COMPLETE TRIP

ITS4US

Task 6 Training:
System Requirements Specification (SyRS)
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Highway Research Engineer
Office of Operations Research and Development
Agenda

- System Requirements Specification (Task 6) Overview

- System Requirements Specification Template
  - Project Overview
  - General System Description
  - System Capabilities, Conditions, and Constraints
  - System Interfaces

- Final Thoughts
  - Useful References
  - Stay Connected
Program Overview
Complete Trip - ITS4US Deployment Program

- A USDOT Multimodal Deployment effort, led by ITS JPO and supported by OST, FHWA and FTA
- Supports multiple large-scale replicable deployments to address the challenges of planning and executing all segments of a complete trip

**Vision**

Innovative and integrated complete trip deployments to support seamless travel for all users across all modes, regardless of location, income, or disability.
Program Goals

1. Spur high-impact integrated Complete Trip deployments nationwide
2. Identify needs and challenges by populations
3. Develop and deploy mobility solutions that meet user needs
4. Measure impact of integrated deployments
5. Identify replicable solutions and disseminate lessons learned
Complete Trip Phase 1 Awardees

- University of Washington
  OR, WA, MD

- California Association of Coordinated Transportation
  CA, OR, and WA

- Heart of Iowa Regional Transit Agency
  Dallas County, IA

- ICF
  Buffalo, NY

- Atlanta Regional Commission
  Gwinnett County, GA
Deployment Phases

**PHASE 1: Concept Development**
- Concept Development for Complete Trip Deployment
- Establish Cohort Roundtables

**PHASE 2: Design & Test**
- Design, Test and Deploy Complete Trip Solutions
- Evaluation Framework and Planning

**PHASE 3: Operate & Evaluate**
- Demonstrate Multiple Large-Scale Deployments
- Evaluate Deployments
- Share Data & Lessons Learned

**Operations Maintenance**
- Sustain operations for a minimum period of five years after the program is completed with no supplementary federal funds

**Deployment**
- Up to 12 months
- Up to 24 months
- Minimum of 18 months

**Post-Deployment**
- 5 years
System Requirements Specification (SyRS)
Task 6 Overview

- A **Systems Requirement Specification**:  
  - Identifies, organizes, and presented requirements that satisfy the needs of the system;
  - Defines the functional, performance, data and interface requirements for the subsystems and system.

- Major components of the Specification:
  - General System Description
  - System Requirements and Interfaces
  - Needs to Requirements Matrix
## Deliverables

<table>
<thead>
<tr>
<th>ID</th>
<th>BAA Section</th>
<th>Task 3: Data Management Plan (DMP)</th>
<th>Due Date</th>
<th>Format</th>
<th>Site Specific Date</th>
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SyRS Interdependencies

Inputs

User Needs
- Task 1B: UNIRP
- Task 2: ConOps

Performance Measures
- Task 3: Data Mgmt. Plan (DMP)

System Requirements Specification

- Introduction
- General System Description
- System Requirements
- Context Diagram
- Standards

Outputs

System Requirements
- Task 7: Enabling Tech.
- Task 8: Human Use
- Task 9: Training Plan
- Task 10: Partner Plan
- Task 11: Outreach
- Task 12: SEMP
- Task 13: ICTD Plan
- Task 14: Dep. Briefing
SyRS Template Sections
Section 1: Introduction

- Sections 1.1, 1.2 and 1.5 of the SyRS should address:

  - **1.1 System Purpose:** Discuss the relationship between the user needs defined in the ConOps and requirements to be defined in this document.

  - **1.2 System Scope:** Identify the proposed system(s), establish how the system(s) will meet the needs identified in the ConOps, and define and quantify the expectations of the system(s).

  - **1.5 System Overview:** Describe the functionality of the system(s) at a high-level.
Section 2: General System Description

- Section 2.1 System Context uses a system context diagram to:
  - Provide an overview of the system
  - Define where internal and external interfaces of the system exist.
## Sections 2.2 to 2.6

<table>
<thead>
<tr>
<th>SyRS Section</th>
<th>ConOps Section</th>
<th>Action for SyRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2 System Modes and States</td>
<td>5.5 Modes of Operations for Proposed System</td>
<td>Expand, include diagram if needed</td>
</tr>
<tr>
<td>2.3 Major System Capabilities</td>
<td>5.2 Description of the Proposed System</td>
<td>Describe the major capabilities of the system and set the logical structure for requirements organization</td>
</tr>
<tr>
<td>2.4 Major System Conditions, Constraints, Assumptions and Dependencies</td>
<td>4.5 Assumptions and Constraints 5.6 Operational Polices and Constraints</td>
<td>Describe conditions: other systems, infrastructure, environment, polices</td>
</tr>
<tr>
<td>2.5 User Characteristics</td>
<td>5.3 Stakeholders and Actors of the Proposed System</td>
<td>Describe how users interact with and use the system</td>
</tr>
<tr>
<td>2.6 Operational Scenarios</td>
<td>6 Operational Scenarios</td>
<td>Summarize existing and add additional scenarios that have been developed since ConOps</td>
</tr>
</tbody>
</table>
Section 3: System Capabilities, Conditions, and Constraints

- Requirements have a simple grammar:
  - Actor [The System]
  - Action [shall do/not do something to]
  - Target [the object of the action]
  - Constraint [how, how often, how many, how fast]
  - Localization [if, when, where]
  - Note: Not all requirements will have both localization and constraint portions.

