34th Annual INCOSE international symposium

hybrid event

Dublin, Ireland
July 2 - 6, 2024

Projects Doomed to Fail Before they start! (Before Notice to Proceed)

Early Lifecycle Activities Missing ⚠

Dale Brown (Hatch) & Jonn Sprakes (Stantec)

Part 1

Jonn Sprakes (Stantec)

Analyzing the Problem

Documented Results: Suboptimal Application of SE to Surface Transportation

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Part 2

Dale Brown (Hatch)

Solutions: TWG Collaborative Activity with APTA

APTA MEMBER
American Public Transportation Association

INCOSE TRANSPORTATION

APTA Systems Lifecycle Engineering (SLE) Subcommittee

Spend the first 15% wisely...

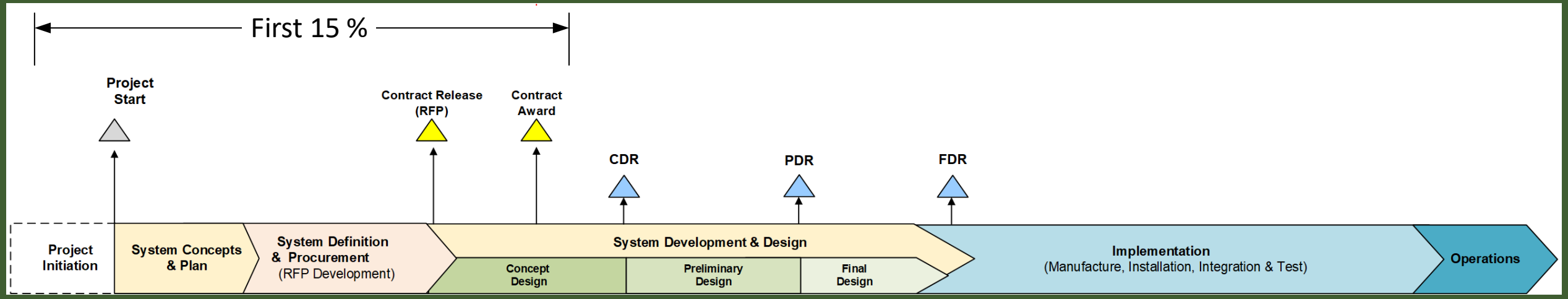
Main Take-Away from today!

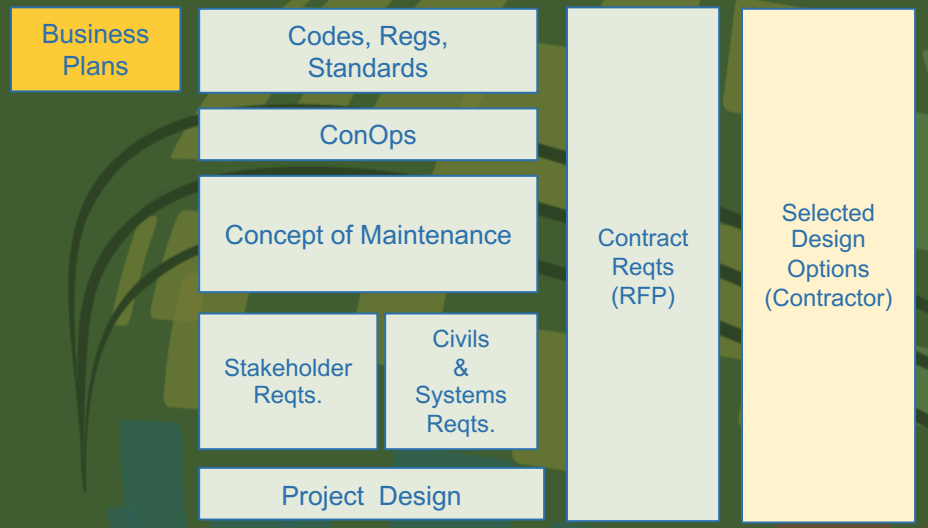
The journey begins…

Deployment of Systems Engineering in the real world…

Part 1: Analyzing the Problem

What is the first 15%?

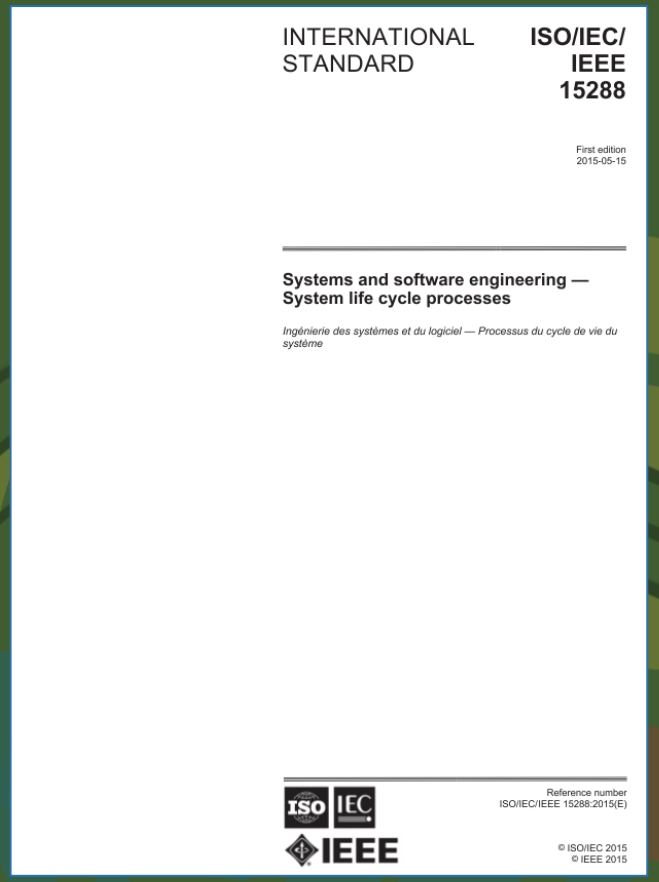




Improve SE methods use <u>early</u> in the project lifecycle in several key areas:

- Business & Capital Planning
- ConOps and Stakeholder Needs & Requirements
- Project Definition & Management
- Contract Development
- Supplier Evaluation & Award
- Project Infrastructure Preparation

Projects are specifying "conformance to SE Standards"…


INTERNATIONAL STANDARD

ISO/IEC/ IEEE 15288

First edition
2015-05-15

Systems and software engineering — System life cycle processes

Ingénierie des systèmes et du logiciel — Processus du cycle de vie du système

ISO IEC IEEE

Reference number
ISO/IEC/IEEE 15288:2015(E)

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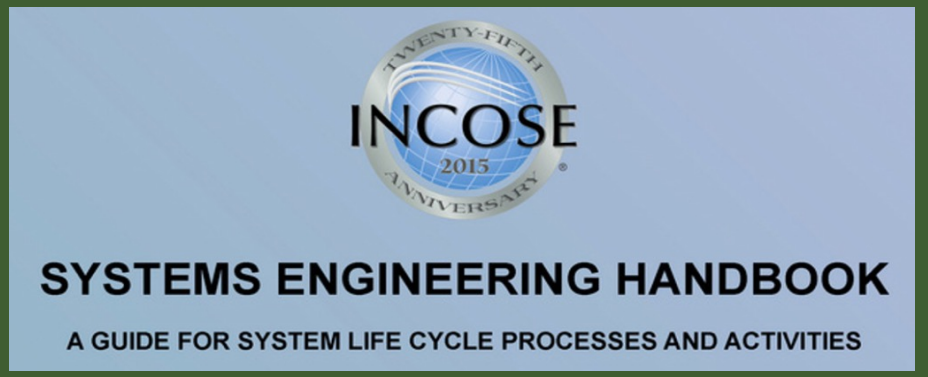


