ITS Joint Program Office

System Acceptance Overview

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January 26, 2010

Purpose

- Introduce the processes behind system acceptance
- Provide increased understanding of:
  - Testing stages and what constitutes system acceptance
  - Considerations for installation, training, maintenance and documentation
  - Full deployment
  - System evaluation/validation
- Provide list of resources

Outline of Presentation

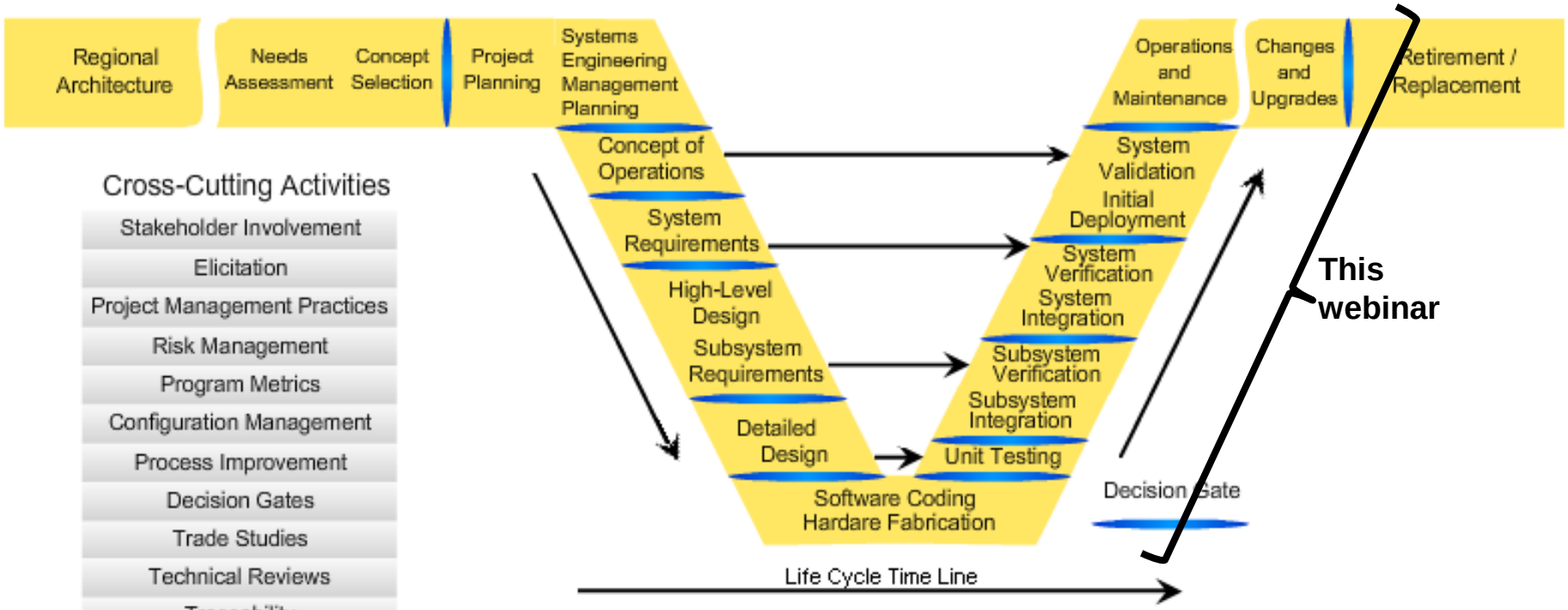
- Brief review of project management and system design
- Installation considerations
- Acceptance testing
- Training considerations
- Maintenance considerations
- Warranty requirements
- Full deployment
- System evaluation
- Resources

Corresponding Portions of the “V”

- System development and implementation:
  - Software and hardware development
  - Integration – installation, testing and documentation
  - Verification – testing and documentation
  - Initial deployment – testing, training and documentation
- Validation, Operations and Maintenance:
  - System validation – testing and burn-in, and system evaluation
  - Operations and maintenance – fully deployment, maintenance and warranty
  - Changes and upgrades

V-Diagram

Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement / Replacement



Cross-Cutting Activities

- Stakeholder Involvement
- Elicitation
- Project Management Practices
- Risk Management
- Program Metrics
- Configuration Management
- Process Improvement
- Decision Gates
- Trade Studies
- Technical Reviews
- Traceability

