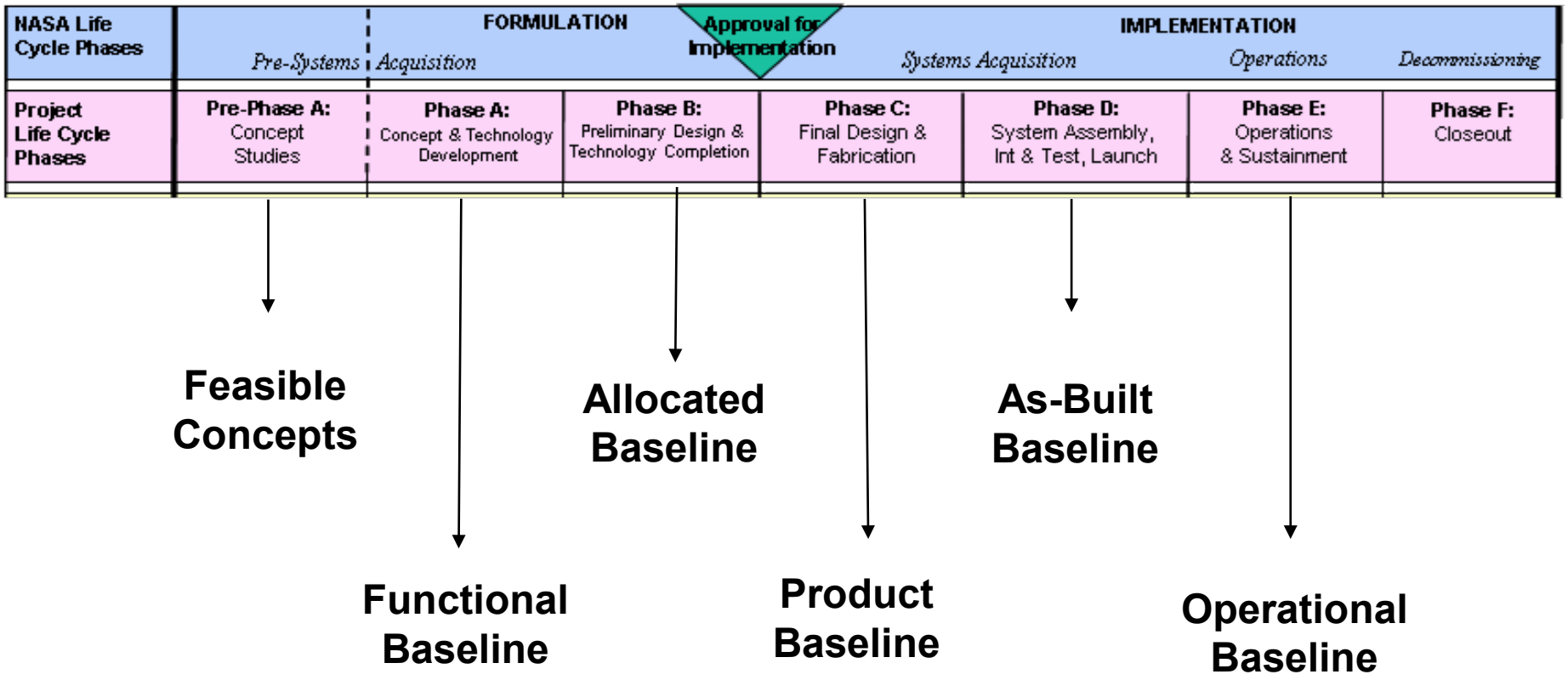
Baselines Periodically Capture the Complete System Representation

A system baseline is a complete system description including the latest requirements, designs, constraints, assumptions, interfaces, resource allocations and team responsibilities at the time the baseline is created.

Baselines Help Ensure Everyone is on the Same Page

- With large teams working on many different parts of a project simultaneously, it is important to make sure there is a common understanding of what is to be done and that no necessary task is ignored.
- Baselines are established at milestone reviews (SDR, PDR, CDR, ORR) and are the common departure point for subsequent design and product maturation.
- Baselines also ensure that the entire project matures at an approximately uniform rate.
  - If one subsystem design is advanced much beyond its peers and it is later discovered that the allocations or interfaces are inappropriate, more rework will have to be done than if the subsystems had advanced at the same rate.