Example:

The System shall generate alerts to travelers containing the closest accessible station exit when the traveler exits the vehicle.
Best Practices for System Requirements

- Criteria for well-formed system requirements that fulfill a need:
  - Necessary
  - Concise
  - Implementation-free
  - Attainable
  - Complete
  - Consistent
  - Traceable
  - Unambiguous
  - Verifiable
  - Allocate-able
  - Style-compliant

Ambiguous language to avoid:
Efficient, Effective, Best, Approximate, Good, Should, Similar, State of the Art, User Friendly
This section should describe high-level system requirements. In a more complex system, it may be necessary to break these down into the subsystems. These requirements should contain the core functionality of the system and needs.
Section 3.2: Physical

- Describe the physical requirements of the system, this will most likely be hardware and/or infrastructure requirements of the system. Break the physical requirements into the following four categories:
Section 3.3: System Performance Characteristics

- Define the performance requirements of the system, including quantitative performance characteristics that the system shall meet in order to fulfill the user needs. These may include:

<table>
<thead>
<tr>
<th>Time-based Functions:</th>
<th>Dynamic Actions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of Time</td>
<td>Rate</td>
</tr>
</tbody>
</table>

|                      | Speed            |
|                      | Noise Level      |

|                      | Light Level      |
|                      |                  |
Specify requirements for the cyber and physical security of the system, with protecting personally identifiable information (PII) as a top priority. These requirements must address:

**Cyber Security:**
- Security
- Privacy

**Physical Security:**
- Hardware
- Infrastructure
- Users
Section 3.5: Information Management

- Detail requirements within the system to manage user privacy and data such as:

  - Passwords
  - Encryption
  - Access Levels
Section 3.6: System Operations

- **System Human Factors**: Requirements pertaining to all interactions between the user and the system
  - This section will be particularly important for the ITS4US Program as each deployment will need to meet the needs identified in Task 2 for users of with disabilities, travelers of low-income, older adults, and other underserved populations.

- **System Maintainability**: Quantitative requirements regarding maintenance activities and support of the system.

- **System Reliability**: Quantitative reliability requirements and the conditions under which the requirements are to be met.
Section 3.7: Policy and Regulation

- Build upon the policies described in section 5.6 of the ConOps and detail the requirements of the system to meet the policies that may impact the operation or use of the system. This should include:
  - Organizational policies
  - External regulatory requirements
  - External regulatory constraints
Section 3.8: System Life Cycle Sustainment

- Describe the system lifecycle sustainment which includes:
  - Quality Activities:
    - Review
    - Measurement collection and analysis
  - Evolution of System:
    - New technology
    - New user needs
    - New ideas
    - Enhancements
Section 4: System Interfaces

Internal System
- Internal system components will need to communicate, this may include:
  - Interfaces between hardware
  - System and operators
  - System and users

External System
- External interfaces between the system and other system shall also be covered. This may include:
  - Interdependencies
  - Communication protocols
  - Standards to be used
  - Formats
  - Geographical representation
Appendix A. Needs to Requirements Traceability Matrix

- The Needs-To-Requirements Matrix (NRTM) is a critical tool for ensuring that your system requirements cover all of the user needs.

- It is important that the NTRM traceability is maintained through the entire process as it is the first link from the user needs into the details of the system. Without this traceability it becomes impossible to determine if the system fulfills the user needs when complete.
# Example NRTM

<table>
<thead>
<tr>
<th>User Need / Requirement ID</th>
<th>Need/Requirement Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6.2.1</td>
<td><strong>Transferring from subway platform to other transportation modes.</strong> Transit users need to navigate from the subway platform to other modes of transportation. A solution that helps the user navigate from the location where they disembark the subway train to the location where they can access a shared use service, will allow the user to change modes and continue their trip.</td>
</tr>
<tr>
<td>ER-1</td>
<td>The system shall operate within an indoor or outdoor subway station.</td>
</tr>
<tr>
<td>ER-2</td>
<td>The system shall operate within a loud environment (&gt;80 db) such as a crowded transit station.</td>
</tr>
<tr>
<td>FR-3</td>
<td>The system shall…</td>
</tr>
<tr>
<td>2.6.2.1.1</td>
<td><strong>Accurate positioning inside buildings.</strong> Transit users with disabilities need to be able to accurately locate their position within buildings. In order to navigate through a transit station, the user needs accurate positioning data.</td>
</tr>
<tr>
<td>DR-5</td>
<td>The system shall provide point-of-interest (POI) locations to the user to aid in localization.</td>
</tr>
<tr>
<td>DR-6</td>
<td>The system shall collect GPS location data, if available, from the user’s device.</td>
</tr>
<tr>
<td>FR-8</td>
<td>The system shall provide GPS corrections via Wi-Fi location when available.</td>
</tr>
<tr>
<td>PR-10</td>
<td>The system shall locate users within 1-meter accuracy inside a transit station.</td>
</tr>
</tbody>
</table>

**Key**  
FR: Functional Requirement  
DR: Data Requirement  
PR: Performance Requirement
Final Thoughts
Useful References

FHWA
- FHWA’s Systems Engineering for Intelligent Transportation Systems
- FHWA Systems Engineering Guidebook for ITS, Concept of Operations Template
- FHWA Applying Scrum Methods to ITS Projects
  https://rosap.ntl.bts.gov/view/dot/32681

State DOT
- North Dakota Department of Transportation Overview of Systems Engineering Process.
  http://www.dot.nd.gov/divisions/maintenance/docs/OverviewOfSEA.pdf

IEEE
  10.1109/IEEESTD.1998.88826

NASA
- NASA Systems Engineering Handbook
  https://www.nasa.gov/seh/appendix-c-how-to-write-a-good-requirement
Stay Connected

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Visit the Complete Trip - ITS4US Deployment Program Website and FAQs:
https://its.dot.gov/its4us/
https://www.its.dot.gov/its4us/its4us_faq.htm
Any questions?