Intelligent Transportation Systems
U.S. Department of Transportation

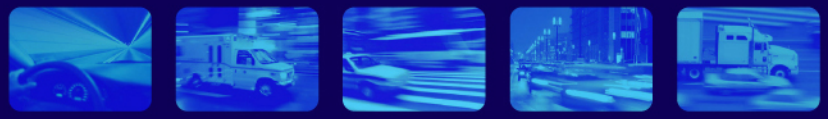
System Design Overview

Sponsored by:

US Department of Transportation

Presented by:

Carol L. Schweiger, Vice President,
TranSystems Corporation

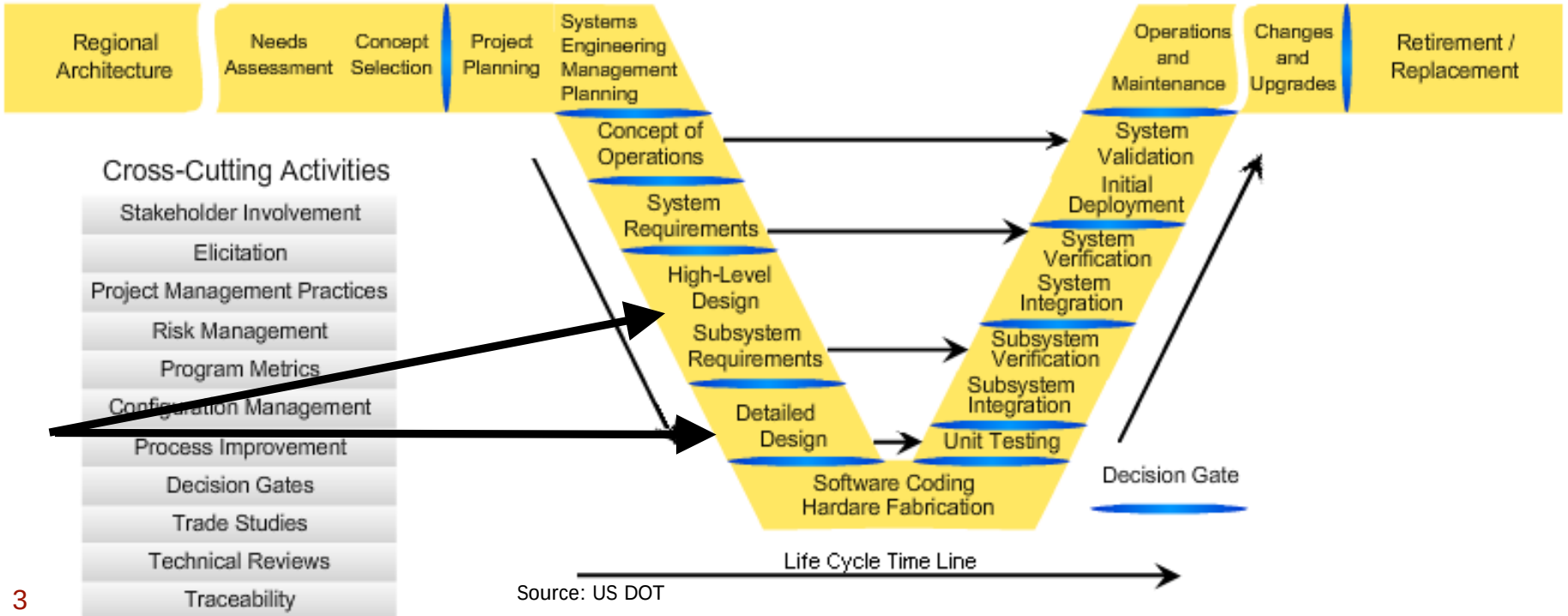


Purpose

- Introduce thought processes behind system design
- Provide increased understanding of:
  - Developing and evaluating system alternatives
  - Identifying and evaluating connections with internal and external systems
  - Selecting and documenting high-level design
- Provide examples
- Provide list of resources

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



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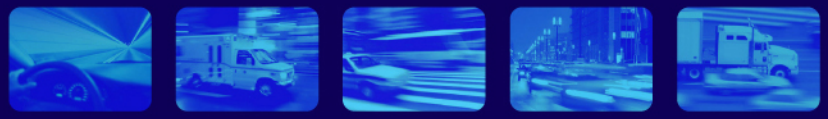
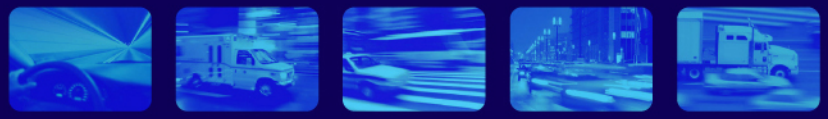