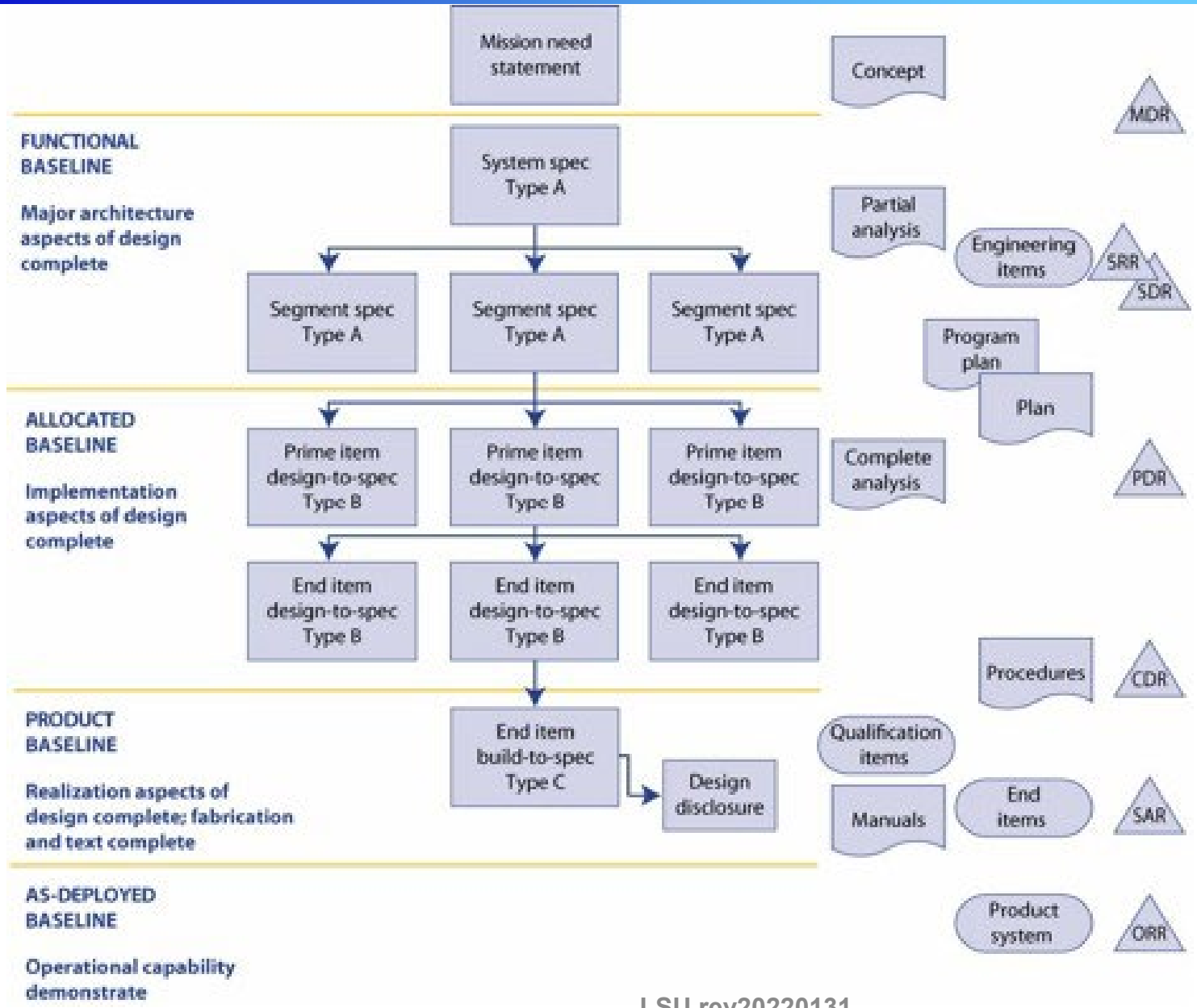
System Maturity Advances Over the Project Life Cycle



Technical Baseline Definitions

- Functional Baseline (Phase A)
  - The functional baseline is the approved documentation describing a system's functional, performance, and interface requirements and the verifications required to demonstrate achievement of those specified characteristics.
  - Established at the System Definition Review (SDR).
- Allocated Baseline aka the 'Design-to' Baseline (Phase B)
  - The allocated baseline extends the top-level performance requirements of the functional baseline to sufficient detail for initiating manufacturing or coding.
  - Established at the Preliminary Design Review (PDR).
- Product Baseline aka the 'Build-to' Baseline (Phase C)
  - The product baseline describes detailed form, fit, and function characteristics; the selected functional characteristics designated for production acceptance testing; the production acceptance test requirements.
  - Established at the Critical Design Review (CDR).
- 'As-Built' Baseline (Phase D)
  - The as-built baseline describes the detailed form, fit, and function of the system as it was built.
  - Established at the Flight Readiness Review (FRR).
- Operational Baseline aka 'As-Deployed' Baseline (Phase E)
  - The as-deployed baseline occurs at the Operational Readiness Review (ORR) . At this point, the design is considered to be functional and ready for flight. All changes will have been incorporated into the final documentation.

