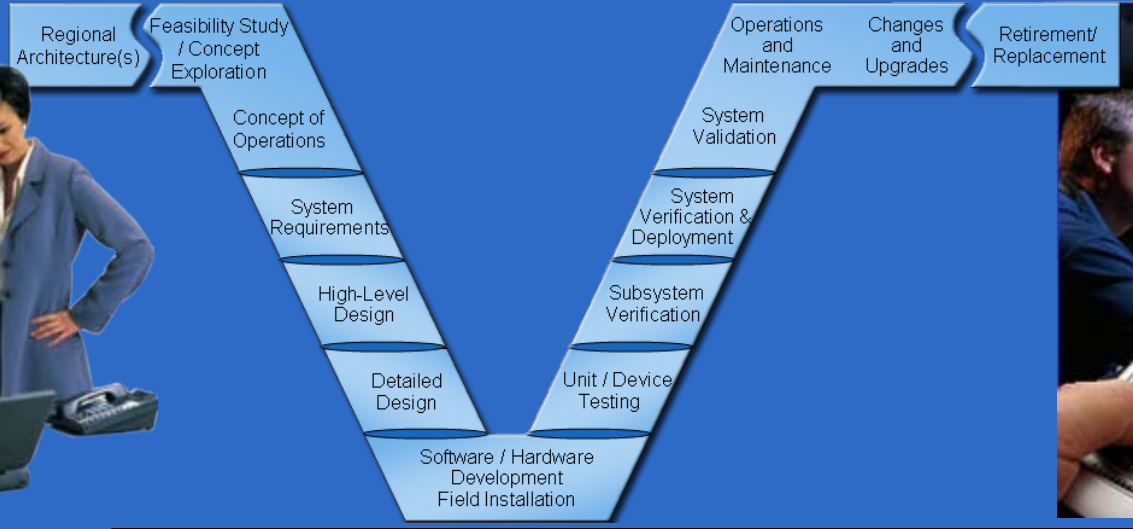


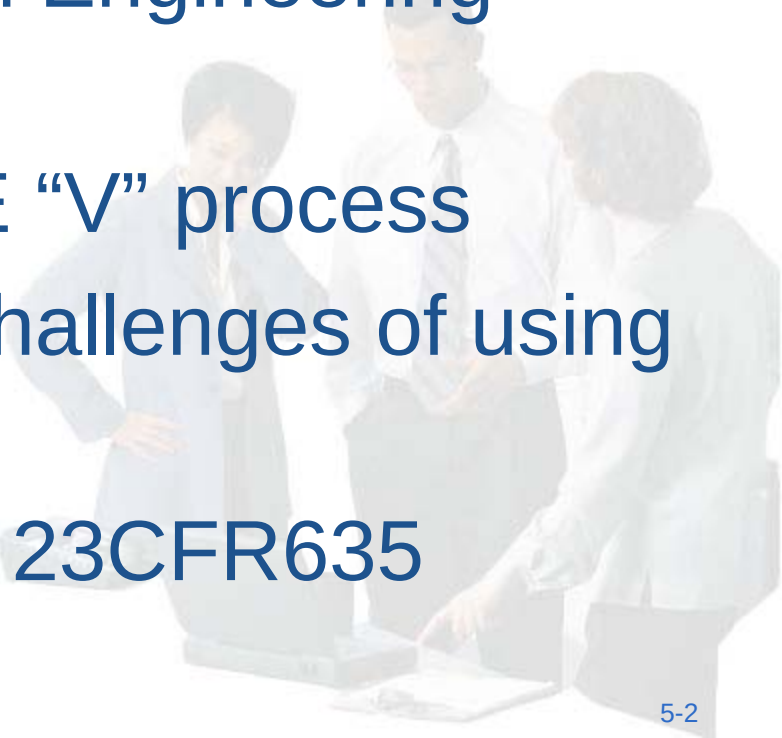
Session 5: Applying SE to a Project

These materials developed under the RITA National ITS Architecture Program

U.S. Department of Transportation
Research and Innovative Technology Administration

Learning Outcomes

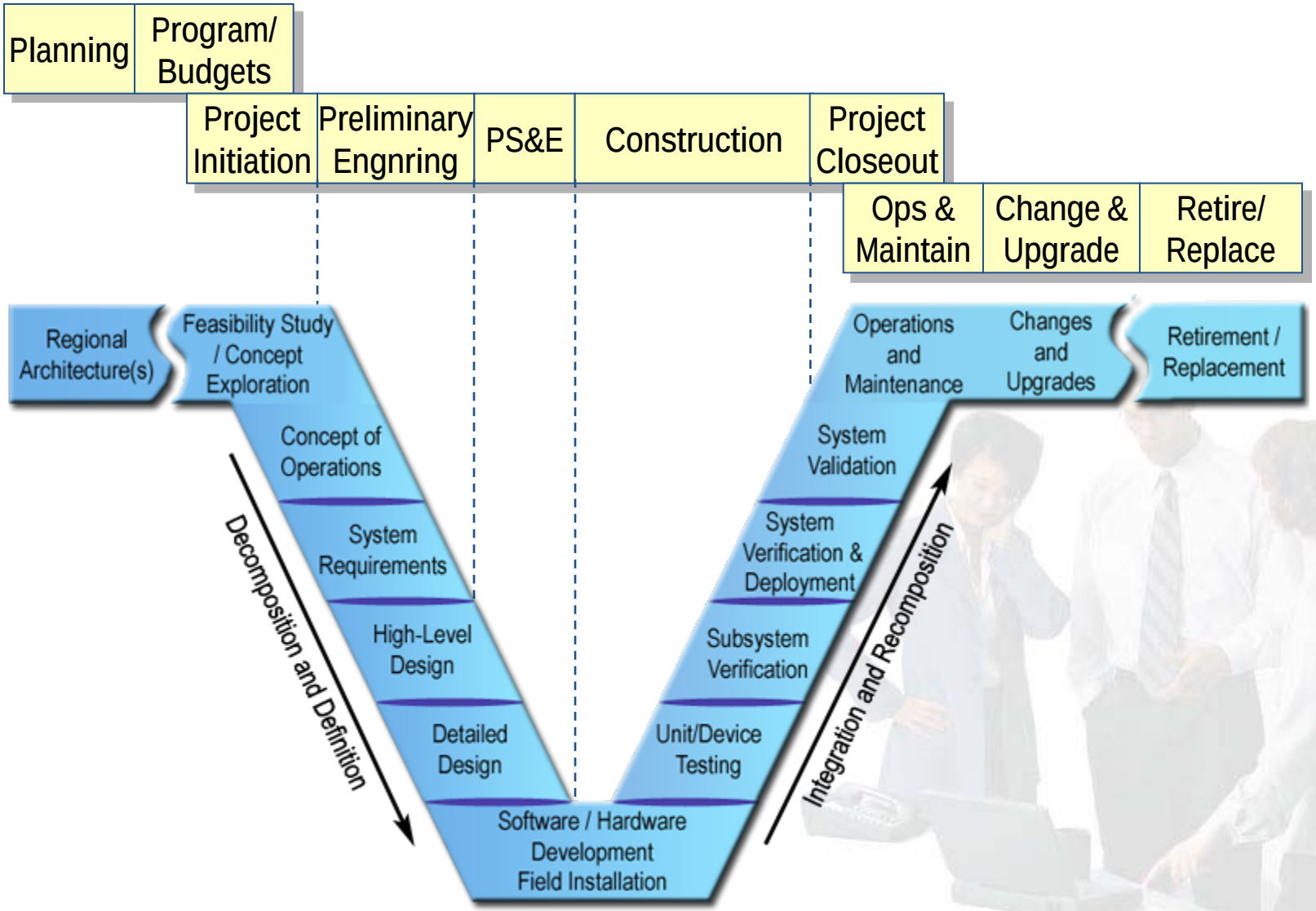
- Define the types of projects for which the SE “V” process is needed
- Explain in general terms the federal requirements for a System Engineering Analysis (SEA)
- Explain how to use the SE “V” process
- Identify the benefits and challenges of using SE
- Explain how SE relates to 23CFR635



Risk Factors for ITS Projects

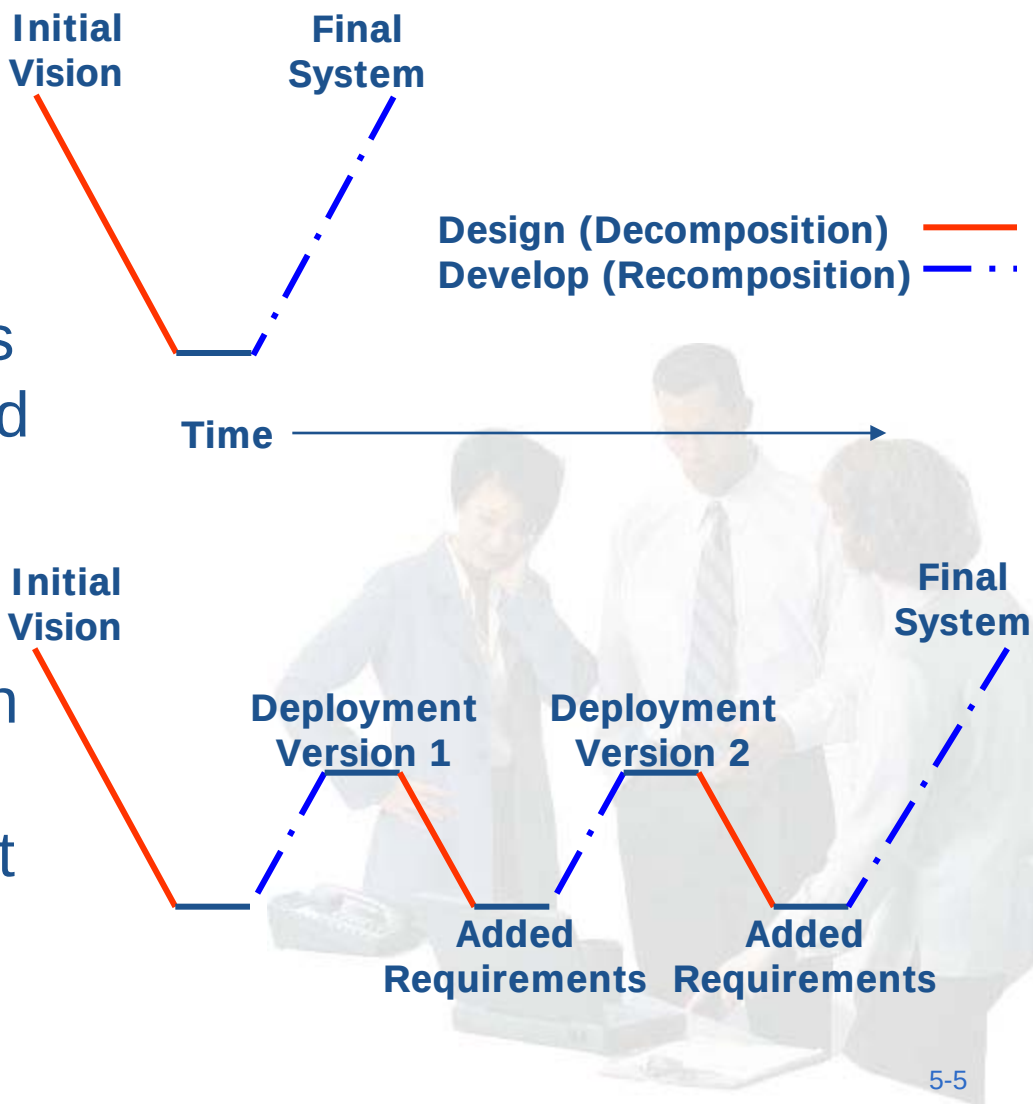
- Custom Software Development
- New Technology Applications
- Multi-Agency Implementation
- New Interfaces (external or legacy)

