Application of Systems Engineering to a Major Intelligent Transportation System Project

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Overview of this presentation

- What is the project we are discussing?
- How did we apply the SE approach?
- What were the benefits of using SE in this context?
- What were the challenges and barriers we experienced?
- What can we conclude from this exercise?

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Westbound I-80 is the No.1 congested corridor in the San Francisco Bay Area

The 10 Most Congested Corridors in the Bay Area

	County	Freeway Corridor	Daily Delay (VHD)
1	Alameda/ Contra Costa	WB I-80, SR-4 to Bay Bridge (a.m.)	10,080
2	Alameda	WB I-580, North Flynn to Airway (a.m.)	5,120
3	Alameda	EB I-580, Hopyard to west of El Charro (p.m.)	4,320
4	San Francisco	EB I-80 & NB 101, Cesar Chavez to west of Bay Bridge (p.m.)	3,840
5	Alameda	EB SR-92, Clawitter to I-880 (p.m.)	3,760
6	Contra Costa	WB SR-4, Lone Tree to west of Loverid	
7	Marin	SB US-101, north of SR-37 to I-580 (a.	
8	Marin	NB US-101, SR-1 to north of I-580 (p.n	
9	Santa Clara	NB US-101, I-280 to north of Trimble (	
10	Alameda/SF	EB I-80, west of Treasure Island to east of Powell (p.m.)	

morning evening

In an alarming reflection of transportation woes

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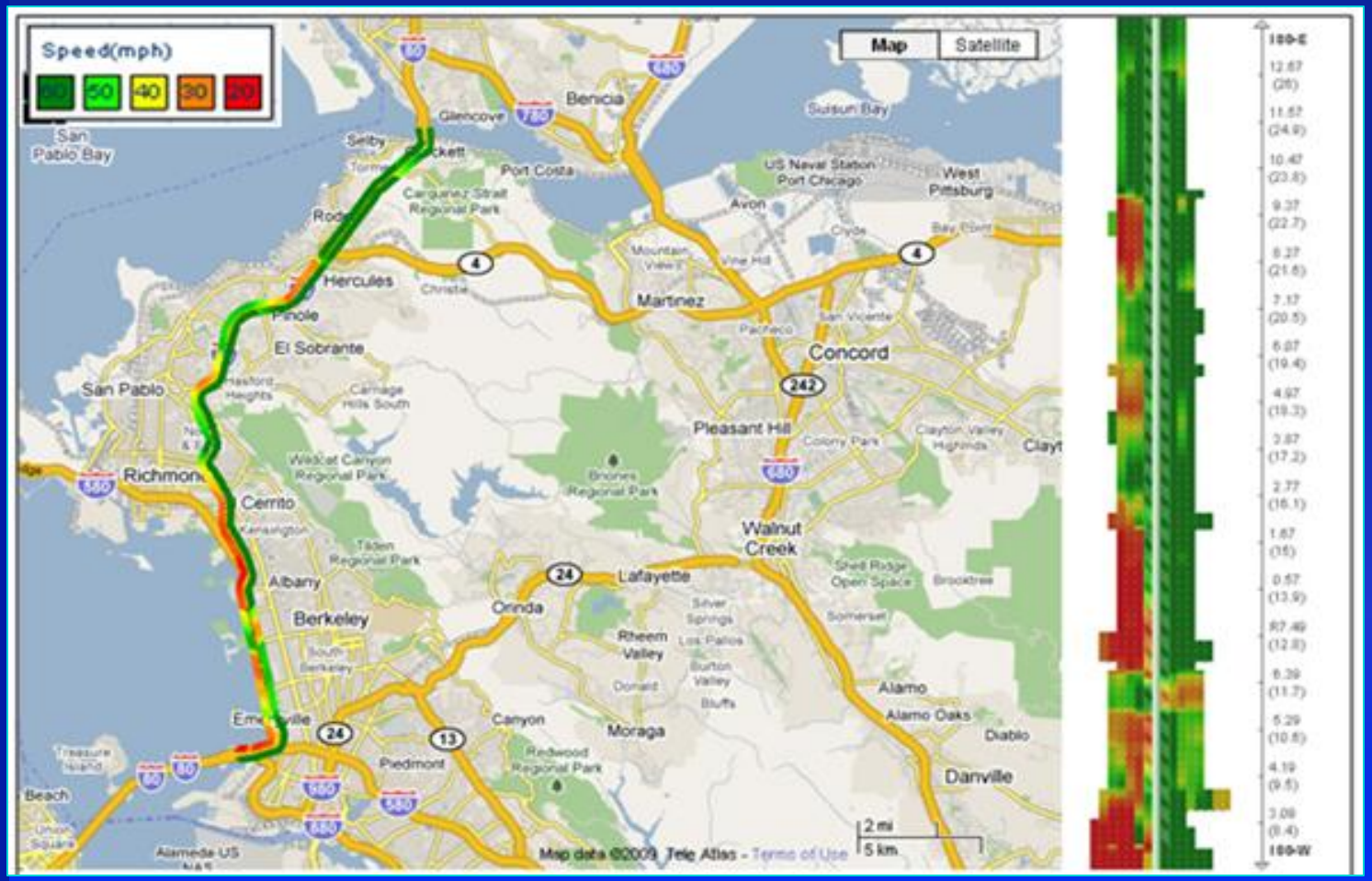
Travel in the corridor is slow and inconsistent during the AM peak….



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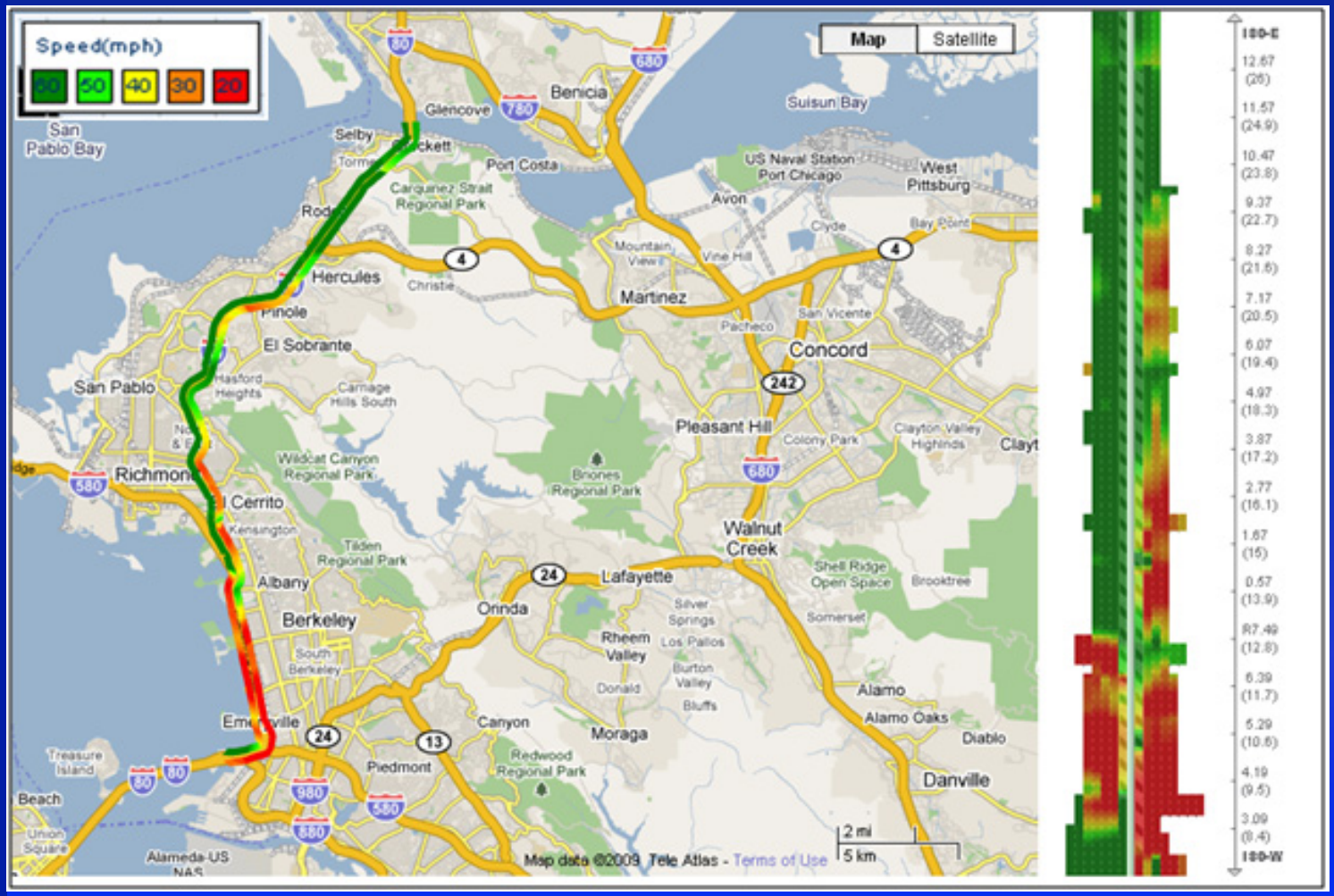
…and also during in the PM peak