Evolution of the Technical Baseline



Baselines Are More Than Just Requirements and Designs

- Technical baseline deals with requirements and design.
- New focus: Integrated program management synchronizes these baselines:
  - Requirements
  - Design
  - Affordability ($$$)
  - Schedule
  - Risk
- *All 5 baselines need to be linked and tracked over the project life cycle.*
- Use of tools and processes to ensure that the linkages and their impacts are captured and updated in all major project documents.
- This practice enables informed decision making for the future.

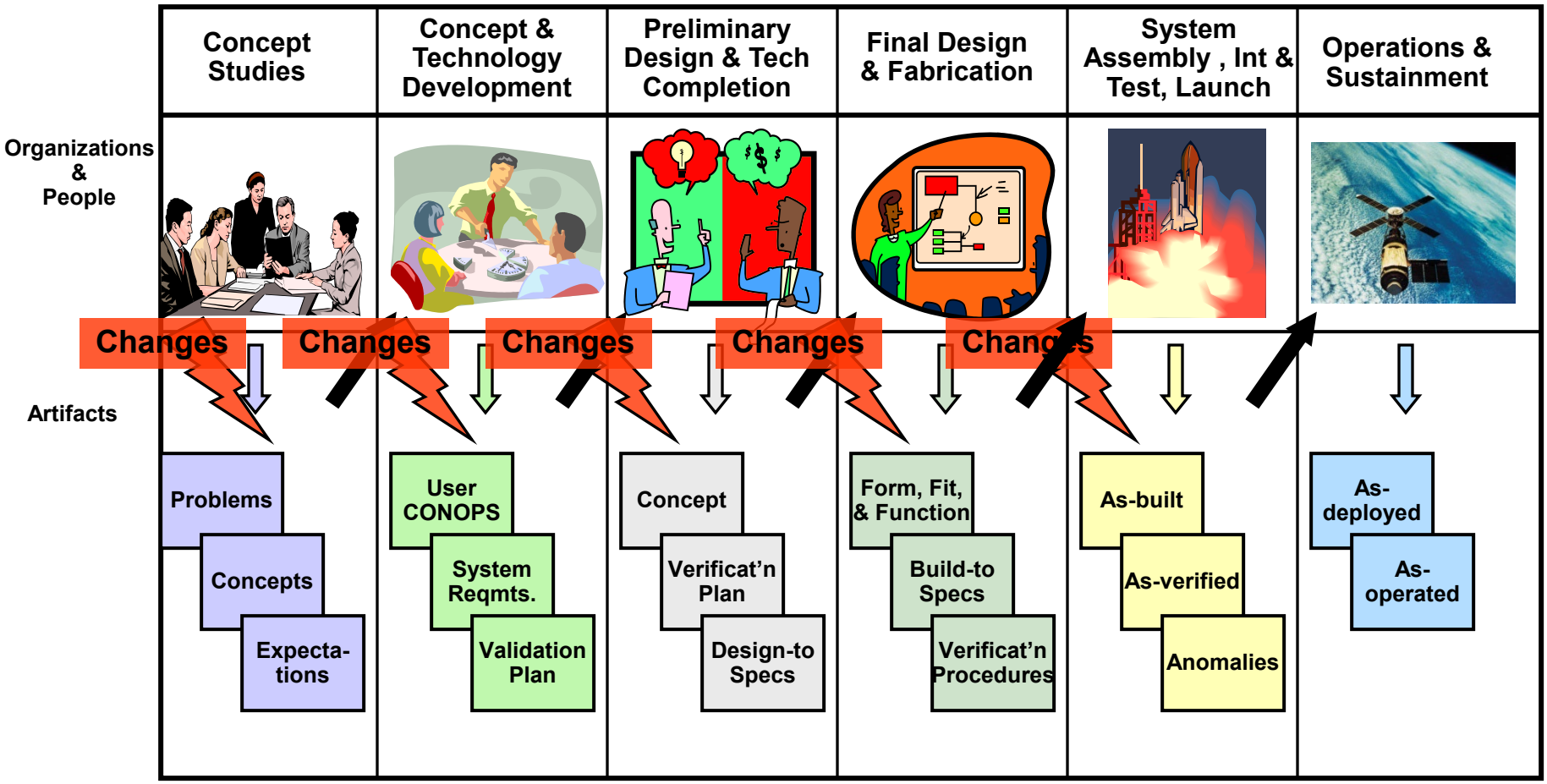
Integrated Program Management

Managing Requirements and the System Configuration is a Necessity

- Capturing all the requirements and their traceability can be a *mess*!
  - Parent requirements beget child requirements
  - Problem-space requirements beget solution-space requirements
  - Functional and performance requirements have lots and lots of peers
  - Traceability, linkages and rationale must be documented and maintained
  - So baselined requirements are required for each control gate

- Management of it all.
  - Configuration management keeps track of all of the requirements, and once hardware is built or software coded, keeps track of what has been built and coded.
  - This is a huge, complex and extremely important bookkeeping job – made easier today by database tools (e.g.,CRADLE or DOORS).