Recall: Two Processes for ITS Projects



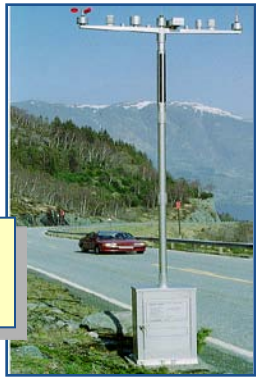
Development Strategies using the "V"

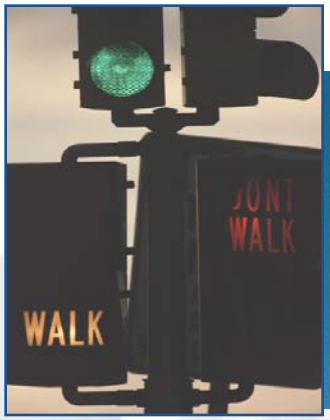
- Once-Through
  - Implement complete system in one pass through the "V"
  - Efficient if requirements are well understood and stable
- Evolutionary
  - Several passes through "V". Implement a little, learn a little, and repeat
  - Good approach for highest-risk projects



Roadway Process Suitable for Low-Risk Projects

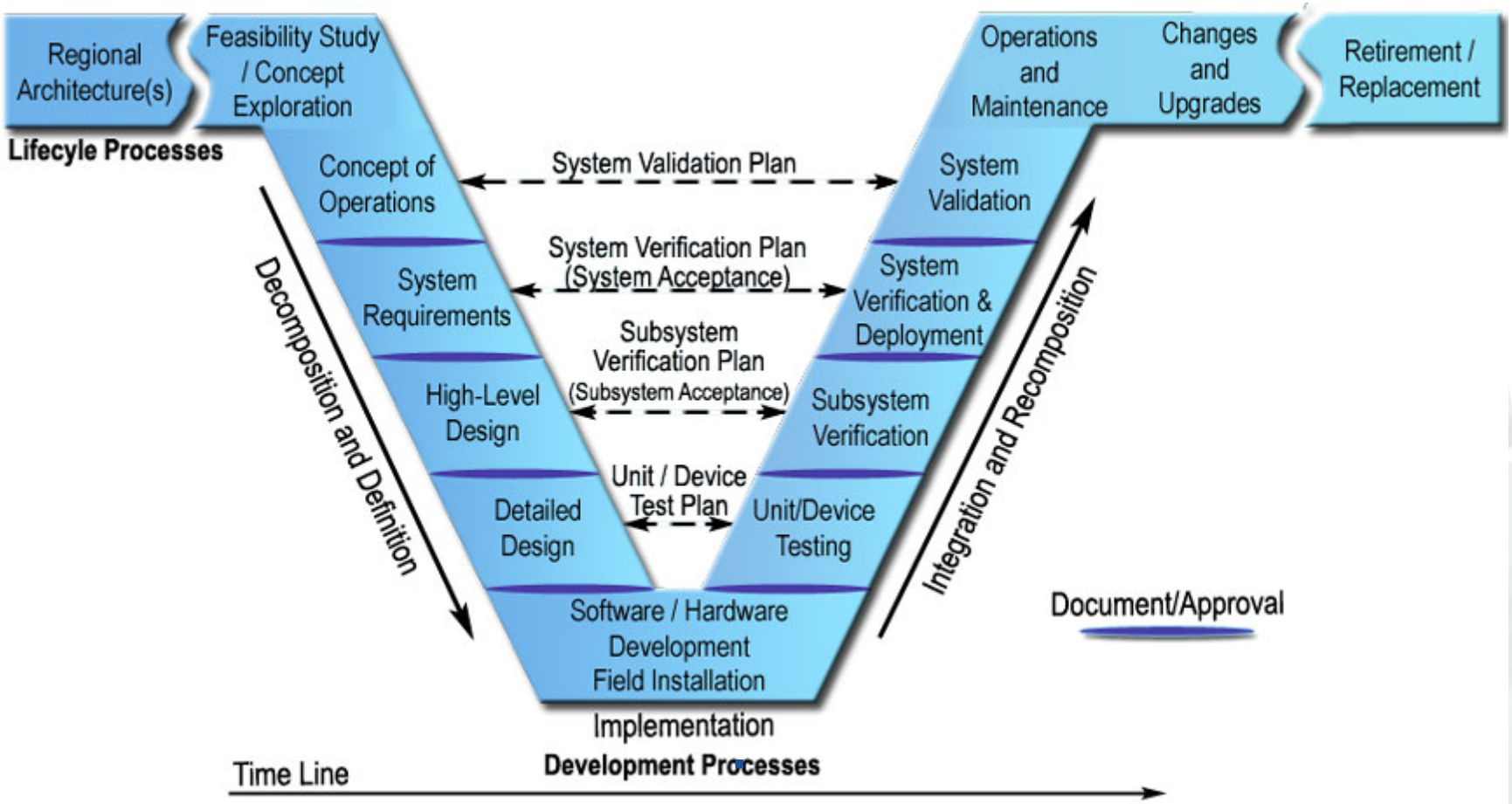
Planning	Program/ Budgets	Project Initiation	Preliminary Engnring	PS&E	Construction	Project Closeout	Ops & Maintain	Change & Upgrade	Retire/ Replace



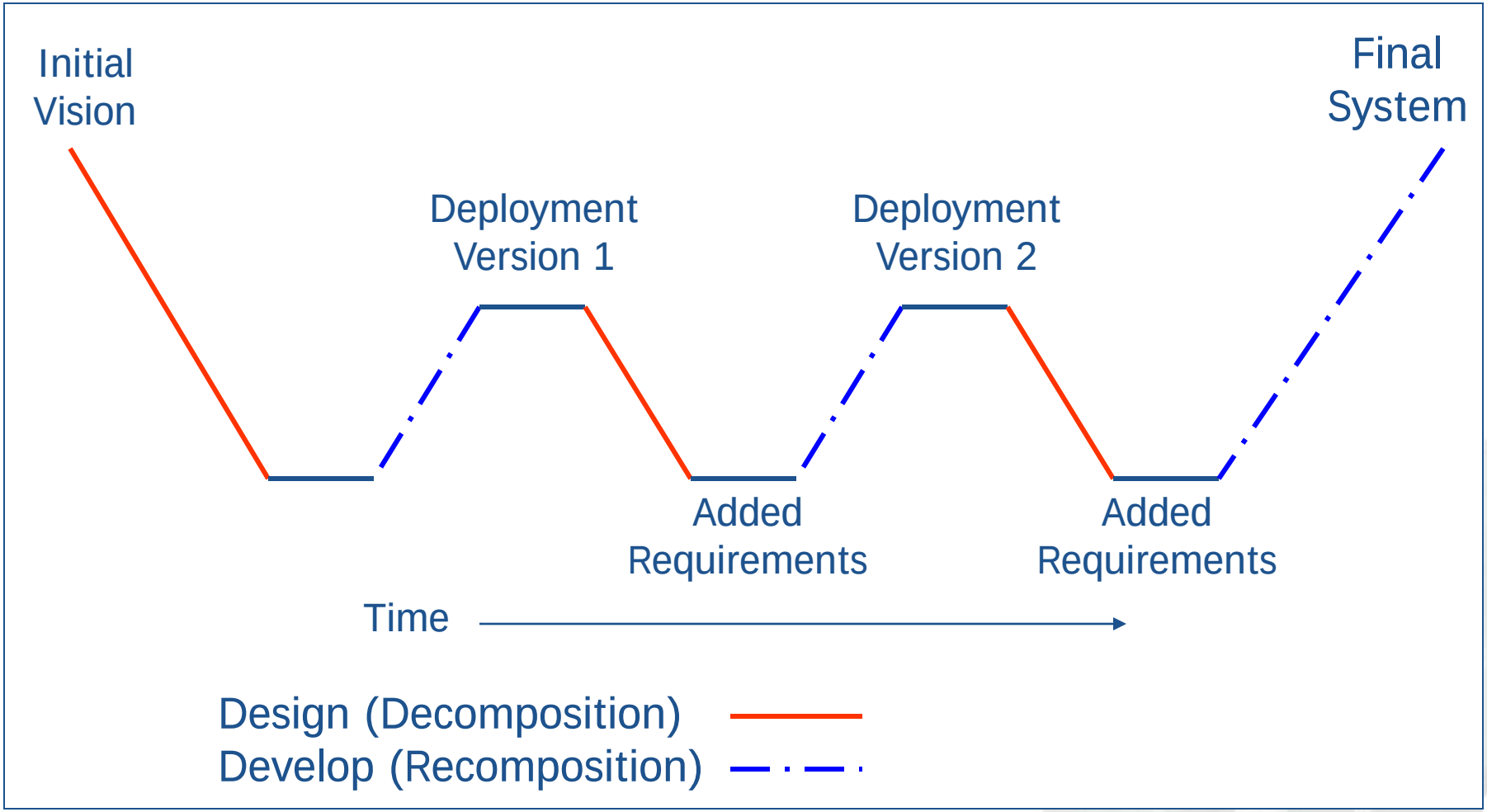


- Requirements Defined
- Product Performance Solid
- Technology Proven
- Designs Documented
- Agency has years of experience

SE "V" Process Needed for Higher-Risk Projects



Evolutionary Development Strategy Best for the Highest Risk Projects



Indicators of Low-Risk ITS Projects

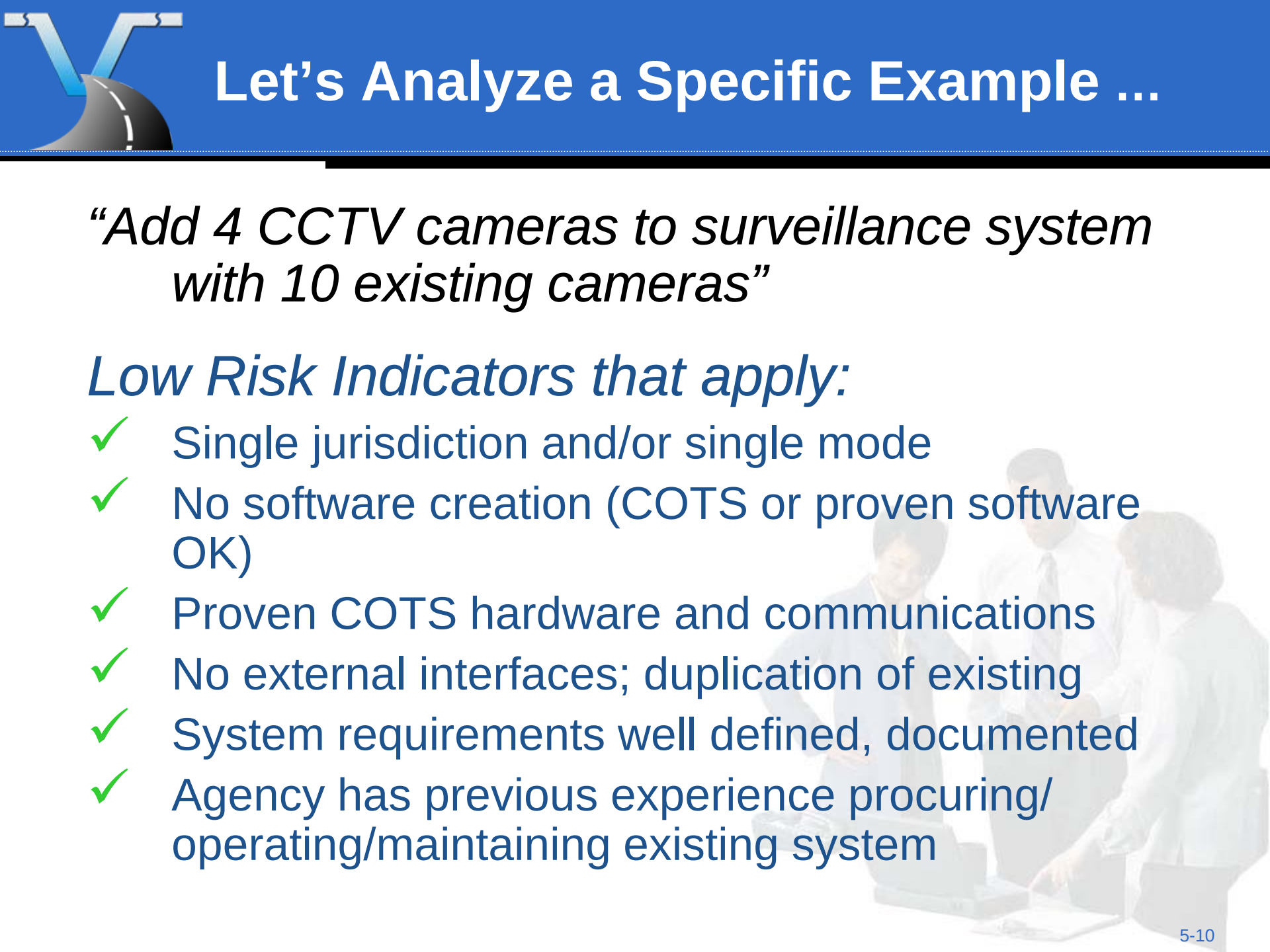
1. Single jurisdiction and/or stand-alone system
2. No software creation (COTS or proven software OK)
3. Proven COTS hardware and communications
4. No new interfaces
5. System requirements well defined and documented
6. Operating procedures well documented
7. Agency has previous experience

Let's Analyze a Specific Example ...