Source: US DOT

Review of Project Management

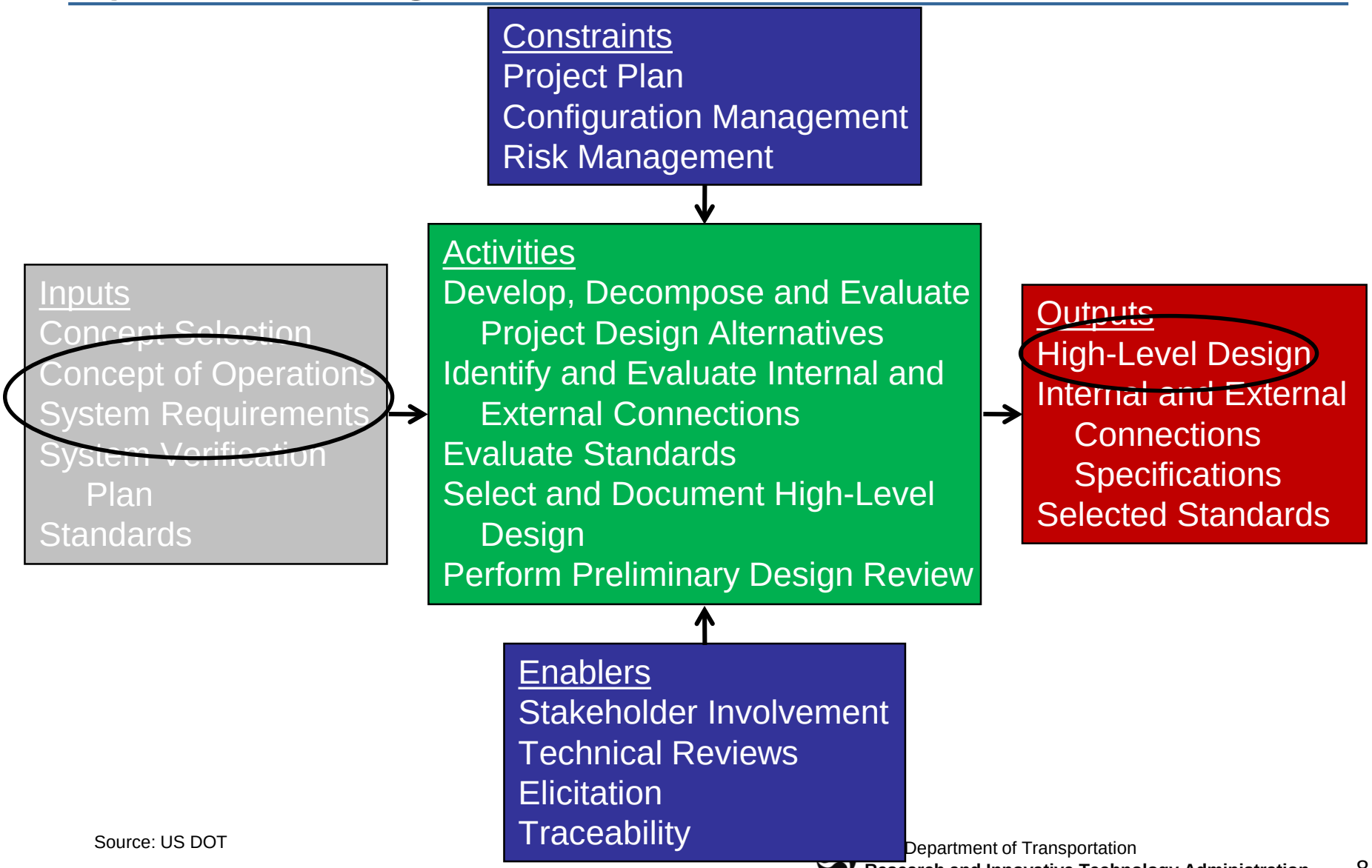
- Project Management Overview:
  - Lifecycle
  - Processes
  - Practices
- Project Planning
- Project Monitoring and Control
- Scope Management
- Other Crosscutting Activities:
  - Risk management
  - Communications management
  - Quality assurance/control

Source: US DOT

Review of System Design

- Move from WHAT system does to HOW system will be implemented
- Breakdown requirements into alternative system designs
- Evaluate designs according to:
  - Performance
  - Functionality
  - Cost
  - Other technical and non-technical issues, such as:
    - Risk
    - “Uniqueness” – indicating level of customization
    - Number of users

System Design Process



Source: US DOT

Two Levels of Design

- High-level design - Process of defining:
  - Hardware
  - Software
  - Connections to other systems
- Detailed design:
  - Defining HOW components developed to meet requirements
  - Performed by vendor/systems integrator
- Should consider previous design experience with similar systems:
  - What worked
  - What did not work

Key Detailed Design Steps

- Requirements review (RR)
- Preliminary design review (PDR)
- Critical (or final) design review (CDR)
- PDR and CDR intended to reduce chance of any misunderstandings on design intent or interpretation of contract requirements
- PDR and CDR do not alter need for successful formal demonstration of each requirement through Acceptance Testing process

Requirements Review (RR)

- As part of project kickoff with vendor
- Initializes Requirements Matrix (RM) (from system specifications)
- Vendor uses RM to produce draft Design Document for conducting Preliminary Design Review (PDR)
- RR meeting discusses, for each requirement:
  - Agency's design intent
  - Intended vendor design approach
  - General vendor approach to demonstration through the acceptance testing process
- Baseline RM prepared after RR meeting

Preliminary Design Review (PDR)

- Vendor submits Preliminary Design Document (PDD):
  - Overview of the equipment, system and configuration proposed for implementation
  - Detailed technical documentation for each equipment item
  - Detailed technical documentation on all software, addressing:
    - Functions of each module
    - Format of all user interface screens
    - Format of all reports
    - Data fields to be included in all data exchange interfaces
    - Any other software aspects warranting advance agreement with agency prior to system customization/configuration
  - Table providing cross-references for each section of PDD to appropriate element of RM
- On-site meeting with vendor

Critical (or Final) Design Review

- Vendor updates PDD to prepare and submit Final Design Document (FDD)
- FDD includes:
  - Updated PDD incorporating agency feedback and comments
  - Final list of equipment to be procured
  - Final design and configurations of system including all customizations to be made
  - Updated table providing cross-references between sections in FDD and elements of the RM
- On-site meeting with vendor
- FDD finalized after CDR

Installation through Full Deployment

- Installation considerations
- Integration
- Testing
- Initial Deployment
- System Evaluation
- Operations and Maintenance
- Changes and Upgrades