Change - The One Constant



Where Do Changes Come From?

- Requirements change when:
  - They are reallocated as the system design matures, since initial allocations are typically suboptimal.
  - New requirements are added to the system, since initial requirements may not have been complete.
  - A stakeholder decides that new functions or performance is needed.
  - Measured performance does not meet requirements. Reallocation or redesign are possible responses to non-compliance in test.

- Configurations change when:
  - What is built is not identical to what is designed. Configuration descriptions strive to be the most accurate possible description of the current system.
  - Something breaks in test. Reallocation or redesign are possible responses to test failures.

Pause and Learn Opportunity

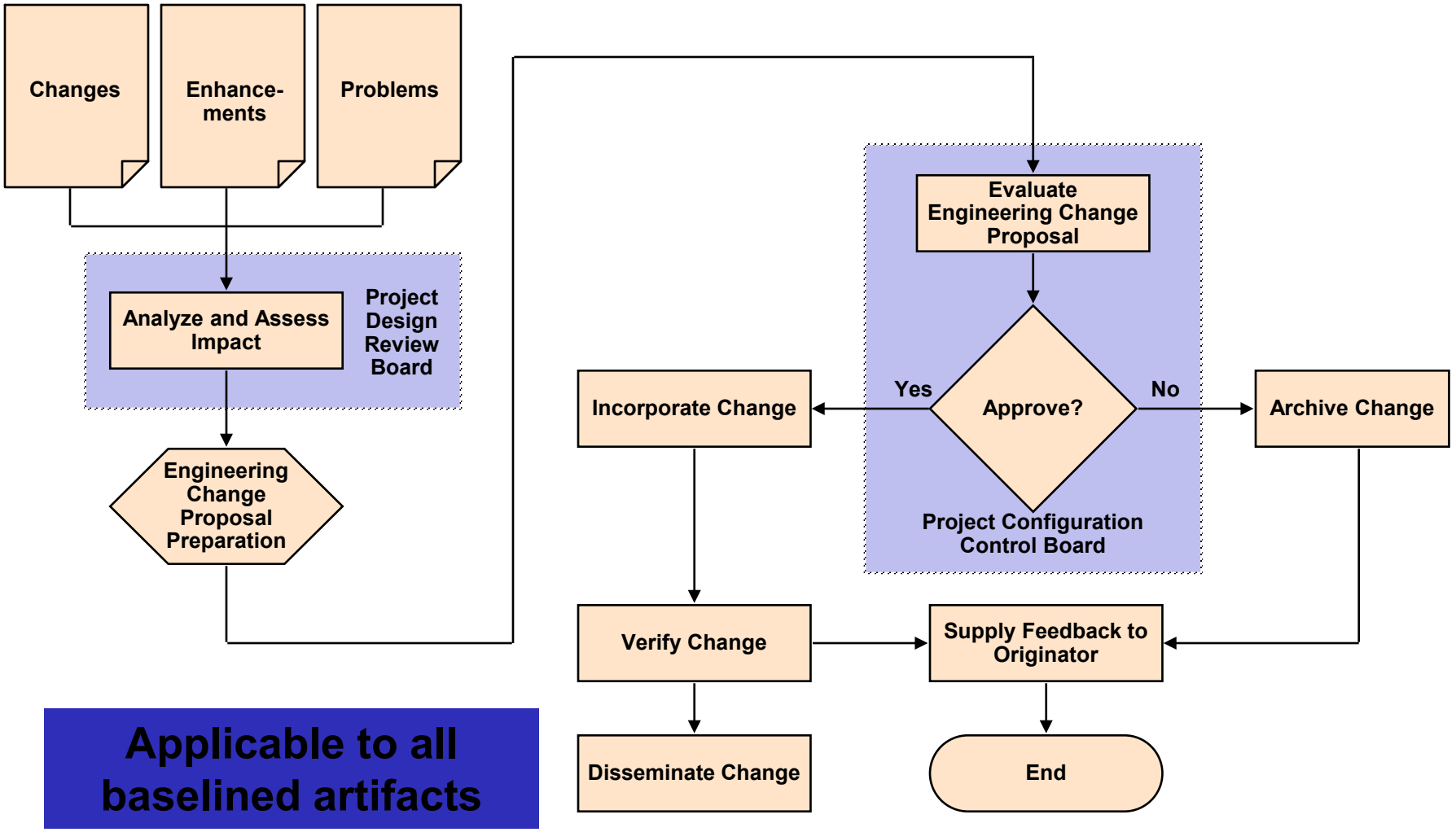
The Cosmic Background Explorer (COBE) satellite was slated to launch on the Space Shuttle in 1989, but the loss of the *Challenger* on January 28, 1986 changed everything. The COBE team was forced back to the drawing board: it had to find a new way to get COBE into orbit.