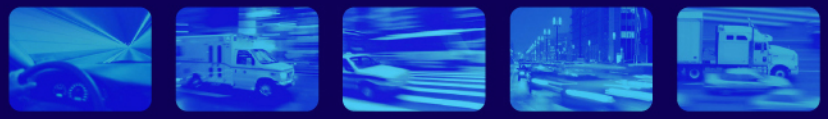
Outline of Presentation

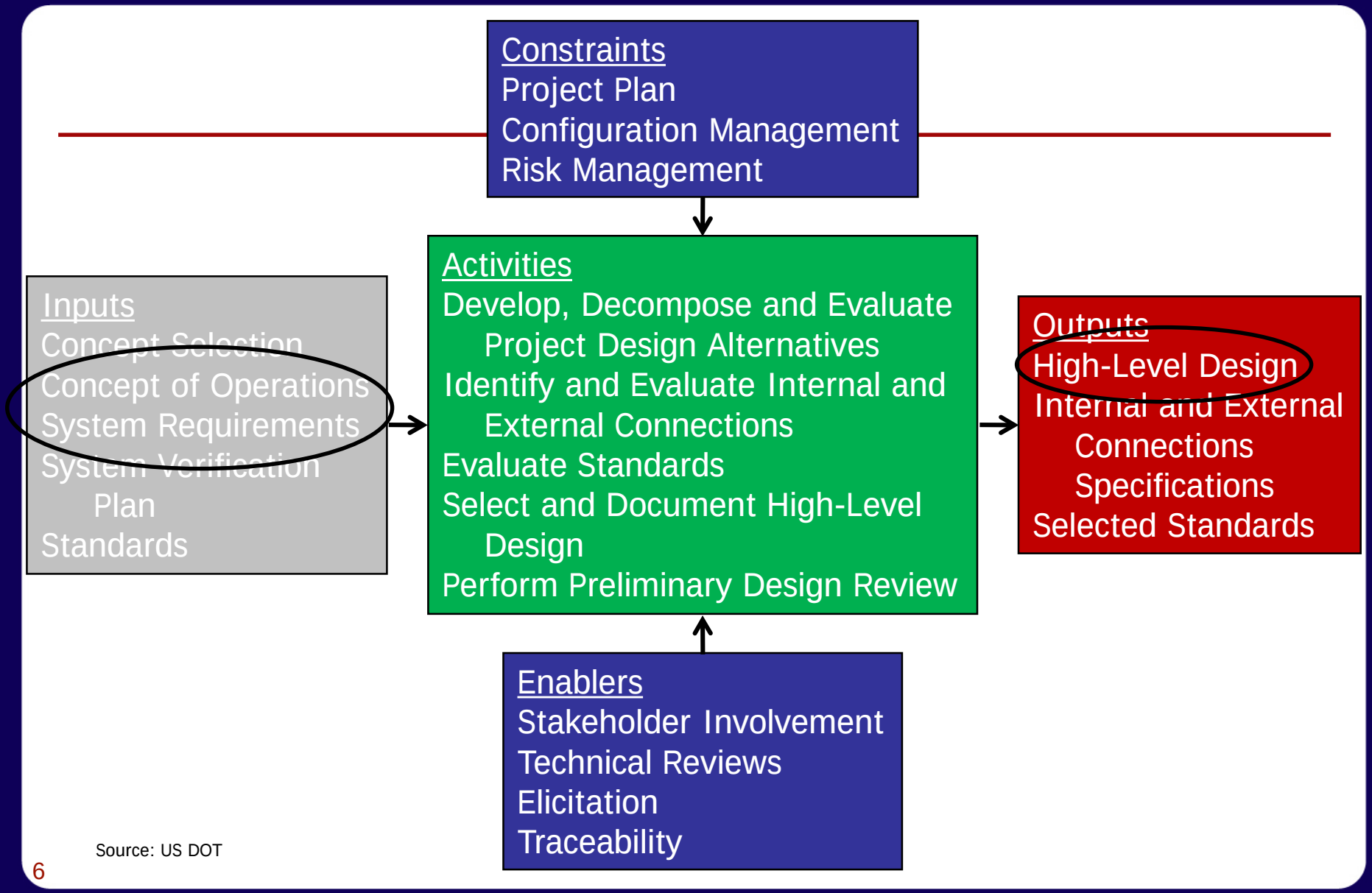
- Introduction
- Develop and evaluate design alternatives
- Analyze and allocate requirements
- Identify and evaluate internal and external connections
- Evaluate standards
- Select and document high-level design
- Perform preliminary design review
- Resources



Basic Concepts

- 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





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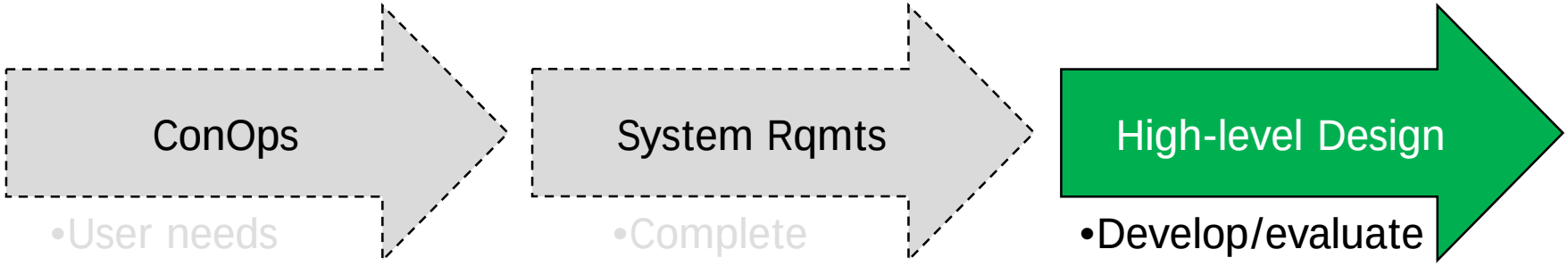
Mapping Requirements to Design