Installation Considerations

- Preparation for installation including defining time of day, location(s), necessary equipment, safety, etc.
- May require vehicles, portions of dispatch center or other fixed end facilities, and/or track or guideway be taken out of service for periods of time
- May require drivers to reposition equipment for vendor
- Agency's internal work and applicable industry standards
- Applicable grant and/or lease provisions on agency's vehicles
- Consider applicable union agreements. May limit where installation can be done or prescribe who must do it

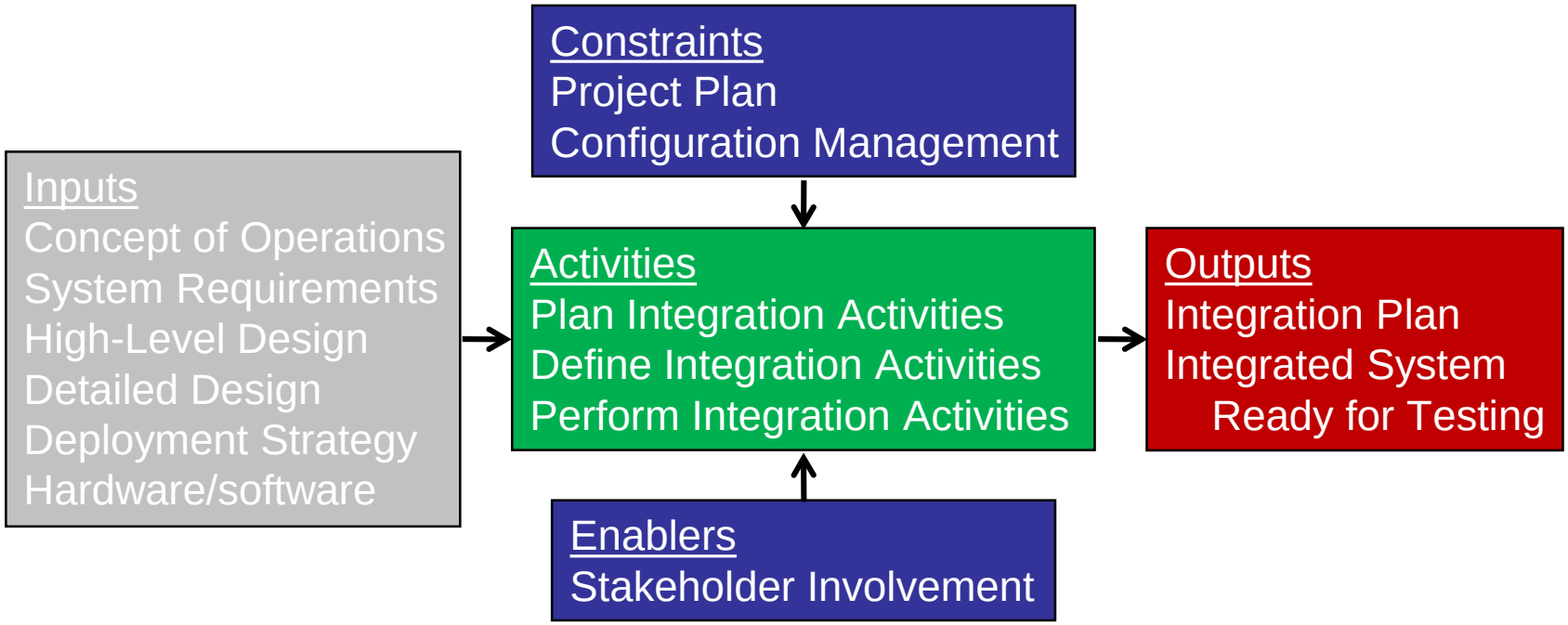
Installation Considerations (continued)

- Vendor submits Installation Design Document (IDD) for agency approval:
  - Text, drawings, illustrations and images for quality installation by technician without further training
  - Details on:
    - Equipment installation locations/mounting
    - Routing, conductors, color-coding, labeling, and connectors for power, communications and vehicle ground circuits
    - Connections with any required modifications to and restoration of existing infrastructure
    - Work area and equipment storage requirements
    - Methods and quality standards
    - Supervision and quality assurance procedures

Installation Management and Supervision

- Manage and monitor process through which vendor:
  - Determines where and how to install system components
  - Executes these installations
- Ensure all contractual and regulatory agency requirements are met
- Oversee vendor's preparation of plans and photo documentation for each installation type
- Refine schedule for fleetwide installation
- Provide quality control by observing initial installations, spot checking subsequent installations and periodically reviewing procedures with installers
- Review installation plans with maintenance