"Add 4 CCTV cameras to surveillance system with 10 existing cameras"

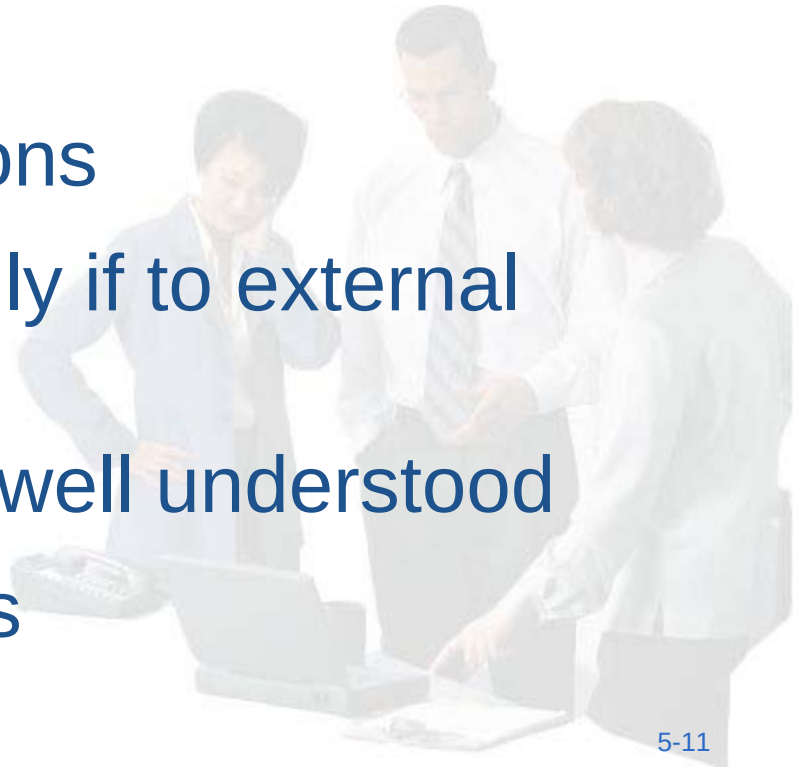
Low Risk Indicators that apply:

- ✓ Single jurisdiction and/or single mode
- ✓ No software creation (COTS or proven software OK)
- ✓ Proven COTS hardware and communications
- ✓ No external interfaces; duplication of existing
- ✓ System requirements well defined, documented
- ✓ Agency has previous experience procuring/ operating/maintaining existing system



Indicators of Higher-Risk ITS Projects

- Multi-jurisdictional and/or multimodal
- New software creation
- New hardware integration
- New technology applications
- New interfaces -- especially if to external systems
- System requirements not well understood
- Likely technology changes

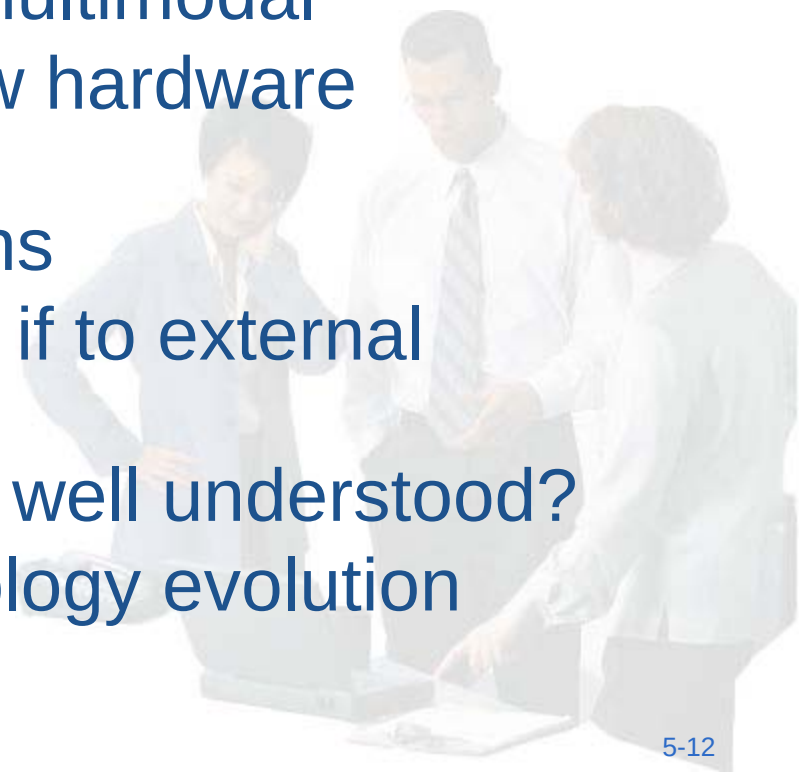


Let's Analyze a Higher-Risk Example

"Share control of existing CCTV cameras between State DOT and adjoining city"

Risk factors that apply -

- ✓ Multi-jurisdictional and/or multimodal
- ✓ New software creation; new hardware integration
- New technology applications
- ✓ New interfaces - especially if to external systems
- ✓ System requirements fairly well understood?
- Need to account for technology evolution

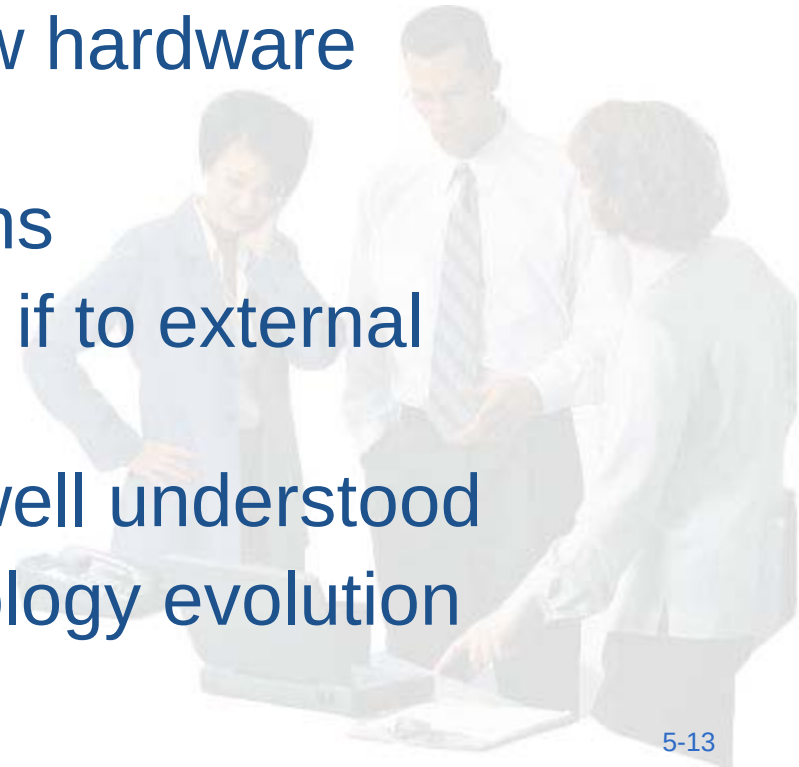


An Even Higher-Risk Example

"Implement a statewide 5-1-1 system"

Risk factors that apply -

- ✓✓ Multi-jurisdictional and/or multimodal
- ✓✓ New software creation; new hardware integration
- ✓ New technology applications
- ✓✓ New interfaces - especially if to external systems
- ✓✓ System requirements not well understood
- ✓ Need to account for technology evolution



How to Choose the Best Process Based on ITS Project Risk

As we complete the Planning/TIP stage …

- Simply from a cursory assessment of the risk factors, we can make an early determination of best process

- Is there an additional resource that should be used for confirmation before we begin project development?

  YES:

  The Systems Engineering Analysis described in the Final Rule and Policy

Systems Engineering Analysis (SEA) Can be Used as Decision Tool

Recall the 7 SEA items:

1. How project fits into regional ITS architecture
2. Roles/responsibilities of participating agencies
3. Requirements definition
4. Analysis of alternative systems and technologies
5. Procurement options
6. ITS standards and testing procedures
7. Procedures and resources needed for O&M

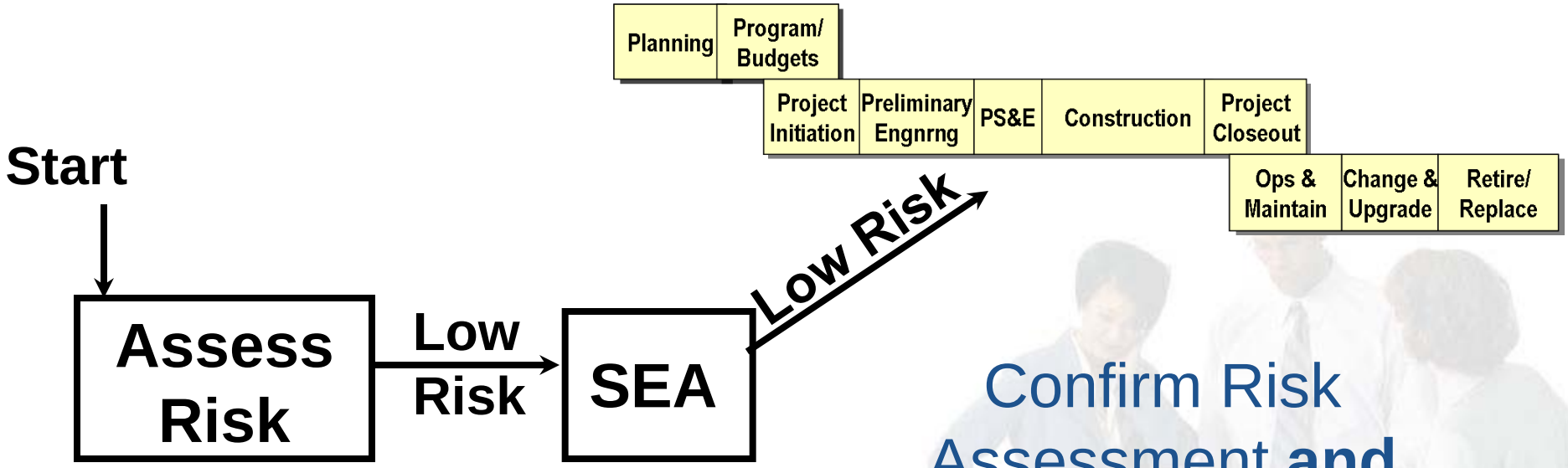
Example 1:
SEA for "Adding 4 Cameras" Project

SEA Requirement	Defined?
1. How project fits into regional architecture…	Yes
2. Roles/responsibilities of participants…….	Yes
3. Requirements definition……	Yes
4. Analysis of alternative systems & tech……..	Yes
5. Procurement options ……..	Yes
6. ITS standards and testing procedures ……..	Yes
7. Procedures and resources for O&M …….	Yes

All 7 items can be answered immediately; hence, this is likely a low-risk ITS project, and the Roadway Process and SEA can be used

Roadmap for Project Implementation

Low Risk ITS Projects



Determine Type of Project
- Preliminary Assessment -

Confirm Risk Assessment **and** document conformance to Final Rule

Example 2: SEA for "Sharing CCTV Control" Project

SEA Requirement	Defined?
1. How project fits into regional architecture…	Yes
2. Roles/responsibilities of participants…….	Maybe
3. Requirements definition……..	No
4. Analysis of alternative systems & tech……..	Maybe
5. Procurement options ……..	Yes
6. ITS standards and testing procedures ……..	Yes
7. Procedures and resources for O&M ……	No

Some of the 7 items can *not* be answered immediately; hence, this is probably a higher-risk ITS project and the SE "V" should be used.

