Applying Systems Engineering to ITS Projects: Advancing Beyond *"Federal Rule 940"*

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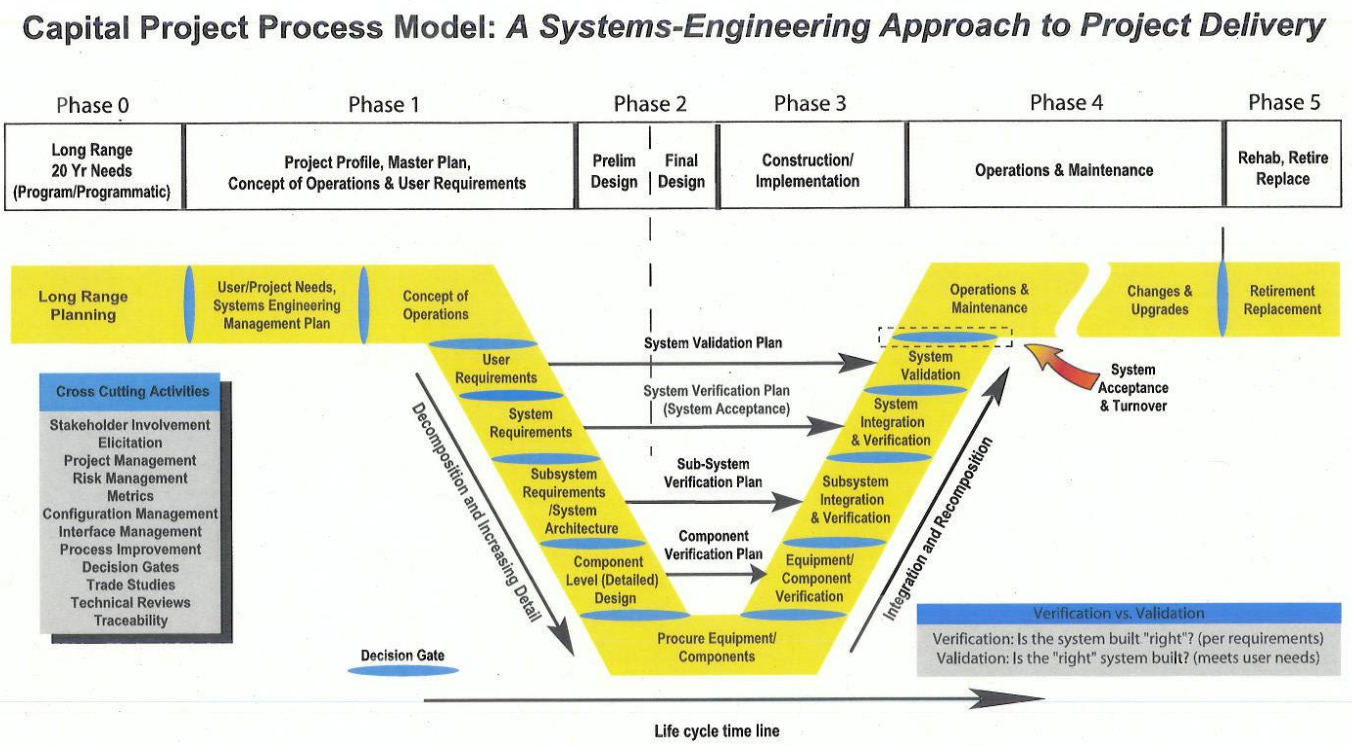
Outline

1) NYCT Systems Engineering (SE) Approach to Project Delivery
2) NYCT's Ongoing ITS Projects
3) Comparison of NYCT's & Federal Rule 940 Processes and Practices
4) SE at NYCT Benefits/Challenges