Using the COBE case study (COBE_case study.pdf) discuss the impact to a system design based on a single baseline change — a new launch vehicle.

Requirements Change Control

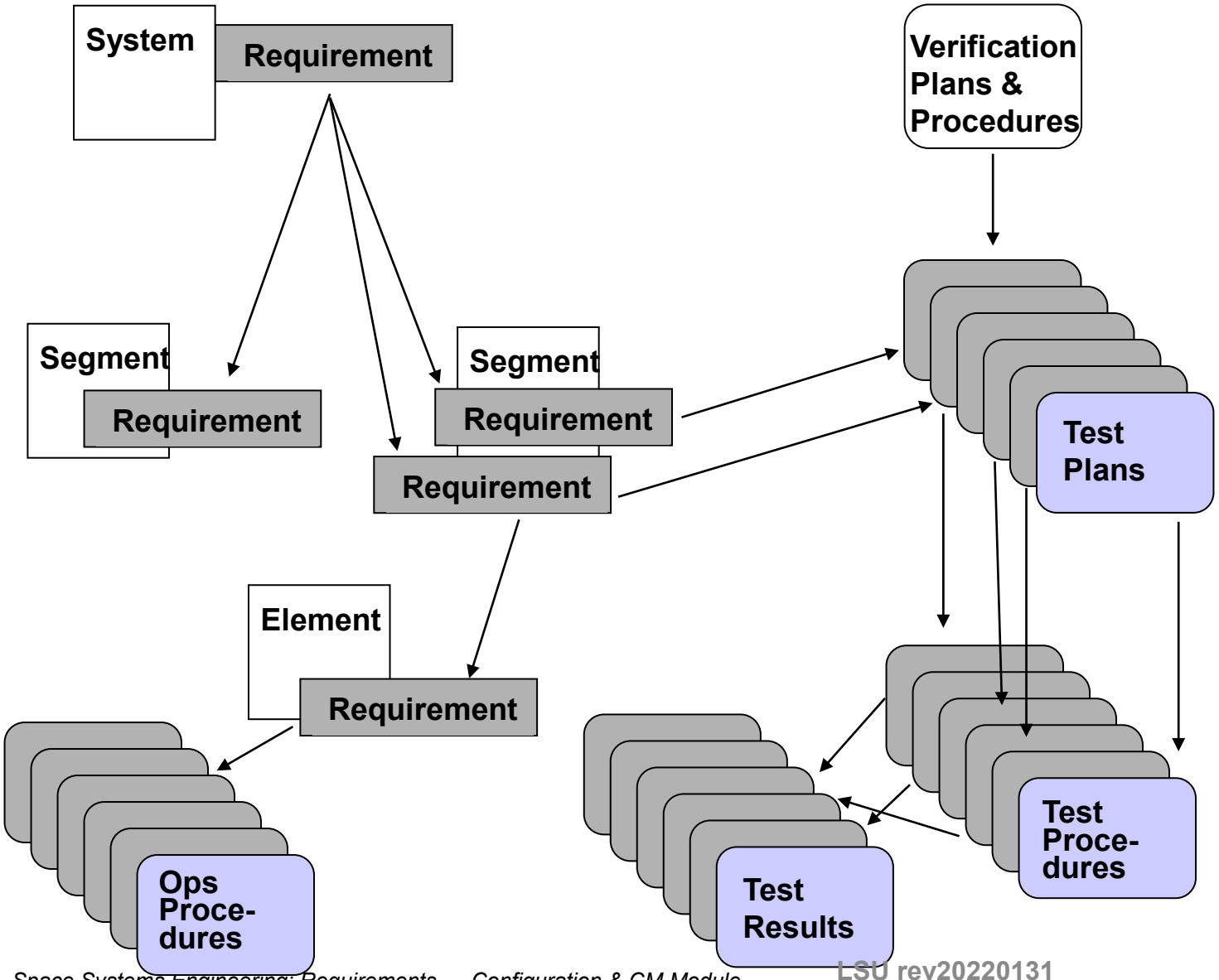
- Capturing the complete set of requirements and assessing the impacts of considered changes are systems engineering responsibilities.
- Top level requirements are captured first, then lower levels as the system design matures.
  - *Top level requirements are typically placed under change control just after the System Requirements Review (SRR).*
  - *Lower level requirements are placed under change control after the corresponding subsystem Preliminary Design Review (PDR).*
- Engineering Change Requests (ECRs) are the means for making changes to requirements, with assessment and review.
- Change Control Boards (CCBs) are established to review and assess the impacts of ECRs.