Roadmap for Project Implementation

Higher Risk ITS Projects

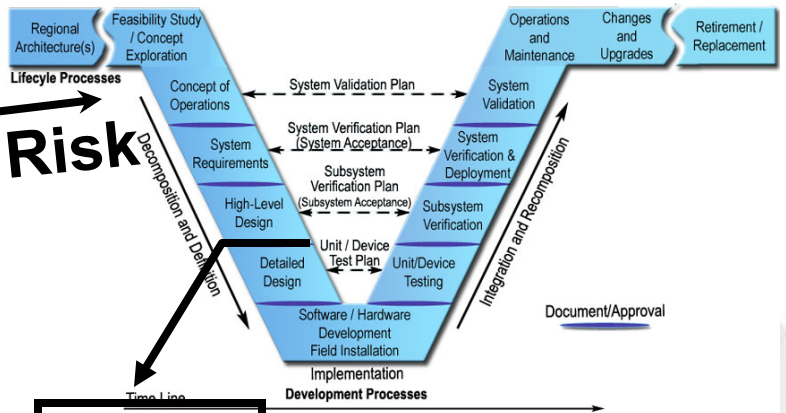
Start

Assess Risk

High Risk

SEA

High Risk



Preliminary Assessment

Confirm Risk Assessment

SEA

Document Conformance to Final Rule

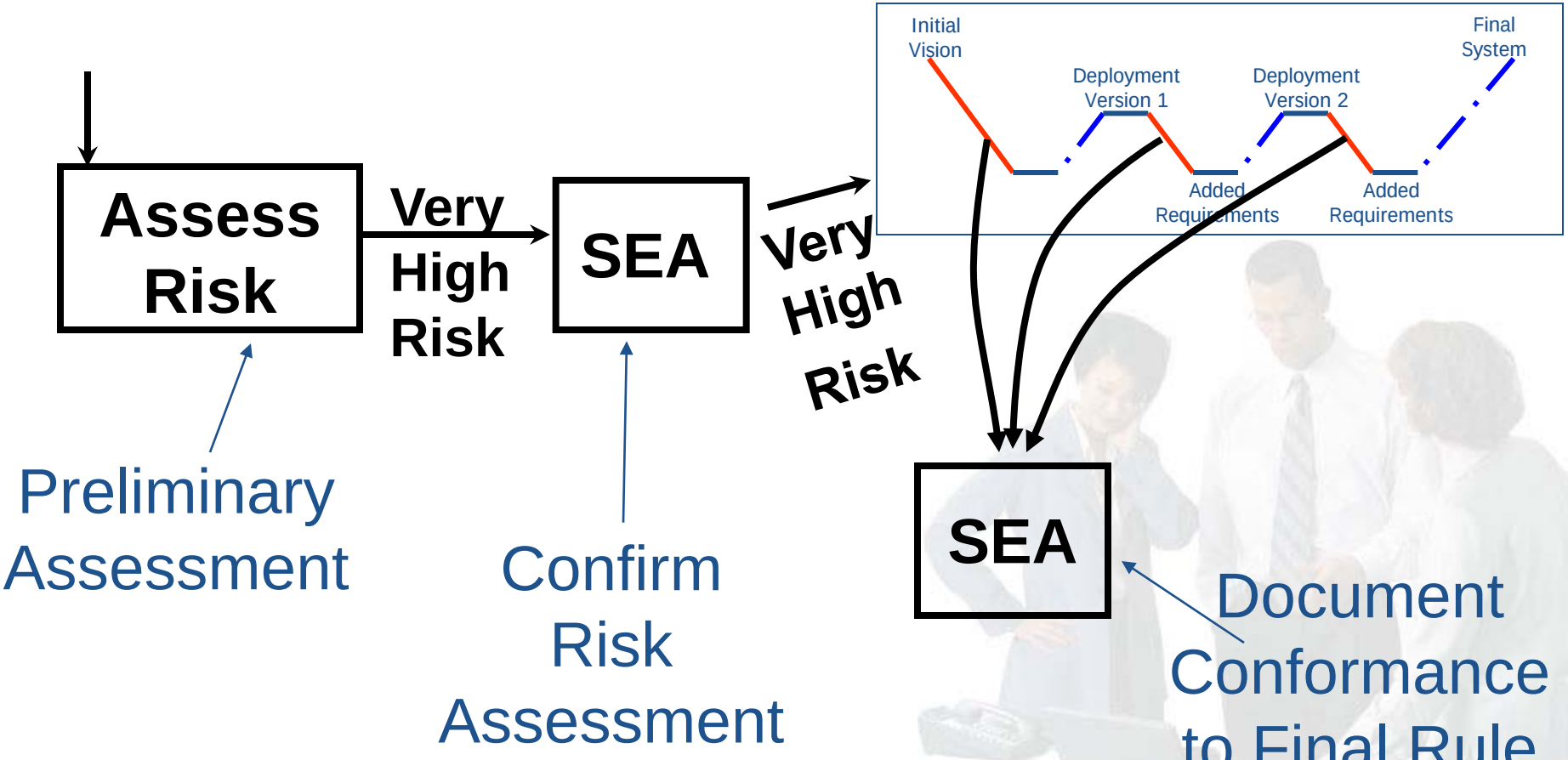
Example 3: SEA for Statewide "5-1-1" Project

	SEA Requirement	Defined?
1.	How project fits into regional architecture…	Maybe
2.	Roles/responsibilities of participants…….	No
3.	Requirements definition……..	No
4.	Analysis of alternative systems & tech……..	No
5.	Procurement options ……..	No
6.	ITS standards and testing procedures ……..	No
7.	Procedures and resources for O&M ……	No

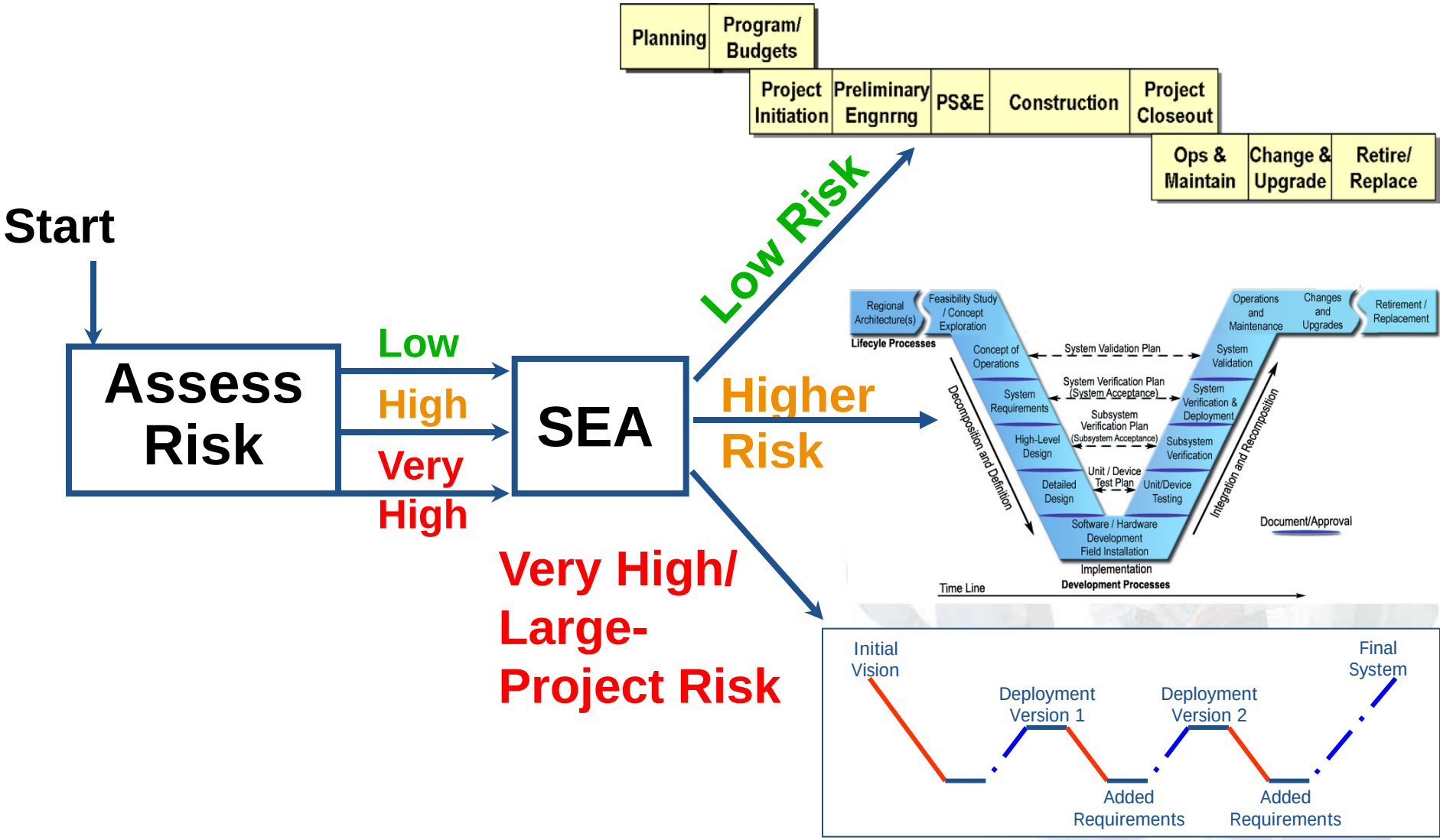
None of the 7 items can be answered immediately; hence, this is probably a very-high-risk ITS project and an evolutionary development strategy should be used.

