Component 1: PCB ITS Case Study – Concept of Operations (ConOps)

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Case Study Format and Purpose

- Case Study Purpose

  - Provide overview of Concept of Operations (ConOps) development for Intelligent Transportation Systems (ITS) as part of a Systems Engineering (SE) process

- Components

  - 1: Presentation (this part)

  - 2: Take Home Exercise

  - 3: Debrief

Exercise Case Study Overview

- Develop Stadium Expansion Concept of Operations (ConOps) Case Study

- Scenario
  - University Football Stadium traffic congestion
    - Planned events
    - Growing attendance/traffic
    - Stadium expansion
    - City transportation system cannot accommodate demand

- Student Role
  - City Traffic Engineer
  - Systems Engineer

- Resources
  - ConOps outline

Exercise Activities

- Task 1: Identify Stakeholders
  - Determine who is involved
  - Roles and Responsibilities

- Task 2: Current Situation
  - Operations
  - System Elements and Connections

- Task 3: Justification for Change
  - User needs
  - Description of Desired Changes

- Task 4: Concepts for Proposed System
  - Policies and constraints impacting the system
  - Description of the proposed system

Identify Stakeholders

↓

Current Situation

↓

Justification for Change

↓

Concepts for Proposed System

What is Intelligent Transportation Systems (ITS)?

- Transportation project involving one or more systems and/or one or more ways to communicate electronically

- Examples
  - Smartphone Transportation Applications
  - Weigh in Motion for commercial vehicles
  - Adaptive Traffic Control Signals
  - Traffic Management Center
  - Traffic Signal Priority
  - Connected Vehicles

ITS Addresses Transportation Needs

- Delivers transportation services that address local needs

- Defines transportation systems and functions needed to deliver services

- ITS does not solve the entire transportation problem

  - ITS provides tools to better manage existing transportation conditions and maximize the capacity and capabilities of current facilities

  - ITS enables travelers to be better informed, make safer and smarter use of transportation systems

Intelligent Transportation Systems (ITS) Example
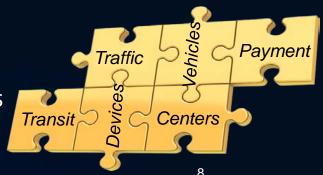
- Traffic Management Center (TMC)
  - Interacts with devices
    - Dynamic Message Signs (DMSs)
    - Traffic cameras
    - Highway Advisory Radios (HARs)
    - Traffic detection
    - Traffic signals
    - Personal Devices

Putting "ITS" Together

- ITS has many systems, interactions, and institutions
    - How does it all fit together?
    - How do the various components interact?
    - What can be used to coordinate deployment?
- USDOT defined the National ITS Architecture (www.iteris.com/itsarch)
    - Common definition for ITS terminology and communication
    - Guide for ITS deployment planning
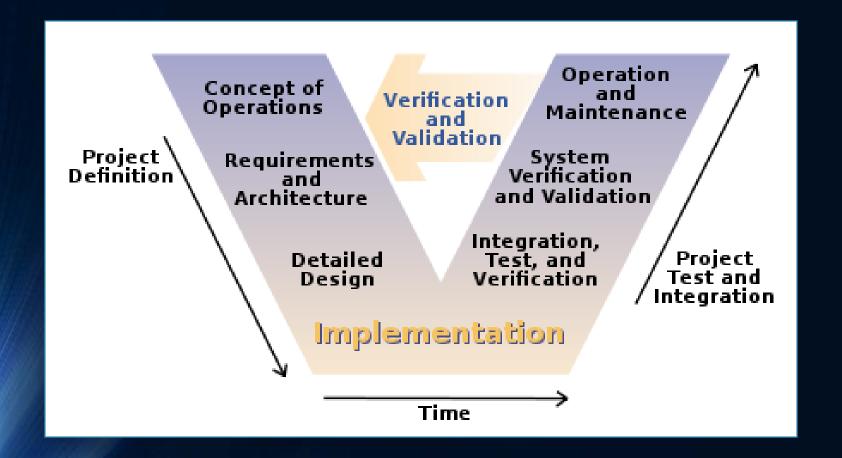   - Defines what is "ITS" in the United States

Systems Engineering (SE)

- Systems Engineering (SE) focuses on the "system" as a whole emphasizing its total operation
  - Views the "system" from the outside as well as the inside
  - Concerned about interactions of the "system" with other systems and the environment
  - Traces the user needs from "system" conception through design/development and into operations and retirement
  - Involves and manages multiple disciplines working together
  - Defines a process useful for controlling system cost and schedule making it an inherent part of project management
  - Balances competing needs/constraints

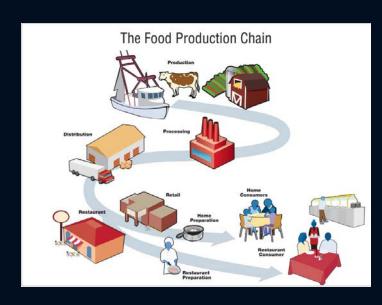"The whole is more than the sum of its parts."