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Project as envisioned at the initial concept stage

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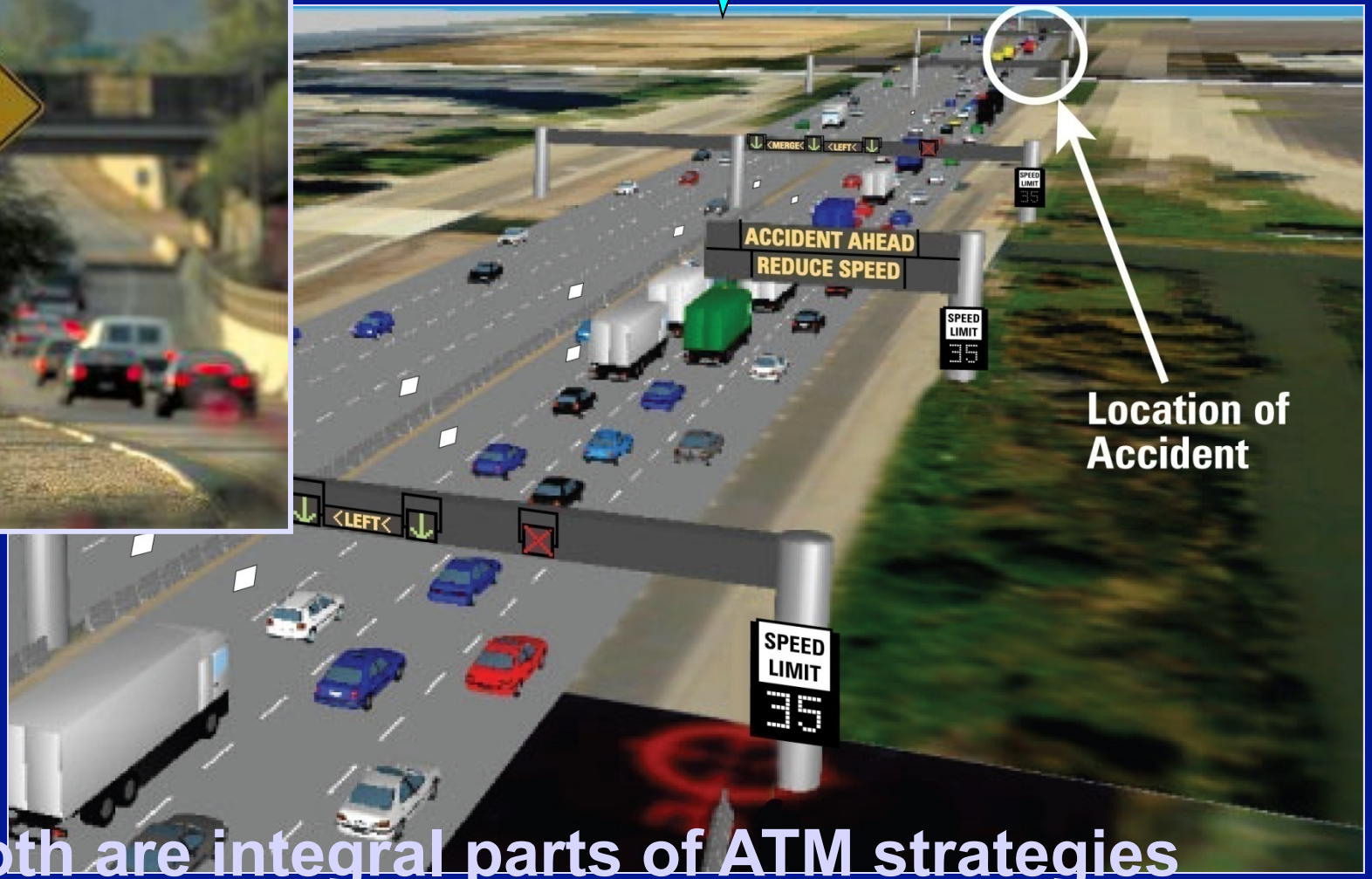
Complex Active Traffic Management System proposed for the corridor

2

Adaptive Ramp Metering

1

Lane Management System



Both are integral parts of ATM strategies

23 jurisdictional stakeholders directly contribute to the project

- Alameda County CMA
- Contra Costa Transportation Authority
- West Contra Costa Transportation Advisory Committee
- California Department of Transportation
- California Highway Patrol
- Federal Highway Administration
- Federal Transit Administration
- Metropolitan Transportation Commission
- AC Transit
- Western Contra Costa Transit Authority
- Water Emergency Transportation Authority
- BART
- Amtrak
- Contra Costa County
- City of Albany
- City of Berkeley
- City of El Cerrito
- City of Emeryville
- City of El Cerrito
- City of Hercules
- City of Pinole
- City of Richmond
- City of Oakland
- City of San Pablo

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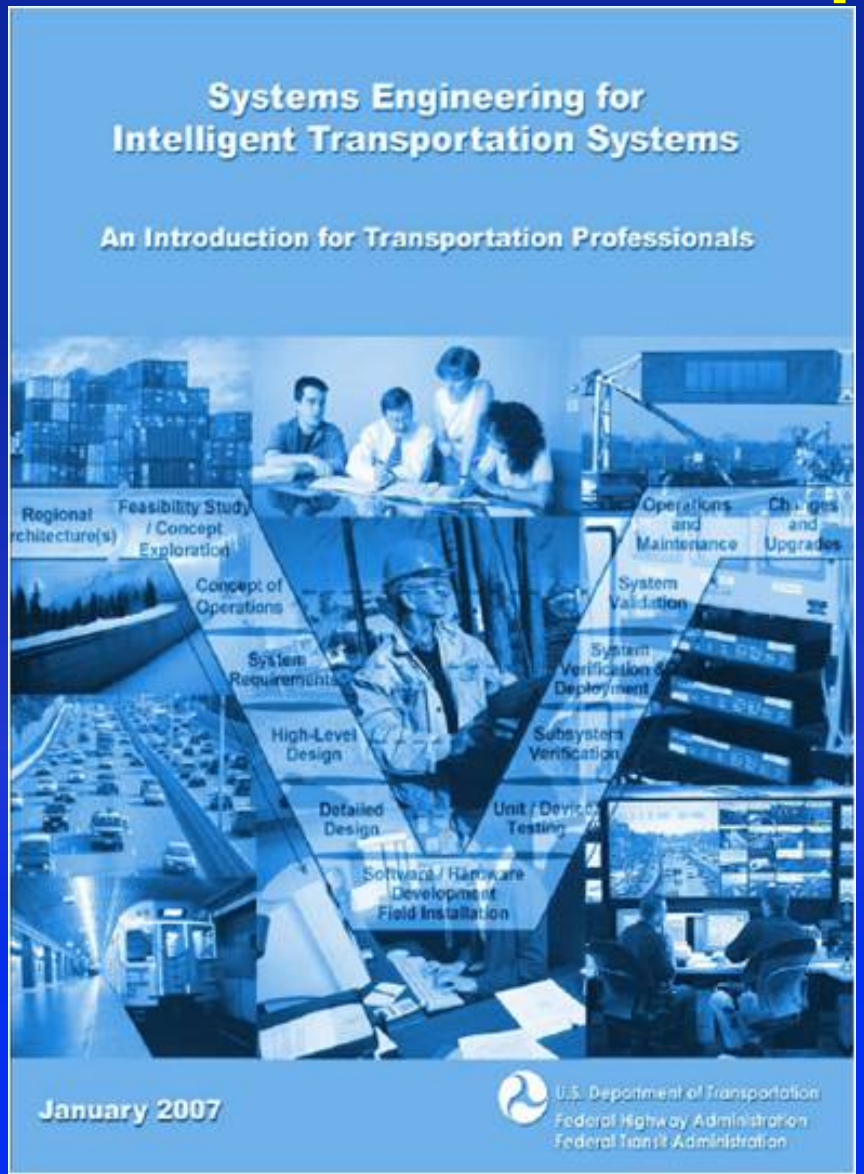
Three key references guided our application of SE to this project