Integration Process

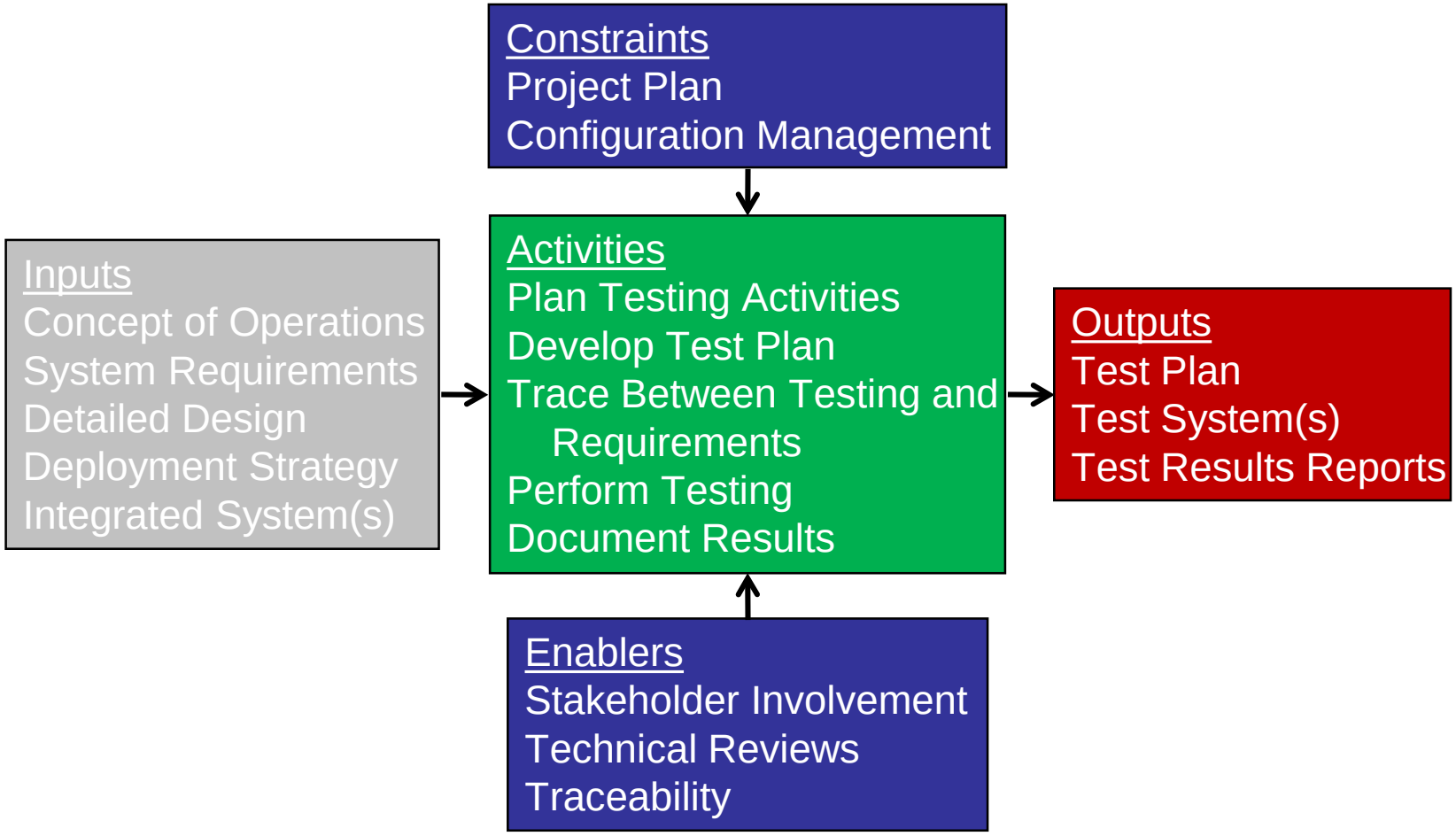


Source: US DOT

Integration Process

- Integration:
  - Forms hardware and software components into complete sub-systems
  - Combines subsystems into larger combined sub-systems
  - Combines all subsystems into final system
- Integration and testing closely linked processes - one follows the other until entire system ready for operational deployment
- Integration activities driven by:
  - System requirements
  - Internal interfaces within system
  - External interfaces to legacy systems and deployment strategy

Testing Process



Source: US DOT

Testing

- Testing (a.k.a. Verification) proves system meets requirements and matches design
- Planning for testing activities starts with Project Plan:
  - General structure of testing identified and compatible with desired deployment plan and system concept
  - Test Plans best written at same time as requirements developed - done to show that requirements can be verified
  - Test procedures developed after detailed design - detailed steps to be taken to verify each requirement and design element
  - Traceability - from each requirement, through Test Plan, to detailed step in test procedures

Testing (continued)

- Testing iterative:
  - Starts with integration activities
  - Progresses through system development to system test
  - Final testing for system acceptance done with installed system
- Testing answers “Was the system built ‘right’”
- After all testing, deployed system ready for operations

Acceptance Testing Phases

- Factory Acceptance Test (FAT) at vendor facility:
  - Test functionality of on-board/wayside equipment, central system software
  - Completed before equipment and software shipped to agency for installation
  - Deficiencies rectified before shipping to agency for installation
  - Witnessed by agency's representatives
- Installation/Pilot/Mini-Fleet Vehicle Test at Agency Facility:
  - Equipment installation on one vehicle of each type and central system installation
  - Field test with installed mini-fleet
  - Test all resolved issues from FAT

Acceptance Testing Phases (continued)

- System Test (ST):
  - Equipment installation rollout to complete fleet
  - Field test with complete fleet
  - Test all resolved issues since FAT
- For each test phase (FAT, IT and ST):
  - Agency team witnesses
  - Vendor documents test results
  - Vendor fixes all outstanding issues resulting from tests
  - Agency team updates RM
- 30 day Burn-in Test (BT)

Acceptance Test Procedures

- Vendor submits Acceptance Test Procedures document before any testing takes place
  - Agency must take active role in developing and reviewing document
- Acceptance Test Procedures address:
  - How each testable specification requirement will be demonstrated, including method for performing test
  - Results that constitute success for each test
  - Responsibilities of both vendor and agency's representatives during each test
  - Cross-reference to which requirements from RM are addressed by each test procedure