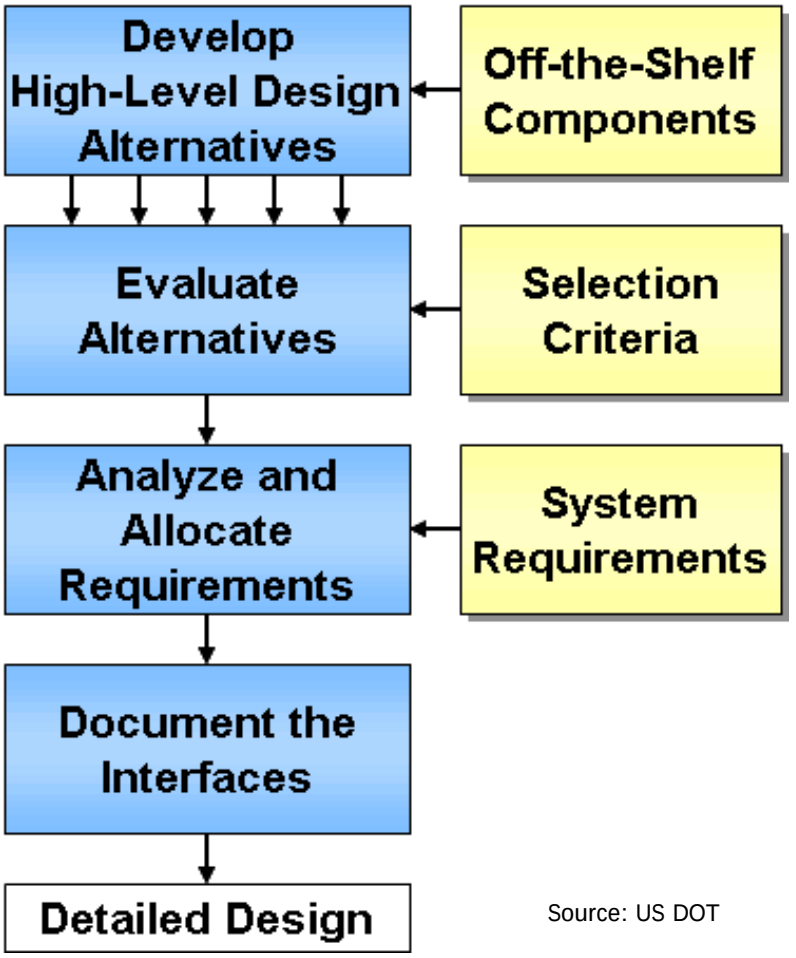


- ConOps
  - User needs
  - Expectations
  - Goals
  - Objectives
  - System operation
- System Rqmts
  - Complete
  - Verifiable
  - Validated
  - Review/approval
- High-level Design
  - Develop/evaluate alternatives
  - Identify connections
  - Consider standards
  - Preliminary design review

Source: US DOT

Definition of System Design

- Bridge from requirements to implementation
- First step in structured design where focus is on the solution. It defines:
  - What system will do (from the requirements)
  - Where system will do it (system components and connections to other systems)



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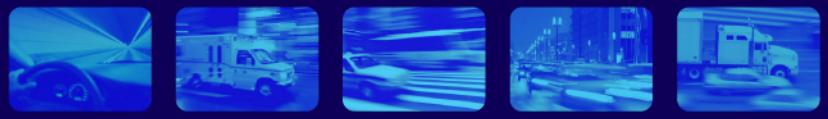
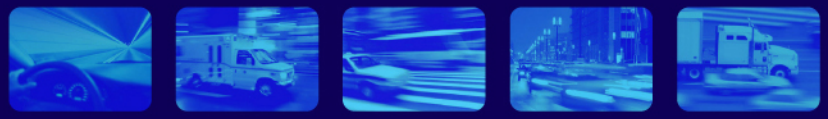


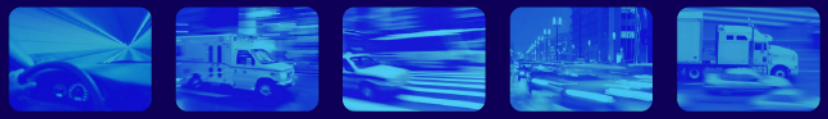
Two Levels of Design

- 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
- Two designs could meet requirements, but one could be superior
- Should consider previous design experience with similar systems:
  - What worked
  - What did not work



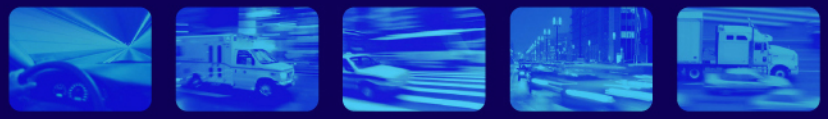
Off-the-Shelf Components

- Also called commercial-off-the-shelf (COTS)
- First step in system design
- Identify components that will be:
  - Purchased
  - Reused
  - Developed from scratch (minimize this!)
- Design constraints may govern product selection
- When COTS product(s) used, design must be consistent with capabilities of COTS product(s)