Typical Requirement and Configuration Control Flowchart



Applicable to all baselined artifacts

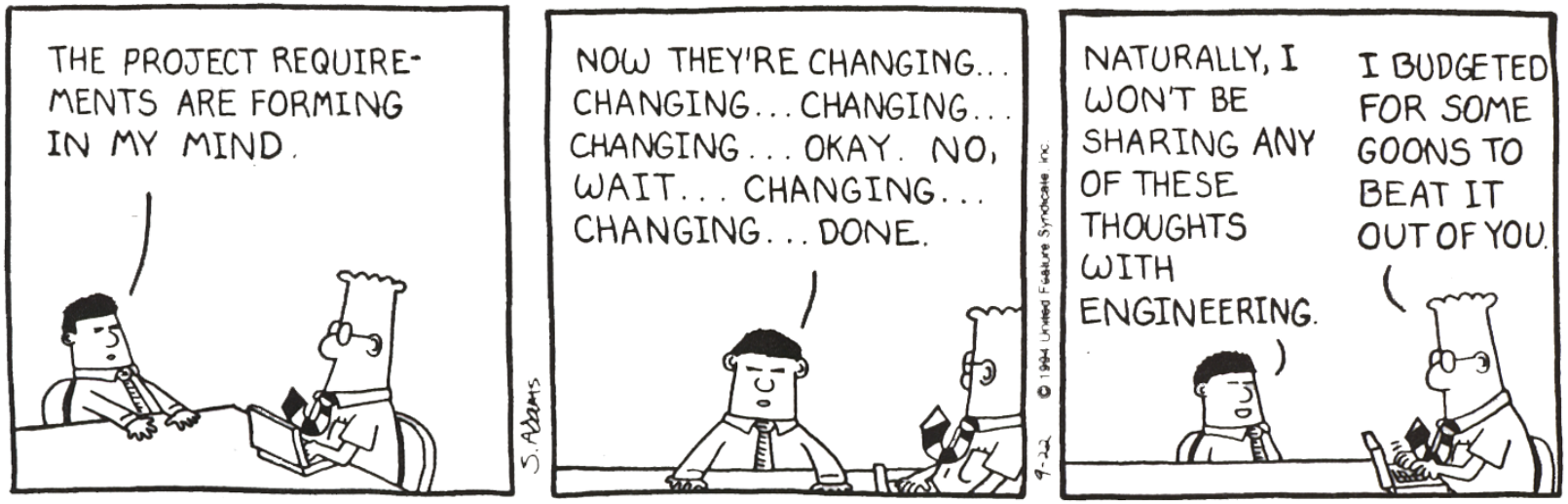
The Later a Change is Proposed the More Costly it is to Implement



- For every hour spent in writing requirements - hundreds of hours will be spent in reading requirements - plus
  - Endless meetings
  - Countless debates
  - Continual rewrites
  - Continual rework

=> $$$$$$

Mission Analysis, Like We Usually Have to Do It



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By Scott Adams

Module Summary: Configuration and Change Management

- System baselines capture the complete, current system description.
- System baselines are updated periodically at five major milestone reviews - SDR, PDR, CDR, FRR and ORR.
- Requirements and configuration changes are inevitable, so a formal process of considering the implications of these changes is used.
- It is important to have managed baselines, requirements and configurations so that the entire team is working with the same assumptions of what the current system is and what it must do.
- Systems engineering is responsible for creating and updating the system baseline, assessing the implications of considered changes and disseminating the news of any accepted changes.