ISO/IEC/IEEE 15288:2015

AGREEMENT PROCESS CLASS (2)

- Acquisition
- Supply

ORGANIZATIONAL PROJECT ENABLING PROCESS CLASS (6)

- Project Portfolio Management
- Infrastructure Management
- Lifecycle Model Management
- Human Resource Management
- Quality Management
- Knowledge Management

TECHNICAL MANAGEMENT PROCESS CLASS (8)

- Project Planning
- Project Assessment & Control
- Decision Management
- Risk Management
- Configuration Management
- Information Management
- Quality Assurance
- Measurement

Foundational / Cross-Cutting

30 Lifecycle Processes

TECHNICAL PROCESS CLASS (14)

- Business/ Mission Analysis
- Stakeholder Needs & Requirements Definition
- System Requirements Definition
- Architectural Definition
- Design Definition
- Systems Analysis
- Implementation
- Integration
- Verification
- Transition
- Validation
- Operation
- Maintenance
- Disposal

Technical

…. but the results are not encouraging

Project	Contract Specification		Status	Causes
	ISO15288	CENELEC		
Project A (P3 LRT Ontario)	✓	✓	• Objectives & Goals not met (in service issues) • Schedule Delays (late into service) • Cost Overrun ($210m over)	• Requirements not fully met or not complete • Lack of V&V • SI Issues • Safety Case (Ops restrictions)
Project B (P3 LRT Ontario)	✓	✓	• Current Projections: • 7 months late • Could be as much as $330M over budget	• Scope gaps • Requirements issues • SE Planning issues
Project C (P3 LRT Ontario)	✓	✓	• Scheduled systems design milestones delayed	• Requirement issues • Interface identification and management issues
Project D P3 (BC)	✓	✓	• Scheduled systems design milestones delayed	• Requirements issues • Safety Analysis Issues • Late Design
Project E (P3 Alberta)	✓	✓	• Objectives & Goals not met (SI issues) • Schedule Delays (late) • Cost Overrun • Contract Litigation	• Scope gaps • Interface issues • Requirement compliance issues

Challenges to SE Adoption

Knowledge Gap:

- SE not seen as core competency - unlike Project Management
- Project Managers come from non-SE oriented backgrounds = not aware of SE

Strategy Issues:

- SE is often not considered in the early Project Development & Delivery Strategies.
- SE considered a “low level” discipline and only applied if required by Contracts

Practice Issues:

- Little or no budget for SE in early project phases
- Inexperienced or junior engineers assigned SE roles

Key Issue:

The phrase SE is **ambiguous** in the transit infrastructure domain. The junior ‘Systems Engineers’ assigned roles are actually understood as Subsystem Engineers! (HVAC, Signaling, Comms, etc.)

Early Lifecycle Activities

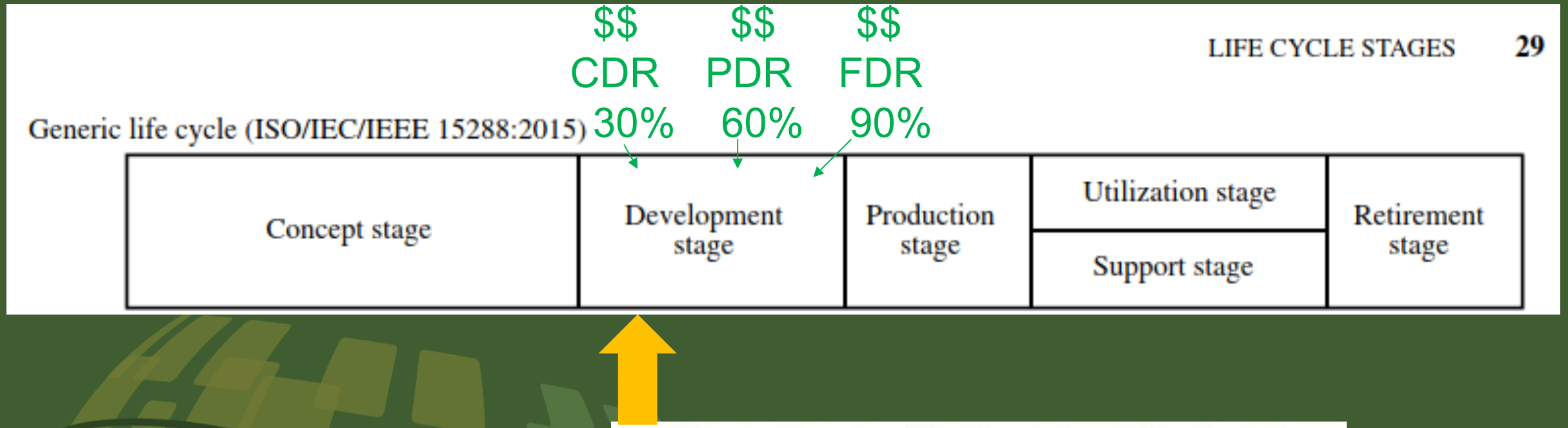
TABLE 3.1 Generic life cycle stages, their purposes, and decision gate options

Life cycle stages	Purpose	Decision gates
Concept	Define problem space 1. Exploratory research 2. Concept selection Characterize solution space Identify stakeholders' needs Explore ideas and technologies Refine stakeholders' needs Explore feasible concepts Propose viable solutions	Decision options • Proceed with next stage • Proceed and respond to action items • Continue this stage • Return to preceding stage • Put a hold on project activity • Terminate project
Development	Define/refine system requirements Create solution description—architecture and design Implement initial system Integrate, verify, and validate system	
Production	Produce systems Inspect and verify	
Utilization	Operate system to satisfy users' needs	
Support	Provide sustained system capability	
Retirement	Store, archive, or dispose of the system	

Early Activities represent a majority of the overall project activities!

…but they are pre-design & low $$, so less interesting to designers and the PMO.

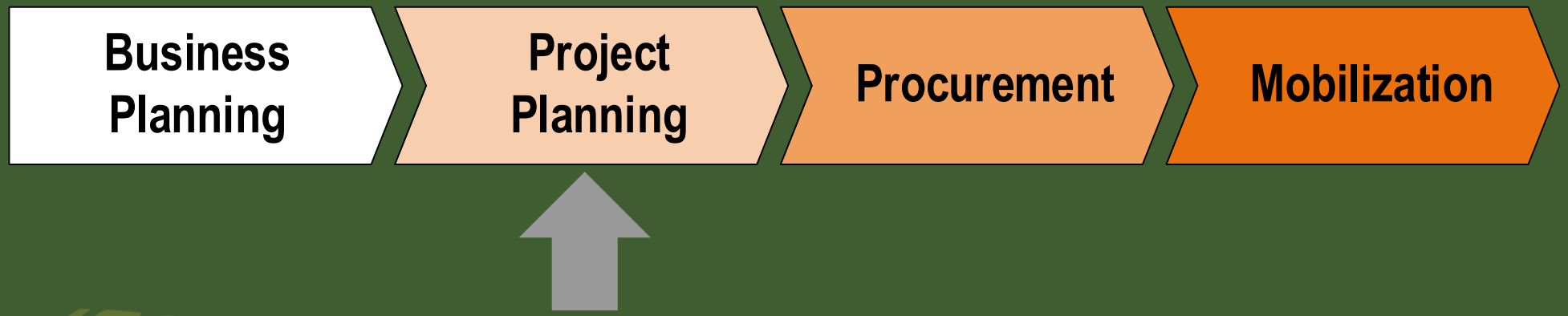
Payment Milestones Apply Significant Pressure



INCOSE SE Handbook Excerpt Section 3.3.1

Many projects are driven by eager project champions who want "to get on with it." They succumb to the temptation to cut short the concept stage, and they use exaggerated projections to support starting development without adequate understanding of the challenges involved, as comically illustrated in Figure 3.4. Many commissions reviewing failed systems after the fact have identified insufficient or superficial study in the concept stage as a root cause of failure.