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Three key references guided our application of SE to this project

Systems Engineering Guidebook for Intelligent Transportation Systems

Version 3.0

U.S.Department of Transportation
Federal Highway Administration
California Division

Caltrans

Visit http://www.fhwa.dot.gov/cadiv/segb for an interactive, on-line version of this document

November 2009

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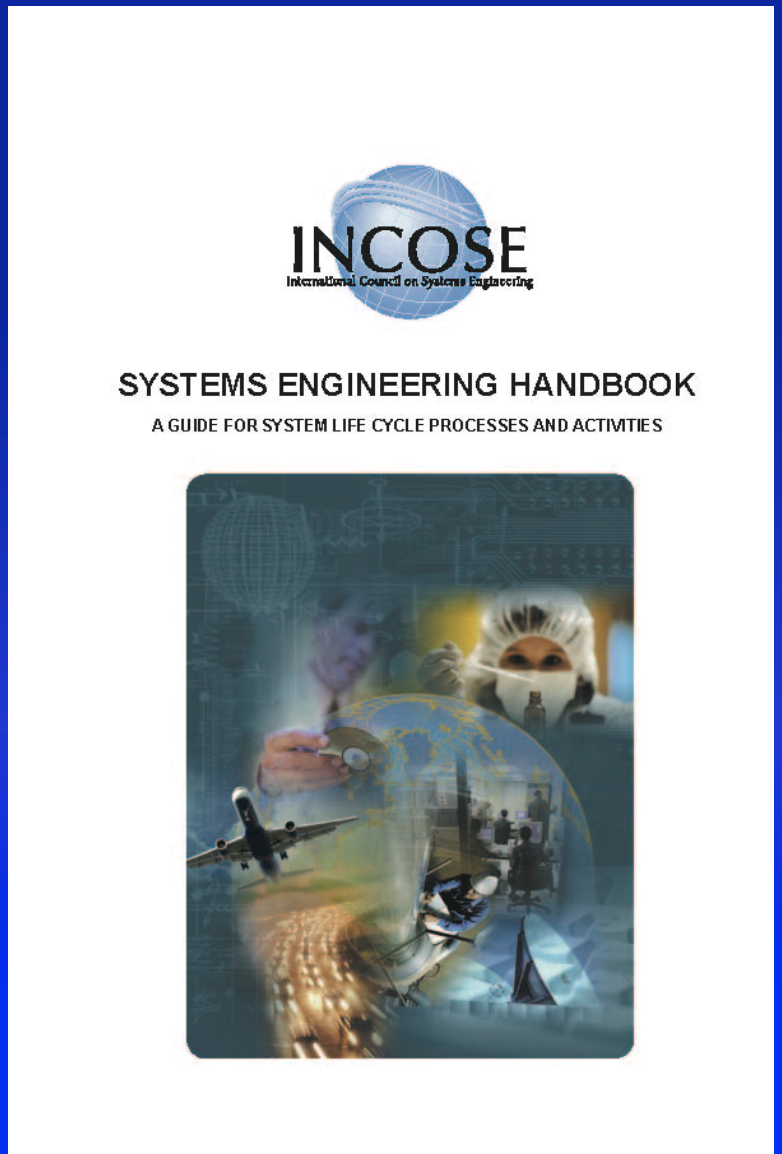
Three key references guided our application of SE to this project



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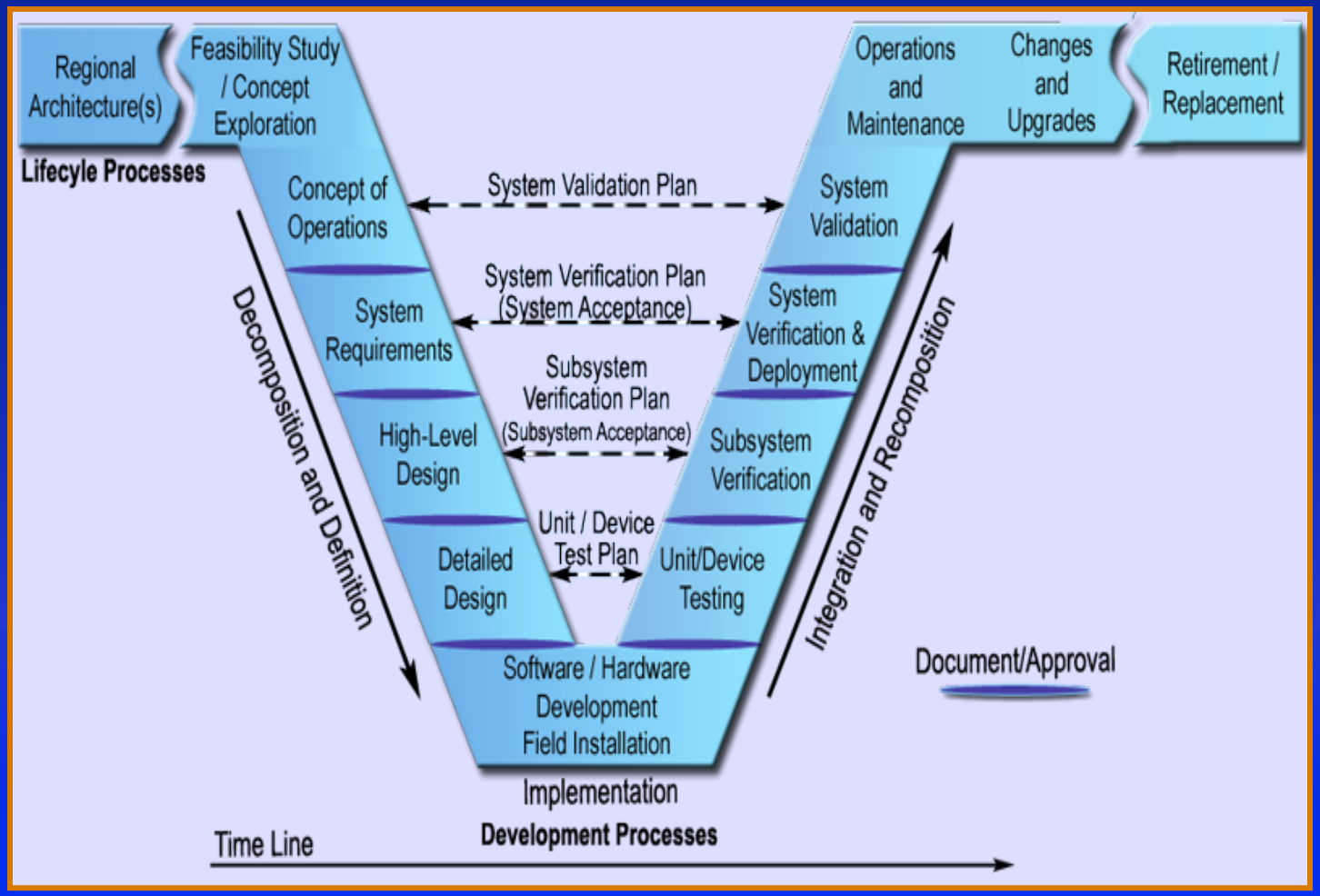
We followed the systems engineering "Winged Vee" diagram