Acceptance Test Procedures (continued)

- Acceptance Test Procedures include:
  - Updated RM
  - Test stage at which each requirement will be demonstrated
  - Cross-reference to test procedure(s) that serve to address each requirement
- Acceptance Test Procedures incorporate distinct testing stages:
  - Factory Acceptance Testing (FAT)
  - Installation/Pilot/Mini-fleet Testing (IT)
  - System Testing (ST)
  - Burn-In Testing (BT)

Acceptance Test Procedures (concluded)

- Vendor prepares Test Results Documentation (TRD) after completing each testing stage:
  - Documents results of each ATP procedure
  - Provides updated RM indicating which requirements have been demonstrated
- TRD must be approved before agency grants system acceptance (SA)
- SA not granted until all requirements formally demonstrated
- RM used as “punch list” to track which requirements have not yet been demonstrated at each stage of testing

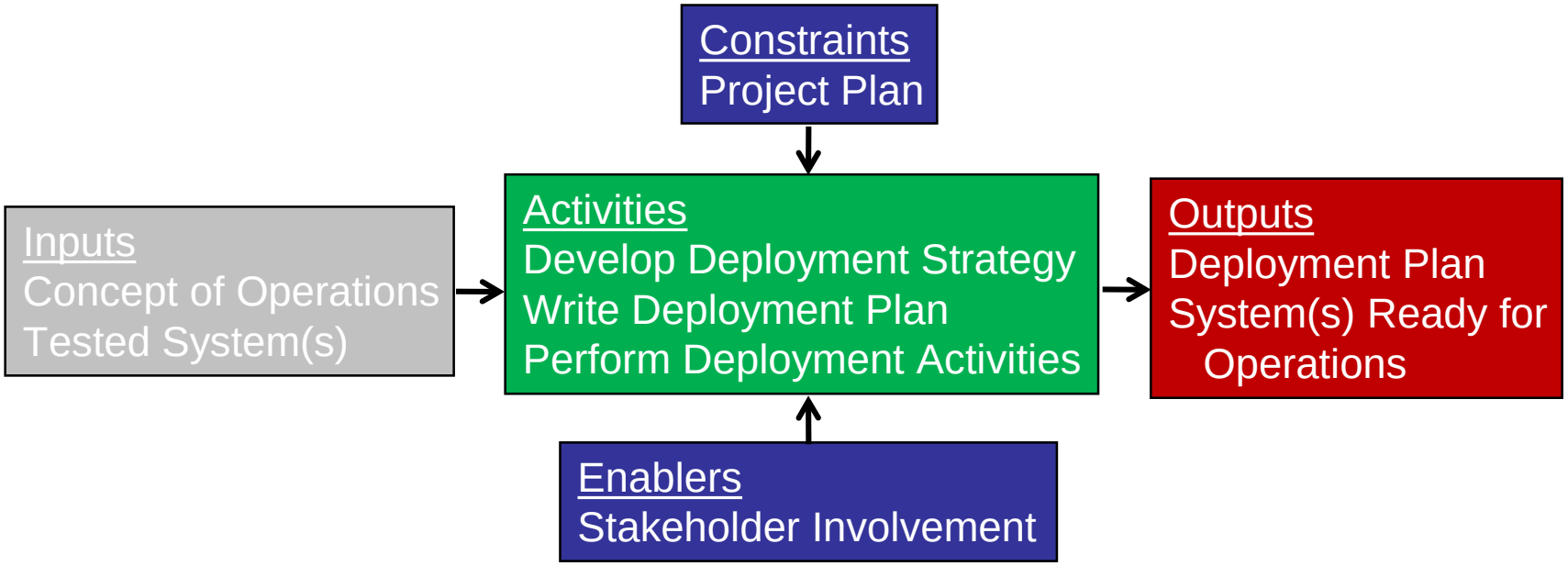
Parallel Testing

- Placing new technology, system and/or procedure in revenue service, while leaving existing one(s) in place
- Also used when technology alters existing data stream or information source, or creates new one
- Allows validation of new against old
- Impacts:
  - On driver or service as long as you are in test phase
  - Sometimes unearths what appear to be errors in new system, but eventually turn out to be bugs in old system which you never knew were there

Parallel Testing (continued)

- Where in the process:
  - May be integral part of acceptance testing; may continue after acceptance (parallel operation)
  - May be later in deployment strategy
  - In some cases, especially with revenue data, may go on for months
- Issues:
  - Increased cost
  - Driver or service impacts
  - Possibility your data has been wrong all along!
- Payoff is confidence in new system

Initial System Deployment Process



Source: US DOT

Initial System Deployment

- Final design/build step in system development
- Deployment Strategy:
  - Reflects Project Plan
  - Provides operationally useful component at each step of process and deployment location
  - May involve single deployment to single site, or multiple, partial deployments to multiple sites over extended period of time
- Deployment Plan:
  - May be necessary if multiple agencies involved
  - Defines all work steps for complete deployment, and who does them
  - Defines configuration, installation and testing hardware and software at each site