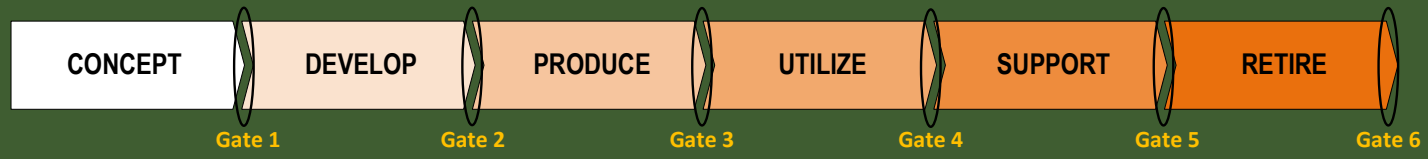
Project Planning Phase is Very Low Quality



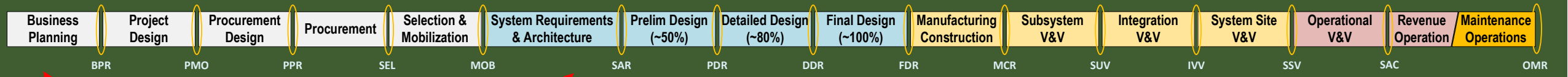
What are the current observations & trends?

- Minimal Stakeholder Engagement
  (leading to missing ConOps / Ops Scenarios)
- Project goals & objectives are not fully defined
  (leading to Technical RFP requirements issues)
- Short Timescales to frame out projects for contract
  (level of effort & budgets are highly constraining)
- Project Class (e.g.,Design-Build) mismatch with methodology definition
  (i.e., missing systems requirements)

Lifecycle Observations: Early Activity



GENERIC SYSTEM LIFECYCLE – ISO/IEC TR24748-1



Typical Rail and Transit Project Lifecycle

Siloed & Low Budget, Minimal or zero effort

Many Infrastructure Projects effectively start here!

Typical Rail and Transit Project Startup Characteristics:

- Project Teams are mobilized on the basis of: "*same as last project - so not a big deal – minimal effort*"
- Dozens of process planning documents are usually due at NTP + 30, 60 ...poor ROI on this shelfware
- System Requirements & Architecture are not adequately budgeted and soon get left behind…
- RM tool, CM tool, Document Control all “assumed” to be operational a few days after NTP – not seen yet!

Posit: Projects are doomed to failure …years before NTP!

Lifecycle Observations: Gate Requirements

Scenario Observed:

1. At NTP+30 or 60, large suite of plans arrive for review.
2. In parallel, design deliverables are being created and arriving, so main motivation is to show progress and get paid for design work products.
3. Gate Process is not fully reviewed, understood or agreed prior to NTP (always lagging because of process structural error in 1 above).
4. QA (if present and functioning independently) is not empowered to enforce the lagging gate process.
5. …so keep moving ahead – 'flood the zone' with design deliverables.
6. Inevitably, events overcome 'gate waivers' and the project steamrolls ahead (because payments are always looming)

Execution of these projects is assumed to be '*carved in stone – always done it this way*'
…we struggle to overcome such inertia!

Concept Segment
Identify & Engage Stakeholders
Confirm Problem Space and Constraints
Confirm Mission-Goals-Objectives
Elicit Stakeholder Needs
Explore Solution Space and Concepts
Develop ConOps
Develop System Validation Cases
Alternatives Analysis, QFD, Trade-offs
Refine and validate Stakeholder Requirements
Lifecycle Cost Analysis
Develop Program or Project Plan
Valid Project Charter
Organization Design
Procurement Plan
Trade-off Plan
Knowledge Management
Quality Management
Initial Risks agreed
Tool configuration and Validation
Process and Tool Training
Design of Procurement
Supplier Evaluation
Bid Evaluation
Processes Agreed and Verified/Validated
Process Tools Configured and Verified/Validated
Training Developed and Verified/Validated
Develop Initial System Requirements

Current Observations/Issues/Experiences today?

Project Issues related to the first 15% of a Project Lifecycle:

Some issues currently being experienced by Transit projects underway NOW:

- **Non - Acceptance of SE Plans and Requirements**
  - (Plans only accepted after 2 years by Client)
- **RFP Contract underwent major revisions in Concept Design due to missed scope**
  - Very Large Change Orders in first 6 months
- **Project acceptance delayed** - compliance evidence missing and/or not captured for requirements in concept design phase such as:
  - Safety Assurance / Safety Case rejected
  - Technical compliance not adequately demonstrated
  - System Assurance arguments not defined

Rail and Transit Project Failure Summary Points

Consistent theme: Poor/Missing Requirements = Failure

Decades of Real Project evidence is available on a global scale

Hidden project costs appear years later = Accountability Fade

Frequent sub-optimal short-term Schedule & Budget-based decisions

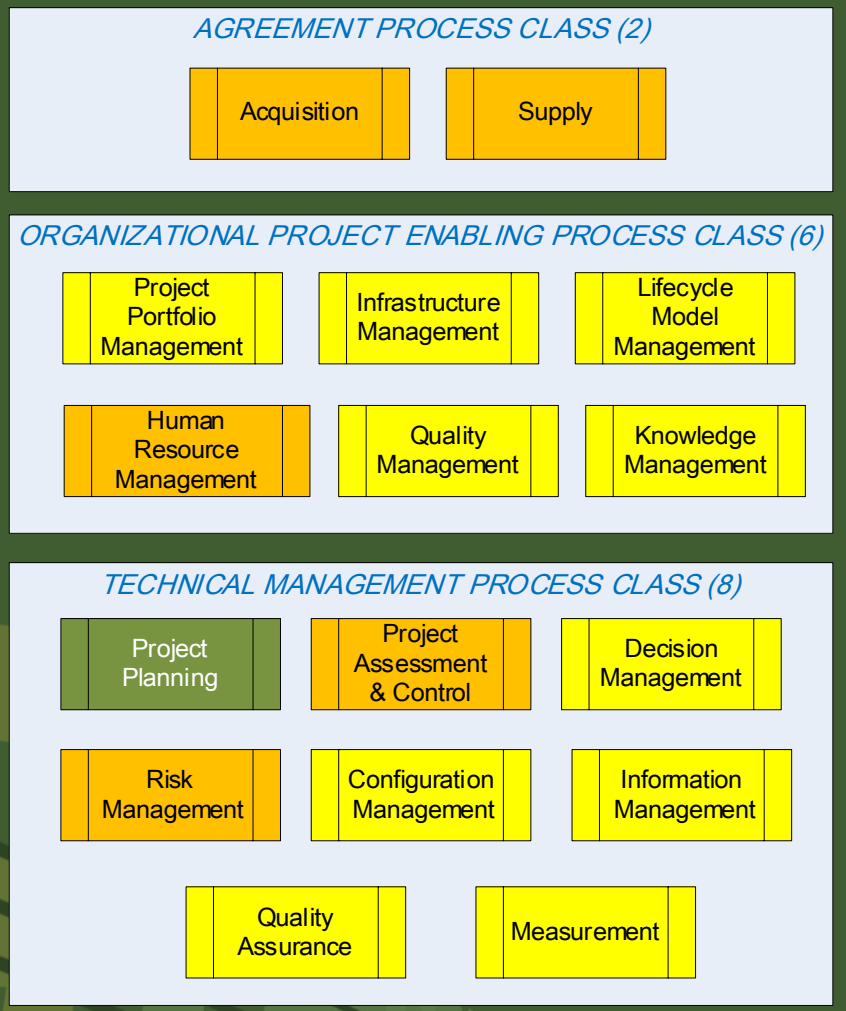
ROOT CAUSE: the short timeline for typical project reward structures.