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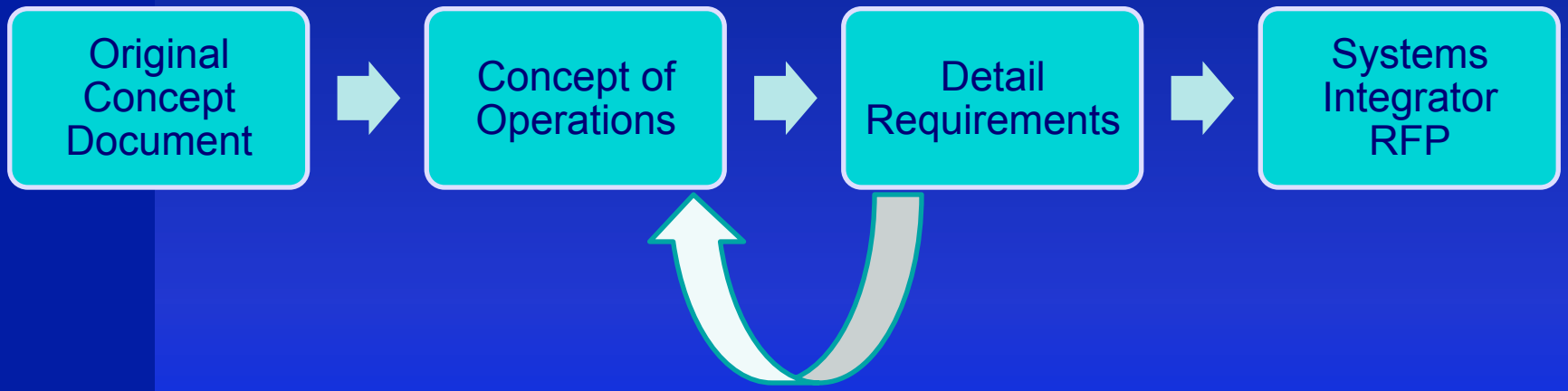
Context of our systems engineering activities



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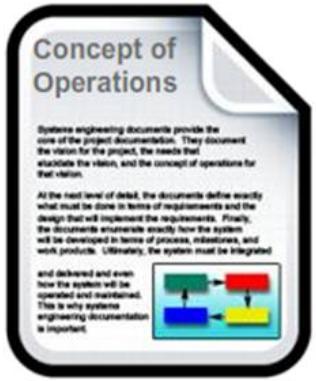
Web-based User Guide provided templates for each required document

Deliverable Templates

- Needs Assessment
- Project Plan
- Systems Engineering Management Plan
- Configuration Management Plan
- **Concept of Operations**
- Requirements Specifications
- Design Specifications
- Integration Plan
- Verification Documents
- Deployment Plan
- Validation Documents
- Operations and Maintenance Plan

Changes and Upgrades | Retirement / Replacement



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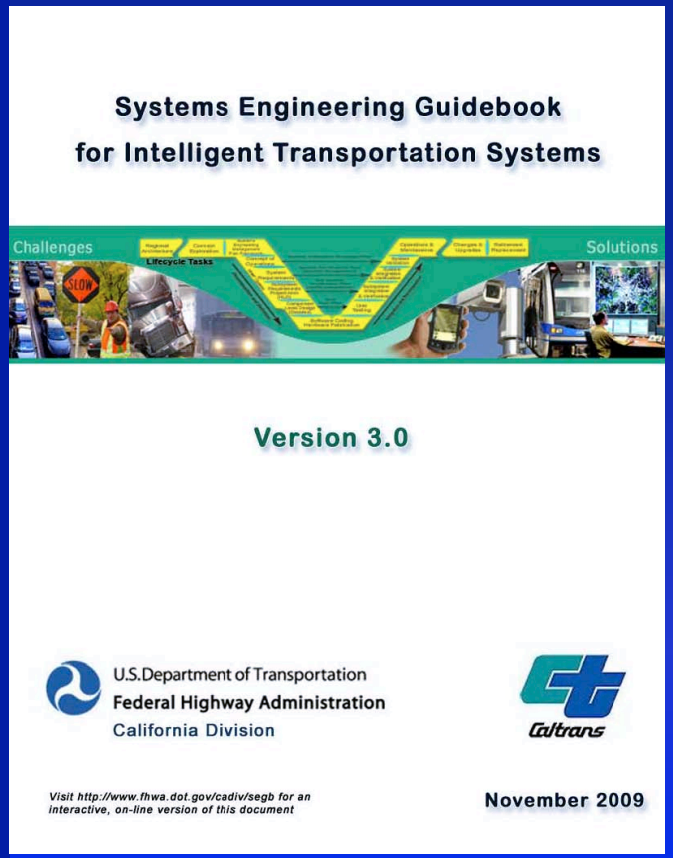
Our experience applying the systems engineering approach to the ICM project…



- Provides Significant Benefits to the Project.
- Faces Some Barriers to Implementation.
- Is Improved with Requirements Management Software.

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SE provides significant benefits to the project

The SE approach helps to:

- Control scope creep
- Build project consensus
- Identify roles and responsibilities
- Define acceptance
- Build project documents

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SE helps to control scope creep

Mapping Requirements – making sure top level and detailed design map to each other.