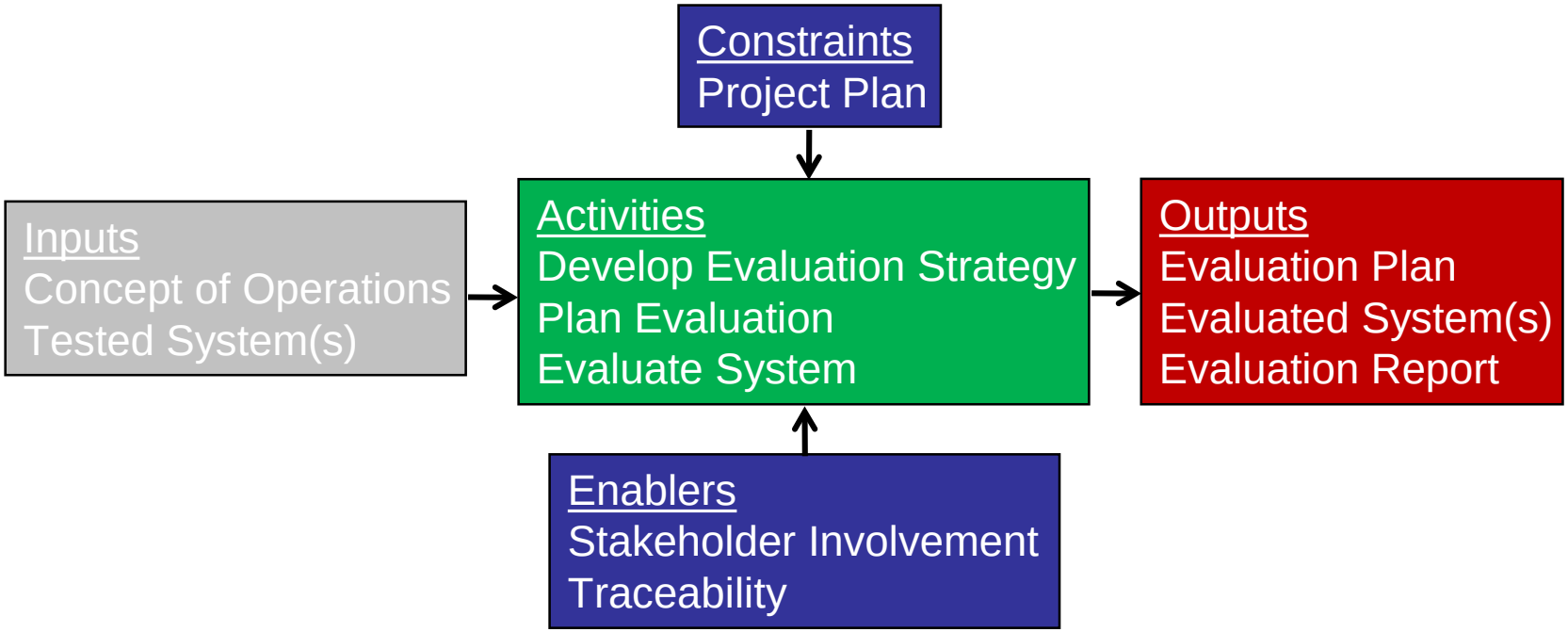
Deployment Activities

- Managing deployment same path as testing
- All needed resources identified, obtained, and trained:
  - All facilities [electrical, communications, lighting]
  - Personnel training for operations and maintenance
- Readiness of resources determined prior to start of each deployment step
- Work-around plans put into effect, if needed
- Progress of each deployment step monitored and reviewed with deployment team on regular basis
- Final step of deployment testing deployed system prior to operational acceptance

Training Considerations

- Vendor submits Training Plan and materials:
  - Training schedule and course outlines
  - Provided to agency for review
  - Must be approved before start of training
- Vendor provides brief refresher versions of each training course
- Vendor provides additional training to original trainees after SA if major modifications made to system