Backup Slides
for Requirements — Configuration &CM Module

Pause and Learn Opportunity

Discuss James Webb Space Telescope (JWST) Requirements Examples using the following document:

JWST Mission Requirements Document (.pdf)

Section 4.1 Descriptions of types of verification

Section 4.2 Verification Matrix

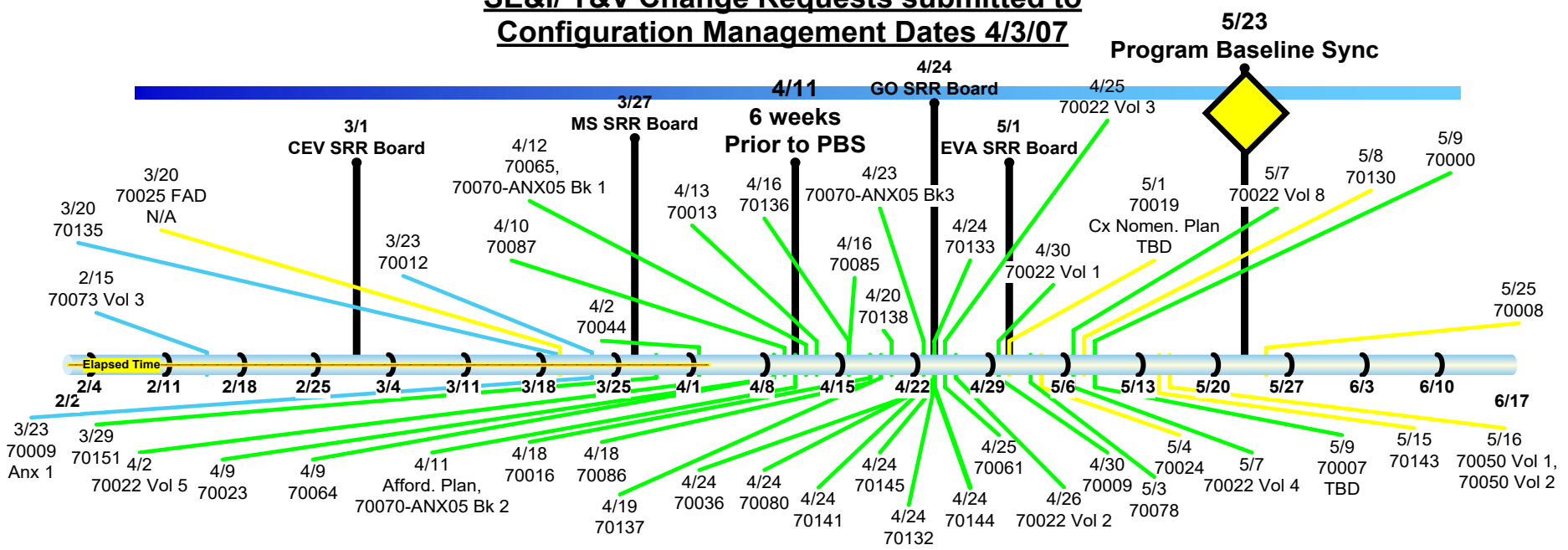
See Notes to this slide for more detail.

Change Control Boards Ensure Coordination of Changes

- Level -1 CCB controls the following:
  - Interface
  - Level-1, 2, or 3 requirements
  - Master Schedule
  - Cost
  - Safety
  - Mission Risk
  - Interchangeability
- Level -2 CCB controls the following:
  - Changes not shown above
  - Outside controlled baseline
  - In-scope cost
  - Prior to formal release (freeze)
- Level -3 CCB controls the following:
  - Changes not shown above
  - Changes not affecting another design team
  - In-scope cost
  - Prototype drawings

- Level -1 CCB players:
  - Project manager
  - Project scientist
  - Project System Engineer
  - Mission Assurance Mgr
  - Config. Mgmnt. Engineer
- Level -2 CCB players:
  - Design teams and their associated
    - Project SE
    - Mission Assurance Mgr
    - Config. Mgmnt. Engineer
- Level -3 CCB players:
  - Cognizant engineers
  - Config. Mgmnt. Engineer