Roadmap for Project Implementation

Very-High-Risk ITS Projects



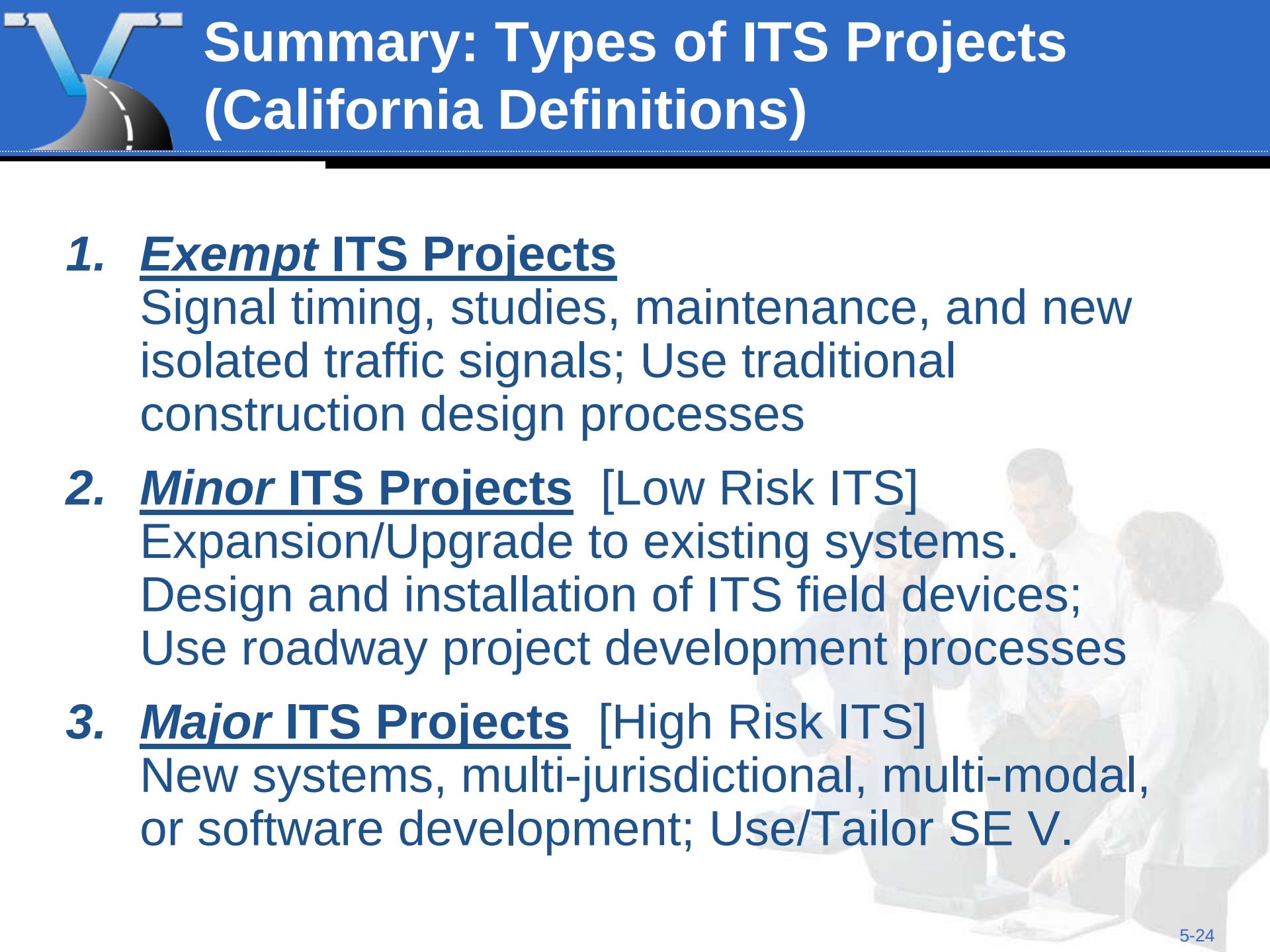
Summary: Roadmap for Project Implementation



State DOT Examples of Documented Processes

Summary: Types of ITS Projects (California Definitions)

1. ***Exempt* ITS Projects**
   Signal timing, studies, maintenance, and new isolated traffic signals; Use traditional construction design processes
2. ***Minor* ITS Projects** [Low Risk ITS]
   Expansion/Upgrade to existing systems. Design and installation of ITS field devices; Use roadway project development processes
3. ***Major* ITS Projects** [High Risk ITS]
   New systems, multi-jurisdictional, multi-modal, or software development; Use/Tailor SE V.



Roadmap to S.E. Compliance (California)

Start

Classify Project

Minor

Major

Exempt

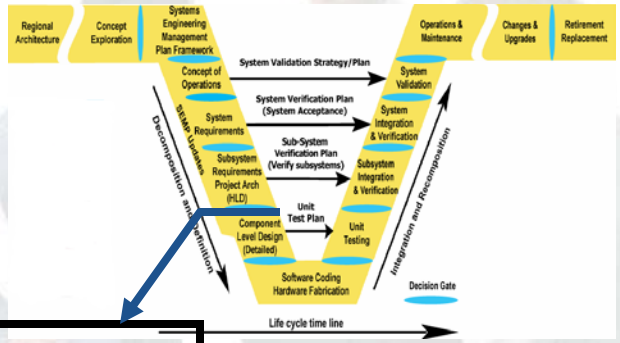
SERF

Minor

Major

Typical Infrastructure Project

Planning → Environment → Design (PS&E) → Construction/ Installation → Operations & Maintenance



SEMP

<u>Preliminary</u> decisions made during TIP programming and Concept Exploration

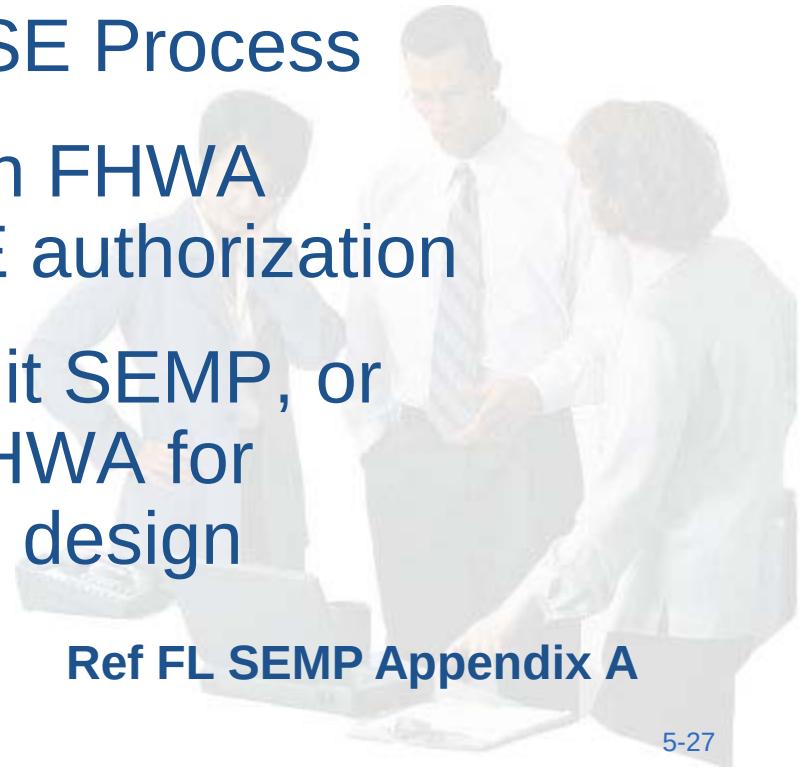
Florida SunGuide ITS Checklist Process Steps

1. Arch Scope & Region
2. Key Agency Providers
3. Agreements
4. ConOps
5. Requirements
6. Interfaces / Info Flows
7. Analyze Alternatives
8. Procurement Options
9. Schedule
10. Standards
11. Maint./Ops. Plan
12. Acceptance Test Plan
13. Config. Mgmt. Plan

Ref FL SEMP Appendix A

Florida SunGuide ITS Checklist Process Steps

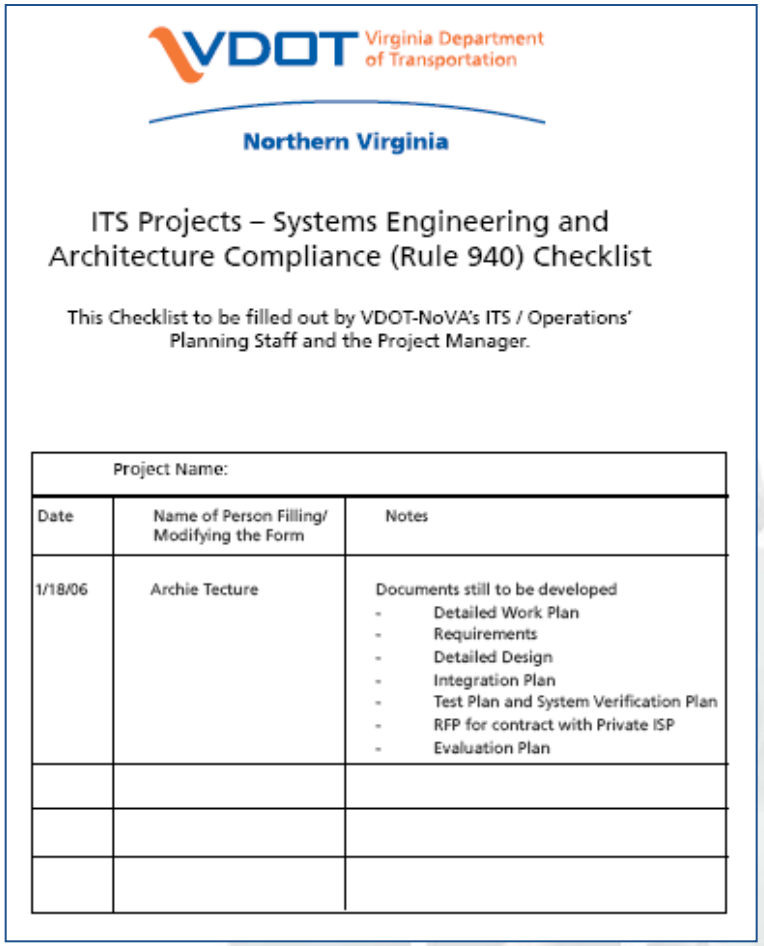
- Assess completeness of the applicable items of the SEMP
- Acknowledge a commitment to address items during early stages of the SE Process
- For all ITS projects – obtain FHWA review/approval prior to PE authorization
- For all ITS projects – submit SEMP, or equivalent document, to FHWA for review/approval of detailed design



Ref FL SEMP Appendix A

Virginia DOT SE and Architecture Compliance

- User Guide for SE and ITS Architecture
  - Explains VDOT processes and incorporation of SE and Architecture
  - Checklists guide user through compliance process



VDOT Virginia Department of Transportation

Northern Virginia

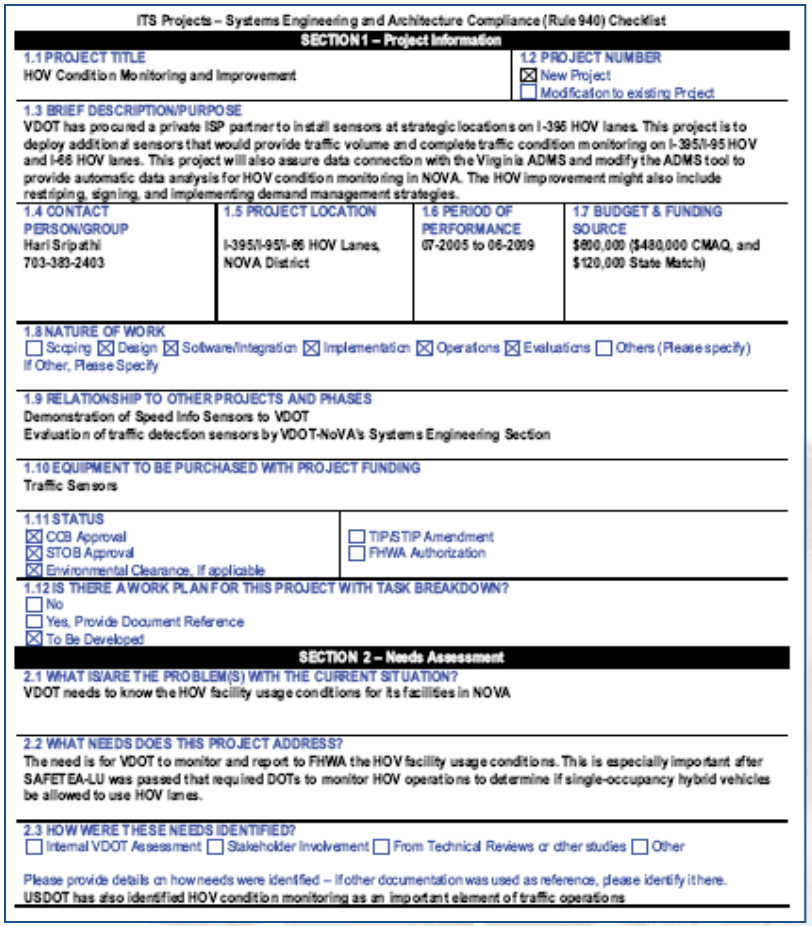
ITS Projects – Systems Engineering and Architecture Compliance (Rule 940) Checklist

This Checklist to be filled out by VDOT-NoVA's ITS / Operations' Planning Staff and the Project Manager.