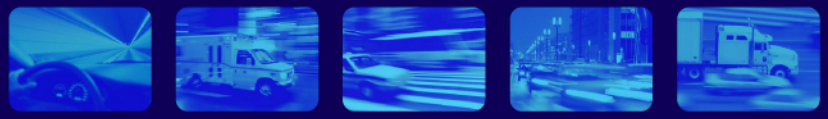
Off-the-Shelf Components (continued)

- Examine available COTS products to satisfy high-level design
- Avoid design that can only be supported by custom solution
- Benefits of COTS:
  - Reduced time to purchase
  - Reduced cost
  - Increased liability
- Weigh against:
  - Requirements not met
  - Loss of flexibility
  - Cost



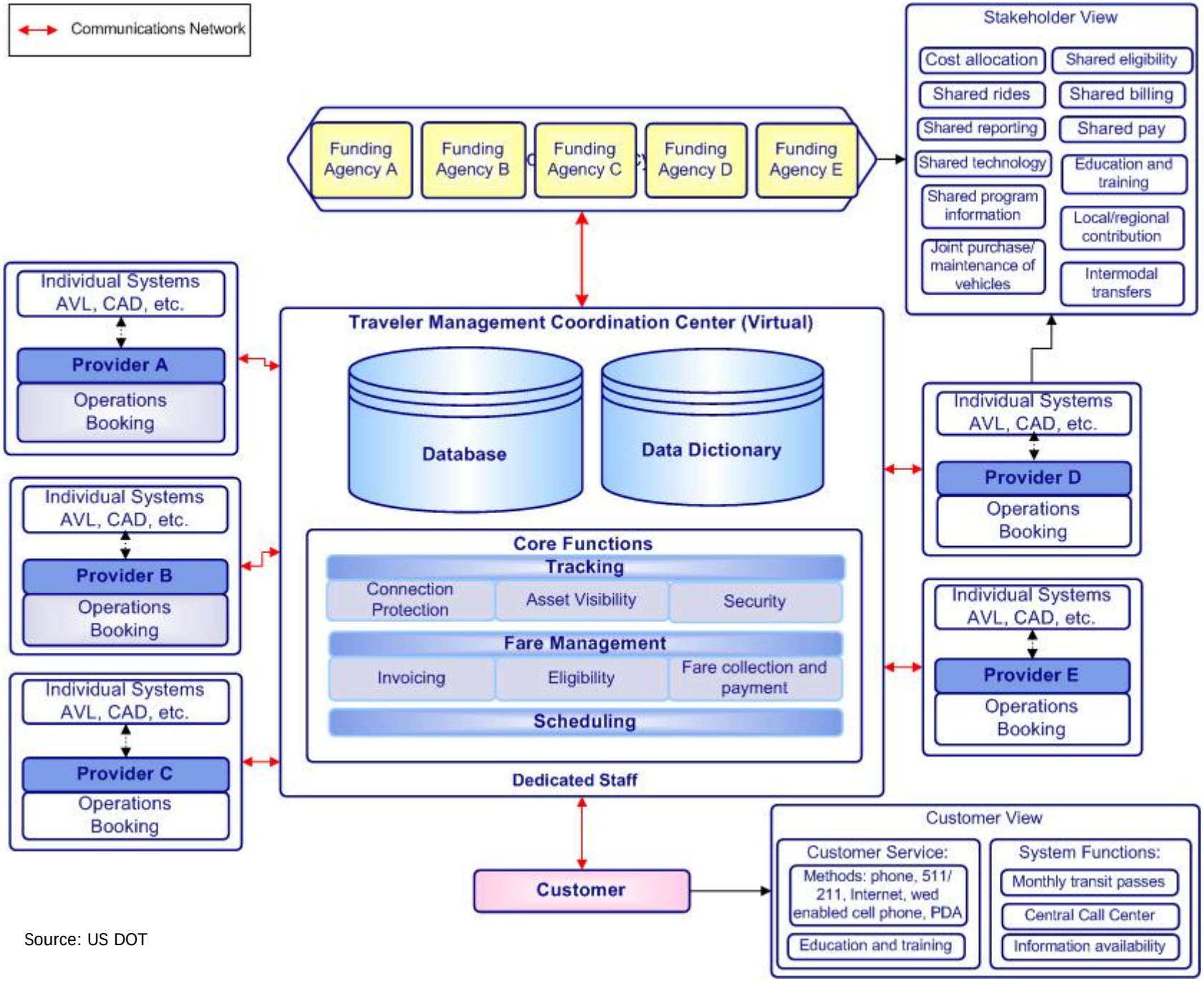
Off-the-Shelf Components (concluded)

- Document decisions to use or not use COTS
- Line between COTS and custom solutions blurry
- **Design should be vendor and technology independent!**



Develop Design Alternatives – First Step

- Grouping system functions and sub-functions into logical physical elements that will make up system
- Typical physical elements:
  - Hardware
  - Software
  - Material
  - Data
  - Facilities
  - People
  - Services
  - Processes