NYCT's SE Approach to Project Delivery



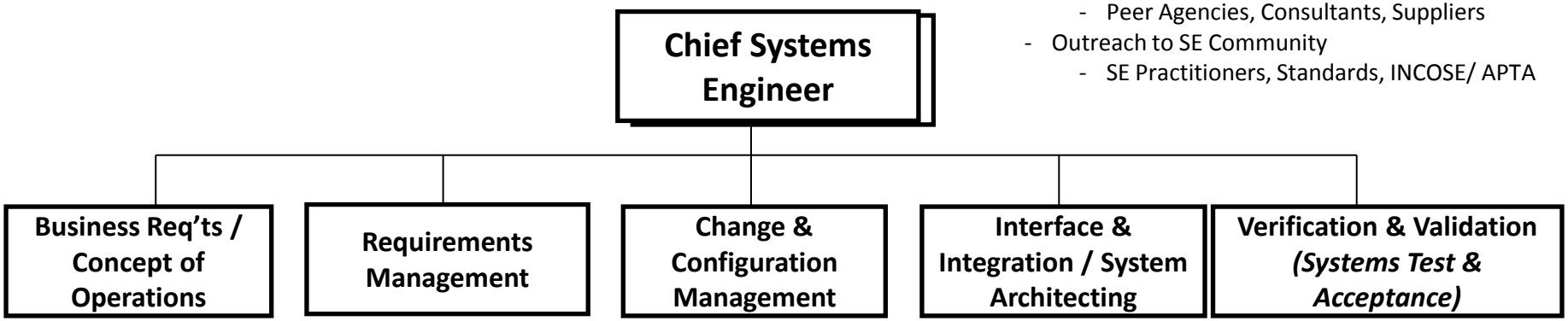
MTA New York City Transit
CPM Systems Engineering

Why is NYCT is adopting SE Practices?

- To reduce risk caused by project complexity
- multiple stakeholder groups (both Operating and Maintenance) with different needs and requirements
- extreme NYCT environment with systems in constant operation 24/7/365
- multiple installation locations
- integration challenges with ever increasing number of systems
- integrating new technologies with older systems
- limited time and funding for a Full Scale Development (FSD) effort to ensure concept/need can be properly implemented efficiently

Systems Engineering Division - Functional Organization Chart

Enterprise SE Activities
- SE Team development
- Tailored SE process implementation
- SE Outreach to Industry
  - Peer Agencies, Consultants, Suppliers
- Outreach to SE Community
  - SE Practitioners, Standards, INCOSE/ APTA



Stakeholder Management
- Identification
- Engagement
- Stakeholder buy-in

User Needs/Business Req'ts
Concept of Operations
Conceptual Alternatives
- Technology Evaluation

Verification/Validation Plans

Requirements Elicitation
Requirements Development
- Requirements Analysis & Tradeoffs
- Requirements Allocation

Requirements Management
- Traceability
- Establish Baseline Req'ts

Requirements Quality
Requirements Engineering Tools

Configuration Identification
Change Management
Status Accounting
Configuration Audits
Data/Information Management
Risk Identification
Risk Assessment/analysis
Risk Mitigation
Risk Tracking

Architecture Development
Architecture Alternatives
Integration planning & definition
Interface Identification
Interface Management
Input to V&V Plan
Reverse Engineering
Prototyping
COTS Product Evaluation

Identify & close systems test & acceptance gaps
Verification, Certification & Validation – end to end
Anomaly Tracking
Regression Testing
Perform Integration
Test Readiness
Deployment, Operations & Maintenance support
Software Code Reviews / vendor walk-thru

SE Training, Technical Standards, and Process – across all functional areas

SE Training
Performance Tracking / Metrics
SE Resources
Systems Integrator Qualifications

SE Tailoring
SE Process Development
SE Standards, PMP/PMG updates

Decision Gate process
Lessons Learned
Supplier (COTS/SW) maintenance support agreements