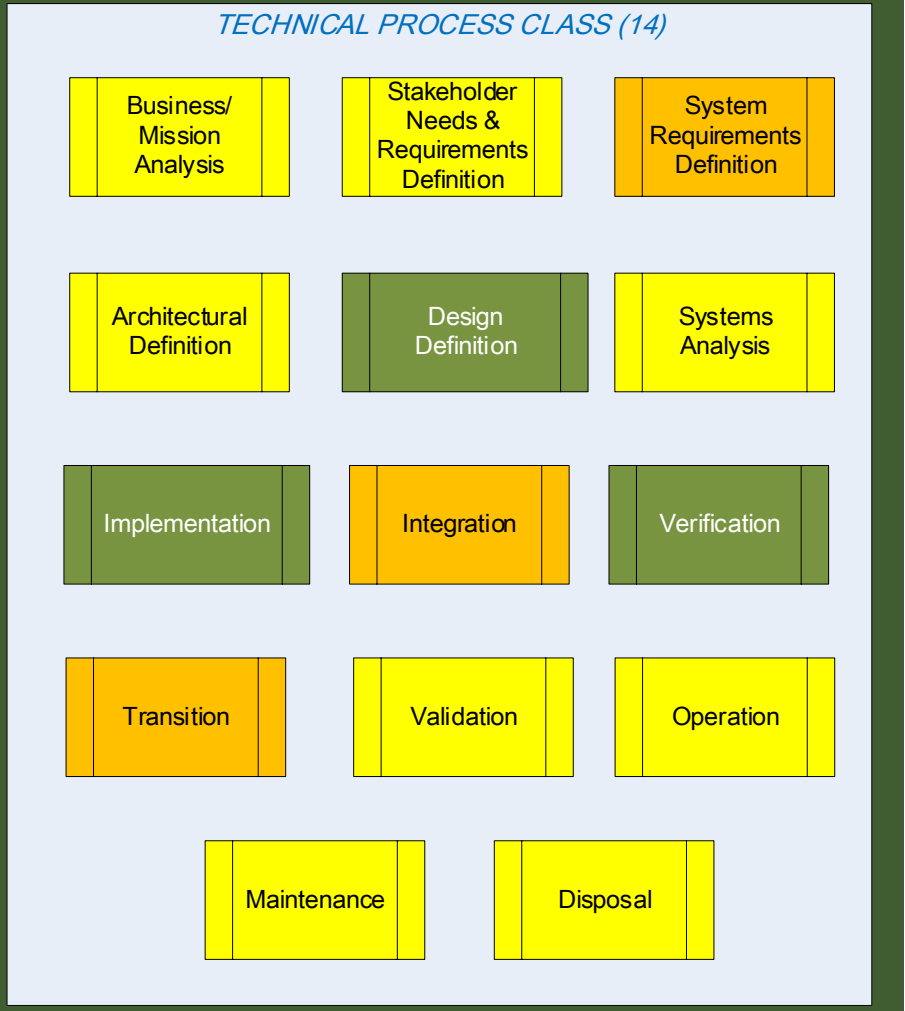
Projects last years/decades, many staff rotate out after a few years…

ISO/IEC/IEEE 15288:2015 Lifecycle Processes

Process Plans missing, ignored, late or very poor quality

Result: Technical Processes are not well executed





Foundational / Cross-Cutting

Technical

Often Lower PRIORITIES

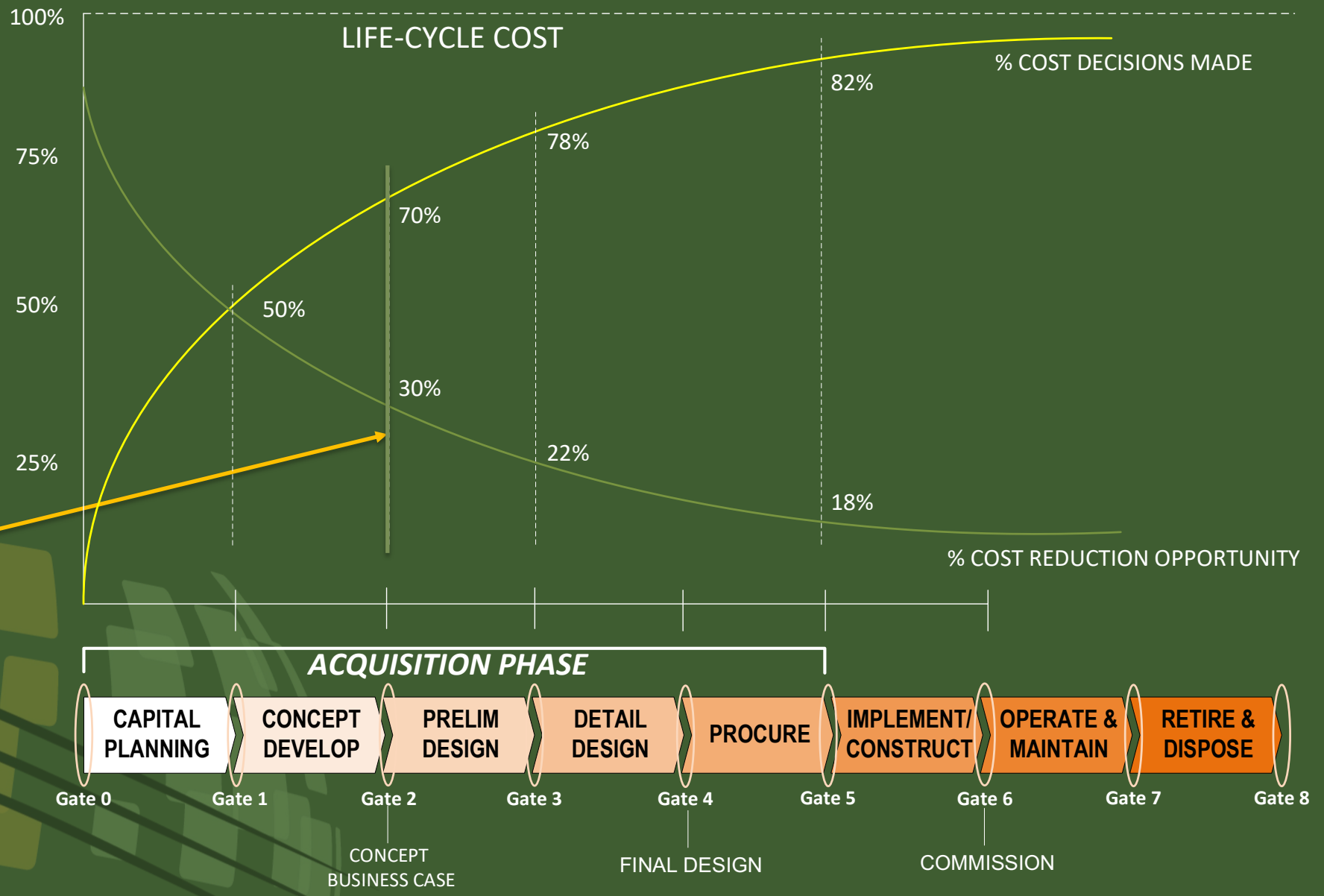
Poorly Implemented

Often Major FOCUS

Initial 8-15% of accrued cost…

determine 70% of the actual Lifecycle Cost of an asset

If 70% of LCC is locked in here, it is reckless to scrimp on the 1st 15%.