Project Name:		
Date	Name of Person Filling/ Modifying the Form	Notes
1/18/06	Archie Tecture	Documents still to be developed - Detailed Work Plan - Requirements - Detailed Design - Integration Plan - Test Plan and System Verification Plan - RFP for contract with Private ISP - Evaluation Plan

Virginia DOT SE and Architecture Compliance

- VDOT Checklist collects information for each step of the systems engineering process, through acknowledgement and references



ITS Projects – Systems Engineering and Architecture Compliance (Rule 940) Checklist

SECTION 1 – Project Information

1.1 PROJECT TITLE
HOV Condition Monitoring and Improvement

1.2 PROJECT NUMBER
☒ New Project
☐ Modification to existing Project

1.3 BRIEF DESCRIPTION/PURPOSE
VDOT has procured a private ISP partner to install sensors at strategic locations on I-395 HOV lanes. This project is to deploy additional sensors that would provide traffic volume and complete traffic condition monitoring on I-395/I-95 HOV and I-66 HOV lanes. This project will also assure data connection with the Virginia ADMS and modify the ADMS tool to provide automatic data analysis for HOV condition monitoring in NOVA. The HOV improvement might also include restriping, signing, and implementing demand management strategies.

1.4 CONTACT PERSON/GROUP	1.5 PROJECT LOCATION	1.6 PERIOD OF PERFORMANCE	1.7 BUDGET & FUNDING SOURCE
Hari Sripathi 703-383-2403	I-395/I-95/I-66 HOV Lanes, NOVA District	07-2005 to 06-2009	$600,000 ($480,000 CMAQ, and $120,000 State Match)

1.8 NATURE OF WORK
☐ Scoping ☒ Design ☒ Software/Integration ☒ Implementation ☒ Operations ☒ Evaluations ☐ Others (Please specify)
If Other, Please Specify

1.9 RELATIONSHIP TO OTHER PROJECTS AND PHASES
Demonstration of Speed Info Sensors to VDOT
Evaluation of traffic detection sensors by VDOT-NoVA's Systems Engineering Section

1.10 EQUIPMENT TO BE PURCHASED WITH PROJECT FUNDING
Traffic Sensors

1.11 STATUS
☒ COB Approval
☒ STOB Approval
☒ Environmental Clearance, If applicable
☐ TIP/STIP Amendment
☐ FHWA Authorization

1.12 IS THERE A WORK PLAN FOR THIS PROJECT WITH TASK BREAKDOWN?
☐ No
☐ Yes, Provide Document Reference
☒ To Be Developed

SECTION 2 – Needs Assessment

2.1 WHAT IS/ARE THE PROBLEM(S) WITH THE CURRENT SITUATION?
VDOT needs to know the HOV facility usage conditions for its facilities in NOVA

2.2 WHAT NEEDS DOES THIS PROJECT ADDRESS?
The need is for VDOT to monitor and report to FHWA the HOV facility usage conditions. This is especially important after SAFETEA-LU was passed that required DOTs to monitor HOV operations to determine if single-occupancy hybrid vehicles be allowed to use HOV lanes.

2.3 HOW WERE THESE NEEDS IDENTIFIED?
☐ Internal VDOT Assessment ☐ Stakeholder Involvement ☐ From Technical Reviews or other studies ☐ Other

Please provide details on how needs were identified – If other documentation was used as reference, please identify it here.
USDOT has also identified HOV condition monitoring as an important element of traffic operations

Checklist at www.vdot-itsarch.com/nova/docs/rule940checklist.doc

How Do We Manage the SE Technical Development?

Systems Engineering Management Plan (SEMP)

- Documents how the technical development will be managed and what needs to be documented
- Details how the process will be tailored and development will be done
- Explains how the process activities will be brought together
- Should be closely synchronized with Project Plan to avoid unnecessary duplication
  - System planning activities (i.e., WBS, training, constraints, decision points)

SEMP Template and Checklist in CA SEGB, Sec. 8.4.2

SEMP Technical Documents

Project's unique characteristics will dictate need

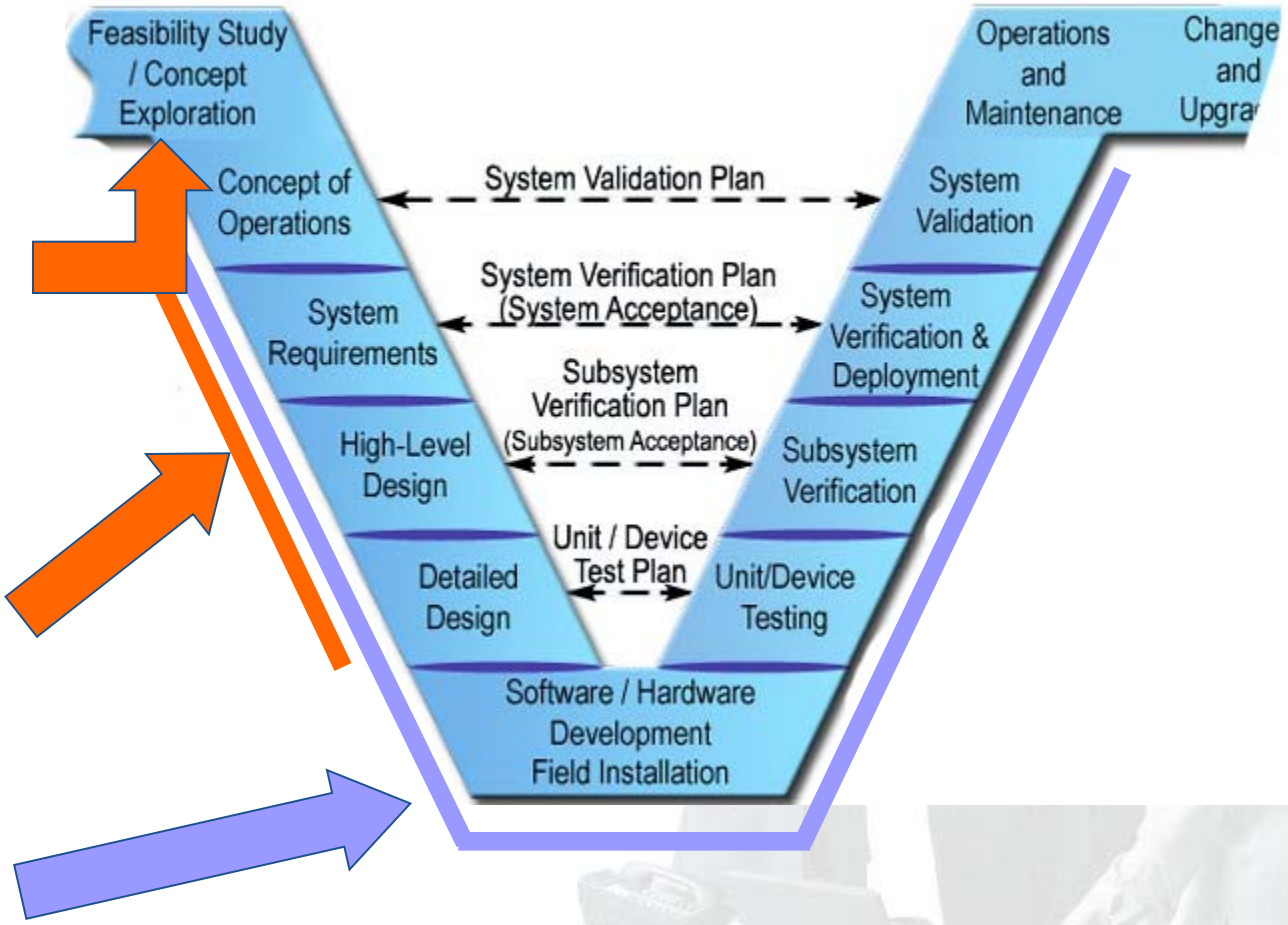
- Technical Review
- Interface Control
- Stakeholders' Cooperation
- Resource Management
- Verification
- Validation
- Configuration Management
- Risk Management
- Technology
- SW/HW Development
- System Integration
- Deployment
- Operations & Maintenance
- Training
- Security
- Safety
- Quality Assurance

SEMP Development Stages

SEMP milestones formalized between Agency and contractor(s)

SEMP Plans developed, delivered, and approved

SEMP Plans used during project implementation



Recall: Benefits of Using SE "V" Process

A few highlights…

Reg. Arch. – Nothing/nobody gets overlooked

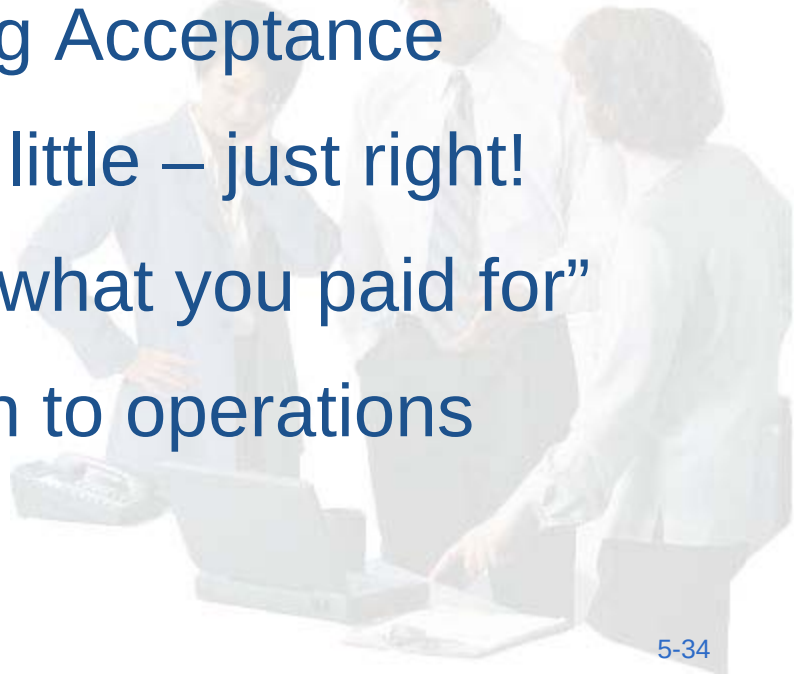
ConOps – Manage expectations, avoid surprises

Reqmts. – Avoid disputes during Acceptance

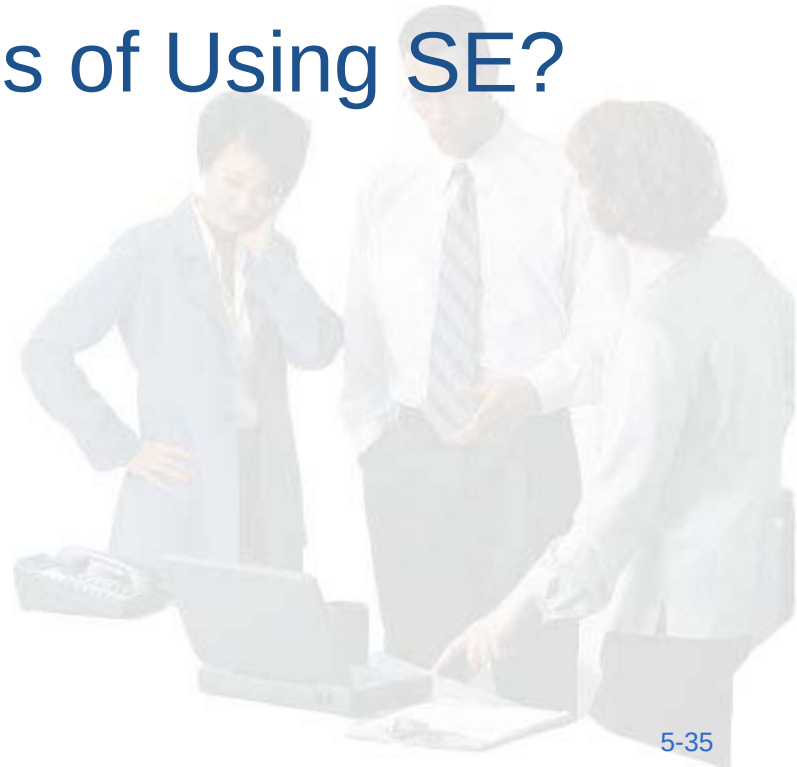
Design – Not too much, not too little – just right!

