# Implementing Rule 940, Caltrans's Experience Appling Systems Engineering on ITS Projects

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# Caltrans Application of Rule 940

- Capitol Program uses Federal Funds for ITS Projects and therefore Requires Rule 940

- Capital Projects Allow ITS Hardware (CMS, CCTV's, ect.), but not ITS Software

- Caltrans Policy is not to use Federal Funds for internal ITS Software Projects

- Caltrans Traffic Operations is working on changing the Capital Project process to allow ITS Software

# Caltrans Application of Systems Engineering; Going Beyond 940

- Caltrans HQ Traffic Operations goal is to implement the full SE Life Cycle Processes on all ITS projects

- Started Practicing SE in 1999

- Matured the SE Process over the Past 16 Years

- In the Process of Completing a Library of SE Templates and Guides used on ITS Projects
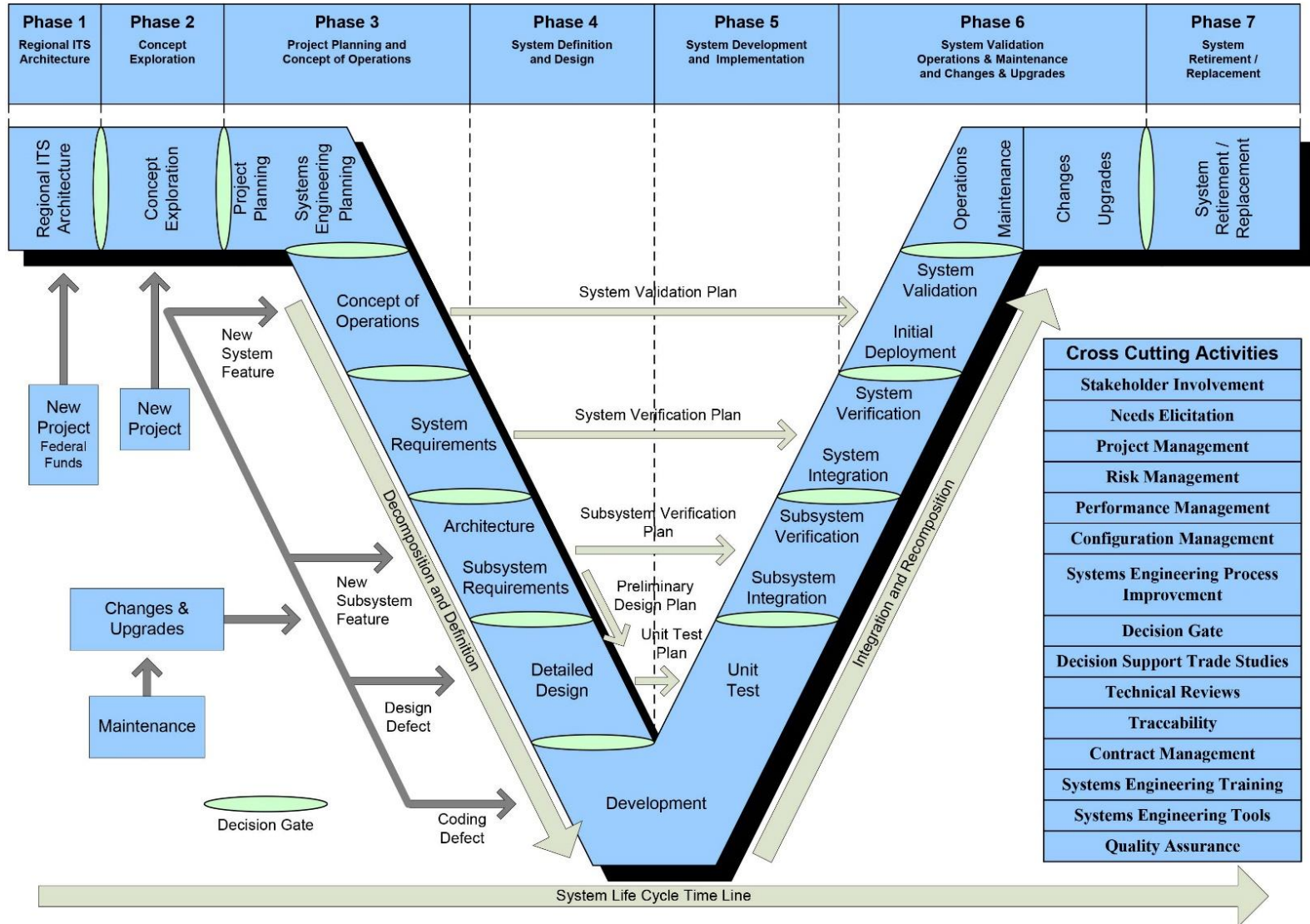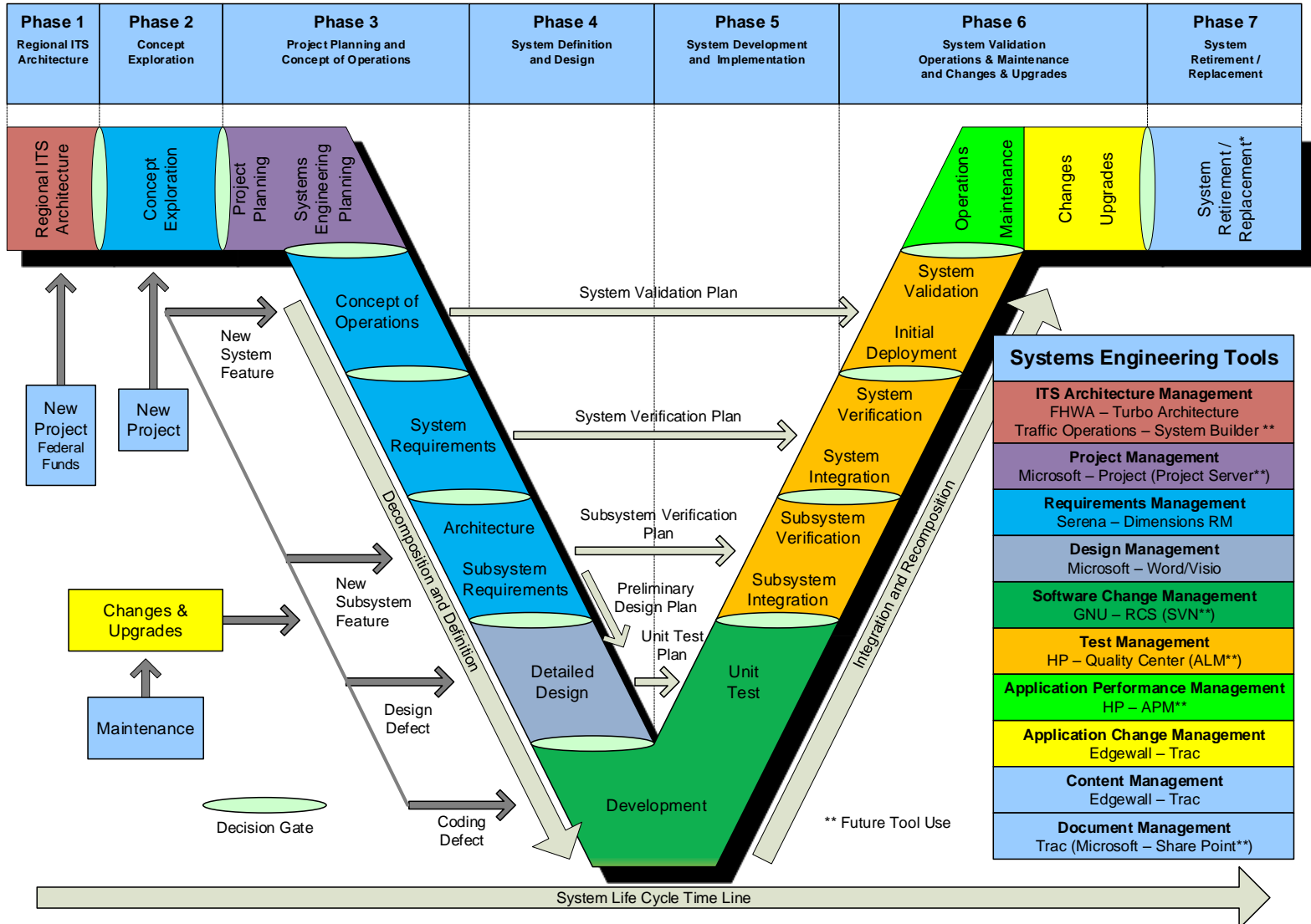
# Example Spec Tree