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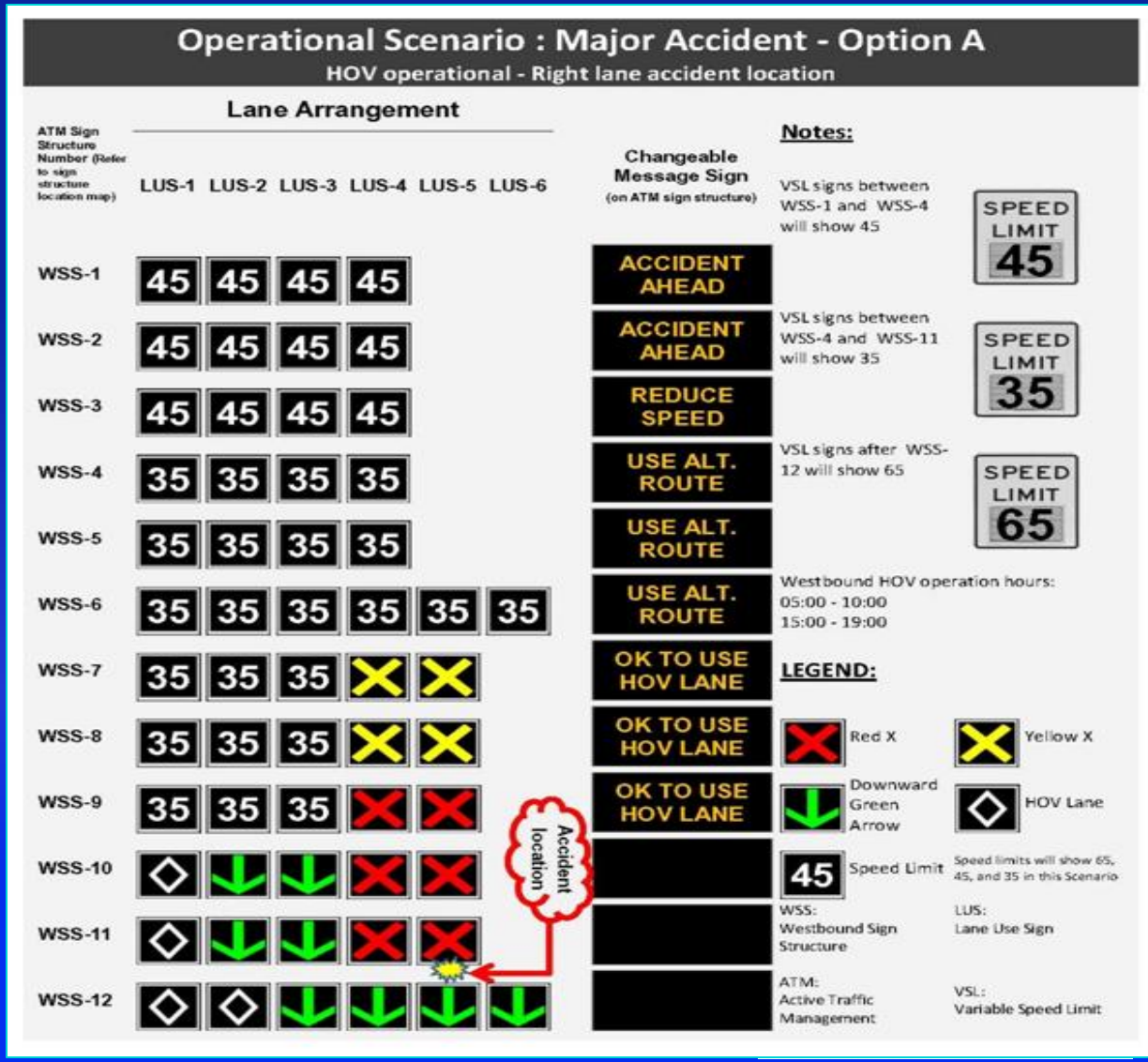
SE helps to build project consensus

Analysis of various scenarios helped to capture and clarify what everybody was intending the project to achieve…



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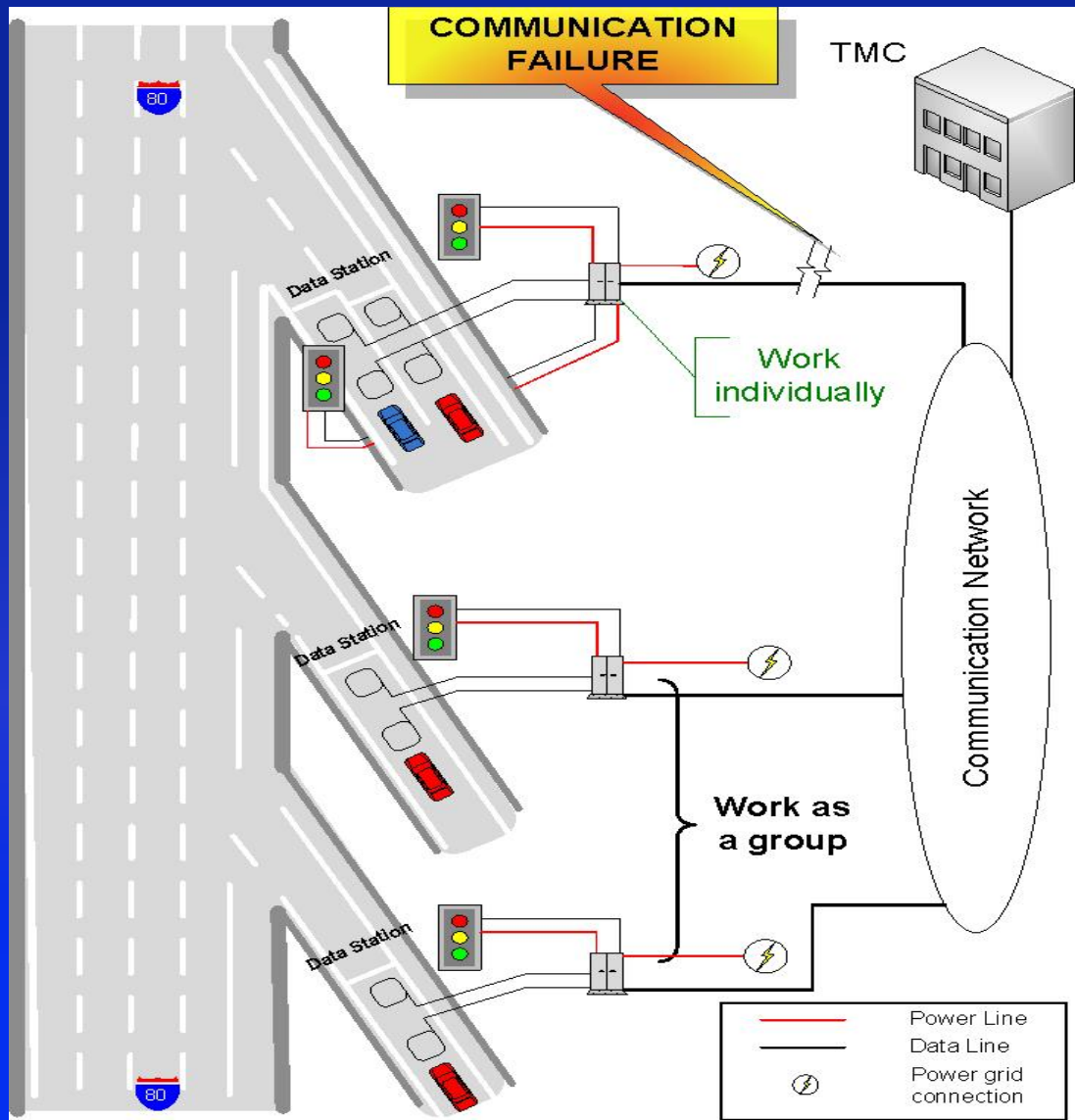
SE helps to build project consensus

…especially when talking about system failure scenarios.