Verification – Ensures "you got what you paid for"

Deployment – Smooth transition to operations



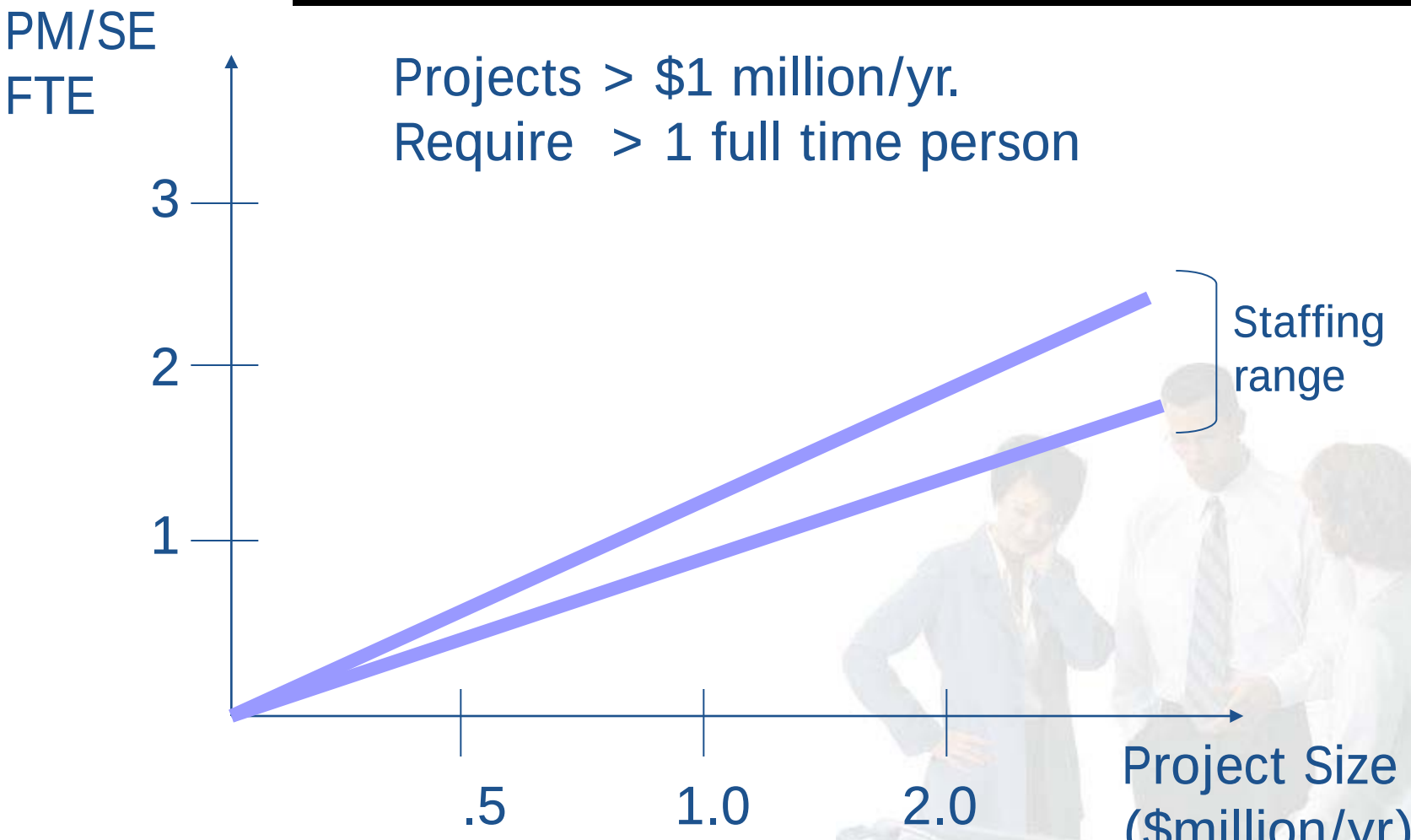
What are the Challenges of Using SE?



Challenges of Using SE

- Time and Skills
  - Assigning Adequate Staff
  - Knowledge of SE Process and SE Management
  - Integrating SE into current project delivery process
- Contracts & Procurement
  - Using best form of contracting
- Selection of Qualified Consultants
  - Determining contractor qualifications

Good Project Management Takes Lots of Time!



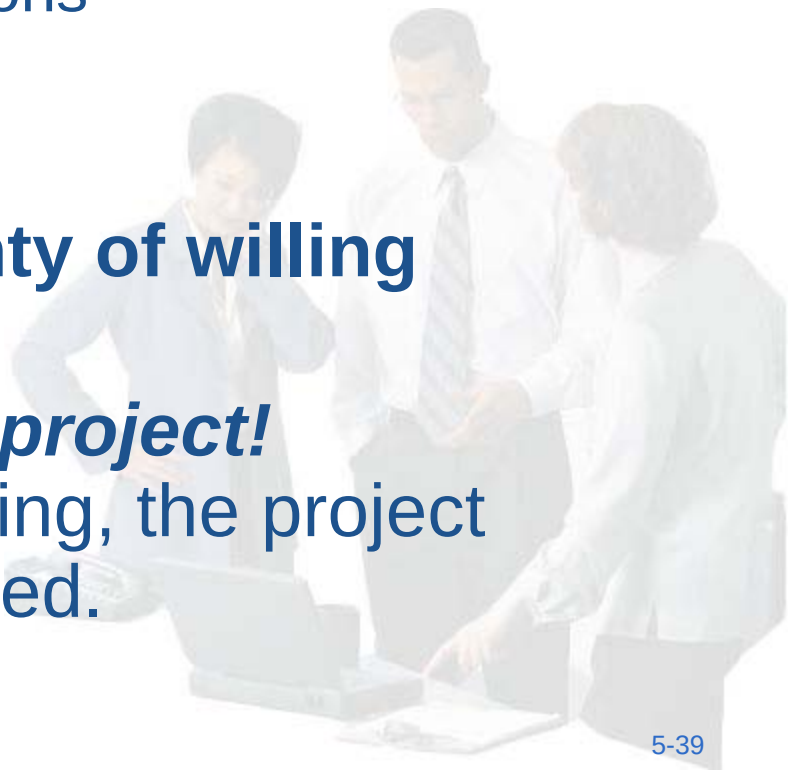
Why Is So Much Staff Time Needed?

1. Develop RFP
2. Contract negotiations
3. Conduct risk analysis
4. Requirements walk-thru
5. Internal coordination
6. Document activities
7. Review documentation
8. Inspect work
8. Review deliverables
9. Acceptance tests
10. Lead project meetings
11. Contract management
12. Review invoices
13. Coord. stakeholders
14. Contribute to website
15. … and more …

Which of these is **NOT** necessary?

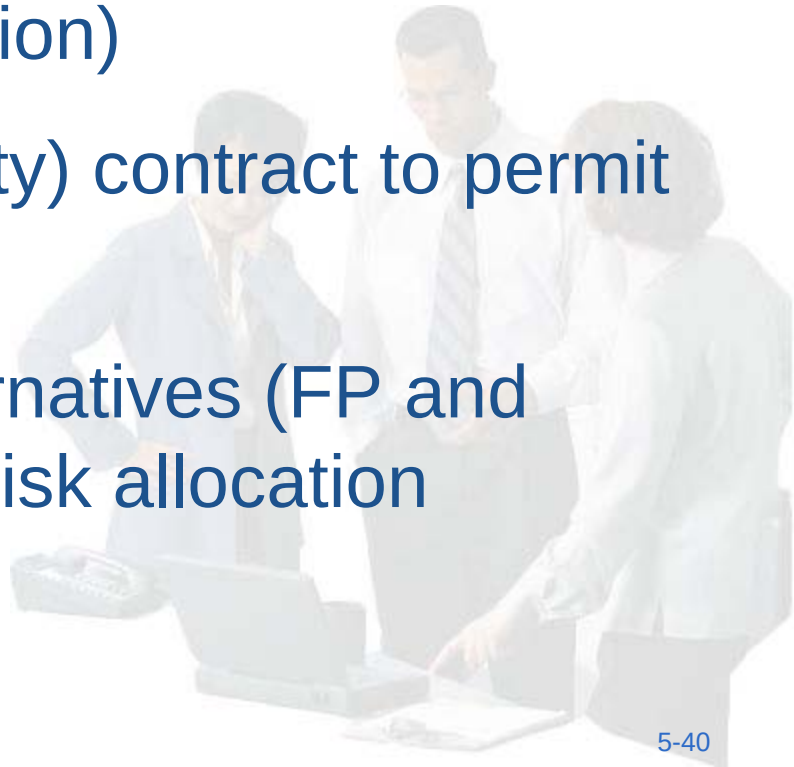
If Your Agency Can't Commit the Staff Time …

- **Supplementary staff are available:**
  - Consultants
  - Universities
  - Not-for-profit organizations
  - USDOT
  - Peers
- **Just ask, there's plenty of willing help out there**
- ***Or do not initiate the project!***
  Without adequate staffing, the project will probably not succeed.



Contracting Should Include…

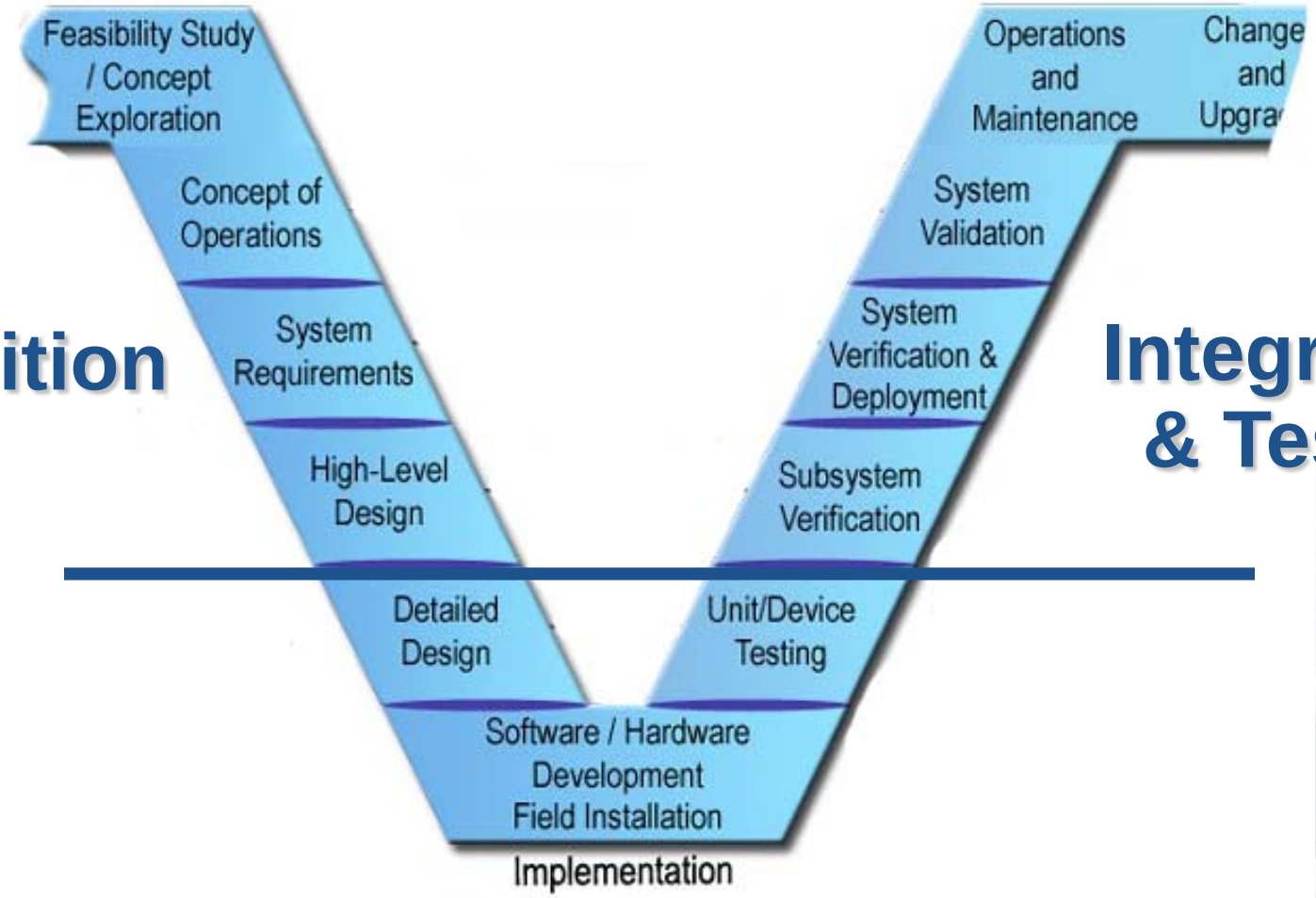
- Contractor participation as early in the development process as possible
- Contractor selection that requires appropriate IT development skills (certification)
- Task order (indefinite quantity) contract to permit use of evolutionary process
- Multiple reimbursement alternatives (FP and T&M) to permit appropriate risk allocation