Aristotle, 384 BC – 322 BC

Systems Engineering "V" Lifecycle Process

Key Concept - Traceability

- Traceability is the glue that holds the SE process together

- Each step in the SE process relates to the previous steps and to the next steps – ensures continuity is enforced

- Traceability will become clearer as we develop our Concept of Operations within the SE approach
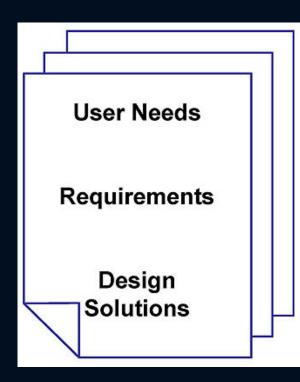
Key Concept – Push technology decisions as close to Implementation as possible

- Why is this concept important?

- Do you really want to be using a computer system specified 5 years ago in a new project?

- Security support, patches, updates last how long?

- Emphasis in the initial stages of SE to be:
  - General
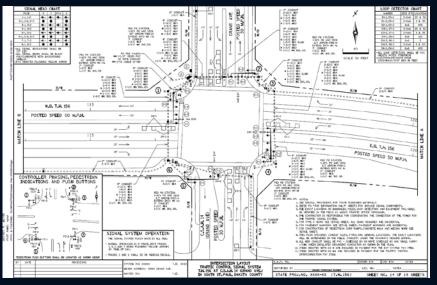 - Abstract
  - Functional
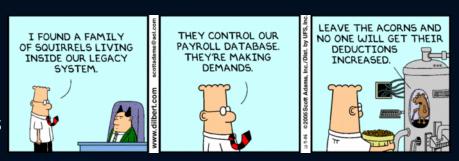 - High-level

Key Concept – Specification

- Initial goal is to develop a specification to be used for procurement

- **Identify and write** description of what the system, equipment and interfaces must do to support operations (features-functions)

- **Develop and Write** (in "*shall*" language) specific functional requirements to satisfy user needs

- **Map** standard-supplied design concepts-solutions to fulfill the project requirements

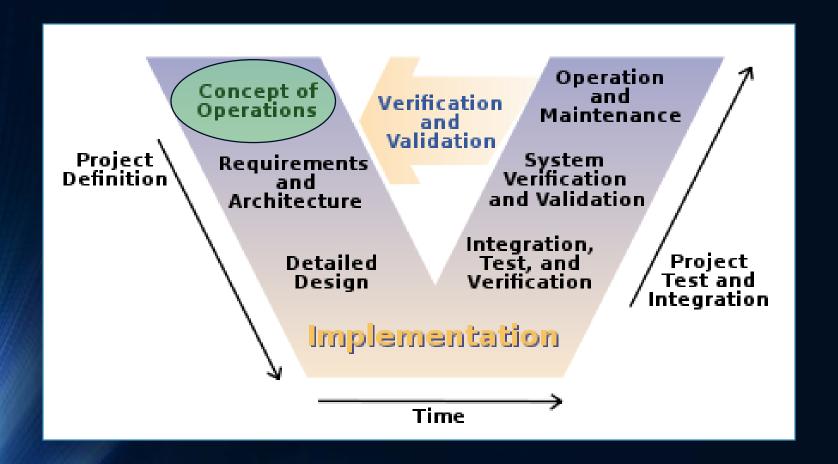User Needs

Requirements

Design Solutions

Rarely get to start with a clean slate

- Typical Preconditions or Constraints for ITS Projects
  - Existing ITS Architecture and/or Plans
  - Existing Infrastructure
    - Electronic plan sets frequently available
    - Existing signs
    - Existing traffic control devices
    - Existing cabinets
    - Existing conduit plant
    - Nearby power and communications

- You may be replacing or have to interface with a Legacy System!

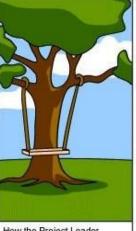# Concept of Operations in the SE "V"
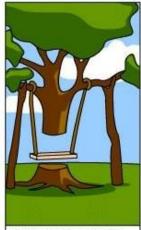
Concept of Operations (ConOps)

- A ConOps is written in conjunction with the stakeholders or <u>users</u> of the proposed system, in the <u>users</u> language and viewpoint and must be understandable by the <u>users</u>

  - The SE idea here is that we really want the proposed system to satisfy the stakeholder/user!