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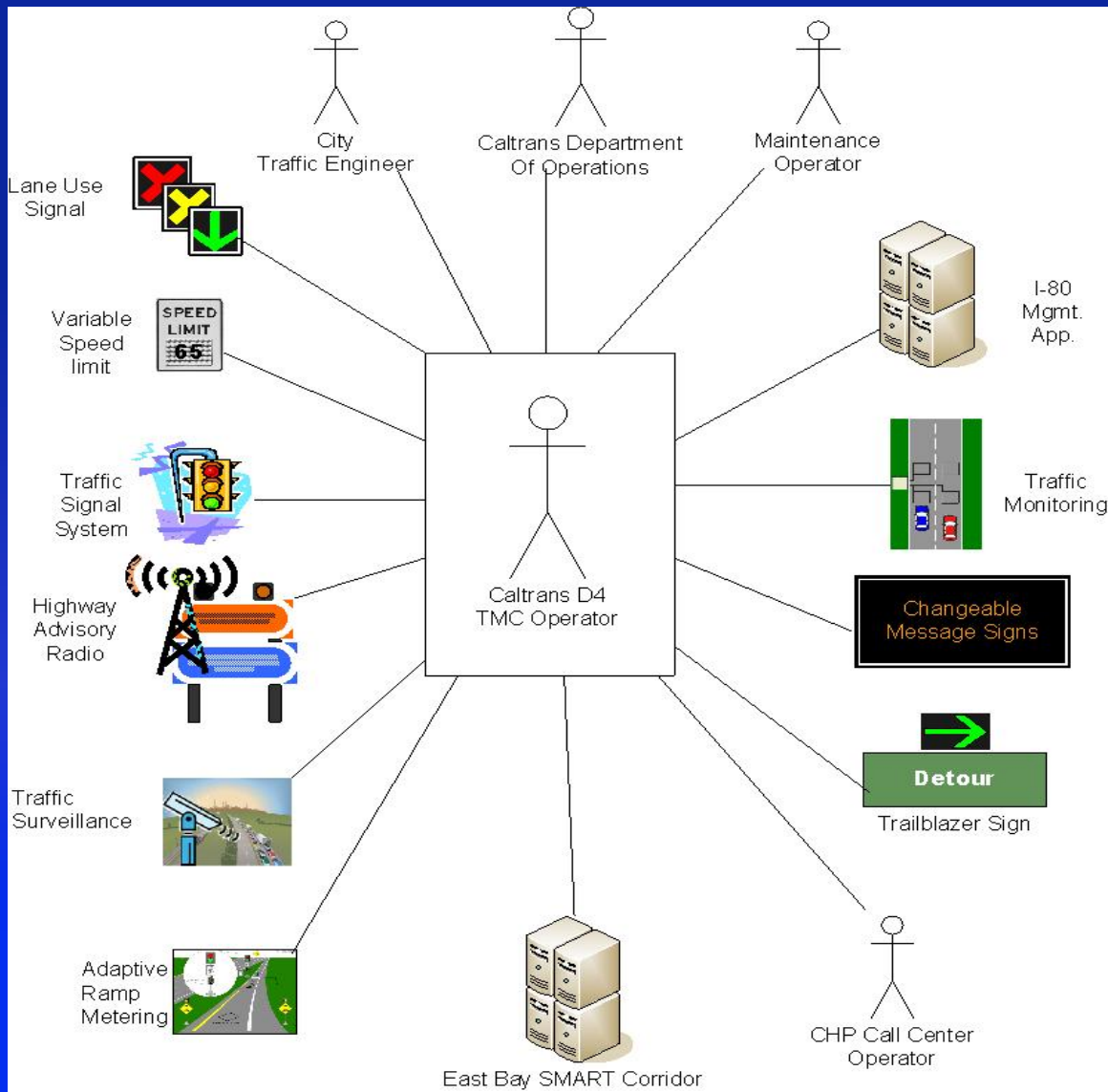
SE helps to identify roles and responsibilities

By analyzing the project in a user/ worker centric manner…



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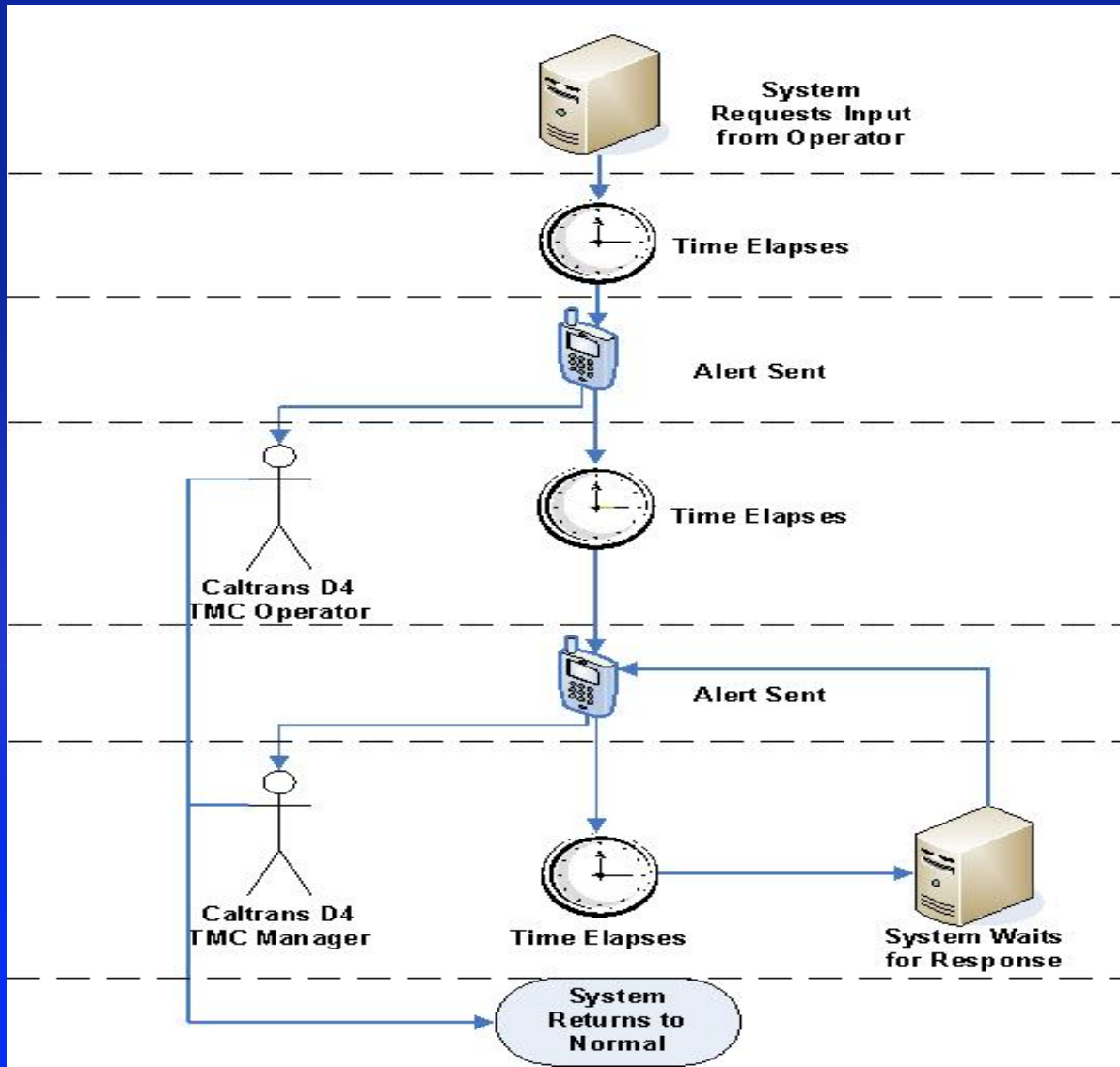
SE helps to identify roles and responsibilities