| Title | Number | Name |
|---|---|---|
| **Project Plan** | EP-32 | XXXX-PRP-nnnn |
| Scope of Work | EP-32-1 | XXXX-SOW-nnnn |
| Work Breakdown Structure | EP-32-2 | XXXX-WBS-nnnn |
| Project Schedule | EP-32-3 | XXXX-PRS-nnnn |
| Project Worksheet | EP-32-3-6 | XXXX-PWS-nnnn |
| Project Schedule Guide | EP-32-3-7 | XXXX-PSG |
| Risk Management Plan | EP-32-4 | XXXX-RMP |
| Communication Plan | EP-32-5 | XXXX-CCP |
| Quality Plan | EP-32-6 | XXXX-QLP |
| Project Status Report | EP-32-7 | XXXX-PSR |
| Decision Gate Guide | EP-32-8 | XXXX-DGG |
| **Systems Engineering Management Plan** | EP-33 | XXXX-SEMP |
| Verification and Validation Master Plan | EP-33-1 | XXXX-VVMP |
| Verification Guide | EP-33-1-1 | XXXX-VMG |
| Validation Plan | EP-33-2 | XXXX-VDP-nnnn |
| Verification Plan | EP-33-3 | XXXXVRP-nnnn |
| Configuration Management Guide | EP-33-4 | XXXX-CMG |
| Engineering Change Proposal | EP-33-4-1 | XXXX-ECP-nnnn |
| Specification Tree | EP-33-4-2 | XXXX-SPT-nnnn |
| Development Guide | EP-33-5 | XXXX-DVG |
| Technical Review Guide | EP-33-6 | XXXX-TRG |
| Operations and Maintenance Plan | EP-33-7 | XXXX-OMP-nnnn |
| Cutover Plan | EP-33-13 | XXXX-COP-nnnn |
| Training Plan | EP-33-14 | XXXX-TNP-nnnn |
| Master Guide | EP-33-21 | XXXX-MSG |
| Design Guide | EP-33-22 | XXXX-DNG |
| Concept of Operations | SP-31 | XXXX-COO-nnnn |
| System Architecture | SP-42 | XXXX-SYA-nnnn |
| Requirements | SP-41 | XXXX-REQ-nnnn |
| Software Detailed Design | SP-43 | XXXX-SDD-nnnn |

# Vee Life Cycle Model

# Systems Engineering Tools



**Systems Engineering Tools**

| Tool Category | Tool |
|---|---|
| **ITS Architecture Management** | FHWA – Turbo Architecture<br>Traffic Operations – System Builder ** |
| **Project Management** | Microsoft – Project (Project Server**) |
| **Requirements Management** | Serena – Dimensions RM |
| **Design Management** | Microsoft – Word/Visio |
| **Software Change Management** | GNU – RCS (SVN**) |
| **Test Management** | HP – Quality Center (ALM**) |
| **Application Performance Management** | HP – APM** |
| **Application Change Management** | Edgewall – Trac |
| **Content Management** | Edgewall – Trac |
| **Document Management** | Trac (Microsoft – Share Point**) |