- The most important part of a ConOps is capturing the <u>user</u> <u>needs</u>

- In order for the ITS project to be successful, the <u>user</u> <u>needs</u> must be met by the project

Managing Expectations

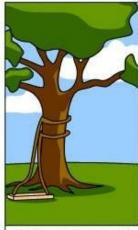# Concept of Operations
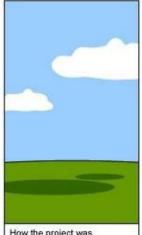
- Shows agreement on:
  - Goals, objectives, and expectations
  - Project scope and vision
  - Stakeholder roles and responsibilities
  - Operational Needs
  - How the system will operate
  - Operational and support environment

Standards governing structure and content of a ConOps

- There are a few standards that specify tailorable content in a ConOps
    - ISO/IEC/IEEE 29148:2011 – Systems and software engineering – Life cycle processes – Requirements Engineering
    - IEEE 1362-1998 – Targets software intensive and software only system development
    - ANSI/AIAA G-043-1992 – Revised standard in process of being approved in conjunction with INCOSE

- Content in these standards is fairly consistent

- Besides user needs, it is useful to explain the existing system that needs to be replaced, the motivation for new system changes and possible user scenarios

Purposes of a ConOps

- Coalesce concepts of the System/Project

- Document system foundational user operational needs and expectations

- Describe how the system would operate to satisfy the user needs and expectations

- Build consensus between the system users and the system developers

Concept of Operations Content

Transit Operational Scenario Example

Marcel, a StarTran bus operator, usually begins his work shift with administrative activities. After receiving supervisory direction, he boards the bus and prepares the AVL (Automatic Vehicle Location) system. He begins by logging into the system.

The system then prompts Marcel for the route to be followed. He enters the planned route number, and the AVL system retrieves the appropriate route and schedule information from the AVL system server. The bus' AVL system then asks Marcel to verify the appropriate route and schedule information were properly retrieved.

Once he provides verification, the bus' head sign is automatically updated to reflect the appropriate route information. The fare payment schedule is automatically adjusted to reflect the verified route, modified as necessary by the system clock to reflect any applicable time-differential rates.

The system then loads the appropriate bus stop announcements for the chosen route. These prerecorded announcements are consistent regardless whether Marcel or another bus operator is driving the route, and have been verified as ADA compliant. These announcements are then broadcast at the appropriate bus stop throughout the route.

From StarTran AVL ConOps

What is a User Need?

- Describes a major capability provided by a system
  - Should a system be developed without first knowing what it is expected to do?
  - Documented user needs are critical to assess/validate that a system does what it is supposed to do
  - The user specifies what the system is supposed to do in the form of user needs
  - User needs tend to remain stable over time
    - If needs change frequently, it would be impossible to build a system to satisfy them
    - This inherent stability of user needs forms the foundation for the system that can then be satisfied by changing technological capabilities
      - e.g., text-to-speech capabilities have greatly improved but the fundamental underlying user need to automate voicing text has not

Some Examples of Not Meeting User Needs

July 17, 2013

Congress' Expectations Remain Unmet

The watchdog listed four main reasons for the aviation agency's consistent failures: an unuseable plan, undetermined requirements to achieve NextGen features, undefined benefits and the FAA's culture that fears overhaul-style changes. "FAA's progress in implementing NextGen has not met the expectations of Congress," Scovel said nearly a decade after the effort began.

https://en.wikipedia.org/wiki/Next_Generation_Air_Transportation_System

http://www.zdnet.com/article/five-reasons-why-windows-8-has-failed/

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Transit Example Observations

- From our transit scenario with Marcel a few observations can be made:

  - He needs to tell the AVL (Automatic Vehicle Location) system the transit bus route

  - The AVL system retrieves the route and schedule information

  - The bus head sign is updated with the route

  - Automatic fare payment system is adjusted for the route

  - Bus stop announcements are queued

  - Announcements broadcast where appropriate along the route

Criteria for Writing a "Well-Written" User Need

When documenting a user need, one must remember that it addresses an operational problem, and "*describe*" it using the following recommended criteria:

1. Provide a structure by assigning a unique number and title to make it **uniquely identifiable**

2. Identify a **major desired capability** (Including functions or features desired from the device/system)

3. Capture the **rationale** by stating why it is needed by the user.

4. Keep it **solution-free**: don't get into how to meet it (design).

Applying the Criteria: Transit AVL Example

UN 3.10 Configure Transit Vehicle Tracking System

<u>Uniquely Identifiable</u>

The Transit Operator needs to enter the bus route information into the transit vehicle

<u>Major Desired Capability</u>

in order for the transit vehicle to track its status against the route schedule and provide bus stop announcements.

<u>Rationale</u>

Note that this user need does not specify how this will be accomplished, it only specifies the user need.