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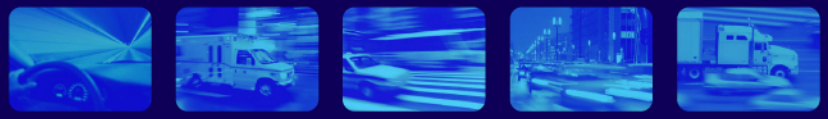
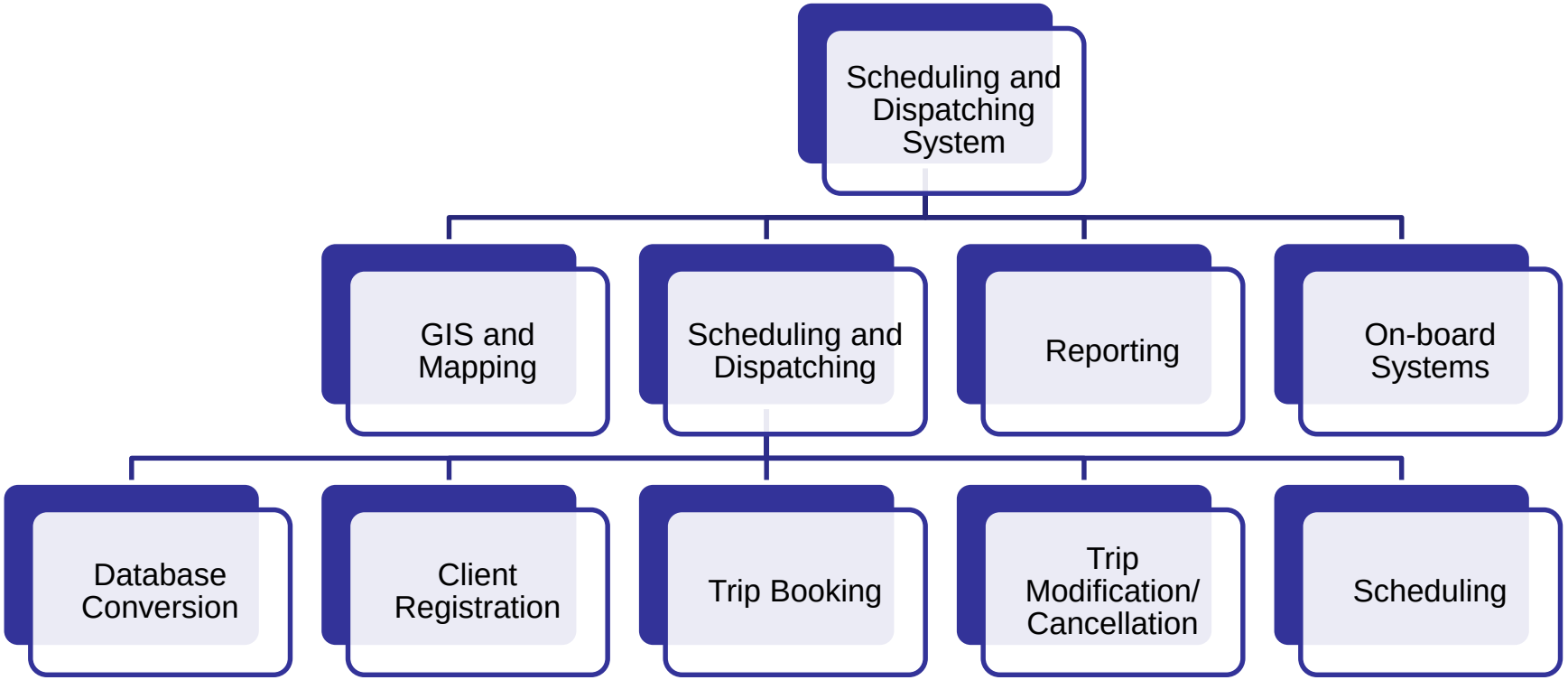


Develop Design Alternatives - Process

- System broken down into subsystems
- Subsystems broken down into smaller pieces
- Process continues until all components are identified
- Resulting design alternatives:
  - Based on how breakdown done (see example on next slide)
  - Have impact on system:
    - Performance
    - Reliability
    - Life-cycle costs
  - Should be developed with respect to defined selection criteria
- There can be several viable alternatives!

Example of Functional Breakdown



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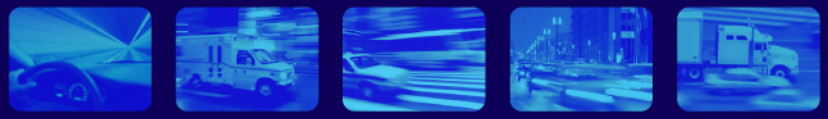
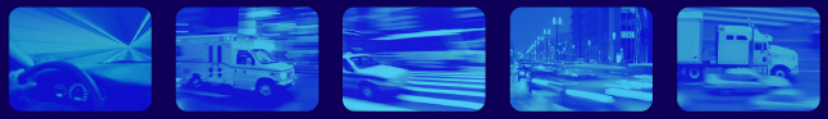


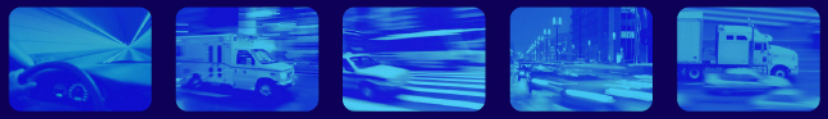
Level of Breakdown Dependent on

- Need for separate procurement(s) of system components
- Deployment of components to different locations, or in different configurations to multiple locations
- Complexity of system