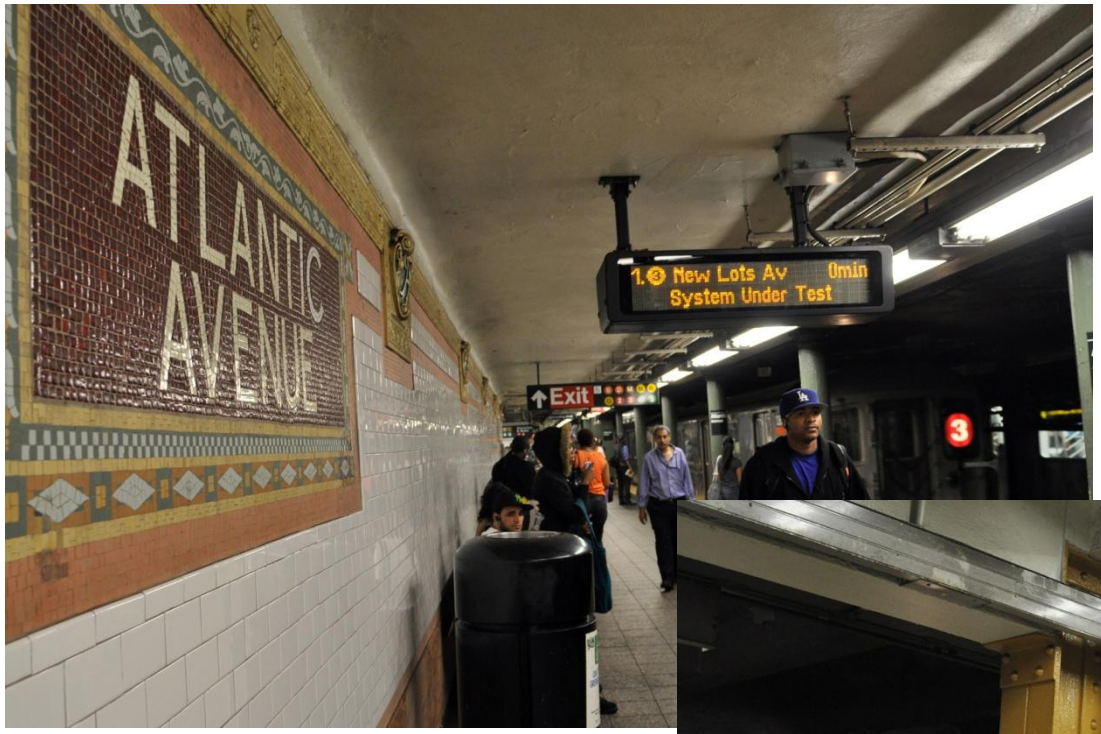
SE Technical & Project Processes for ITS Projects

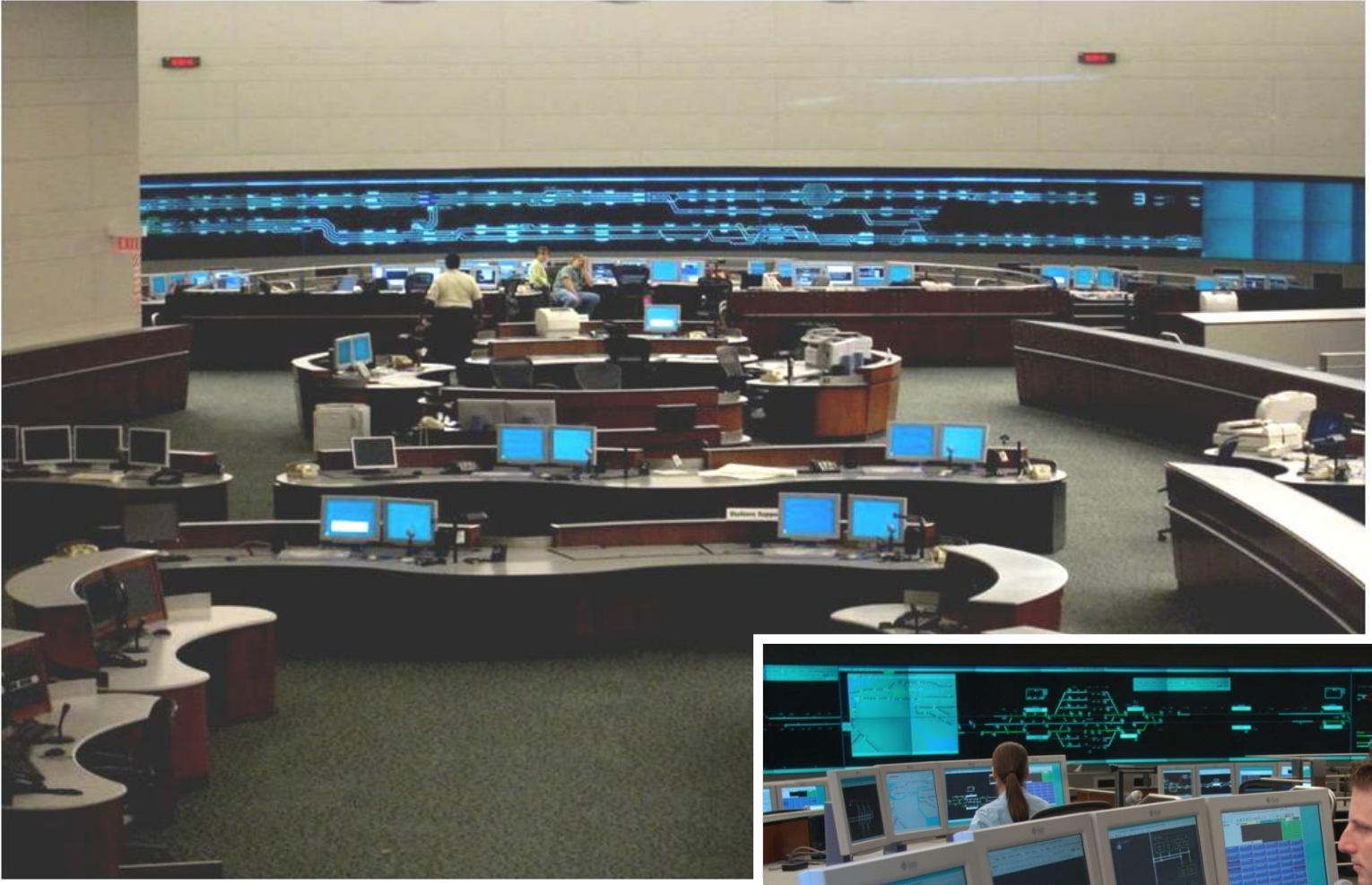
- Stakeholder Requirement Definition (including: stakeholder management, defining stakeholder needs & business requirements – ConOps)
- Alternative Analysis (Procurement & Deployment)
- Architectural Design
- Interface Management
- Configuration & Change Management
- Verification & Validation
- System Integration
- SE Specialties (RAMS, Human Factors, Organizational Change Management – OCM)