<u>Solution-Free</u>

Transit AVL Example of Proposed System

- As you begin to understand how the various pieces of the project fit together it is helpful to develop a block diagram

City Transit Management Center	City Transit Vehicle	Transit Vehicle Operator

Transit Management Center tracking Marcel's Bus

Marcel's Bus

Marcel

Smart Phone Top 10 Feature List

10. Wireless Charging
9. Fingerprint Sensor
8. Infrared Remote Control
7. Plenty of Storage Space
6. Multiple Windows

Smart Phone Top 10 Feature List

5. Near Field Communications (NFC)
4. A Great Camera
3. Crystal-Clear Display
2. Warp Speed Processing
1. A Long-Lasting Battery

ConOps development approach

- Reality is that an ITS project will have constraints imposed on it

- System concept must take into account both the user needs and constraints

- Initial versions of the ConOps do not have to be perfect, changes will occur as further system development thinking occurs or the system environment changes

- Change is inevitable, SE provides a way to manage change

- ConOps document may need to be revised after the initial baselined version

Recommended ConOps Outline*

1. Document Scope

2. Reference documents

3. Current system or situation

4. Justification for change

5. Concepts for proposed system

6. Operational scenarios

7. Summary of impacts

8. Analysis of proposed system

9. Appendices

10. Glossary

* Based on ISO/IEC/IEEE 29148:2011 and IEEE 1362-1998

Recommended ConOps Outline (cont)

1 - Document Scope

- Document identification
- Document overview
- System raison d'etre
  - Briefly state why the system exists (if it does)
- System Overview
  - From a summary level, what is the system

2 - Reference documents

- Sources providing foundation for this ConOps
- Includes standards and project-specific documents

Recommended ConOps Outline (cont)

3 - Current system or situation

- Most relevant for system updates and expansions
- Provides context for statement of stakeholder need

4 - Justification for change

- Evolution of system capability
- User needs (Stakeholder needs)
  - Stated from the perspective of the user or stakeholder
  - Form the basis for system requirements
  - Need to be as comprehensive as possible
- Description of desired changes

Recommended ConOps Outline (cont)

5 - Concepts for proposed system

- Policies and constraints impacting the system
- Description of the proposed system

6 - Operational scenarios

- Provides an overview of the major operational uses of the system
  - What the system does
  - What people/organizations benefit from the system and how they benefit
  - What people/organizations operate the system and components
  - What people/organizations maintain the system and components
- Scenarios examined should cover important expected situations

Recommended ConOps Outline (cont)

7 - Summary of impacts

- Changes in operation
- System costs
  - Acquisition
  - Operations and maintenance
  - Planned enhancements (if any)
  - Decommissioning (if any)

8 - Analysis of proposed system

- Benefits
- Limitations
- Alternatives considered

Recommended ConOps Outline (cont)

9 - Appendices

- Material important to be available for reference

    - Portions of reference documents

    - Unpublished analysis or rationale

    - Data relevant to operational concepts

10 - Glossary

ConOps User/Stakeholder Review

- Do not develop a ConOps in a vacuum

- Must include input from the users/stakeholders

- Schedule a time to review the ConOps with everyone involved

- How do you know when all the ConOps and user needs are defined?

  - All Major Desired Capabilities are captured in the document

  - General group consensus that the ConOps fully explains the proposed ITS project/system
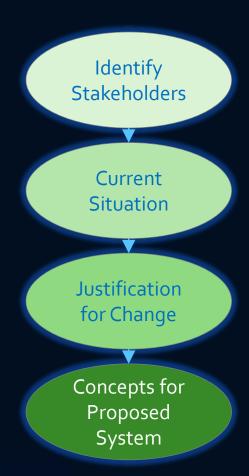
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- Scenario

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- Student Role

  - City Traffic Engineer

  - Systems Engineer

- Resources

  - ConOps outline

Exercise Activities

- Task 1: Identify Stakeholders
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Identify Stakeholders

Current Situation

Justification for Change

Concepts for Proposed System

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Case Study Purpose

- Provide understanding of systems engineering

- Gain experience in beginning development of a systems project with a Concept of Operations

- Explore balancing priorities in establishing project scope

Take Home Exercise

- Review Component 2 – Concept of Operations Exercise material

- Understand your role and the project environment description

- Task 1 – Identify the Stakeholders

- Task 2 – Determine the Current Situation

- Task 3 – Justification for Change

- Task 4 – Concepts for the Proposed System

Benefits of Developing a Concept of Operations

- Early stakeholder agreement on:
  - System capabilities
  - Roles and responsibilities
  - Key performance measures and a basic plan for system validation

- Manage stakeholder expectations

Start with Your Eye on the Finish Line
A ConOps helps the project team visualize the final system at the beginning of the project.

ConOps Summary

- The ConOps document:

  - Captures the important user needs (major desired capabilities)

  - Written in the User/Stakeholder's language

  - Helps everyone understand the system operations and the scope of the system

  - Includes background and scenarios for the system

  - Provides a basis for Systems Engineering traceability through system validation testing