Selection/Comparison Criteria

- Should reflect consistency with existing physical, organizational and institutional boundaries
- Consider ease of development, integration and upgrading
- Consider management visibility and oversight requirements
- System connections and interactions should be simple, standard and as foolproof as possible
- Criteria should be:
  - Independent of each other
  - Agreed to by stakeholders in terms of relative importance
  - Documented (along with analysis that results in alternative selection)

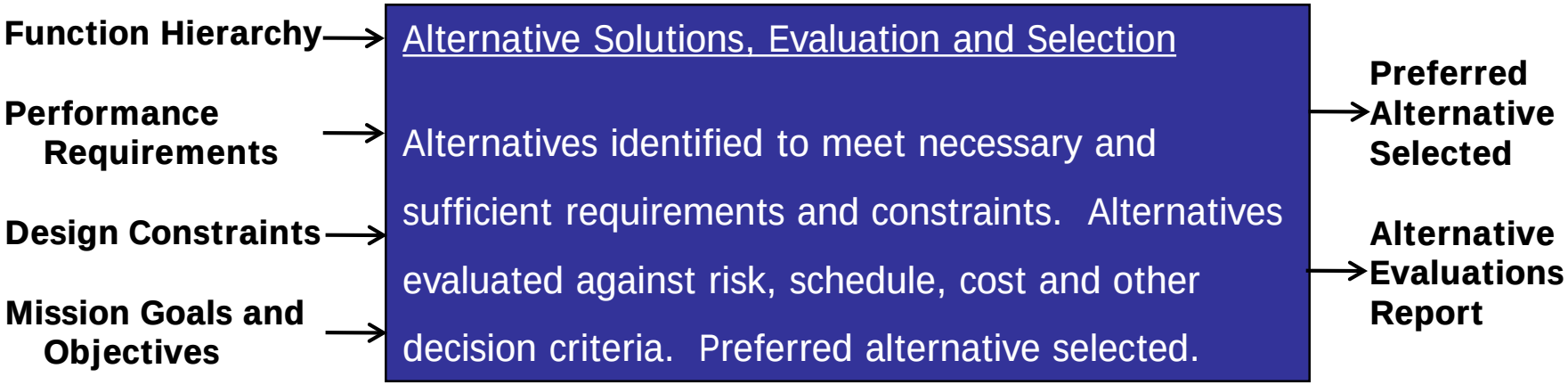


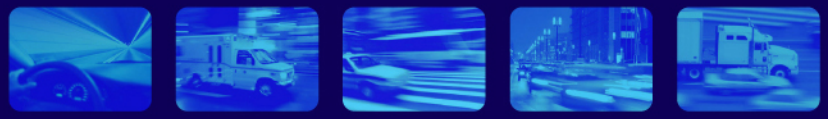
Sample Selection Criteria

- Start with goals and objectives of the system
- Basic criteria could include:
  - Cost (including labor, and operations and maintenance)
  - Time/schedule
  - System performance
  - Risk
- Additional criteria:
  - Organizational values
  - Stakeholder values
  - Technology maturity (could be part of risk)
- Can use weighted criteria to indicate relative importance

Evaluate Alternatives

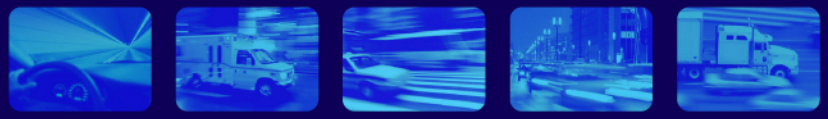
- To determine which best satisfies:
  - Allocated functional and performance requirements
  - Derived requirements
  - Interface requirements
  - Constraints





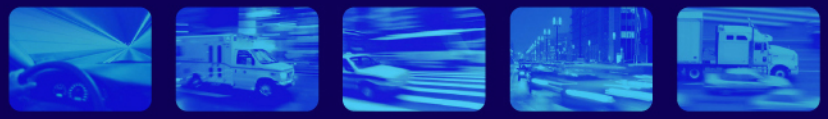
Analyze and Allocate Requirements

- Break requirements into smallest pieces (you have probably done this already). Do not go too low!
- Allocate pieces to system components identified in design
- Need to understand relationships between/among functions through analysis
- Try to keep components independent



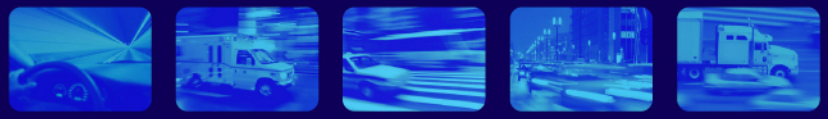
Internal and External Connections

- Identify connections (interfaces) between:
  - System components (internal)
  - Other agency systems
  - External systems (e.g., 211)
- Interfaces between this and external systems should be governed by formal agreements (not by handshakes)
- Throughout system design process, interfaces should be:
  - Documented
  - Managed
- Process leads to identifying appropriate standards



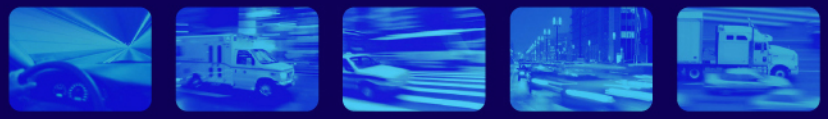
Identify Appropriate ITS and Industry Standards