Initial 8-15% of accrued costs determine 70% of the actual lifecycle costs of an asset

(DAU – 1993)
INCOSE SE Handbook v4 2015

Fiducial Evidence for our theme: Industry SE Study (ROI)

Level of Project SE Effort	Cost Overrun (%)
0%	53%
7% (average)	15%
12% - 14%	**2%**
20%	10%

Source: Honour; “systems engineering return on investment” (2013)

Key Takeaways from Study:

12% - 14% SE Effort has the best impact on reducing overruns as this enables:

- More effort generating Mission, Goals, Objectives, User Needs and Design Input Requirements and measures for success.
- More effort for System Analysis and System Architecture Trade-offs against known success factors including cost, schedule and technical.
- Higher level of SE effort (> 14%) leads to increased cost over runs due to unnecessary analysis.

Summary: What we can do better

…with the first 15%

1. **Framework**
   - SE embedded in PM framework (APTA SLE Standard)
   - SE techniques and tools used in the business planning cycle

2. **Quality**
   - Much higher quality Contract Requirements (ISO29148, RWG NRM)
   - Gates Process needs to be respected & enforced
     [including early lifecycle (Pre-Contract) gates]

3. **Communication**
   - Awareness Campaigns (INCOSE, SE Branding for Infrastructure)
   - Active listening (really understanding and engaging our stakeholders)

We will address these issues in the next section!

Spend the first 15% wisely…

Main Take-Away from today!

Part 2: Solution Space !

The journey continues…

Solution Space – TWG & APTA addressing the defined problem

American Public Transportation Association
Systems Lifecycle Engineering Subcommittee

Part 2: Solution Approaches

TWG Approach = Outreach and Education

American Public Transportation Association
Systems Lifecycle Engineering Subcommittee

- Providing Training to APTA Members
- Promoting awareness of and prep for ASEP or CSEP
- Collaborating on APTA process standards

Project Management Institute

Extracting Shared knowledge and training for improved project design and stakeholder engagement

Smart Cities Initiative

Collaboration on presentations and technical products

Infrastructure Working Group

MoU with American Public Transportation Assoc.

- INCOSE brings SE global practitioner expertise
- APTA brings legislative advocacy capabilities
- APTA represents <u>all</u> agency stakeholders (i.e., procurement, legal, operations & maintenance)

Areas of Strong Professional Collaboration

Initial practical collaboration: New APTA Systems Lifecycle Engineering (SLE) Standard

Terminology – Critical for Communication

The word “System” is problematic in the Transportation and Infrastructure industry.

Most practitioners use it colloquially as the contraction of “Sub-System”

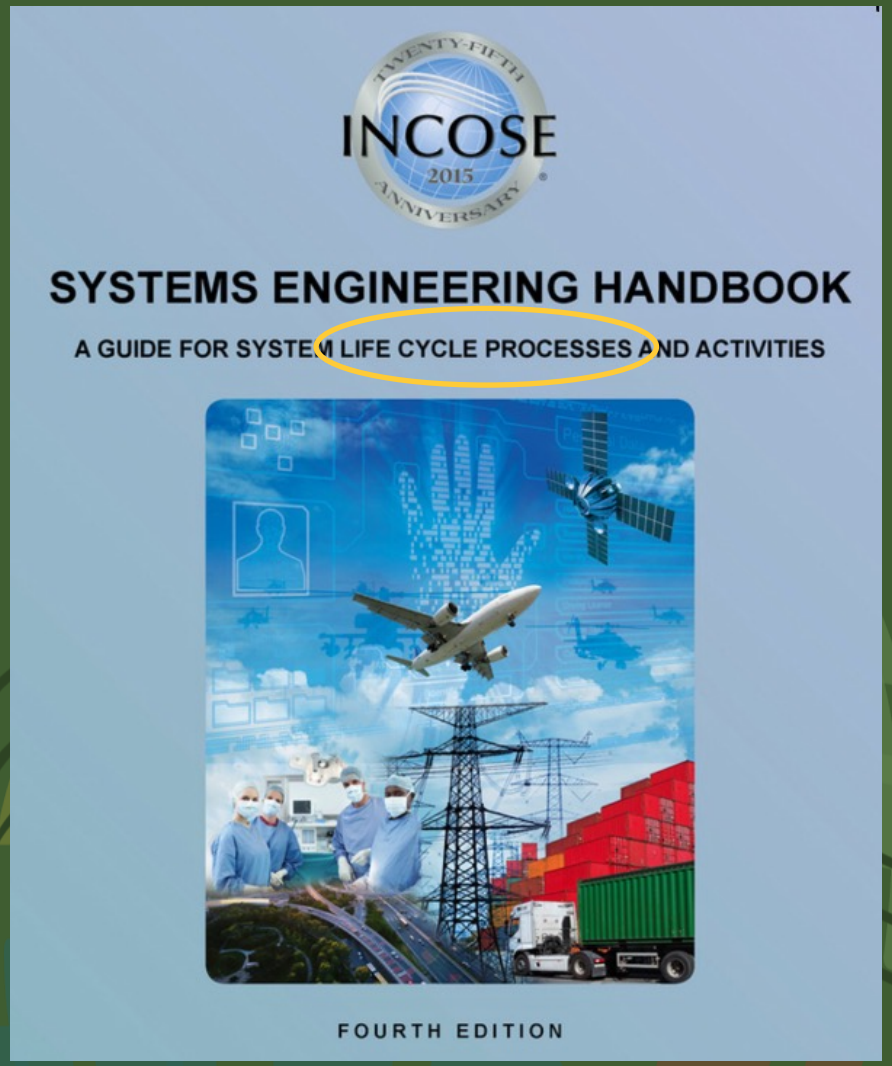
…meaning HVAC, Electrical, IT, Comms, Train Control, Signaling ,etc.

Commonly used…but ambiguous

“Systems Lifecycle Engineering” now in common use by APTA

…leading to more productive communications

‘Lifecycle Processes’ is a featured phrase…



INTERNATIONAL STANDARD

ISO/IEC/ IEEE 15288

First edition
2015-05-15

Systems and software engineering — System life cycle processes

Ingénierie des systèmes et du logiciel — Processus du cycle de vie du système

ISO/IEC/ IEEE 29148

First edition
2011-12-01

Systems and software engineering — Life cycle processes — Requirements engineering

Ingénierie des systèmes et du logiciel — Processus du cycle de vie — Ingénierie des exigences

Procurement Silver Bullet…

- ✓ISO15288 84 pages
- ✓ FHWA ITS Handbook 300+ Pages
- ✓ INCOSE 4.0 Handbook 400+ Pages

None of these guidance documents are well served by a poorly formed statement such as;
"The supplier shall comply with ISO15288"
…yet this does happen frequently & increased during the last decade of RFPs.

Rhetorical: *How is a civil contractor or civil engineering firm expected to wade through and comply with the imposition of all this unfamiliar process material?*

Answer: They don't!

"…we have been building roads, tunnels, bridges and other infrastructure for thousands of years…we don't need this extra bureaucracy" (a real quote)

Magic Bullet (SLE Processes) activity then degrades to;

- Sub-out SLE - quickly becomes a "tick-box exercise" to close the project, or
- ignore SLE contract process requirement and steam-role over by design, or
- negotiate most of SLE budget away during BAFO, or
- a combination of the above.