Choosing the Right Contracting Approach

http://www.citeconsortium.org/Model/index.htm

Contractor Roles Vary Across the Three Phases of the "V" Process

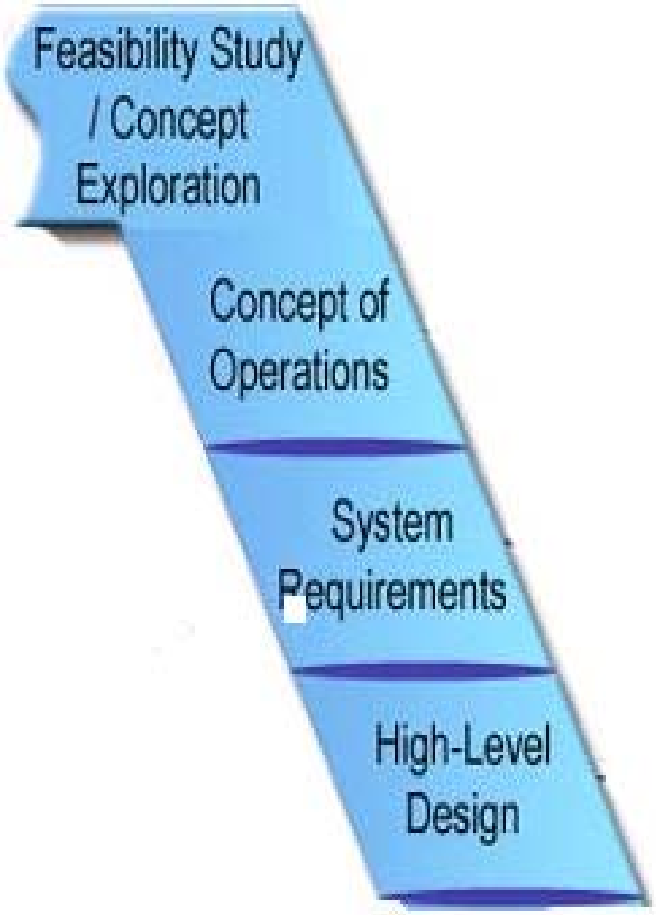


Definition

Integrate & Test

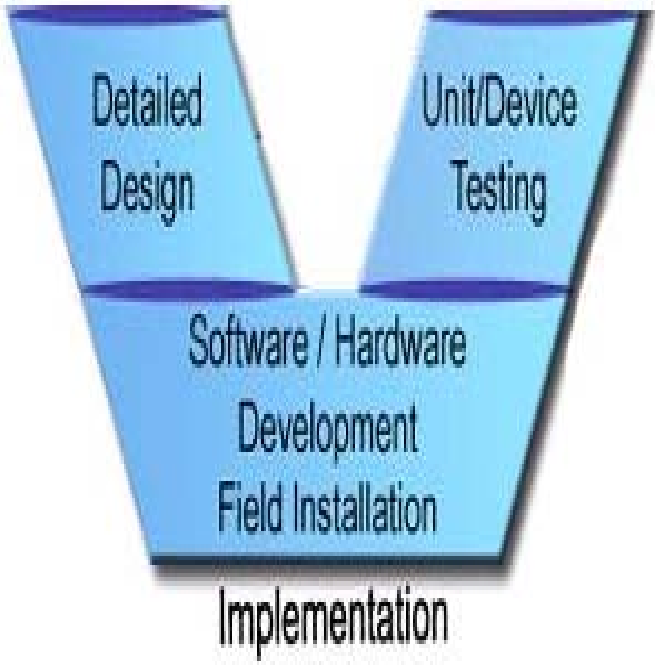
Implementation

Roles and Responsibilities in the *Definition* Phase



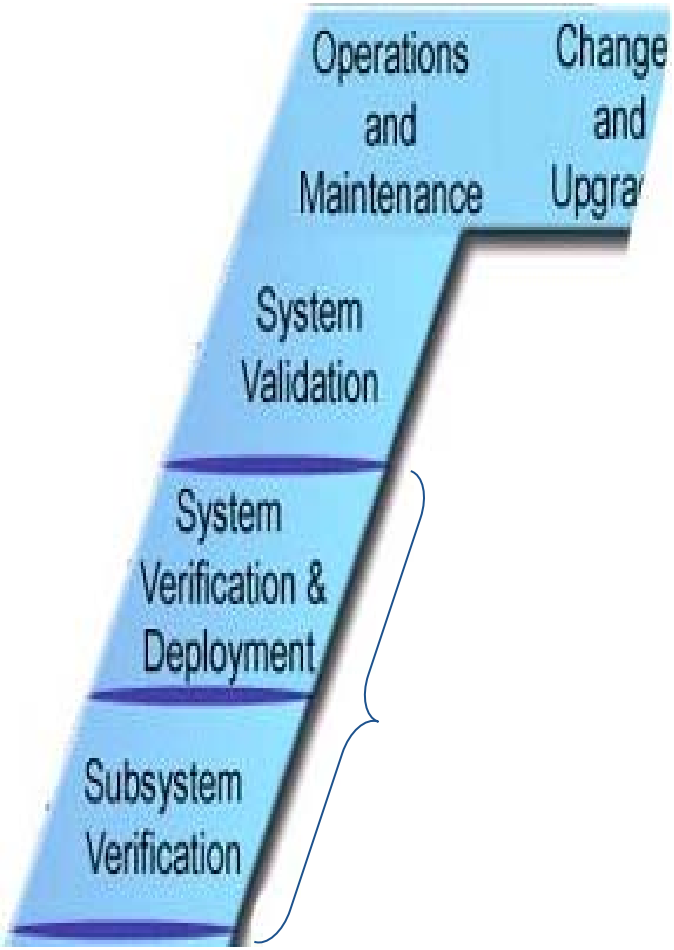
Role	Action	Activity
Owner/ Agency	Review Participate Approve	Needs, Vision, Constraints, Eval Plan, Agreements, Resources
System Engineer (SE)	Identify Prepare Document Support	Vision, Ops Scenarios, Requirements, Test Plans, Interfaces, High-Level Design
System Integrator (SI)	Review Comment	(No official role)

Roles and Responsibilities in the *Implementation* Phase



Role	Action	Activity
Owner/ Agency	Review Participate Approve	Tech Reviews, CM activities, Product Reviews, Detailed Design, SI RFP
System Engineer (SE)	Support Participate Review Report	SI Eval, Product Eval, Detailed Design, RM, Tech Plans
System Integrator (SI)	Identify Perform Document Implement	Tech Plans, CM, Development activities, Unit Test

Roles and Responsibilities in the *Integrate & Test* Phase



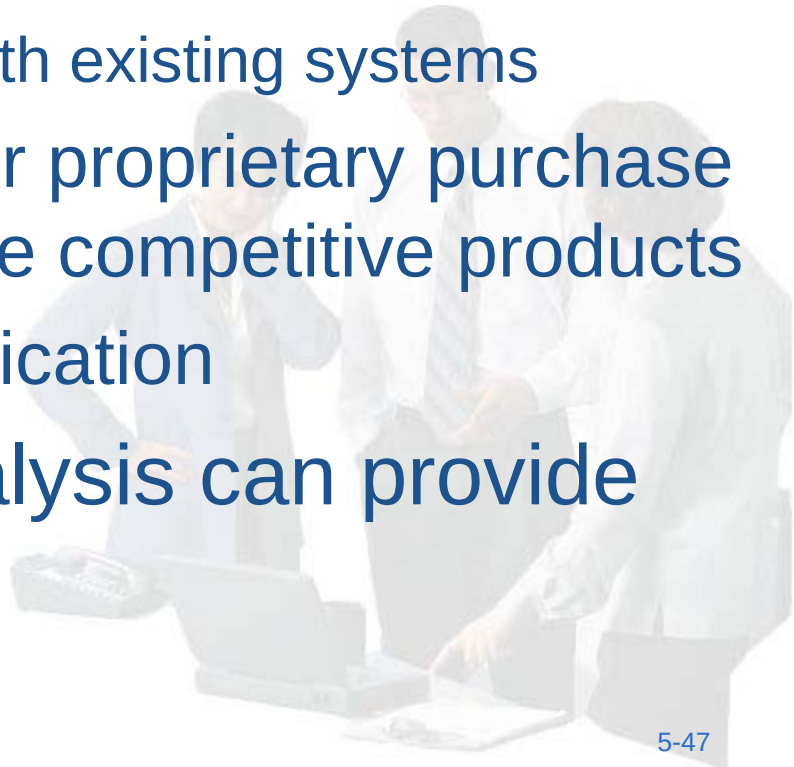
Role	Action	Activity
Owner/ Agency	Review Participate Approve	Integration Plan/ Support, Training, Test Plans/ Procedures
System Engineer (SE)	Support Participate Monitor Report	Integration reviews, Training, Test procedures, Tests, RM
System Integrator (SI)	Perform Document Implement	Integrate, Test, Resolve Defects, Verification, CM, RM

When You Are Hiring Consultants, SE Capabilities Can be Measured

- *Transportation Engineers* have certifications (PE, PTOE) to measure their level of expertise
- *Systems Engineers* have certifications for people (CSEP, PMP), and also for organizations (CMMI), to measure their level of expertise
- SE certifications for individuals and organizations should be evaluation criteria in ITS procurements
  - For CMMI info: http://www.sei.cmu.edu/cmmi/
  - For CSEP info: www.incose.org
  - For PMP info: www.pmi.org

A Last Word: Proprietary Acquisition

- Proprietary Materials (23 CFR 635.411)
  - **Certification** of no available competitive product
    - Uniquely fulfills the *requirements* imposed on the product
    - Achieves *synchronization* with existing systems
  - **Public Interest Finding** for proprietary purchase despite *alternative* available competitive products
  - Limited **experimental** application
- Systems Engineering Analysis can provide justification



Verify Learning Outcomes

Open-book quiz…

1. Give examples of some projects for which SE "V" process is needed
2. What are the items in SE Analysis?
3. What are the steps of the SE "V" process?
4. What are some benefits of using SE "V"?
5. What are challenges in using SE "V"?