- If Regional ITS Architecture used in ConOps development, find out what ITS standards are identified
- Vendors should see http://www.standards.its.dot.gov/ for more information about ITS standards
- Other standards to consider:
  - Local
  - Regional
  - State
  - Adjoining states, if multi-state deployment



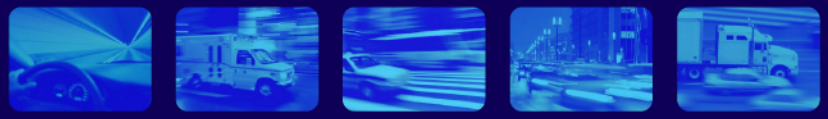
Identify Appropriate ITS and Industry Standards (continued)

- Assessment of standards for each interface (done by vendor/system integrator):
  - Which ones are relevant?
  - Which should be deployed?
  - Which should be phased in over time?
- Document for external and internal interfaces in detailed design (done by vendor/system integrator):
  - Nature of data
  - Formats
  - Ranges of values
  - Periodicity of information exchanged on interface



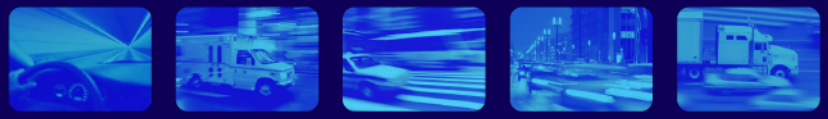
Select Best Design

- Analysis started in earlier step using selection criteria
- Process:
  - Select one design based on selection criteria
  - Ensure design meets all requirements
  - Document design
- This step leads directly into detailed design, which will be done by vendor/system integrator:
  - Design of hardware and software for all system components
  - Results in specifications used for procurement



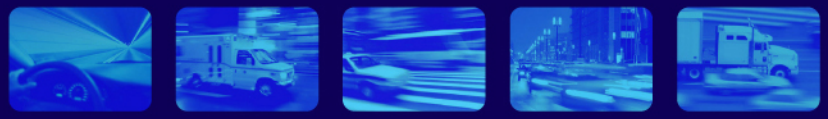
Document Design

- Process:
  - Describe all design alternatives
  - Describe process for evaluating alternatives and selecting one design
  - Describe selected design in as much detail as possible
- "Best" way to document design must satisfy variety of users with different needs and viewpoints (see Design Views slide)



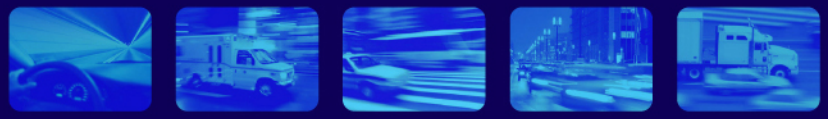
Hardware Definition in Design

- Generic (e.g., workstation, server)
- Specific (e.g., manufacturer, model) – if you have existing components and need to be compatible. Example:
  - Agency uses ICM PC-compatible workstations
  - Agency contract with PC vendor (e.g., Dell)
  - Agency contract with telecom firm (e.g., AT&T)



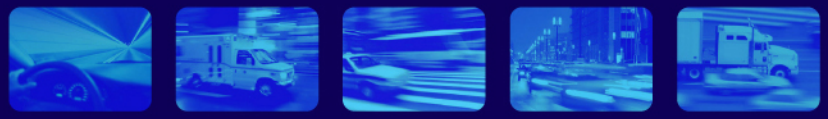
Software Definition in Design

- Custom-developed parts:
  - Allocation of functional and performance requirements most important
  - Have to consider cost and effectiveness
- COTS parts:
  - Operating system
  - Database software
  - Communications software