SE&I/ T&V Change Requests submitted to Configuration Management Dates 4/3/07



CxP Doc #	Title	Submit CR to CM	Comments	Org	Doc Owner	Change Flag
70000	Constellation Architecure Requirements Document, Revision A	5/9/2007	Per update from PRIMO 2/26/07	PRIMO	C. Adamek	
70007	DRM & Operations Concept Document	5/9/2007	**Submit date reflected in the IMS inputs for 3/30.**	PRIMO	B. Teague	
70008	Master Integration & Verification Plan	5/25/2007	Date changed in 3/8 verison of IMS - changed color to yellow	T&V	R. Cox	
70009	System Integrated Analysis Plan	4/30/2007	Added. Per IMS Update of 3/14/07	ATA	A. Zuniga	
70009 Anx 1	System Integrated Analysis Plan, Annex 1 for IDAC-3	3/23/2007	**Submit date reflected in the IMS inputs for 3/30.**	ATA	A. Zuniga	
70012	Constellation Reference Architecture Document for IDAC3	3/23/2007	**Updated per e-mail on 3/27. Expected to be reflected in the IMS inputs for 4/6.**	ATA	D. McKissock	
70013	Systems Engineering Management Plan	4/13/2007	Confirmed by James A. on 2/26 and Dave C. on 3/8.	COS-T	J. Afarin	
70016	Requirements Engineering Management Plan	4/18/2007	Updated per IMS updates for 3/23	PRIMO	M. DiGiuseppe	
70022 Vol 1	C3I Interoperability Standards Book	4/30/2007	Updated per IMS updates for 3/23	CSI	K. Muery	
70022 Vol 2	CSI Spectrum and Channel Plan	4/26/2007	Updated with CSI input rec'd 3/19	CSI	C. Sham	
70022 Vol 3	CSI Master Link Book	4/25/2007	Updated with CSI input rec'd 3/19	CSI	J. Brase	
70022 Vol 4	CSI Information Representation Spec	5/7/2007	Updated per IMS updates for 3/23	CSI	J. Differding	
70022 Vol 5	CSI Data Exchange Protocol Specification	4/2/2007	Updated with CSI input rec'd 3/19	CSI	M. Stagnaro	
70022 Vol 8	Common Command & Control Requirements	5/7/2007	Updated with CSI input rec'd 3/19	CSI	M. Severence	
70023	Constellation Program Design Specification for Natural Environments (DSNE)	4/9/2007	Updated per 3/19 IMS inputs	E&C	K. Hwang	
70024	Constellation Human Systems Integration Requirements	5/4/2007	IMS input on 3/9 shows CR drop 5/4 (but this is prior to all updates in). Will confirm before updating here.	HFSIG	K. Ess	
70025	Functional Analysis Document	N/A	FAD through RWG only, no board baseline required. B/L date in schedule of 6/27 is currently out of sync with PBS need dates	PRIMO	J. Williams-Byrd	
70036	Constellation Program Environmental Qualifications and Acceptance Testing Requirements (CEQATR).	4/24/2007	Update from Ed Strong, 2/21	T&V	E. Strong	
70044	Constellation Program Natural Environment Definition for Design (NEDD)	4/2/2007	Updated per 3/19 IMS inputs which confirmed date	E&C	L. Smith	
70050 Vol 1	Electrical Power System Specification, Volume 1: Electrical Power Quality Performance for 28 VDC	5/16/2007	Schedule update received 3/9. Doc will be submitted but not baselined in time for PBS	Power	R. Scheidegger	
70050 Vol 2	Electrical Power System Specification, Volume 2: User Electrical Power Quality Performance for 28 VDC	5/16/2007	Schedule update received 3/9. Doc will be submitted but not baselined in time for PBS	Power	R. Scheidegger	
70061	C3I Strategic Plan	4/25/2007	Updated per e-mail on 3/27. This will need to be updated in the IMS inputs for 3/30. (was 3/30)	CSI	P. Paulsen	
70064	Supportability Plan	4/9/2007	**Updated per IMS inputs from 3/30 (was 3/23/07)**	SOA	K. Watson	Slipped

Blue text indicates changes from last update

On plan and will be baselined prior to PBS
Plan confirmed but cannot be baselined prior to PBS (CR submitted within 2 weeks of PBS) or requires IMS update.
No plan confirmed
Submitted to CM

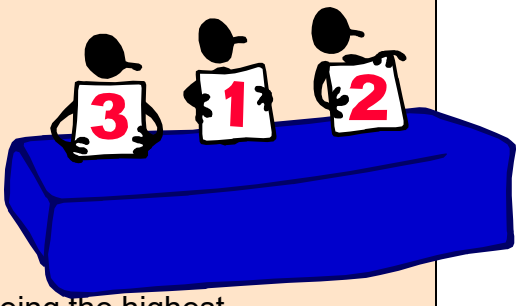
Prioritization

- List items that are mandatory.
- Group them as “musts.”
- All other items are “wants” that can be prioritized.
- Important “wants” are given a high weighted value.
- When candidate concepts are evaluated, if they do not satisfy all the “musts,” they are eliminated.

Be careful about overstating the “musts.” Otherwise, promising candidates may be prematurely eliminated.

Prioritizing Wants

- Several methods:
  - High, Medium, Low
    - Select highs and lows and all else falls into medium
  - One, Two, Three
    - Same as high, medium, and low
  - Relative to a base of ten
    - Relative importance assigned a number against a scale (0-10), with ten being the highest.
  - Pair-wise comparison
    - Each “want” is compared to each other and a decision is made as to which one is more important. When all comparisons have been made a priority stacking results.
  - Categorize “satisfaction” and “dissatisfaction”
    - “How pleased will you be when this capability is provided?”
    - “How upset will you be if we cannot provide this capability?”



Get the users involved to establish and baseline the priorities.