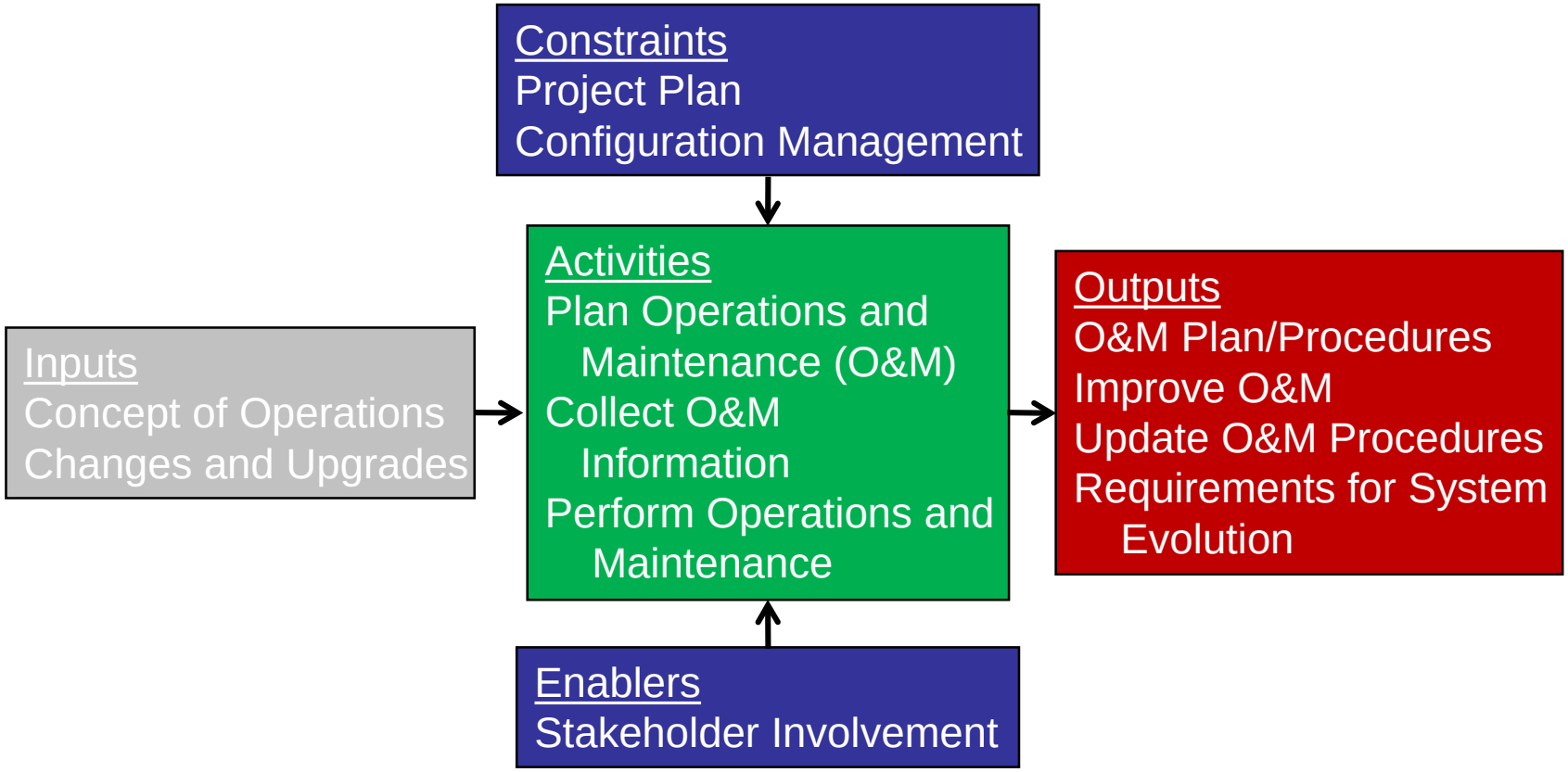
System Evaluation Process



System Evaluation

- System assessed against needs and requirements
- Evaluation process has three primary activities:
  - ***Planning*** who will be involved, what will be evaluated/validated, what is schedule for evaluation and where evaluation will take place
  - ***Evaluation strategy*** defines how evaluation will take place and what resources will be needed. For example, whether a before and/or an after study will be needed. If so, the before study will need to be done prior to deployment of the system
  - ***Perform evaluation*** after system accepted, system assessed based on planning and strategy, and results documented
- System's owner and stakeholders responsible for evaluation

Operations and Maintenance Process



Source: US DOT

Operations

- Operating system
- Monitoring system performance
- Making repairs
- Hiring and training operators
- Testing system after changes made
- Tuning system
- Preparing for system breakdowns
- Developing operational procedures when unscheduled events occur

Types of Maintenance

- Preventive maintenance: inspection and proactive actions, such as:
  - Cleaning
  - Replacement of components prior to end of their rated life
  - Backing up software
  - Storing data
  - Replacing components that have become obsolete and unsupported
- Reactive maintenance - correcting faults

Types of Maintenance (continued)

- Software maintenance:
  - Correcting malfunctions
  - Upgrading components that become obsolete and unsupported
  - Making minor modifications as needed to improve functionality

Maintenance Considerations and Warranty Requirements

- Spares: 15% - 25%
- Support: technical support for all hardware and software:
  - 24x7 support line
  - Providing, licensing, installing and integrating all released software patches and updates
  - Four-hour response, when needed, to assist with fault diagnosis or component replacement
- Warranty Requirements:
  - Period runs concurrently for all system components from date of their acceptance
  - Option to extend warranty period

Maintenance Issues

- In house vs. partial or total outsourcing
- Providing for software maintenance and customization
- Full life cycle analysis is key
- Including adequate spares in the bid
- Including new test equipment if needed
- Determine where maintenance performed and special considerations
- Identify changes to maintenance information system (if any)