User Interface in Design

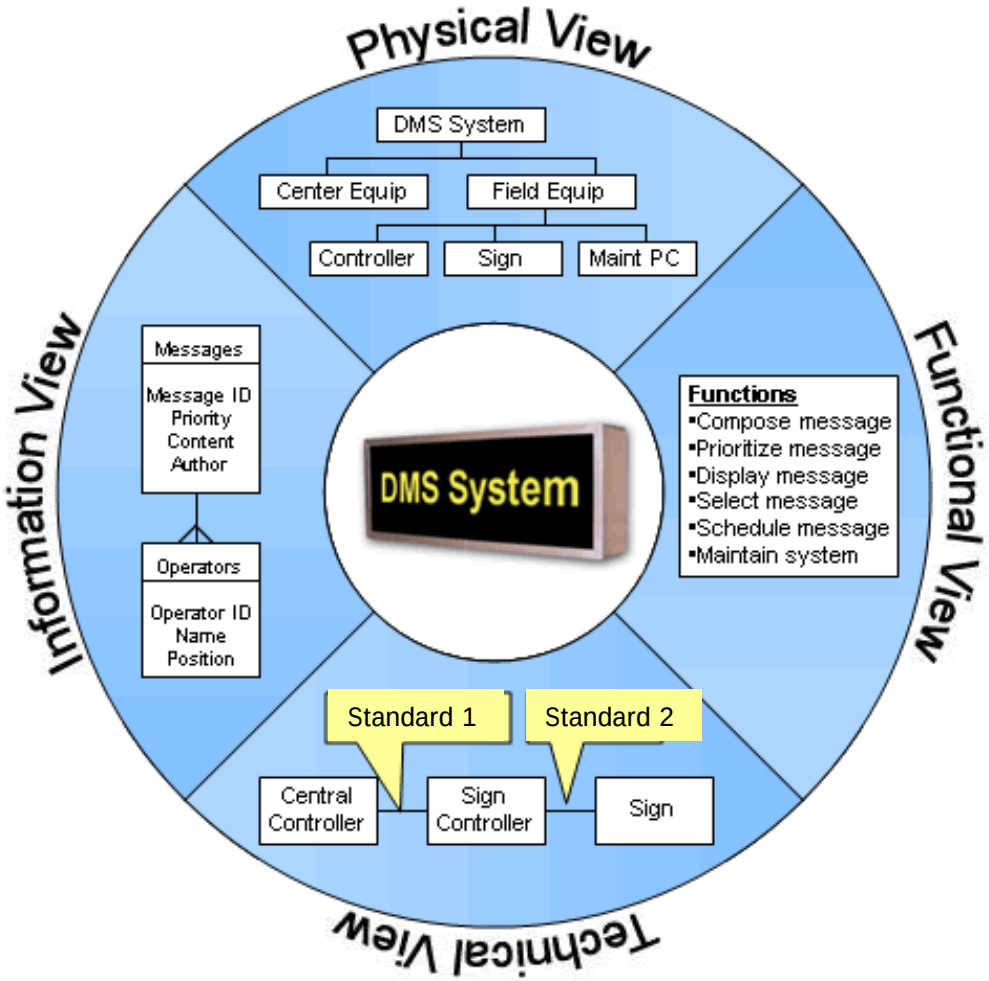
- Must describe in detail:
  - What is displayed to user
  - All actions that user can take
- Example: If display includes a map, the map must be defined in terms of:
  - What it looks like
  - When it is displayed
  - Interaction with it by user (e.g., data entry, zoom/pan)
- Should limit user error
- Do not leave to software developers to decide!



Design "Views"

- Operational/Functional – describes how system will react when used
- Informational – describes data flows, access, storage, communication
- Network/Technical – describes analysis of interactions between system components
- Physical – describes hardware to be used in system

Sample Design View



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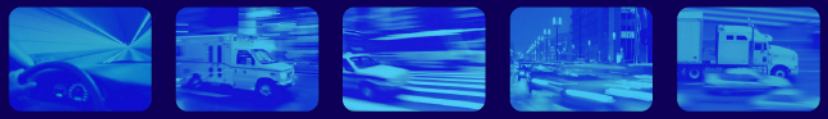
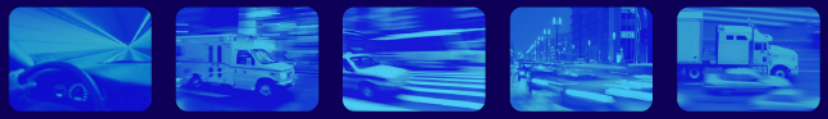


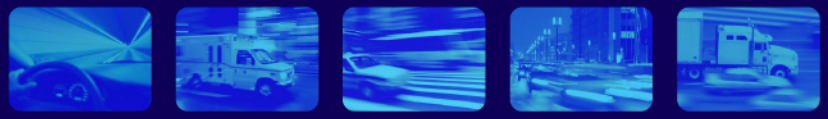
Preliminary Design Review

- Conducted:
  - After procurement of system
  - Led by agency or agency's consultant
- Ensures that system:
  - Can proceed into development by vendor
  - Meet requirements within constraints (e.g., cost, schedule, risk)
- Ensures that each function has been allocated to one or more system components (see slide 13 for list of components)
- Assesses preliminary design as determined in earlier step
- Are there requirements missing? You can add "derived" requirements (those not based on needs)



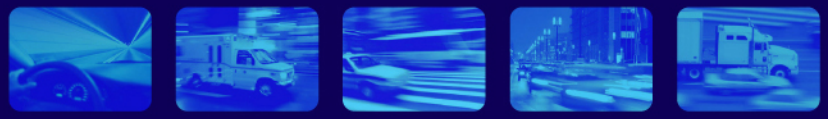
Preliminary Design Review (continued)

- Vendor required to submit initial design review documentation and agency/agency consultant provides feedback
- Opportunity to:
  - Uncover fundamental issues with vendor's interpretation of design
  - Discuss alternative implementation approaches to achieve design intent to:
    - Best meet agency needs
    - Within vendor constraints
- Vendor will demonstrate more flexibility at this point, rather than after they have developed software customizations or installed equipment



Resources

- Mitretek, “The Road to Successful ITS Software Acquisition,” prepared for Federal Highway Administration, July 1998, http://www.fhwa.dot.gov/tfhrc/safety/pubs/its/architecture/rdsuccessvol1.pdf
- INCOSE Tools: http://www.incose.org/ProductsPubs/products/toolsdatabase.aspx
- R. Ian Faulconbridge and Michael J. Ryan, Managing Complex Technical Projects: A Systems Engineering Approach, © 2003, Artech House, ISBN 1580533787



Resources

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- Buede D. M., The Engineering Design of Systems: Models and Methods, Wiley Inter-Science, 2000
- 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/