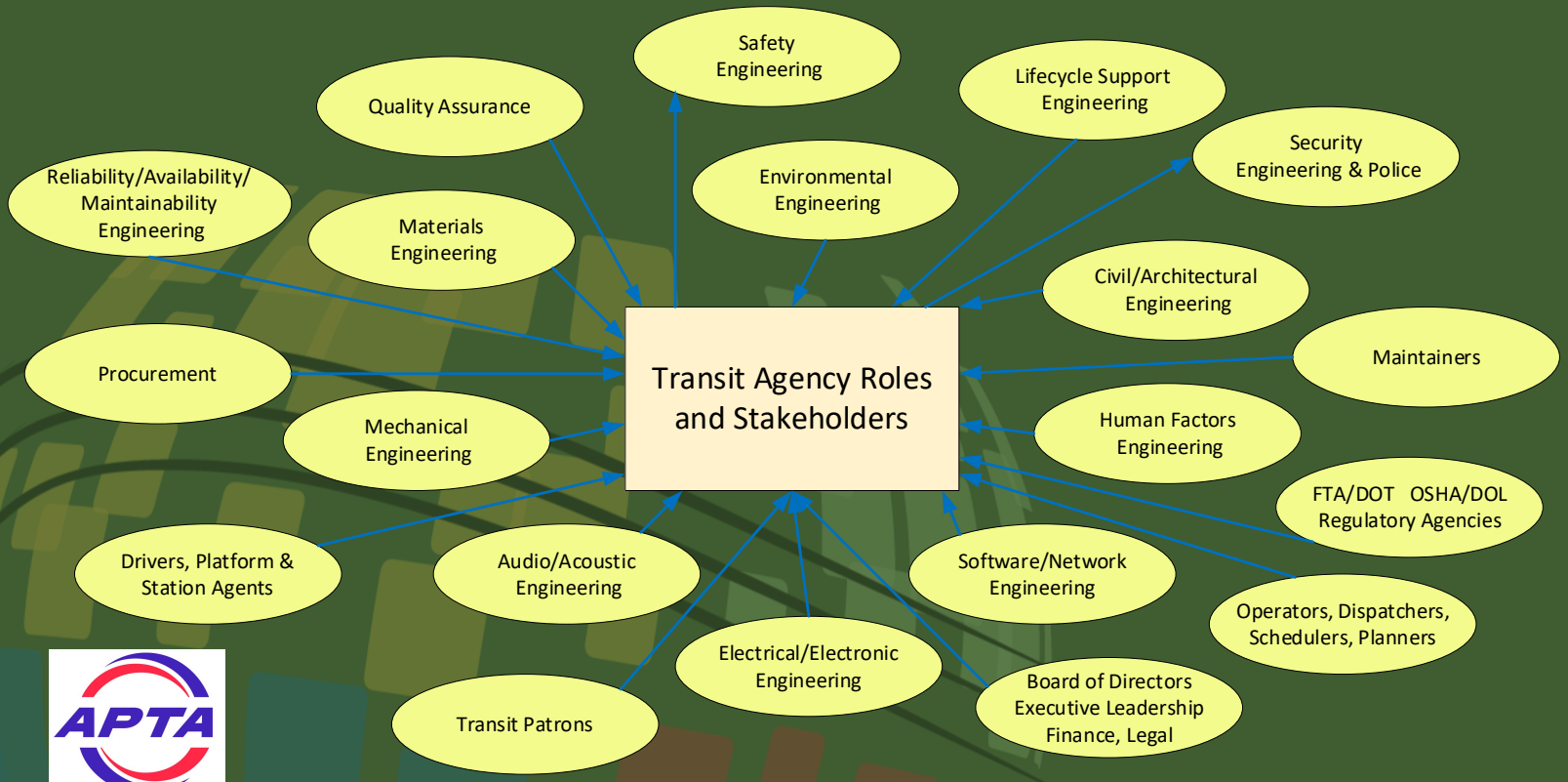
Transit Agencies are asking for more practical guidance from the TWG and INCOSE

- ✓Providing formal SLE Training to APTA Members
- ✓Promoting awareness of INCOSE Certification
- ✓Aiding them in preparation for ASEP or CSEP
- ✓Helping them advocate to C-Suite and external
- ✓Collaborating on APTA process standards

Engage with Stakeholders across full Lifecycle

Human Lifecycle
(Cradle – Grave)

All entities follow a lifecycle.



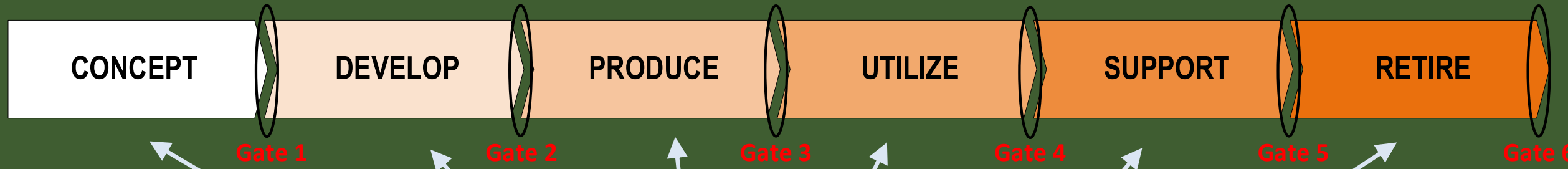
Breadth (Time) →
Consideration of cost, functionality, value and performance over the entire lifecycle of an asset (or project) is a key driver of APTA SLE activity.

Depth (Knowledge)
↓ Inclusion of the correct stakeholders at each point in the lifecycle is also a key driver of APTA SLE activity.

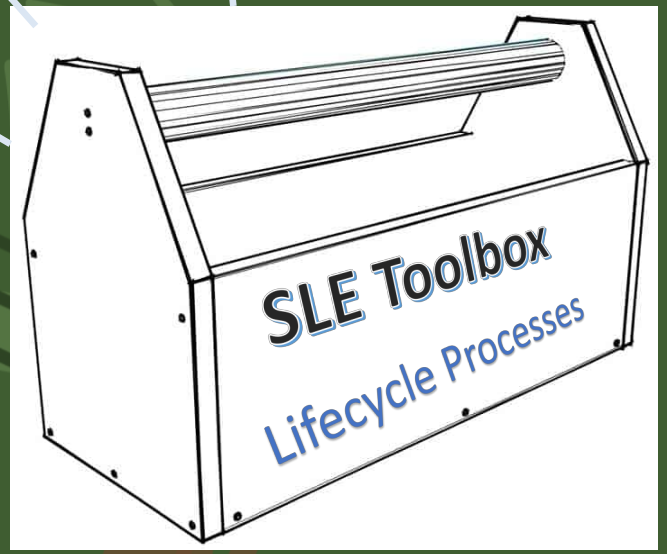
APTA SLE Subcommittee

Systems LIFECYCLE Engineering (SLE)

GENERIC SYSTEM LIFECYCLE – ISO/IEC TR24748-1



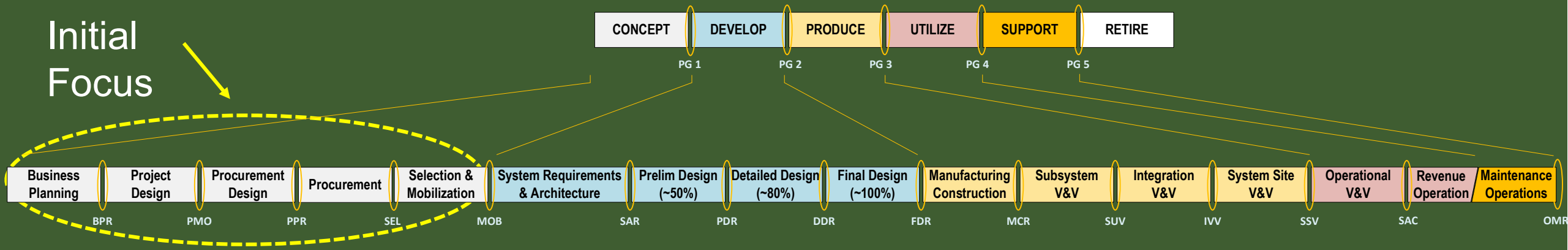
Competently deploy the processes across the entire lifecycle – especially at the beginning! (1st 15%)