…and also in a system centric manner



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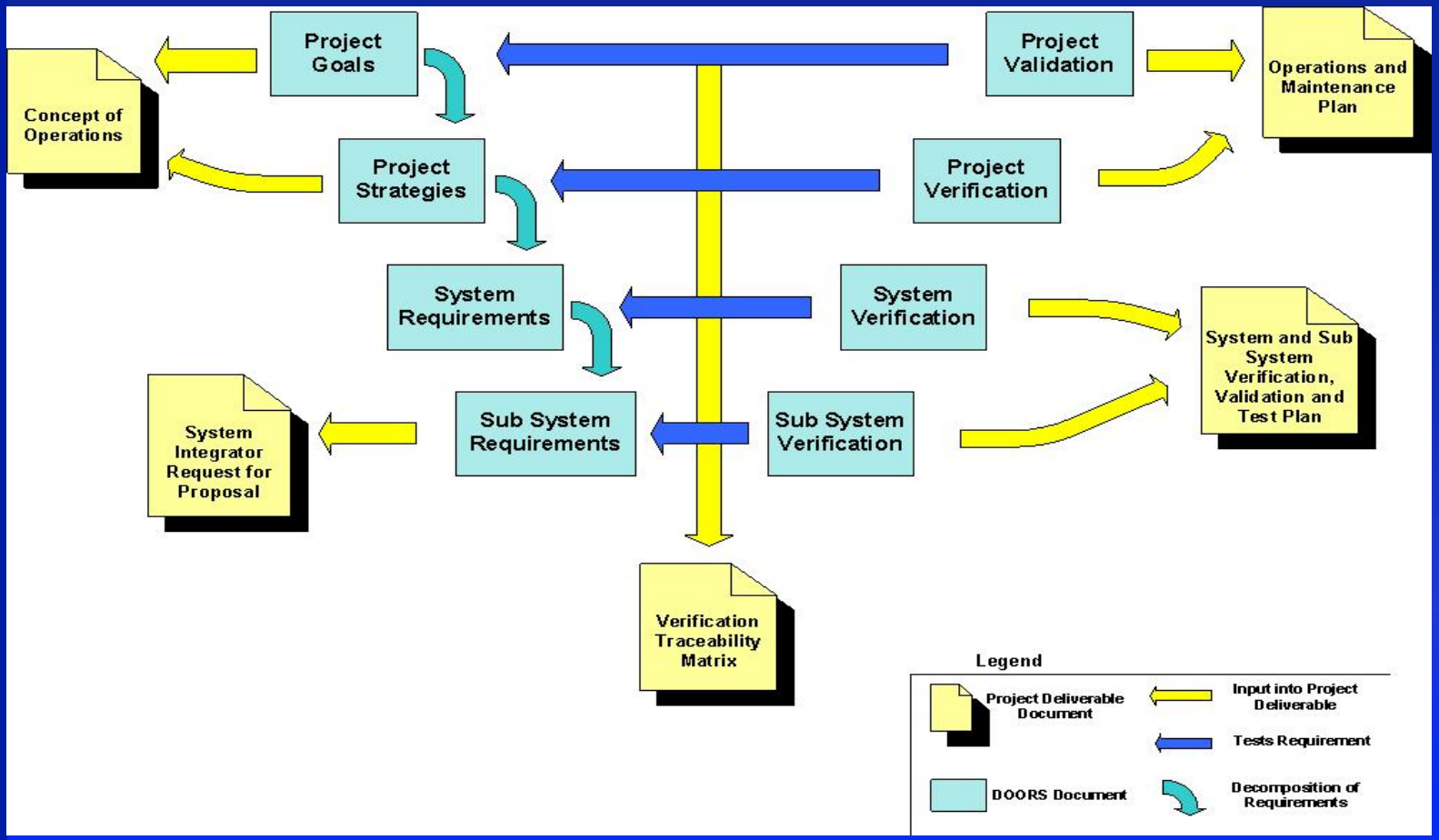
SE helps to develop project documents



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Barriers to implementation of SE

- Belief that the project solution is already agreed at the beginning of the project
- Belief that the PS&E process is the only required process for this project
- Not understanding the purpose of the SE process

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Project solution already agreed?

Actual stakeholder response to our Con Ops document…

"This Concept of Operations document is not about OUR project, it talks about elements that we have already decided against…"

The FHWA outline helped guide this discussion

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The FHWA outline helped guide this discussion with stakeholders

Chapter		Chapter (cont.)	
1	Purpose of Document	7	Operational Needs
2	Scope of Project	8	System Overview
3	Referenced Documents	9	Operational Environment
4	Background	10	Support Environment
5	Concept for the Proposed System	11	Operational Scenarios
6	User-Orientated Operational Description	12	Summary of Impacts

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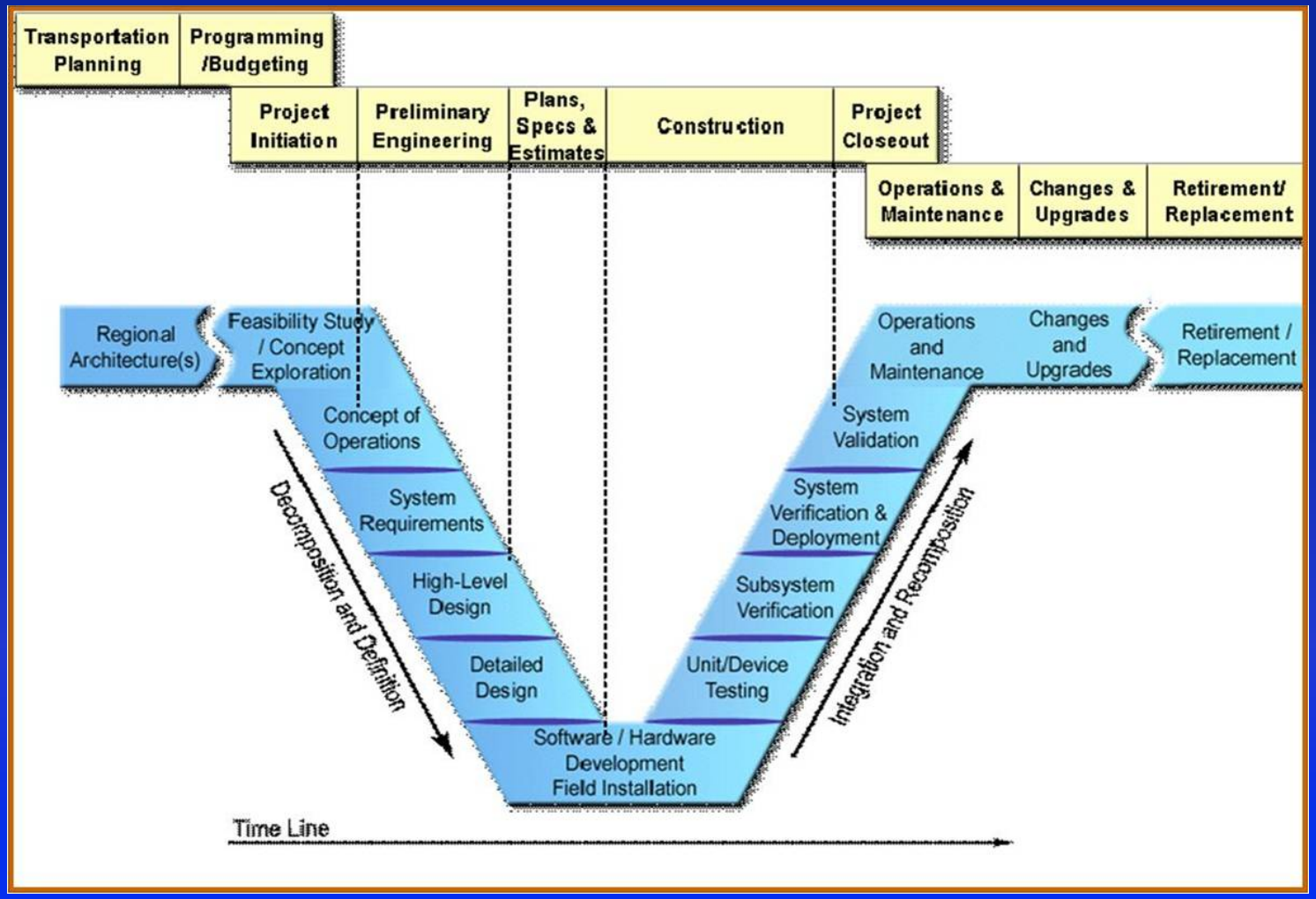
Traditional PS&E process is sufficient?