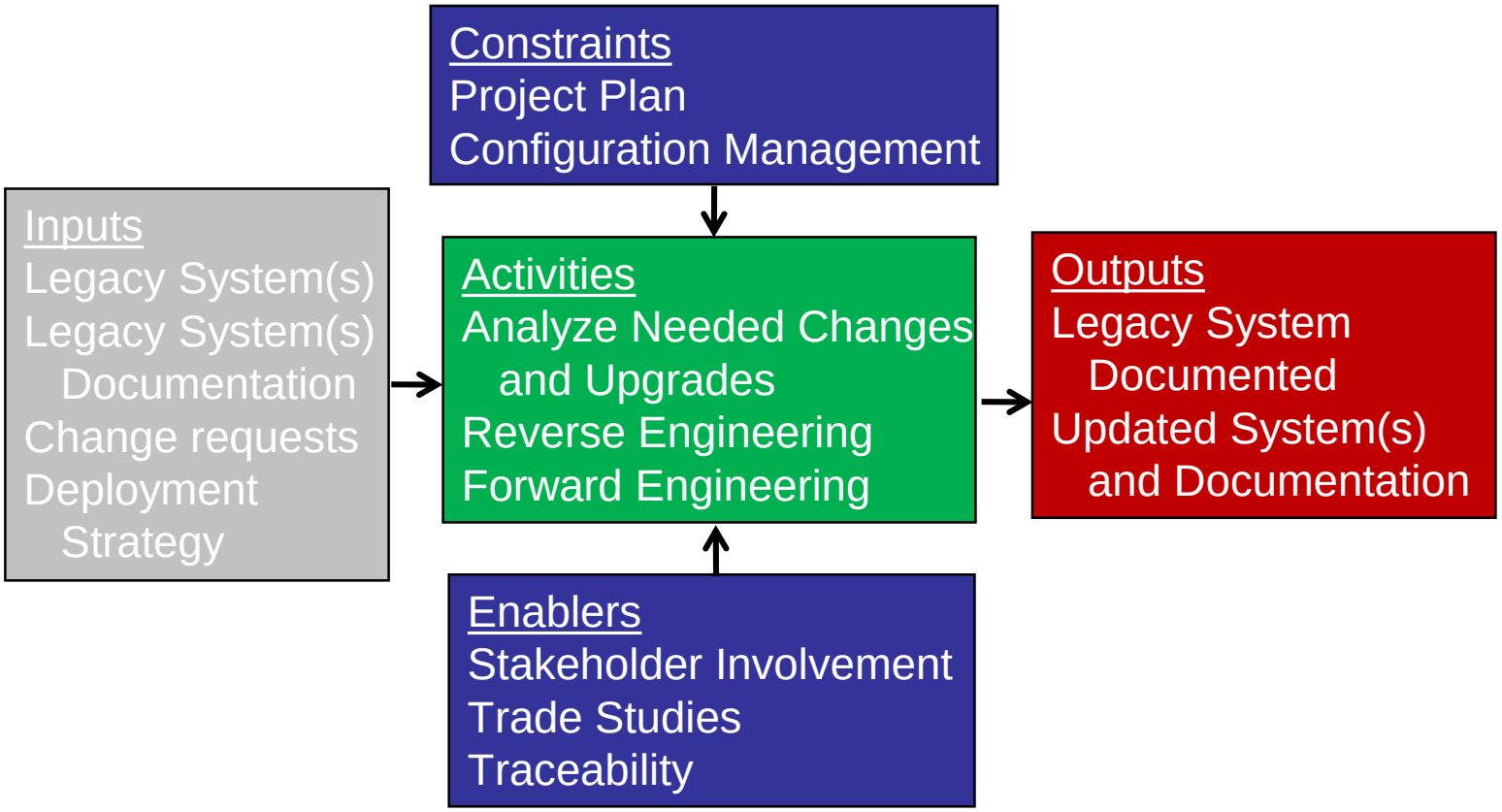
Maintenance Issues (continued)

- Estimate impact on maintenance schedules and vehicle availability
- Coverage/response time
- Long-term parts price guarantees

Maintenance Operations/Procedures Issues

- Modify daily, intermediate, long-term maintenance routines
- Modify functional areas and layouts in maintenance facilities
- Entry of new jobs and components into maintenance information system
- Modify operating rules and procedures re: maintenance
  - Event status of component failure
  - Mobile maintenance calls required?
- Modify vehicle inspection checklists and reports

Changes and Upgrades Process



Source: US DOT

Changes and Upgrades

- System evolves to keep pace with:
  - Changing needs
  - Advancing and changing technology
  - Added system capabilities
- Changes and upgrades performed in systematic way to maintain or establish system integrity
- Integrity: System's functional, performance, physical, and enabling products accurately documented by requirements, design and support specifications
- Changes & upgrades performed by any competent development team

Changes and Upgrades (continued)

- Addresses planned upgrades and those based on new stakeholder needs
- Guidance on implementing upgrades:
  - On system not well documented
  - On handling commercial-off-the-shelf (COTS) products and applications which may have:
    - Become obsolete
    - Changed in design
    - Aged beyond its contracted support life

Planning for System Upgrades

- What are typical reasons for upgrades?
- Upgrades can be provided for as optional future phases, and bids solicited
- Describe future phases regardless
- Participate in standards efforts
- Ask bidders to describe migration path to future phases
  - Approach logical & comprehensive?
  - Open systems solution?
  - Previous investments protected?
  - Using different vendors in future

Planning for System Upgrades (continued)

- Consider how you will decide whether to upgrade. What will it be contingent on?
- Provide for process you have identified in your procurement
- Consider that:
  - Technological advances are inevitable
  - Changes in operating and financial environment are too
  - Best we can do is to build in regular evaluation points to allow adjustments

Resources

- Rex Black, ***Managing the Testing Process: Practical Tools and Techniques for Managing Hardware and Software Testing***, Edition 3, 2009
- INCOSE Tools: http://www.incose.org/ProductsPubs/products/toolsdatabase.aspx
- System Development Methodology Guidebook, http://www.sba.gov/ocio/sdm/fram1.htm
- System Acceptance, Section III:5 of New York State Project Management Guidebook, http://www.oft.state.ny.us/pmmp/guidebook2/SystemAcceptance.pdf

Resources

- Systems Engineering for Intelligent Transportation Systems, Federal Highway Administration, http://ops.fhwa.dot.gov/publications/seitsguide/index.htm
- Systems Engineering Guidebook for ITS, Version 2.0, http://www.fhwa.dot.gov/cadiv/segb/
- Building Quality Intelligent Transportation Systems Through Systems Engineering, http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13620.html
- Systems Engineering: Lessons Learned, http://www.itslessons.its.dot.gov/its/benecost.nsf/LessonSystemsEng