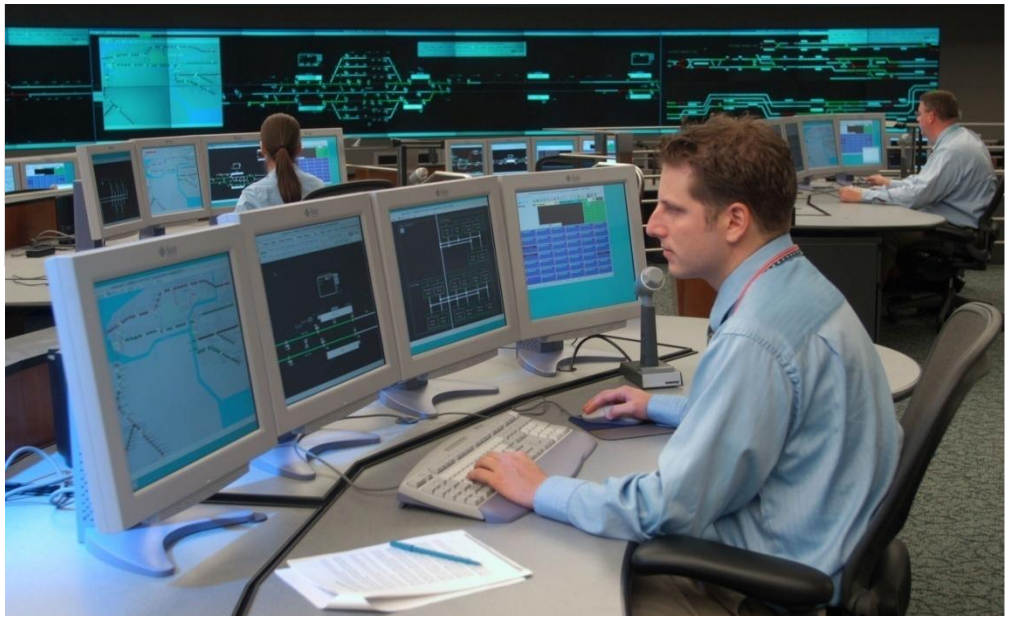
…. Ongoing ITS Projects at the MTA and NYCT

- New Fare Payment Collection (NFPC) System
- Subway Traction Power SCADA System
- Public Assistance and Customer Information Screens (PA/CIS)
- Integrated Service Information and Management: Division B (ISIM-B) Project

Public Assistance and Customer Information System







Rail Control Center – Integrated Service Management System

Application of SE Processes on the ISIM-B Project

- **Project Planning Phase**
  - **Stakeholder Management –** ***Identification and Engagement***
  - **Concept of Operations –** ***Development of ConOps document that defined; i) the business objectives and stakeholder needs, ii) the proposed Operational Concept for the new system; and iii) identified the various groups within the organization that would be impacted with the new system.***
  - **Alternative Analysis –** ***Evaluated both technical and procurement options for the development and deployment of the new system.***
  - **System Requirements Management -** ***Development of system requirements including, traceability to business objectives and stakeholder needs and operational concepts.***