** Future Tool Use

# Example WBS

| Phase - Task | Caltrans | SE | Develop | SE Tools |
|---|---|---|---|---|
| **1     Regional ITS Architecture** | | | | |
| **1.1      FHWA Systems Engineering Compliance** | | | | |
| **1.1.1     EP-11 FHWA SE Compliance Document** | | | | Turbo Arch |
| 1.1.1.1    XXXX-SEC Document – Draft | | **SE** | | |
| 1.1.1.2    FHWA SE Compliance Workshop(s) and Review | **CTP, RS** | SE | | |
| 1.1.1.3    XXXX-SEC Document – Final | | **SE** | | |
| 1.1.2    Decision Gate – Regional ITS Architecture | **PM**, CTP, RS | SE | | |
| **2     Concept Exploration** | | | | |
| **2.1     Concept Exploration** | | | | |
| **2.1.1     EP-21 Needs Assessment Document** | | | | RM Dim |
| 2.1.1.1    Needs Assessment Workshop(s) and Review | CTP, RS | **RE** | | |
| 2.1.1.2    XXXX-NDA Document – Draft | | **RE** | | |
| 2.1.1.3    Needs Assessment Review | **CTP, RS** | RE | | |
| 2.1.1.4    XXXX-NDA Document – Final | | **RE** | | |
| **2.1.2     EP-22 System Concept Exploration Document** | | | | MS Word |
| 2.1.2.1    XXXX-SCE Document – Draft | | **SE** | | |
| 2.1.2.2    System Concept Exploration Workshop(s) and Review | **CTP, RS** | SE | | |
| 2.1.2.3    XXXX-SCE Document – Final | | **SE** | | |
| **2.1.3     EP-23 IT Concept Paper Document** | | | | MS Word |
| 2.1.3.1    XXXX-ITCP Document – Draft | **PM** | | | |
| 2.1.3.2    IT Concept Paper Workshop(s) and Review | **PM**, CTP, RS | | | |
| 2.1.3.3    XXXX-ITCP Document – Final | **PM** | | | |
| **2.1.4     EP-24 Feasibility Study Report Document** | | | | MS Word |
| 2.1.4.1    XXXX-FSR Document – Draft | **PM** | | | |
| 2.1.4.2    Feasibility Study Report Workshop(s) and Review | **PM**, CTP, RS | | | |
| 2.1.4.3    XXXX-FSR Document – Final | **PM** | | | |
| 2.1.5    Decision Gate – Concept Exploration | **PM**, CTP, RS | SE, RE | | |

# Roles and Tasks View

| Teams | Roles | 1.1–SE Compliance | 2.1–Concept Exploration | 3.1–Project & SEMP Planning | 3.2–Concept of Operations | 4.1–System Requirements | 4.2–Subsystem Requirements | 4.3–Detailed Design | 5.1–Development | 5.2–System Verification | 5.3–Subsystem Verification | 6.1–System Validation | 6.2–Operationss & Maintenance | 6.3–Changes & Upgrades | 7.1–System Replacement | Crosscutting Activities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caltrans | Project Manager – PM | | X | | | | X | X | | | | | | | | X |
| Caltrans | CT Planner – CTP | X | X | | | | | | | | | | | | | |
| Caltrans | Regional Stakeholder –RS | X | X | | | | | | | | | | | | | |
| Caltrans | System Stakeholder – SS | | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Caltrans | TMS Support – TMS | | | | | | | | X | X | X | | | | | X |
| Caltrans | IT Support – ITS | | | | | | | | X | X | X | X | | | | X |
| Caltrans | Change Control Board – CCB | | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Caltrans | SE Team Manager – SETM | | | | | | | | | | | | | | | X |
| Systems Engineering | Systems Engineer – SE | X | X | X | X | X | X | X | X | | | | | | X | X |
| Systems Engineering | Quality Assurance – QA | | | | X | | | | X | X | X | X | | | | X |
| Systems Engineering | Configuration Manager – CM | | | | | | | | | | | | | | | X |
| Systems Engineering | Requirements Engineer – RE | | X | | X | X | X | | | | | | | X | | X |
| Systems Engineering | Risk Manager – RM | | | X | | | | | | | | | | | | X |
| Development | Dev Team Manager – DTM | | | | | | | X | | | | | | | | X |
| Development | Project Lead – PL | | | | | | | X | X | | | | | | X | X |
| Development | Designer – D | | | | | | | | X | | | | | X | | X |
| Development | Coder – C | | | | | | | | X | X | X | | X | | | X |
| Development | Builder – B | | | | | | | | X | | | | | | | X |
| Development | Tester – TS | | | | | | | | | X | X | | | | | X |
| Development | Trainer – T | | | | | | | | | X | | | | | | X |
| Development | IT Support – ITS | | | | | | | | X | X | X | | X | | | X |

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# Challenges Implementing ITS Projects

- Over the Past 16 Years Traffic Operations gained a lot of Tractions and Support for Systems Engineering
  - But were not there yet!
- Continue to Create a Systems Engineering Culture
- Develop Management Support
- Influence other Project Managers to use the Systems Engineering Process

# Benefits Implementing Systems Engineering

- Stakeholder Involvement

- Project Transparency

- Repeatable Process

- Improving the Process

# How the INCOSE Transportation Working Group could Help

- Future of Caltrans Projects are not building more Freeways, but are going to be ITS Operational Oriented
  - New Skills (SE, Software, Testing) will be needed to implement these Projects
- Help Establish an SE Certification in Caltrans Equivalent to the PE Licensing, as done in NYCT

# Questions?