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Requirements management software improved SE implementation

- Easy to create structure
- Input to correct level
- Provides an easy audit trail
- Identify orphan and childless requirements
- Validation, verification and testing easily prepared
- We used IBM Rational DOORS

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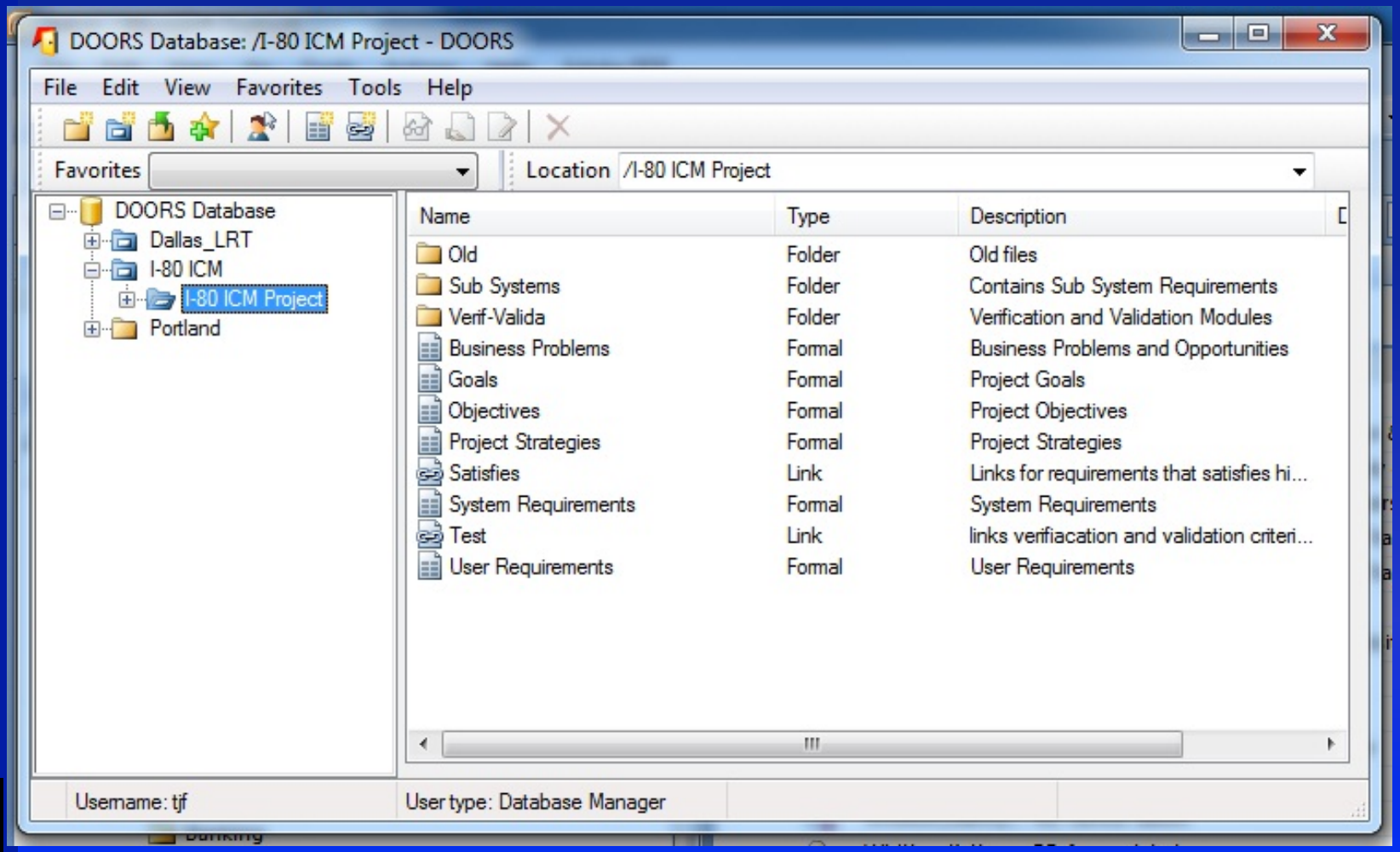
DOORS organization – high level



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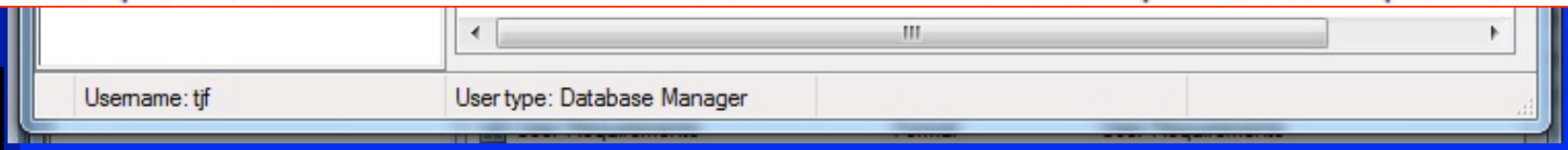
DOORS organization – low level

Name	Type	Description
ARM Requirements	Formal	Adaptive Ramp Metering
AVL Software Upgrade	Formal	AVL Software Upgrade
EVP Requirements	Formal	EVP Requirements
HAR Requirements	Formal	HAR Requirements
LUS Requirements	Formal	Lane Use Signal Sub System Requir
Management Application Requirem...	Formal	I-80 ICM Management Application
Traffic Control System	Formal	Traffic Control System
Traffic Monitoring Requirements	Formal	Traffic Monitoring Requirements
Traffic Surveillence Requirements	Formal	Traffic Surveillence Requirements
Trailblazer Requirements	Formal	Trailblazer Requirements
Transit Dispatch Center	Formal	Transit Dispatch Center
TSP Requirements	Formal	Transit Signal Priority Requirements
VMS and SMS Requirements	Formal	VMS Requirements
VSL Requirements	Formal	Variable Speed Limit Requirements



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CONCLUSIONS

- SE process provided clear, logical structure to the project
- Requirements tool improves audit trail, reduces scope creep
- SE not yet well accepted by the transportation community

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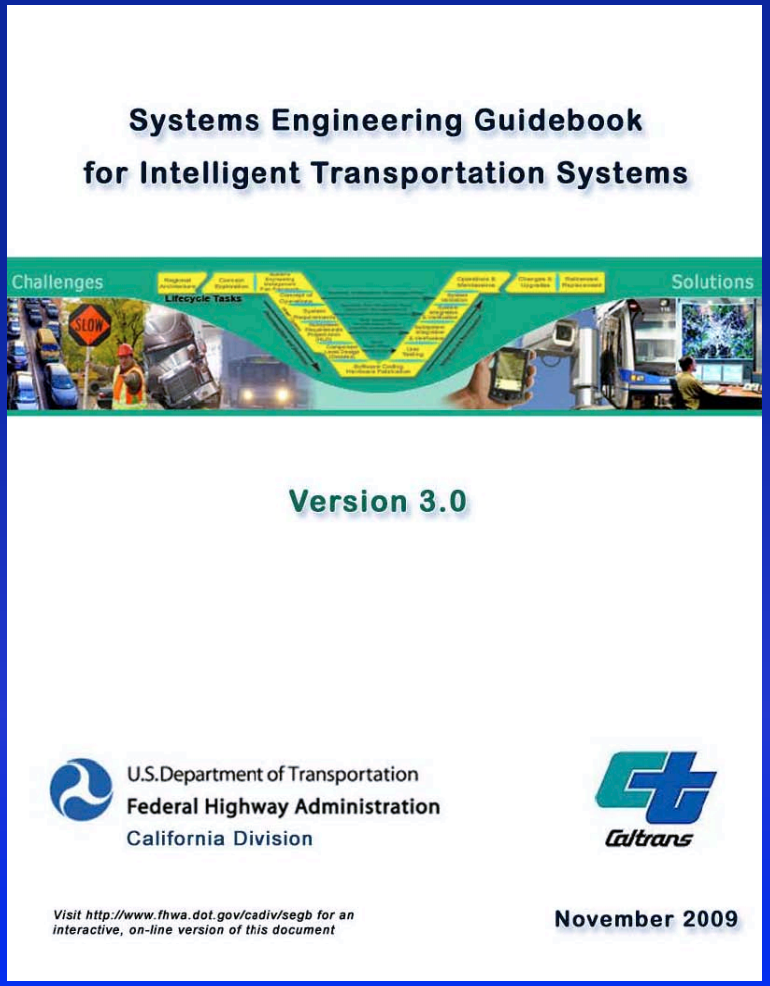
Systems Engineering Approach to a Major Integrated Corridor Mobility (ICM) Project

In summary, SE greatly improved the quality of the project.



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