Application of SE Processes on the ISIM-B Project (cont'd)

- **Development (Preliminary Design) Phase**
  - **Sub-system Requirements Management -** ***Development of sub-system requirements; functional and non-functional (including requirements for all the "ilities" – life-cycle support, usability analysis/human –system integration and organizational / business change requirements).***
  - **Verification & Validation -** ***Development of the System & Sub-system Verification and Validation Plan.***
  - **SE Technical & Project Process Definition -** ***Development of new and tailoring of existing SE technical, project and specialty processes from industry "best practices" (ie. INCOSE SE Hdbk V3.2.2, ISO/IEEE-15288, ISO/IEEE-12207)***

NYCT SE versus Federal Rule 940 - Compliance Matrix

Federal Rule 940 Analysis \ NYCT-SE Processes	Stakeholder Requirement Definition (ConOps)	Alternatives Analysis (Procurement & Deployment Strategies)	Requirements Management	Architectural Design	Interface Management	Configuration & Change Management	Verification & Validation	System Integration	SE Specialties (RAMS, HF, OCM)
Regional ITS Architecture Implemented									
Project-level ITS Architecture Implemented				X					
Participating Agency Roles and Responsibilities	X								
Requirements Definition			X						
Alternatives Analysis		X							
Procurement Options		X							
ITS Standards and Testing Procedures			X				X		
System Operations and Management Procedures and Resources	X								
ITS Project Scope	X								
Operational Concept	X								
Functional Requirements			X						
Interface Requirements			X		X				

Explanation of Federal Rule 940 activities

Development of the Regional ITS Architecture and the use of the National ITS Architecture as a resource for its development.

- NYCT is compliant with the provisions of 940
- Regional ITS Architecture Implementation is project dependent. Regional architecture for a particular project may currently be in development or not fully deployed.

Additional NYCT Processes that go beyond Federal Rule 940:

- Configuration and Change Management
- SE Specialties (RAMS, HF and OCM)

Federal Rule 940 (SWOT) Analysis

- **Federal Rule 940 – Strengths & Weaknesses:**
  - **Architecture Design Focused -** *Extremely important process for the planning phase to ensure consistency with the transportation planning process and improvement of system integration on major ITS projects.*
  - **Stakeholder Requirement Definition –** *Similar to other Systems Engineering "best practices" , requires the need to develop the operational concept (ConOps document), to ensure:*
    - ***i.*** ***Roles and responsibilities are defined*** *"… of participating agencies and stakeholder in the operation and implementation of the systems included in the regional ITS architecture". - ref: Federal Rule 940, section 940.9.d.3*
    - ***ii.*** ***Any agreements (existing or new) required for operations*** *"… including at a minimum those affecting ITS project inter operability, utilization of ITS related standards, and the operation of the projects identified in the ITS regional architecture." – ref: Federal Rule 940, section 940.9.d.4*

Federal Rule 940 (SWOT) Analysis (cont'd)

- **Federal Rule 940 – Opportunities & Threats:**
  - **Continual Outreach with FTA and INCOSE -** *The need for the INCOSE community of SE practioners to work with the FTA to ensure that the System Engineering practices are applied throughout the life-cycle stages for all systems. – and not just the planning and design stages.*
  - **Governing policies for SE practices -** *Concerns with Federal policies being institutionalized without a full understanding of System Engineering practices.*

Systems Engineering at NYCT
Benefits / Challenges

- **Benefits of SE at NYCT**
  - Better Project Stakeholder Agreements with alignment of Stakeholders Needs and Business Objectives to system requirements. Engagement of the stakeholders during all the life-cycle stages of the project not just at acceptance testing.
  - Systems Engineering Processes provides basis for the development and implementation methodology to improve the delivery of complex projects.
  - Better Verification and System Integration through complete testing and traceability to source requirements.
- **Challenges of SE at NYCT**
  - Maturity of the Transportation sector vendors as opposed to Military (DoD) sector
  - Complexity of deploying the proper Agreement Processes (Acquisition and Supply) that extends past the traditional agreements used in the Transportation ("brick & mortar") sector. – Needs to extend past the system delivery stage into the Utilization, Support and Retirement stages.
  - Evolving Senior Management knowledge on the importance of applying SE practices/processes on complex projects. – The need to provide more effort and project time in the planning and development stages of the project. Organizational and Cultural changes take time to implement and be accepted.