APTA
SLE Subcommittee

APTA SLE Standard - Proposed Lifecycle

Initial Focus



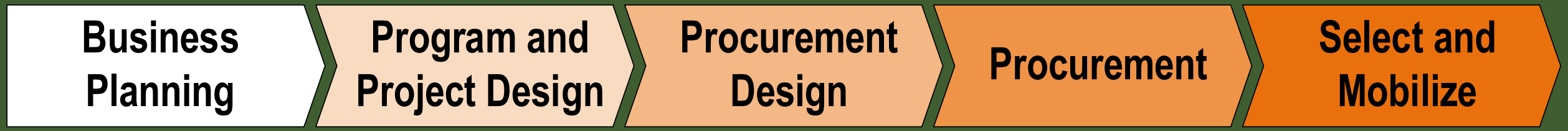
Using the ISO TR24748 six segment lifecycle model as a baseline and the typical tasks & work product expected with each segment, the SLE subcommittee developed a **prototype APTA Lifecycle** to provide a **framework** for the APTA SLE standard.

Each of the sixteen lifecycle segments will have an accompanying set of requirements and a deliverables list (being developed) that can be used by any project. Tailoring, with justification, will be allowed by the standard.

This prototype lifecycle model will serve as a framework for discussion and focus on the early lifecycle activities that are key to successful transportation aquisition.

DB

APTA SLE Standard - Early Lifecycle Focus



Initial Sections of planned APTA Systems Lifecycle Engineering (SLE) Standard will focus on five early lifecycle phases:

- Business Planning (Work with APTA & Transit Agency CPM/CIP/EAM groups to review & approve)
- Project Design (Work with APTA & Transit Agency PMO to review & approve)
- Procurement Design (Work with APTA & Transit Agency Legal & Procurement to review & approve)
- Procurement (Work with APTA & Transit Agency ALL to review & approve)
- Select & Mobilize (Work with APTA & Transit Agency ALL to review & approve)

Work is proceeding well on these initial group of sections because of the urgent need in our industry!

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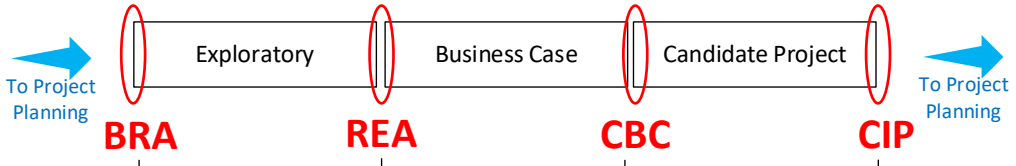
Early Lifecycle Attention – Business Planning

Business Planning Phase – 4 Stage Gates



BAINSTORMING

Brainstorming - CDRL	
Agency Goals	
Agency Gaps	
Risk Register Review	
Mega Trends (i.e., ITS, RSIA)	
S-W-O-T Contributions	
Candidate Ideas List	

REDUCTION Analysis

Exploratory Reduction - CDRL	
Stakeholders List	
Concept - Executive Summary	
Initial Timing Estimates	
Needs Statements	
Features and Benefits	
Initial Cost Analysis	
Impact List	
Update Risk Register	

CONCEPT BUSINESS CASE

- Create CRs for new/changed projects
- Update CIP
- Modify or delete existing projects

Concept Business Case - CDRL	
Stakeholder Engagement Plan	
Concept of Operations - 1st Draft	
Project Charter	
Project Plan - High Level Milestones	
Publicity Strategy - Marketing Plan	
Needs Alignment - Traceability Report	
Cost Analysis	
Impact and Risk Analysis	
Validation Plan Outline - Measures of Success	
Update Risk Register	

BoD Meeting
CIP Approval

From the start include ‘full-lifecycle stakeholder’ needs:

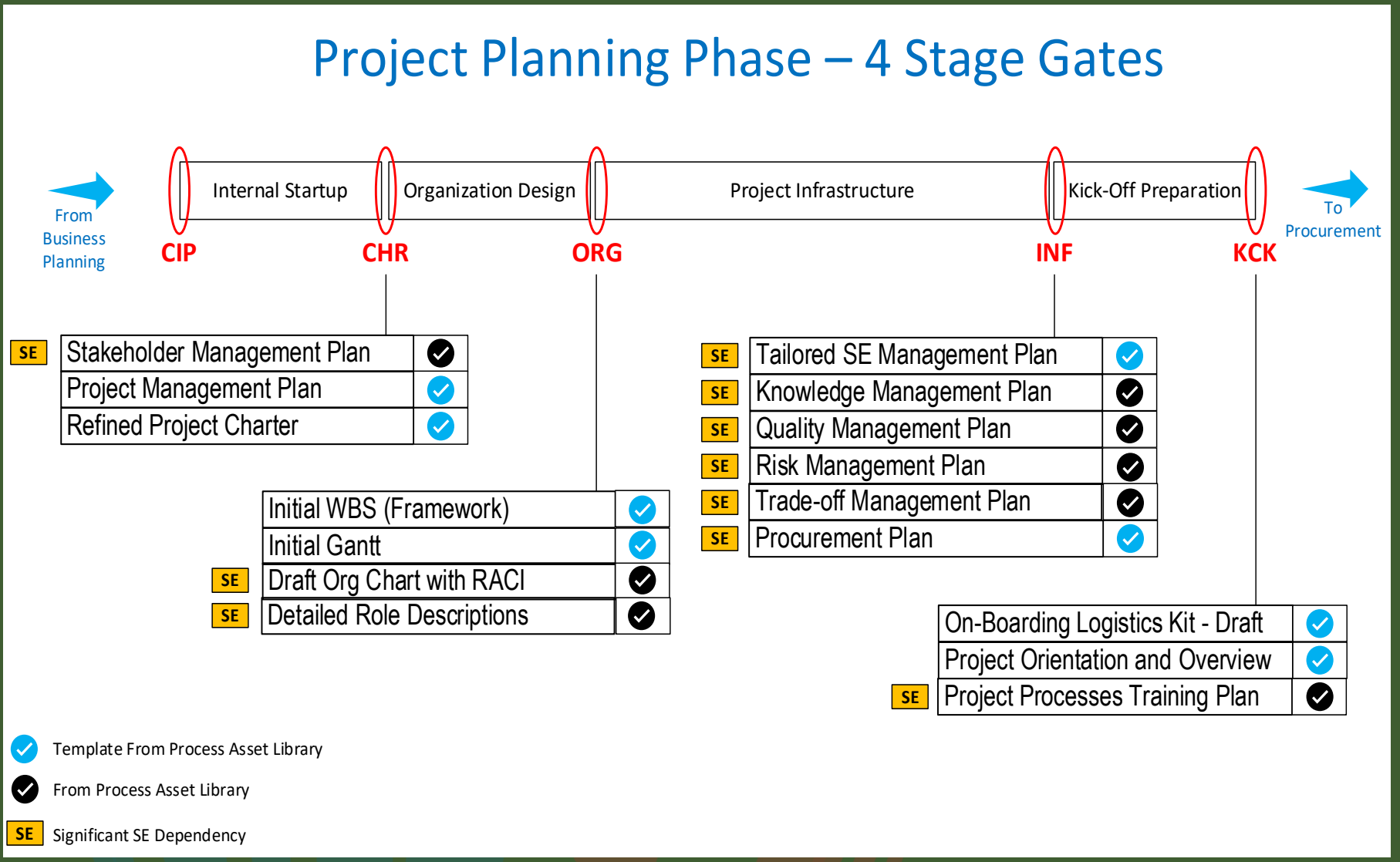
- Riders
- Taxpayers
- Operators
- Maintainers
- First Responders
- Disadvantaged
- Disabled

