



Orange County Adaptive Signal System

Financial Project No. 434917-1

Performance Measurement Using Bluetooth Readers

Concept of Operations

Table of Contents

1. Scope
 - 1.1. Identification
 - 1.2. Concept of Operations Role within the Systems Engineering Process
 - 1.3. System Overview
 - 1.4. Goals and Objectives
 - 1.5. Vision for the System
2. Referenced Documents
3. User-Oriented Operational Description
 - 3.1. Description of Existing Situation
 - 3.2. Identification of Stakeholders, Roles and Responsibilities
4. Operational Needs
 - 4.1. Bluetooth Reader Collection Station Needs
 - 4.1.1. Identify Unique MAC Address
 - 4.1.2. Bluetooth MAC information Anonymity
 - 4.1.3. Non-Intrusive Simple Installation
 - 4.1.4. Bluetooth Reader Locating
 - 4.2. Software Needs
 - 4.2.1. Operator Interface
 - 4.2.2. Device Integration
 - 4.2.3. Travel Time Calculation
 - 4.3. Maintainability Needs
 - 4.3.1. Bluetooth Reader Preventive Maintenance
 - 4.3.2. Bluetooth Reader Reliability
 - 4.3.3. Bluetooth Reader Reparability
 - 4.3.4. Bluetooth Reader Maintenance Diagnostics
 - 4.4. Integration and Configurability Needs
 - 4.4.1. Bluetooth Operational Configuration
 - 4.4.2. Bluetooth Interface Needs
 - 4.5. Physical Construction Needs

- 4.5.1. Bluetooth Reader Positioning
- 5. System Overview
 - 5.1. Bluetooth Subsystem
 - 5.1.1. Bluetooth Reader Equipment Locations
 - 5.1.2. Bluetooth Reader Communications
 - 5.1.3. Bluetooth Reader Software
- 6. Operational and Support Environment
 - 6.1. Personnel
 - 6.1.1. Staffing Requirements
 - 6.1.1.1. Operations
 - 6.1.1.2. Maintenance
 - 6.1.1.3. Integration
 - 6.2. Facilities
 - 6.3. Hardware and Software
 - 6.4. Operating Procedures
 - 6.5. Maintenance
- 7. Operational Scenarios
 - 7.1. Bluetooth Reader Design
 - 7.2. Bluetooth Reader Installation and Configuration
 - 7.3. Bluetooth Reader Maintenance
- 8. Next Steps
 - 8.1. Detailed Requirements
 - 8.2. System Design
 - 8.3. Software / Hardware Development Field Installation
 - 8.4. Unit / Device Testing
 - 8.5. Subsystem and System Verification and Acceptance
 - 8.6. System Validation
 - 8.7. Operations and Maintenance
- Appendix 1, High-Level Requirements
- Appendix 2, Validation Plan

1. Scope

1.1 Identification

This Concept of Operations describes user needs for the deployment of the Orange County Adaptive Signal Performance Measurement System.

1.2 Concept of Operations Role within the Systems Engineering Process

Within the systems engineering process, the Concept of Operations describes what the users of the system will do. The ConOps is the first document in the systems engineering process, and is followed by the requirements documents, design documents, and various testing and verification documents. The purpose of the ConOps is not to describe the system. Its purpose is to describe the agency using the system. This description will support the developmental requirements that are traced directly to those activities, in order to ensure that the system will support those activities.

This document will be used to describe user needs regarding performance measurement system components. This includes Bluetooth readers and associated software. Maintenance needs and activities are also described. These needs will lead to requirements for the various components of the travel time system.

This document also includes a high-Level requirements document in the Appendix.

These requirements are traced directly to the needs described herein and that traceability is documented in a requirements traceability matrix. These high-level requirements are used to evaluate a master plan for arterial travel time, which is also included as an appendix. The appendix also includes a validation plan that will demonstrate that the proposed Bluetooth readers will support the documented activities of Orange County as described herein.

The purpose of the validation plan is to demonstrate that Bluetooth readers support the operation and maintenance activities of Orange County.

1.3 System Overview

The arterial travel time system uses roadside Bluetooth reader collection stations to measure roadway travel times. The system currently uses “Chameleon ITS” software developed by FLIR 360 Surveillance, Victoria, BC. The software continually monitors an internet based XML data-feed provided by the Bluetooth reader manufacturer. The XML data-feed output consists of the post processed Bluetooth pair travel time based on real time data collected from the Bluetooth reader stations.

1.4 Goals and Objectives

The goals and objectives are to enhance mobility by making the transportation system more user-friendly. This includes supporting traveler information services.