Informs

Project planning
Capital planning

DB

Early Lifecycle Attention – Project Design



Often "over the wall" to Legal & Procurement group:

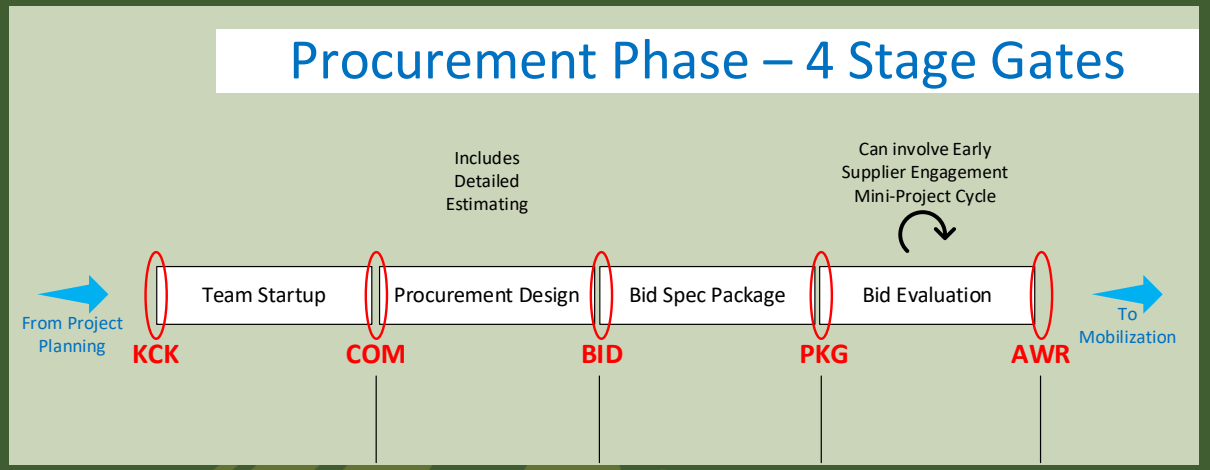
- Valid Project Charter
- Organization Design
- Procurement Plan
- Project Plan
- Trade-off Plan
- Quality Management
- Initial Risks agreed

Informs

Procurement Design

DB

Early Lifecycle Attention – Procurement Design



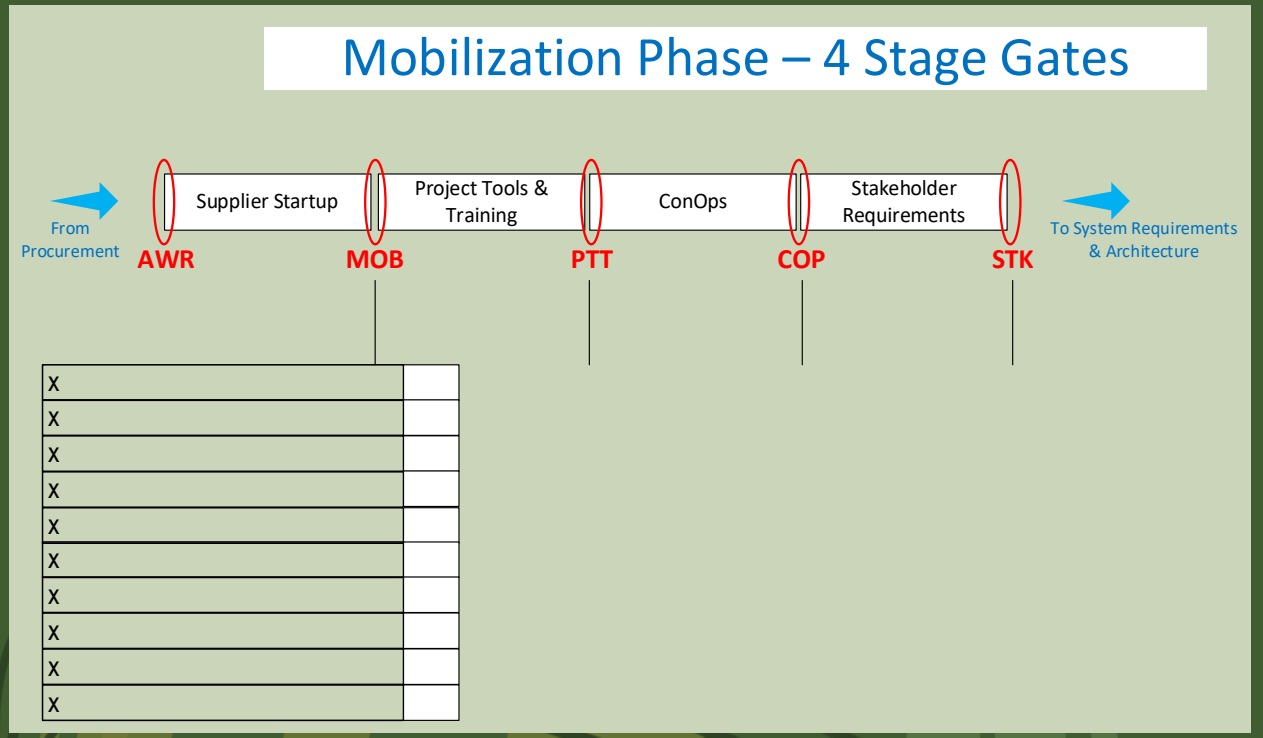
Need to change the approach away from a Purchase Order to a Designed Procurement:

- Early Supplier Engagement
- Active vs. Passive Supplier Audit
- Independent 3rd Party Auditors
- Suppliers bid on & use Agency Processes (stop wasteful NTP+30 syndrome)

- Better use of Pilot Projects – Run Design Competitions to better validate the proponent team
- System Requirements not optional - needed as RFQ input data for Design-Build contracts
- Improve analysis precision on RFP responses
- Design and validate the procurement – not just “over the wall and same as last time”
- Better quality (and fewer) Stakeholder and System Requirements
- Improve Stakeholder Engagement as procurement is being designed – use lean techniques

DB

Early Lifecycle Attention – Mobilization Phase



Ignored or started too late:

- Valid Processes drive Tool Design
- Tool Design and User Testing
- Training Packages Created
- Audit Supplier early - processes
- Validate the ConOps (stakeholder)
- Create Stakeholder Requirements
- Start project process training early!

Enables

Higher Quality Process Execution
Improved Team Performance

Spend the first 15% wisely…

Main Take-Away from today!

Wrap-up and Discussion

JS

Discussion: Major Obstacles facing you today?

Current TWG Observations and Issues

- ✓ Cost over runs (40% are over budget)
- ✓ Re-design due to requirement gaps
- ✓ Not enough evidence for Security case
- ✓ Not enough evidence for Safety case
- ✓ Technical issues identified late – interface, function, performance
- ✓ Far too many defects occurring at Test & Commissioning

What are the 3 biggest obstacles from audience (your) perspective?

Time?

Cost?

Culture?

What trends do you see? Let us know!

Thank You!

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hybrid event

Dublin, Ireland
July 2 - 6, 2024

www.incose.org/symp2023

Back Up slides

SE Value Proposition and Study Citations

JS

Some Evidence / Citations to back our claim:

Key Sources:

- INCOSE UK Z3 Guide
- Understanding the value of SE (Eric Honor)
- Understanding the benefits of SE (Elm, Goldenson)
- Airbus
- MIT

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