These system goals lead to specific stakeholder needs, which in turn lead to specific requirements that can be used to drive the development of plans and specifications for ITS elements implemented in new locations or to replace existing elements.

1.5 Vision for the System

The goals and objectives for the Adaptive Signal Performance Measurement System were outlined in the Orange County ATMS Feasibility Study and Implementation Plan dated April 2002. The study listed the goals and objectives as follows:

- Minimize operational and maintenance effort and costs to the County through the deployment of state-of-the-art equipment and advanced systems.
- Increase operational efficiency of the arterial network by deployment of coordinated systems.
- Provide and facilitate information sharing between entities within Orange County and within the defined regional area of Central Florida.
- Improve the efficiency of the roadways within Orange County through advanced technology and therefore minimizing the congestion to the traveling public.
- Provide residents with better responsiveness to roadway system conditions and issues through advanced technology.

2. Referenced Documents

Orange County ATMS Feasibility Study and Implementation Plan dated April 2002

3. User-Oriented Operational Description

3.1 Description of Existing Situation

The Adaptive Signal Performance Measurement System ConOps suggests that system should be deployed along the same roadways on which the adaptive signal system will be deployed by installing well placed Bluetooth reader collection stations.

3.2 Identification of Stakeholders, Roles and Responsibilities

The stakeholders are identified on Page 17 of the Orange County ATMS Feasibility Study dated April 2002.

Orange County Traffic Engineering personnel will perform emergency and preventative maintenance of the Bluetooth reader collection stations and associated communication network.

4. Operational Needs

This Concept of Operations will define the needs of the Adaptive Signal Performance Measurement System. The system is divided into two separate elements: the Bluetooth reader collection stations and associated backend software. The operational needs for the combined elements fall into or imply six categories specific to the specification of the system. The categories are:

- Bluetooth Reader Collection Station Needs
- Software Needs
- Maintainability Needs
- Integration and Configurability Needs
- Physical Construction Needs

4.1 Bluetooth Reader Collection Station Needs

4.1.1 Identify Unique MAC Address

The Bluetooth reader needs to be capable of monitoring and measuring vehicular movement by identifying and comparing unique MAC (Media Access Control) addresses associated with Bluetooth-enabled electronic devices.

The MAC address received by a sequence of two or more Bluetooth receivers can be matched and used to develop a sample of travel time for that particular segment of roadway, based on relative detection times recorded by adjacent units.

4.1.2 BT MAC Information Anonymity

One of the first things that motorists think of when first hearing of a project that tracks vehicles traversing public roadways is “Big Brother” is watching. It brings up concerns over privacy and the invasion thereof. So it is very important that the information collected by the Bluetooth reader remains anonymous.

The Bluetooth MAC address that is collected from a Bluetooth-enabled device needs to be anonymous. The MAC address is a hardware identifier that indicates the manufacturer and specific electronic device type. MAC addresses are not associated with any specific user account or any specific vehicle. The MAC address should not be linked to a specific person through any type of central database, but is assigned by the Bluetooth electronic chip manufacturer and should not be tracked through the sales chain.

This should eliminate concerns typically associated with alternative probe systems.

4.1.3 Non-Intrusive Simple Installation

The Bluetooth readers will be installed at signalized intersections. For this reason the reader needs to be compact and simple to install.

4.1.4 Bluetooth Reader Locating

As stated previously, positioning the Bluetooth reader is critical to proper system operation.

When a travel time to a downstream signal is determined, the travel time starts at the upstream signal. Thus, the travel time sensing system must be able to measure or estimate travel times from one signalized intersection to another. However, the minimum distance between Bluetooth readers is quarter a mile. Therefore, Bluetooth readers at some signals may not be installed to meet this spacing requirement.

4.2 Software Needs

4.2.1 Operator Interface

The software needs to communicate with all Bluetooth locations using standard protocols sufficient to support all activities that relate to the statewide Sunguide system. The graphical user interface (GUI) needs to be easy to operate and configure.

4.2.2 Device Integration

The system software needs to be easily integrated with both the existing and future Sunguide system. All of the Bluetooth readers will communicate via an IP network.

4.2.3 Travel Time Calculation

The travel time calculations will be done by the Bluetooth device provider and posted via XML data feed at an internet URL address.

All travel time calculations need to be done by the Bluetooth device provider.

4.3 Maintainability Needs

4.3.1 Bluetooth Reader Preventive Maintenance

Preventive maintenance is performed annually. Technicians will perform the PM without support from the TMC. PM is performed during normal system operation without removing the reader from communications with the associated server for specific PM procedures.

The activities performed during preventative maintenance include general cleaning inside the reader cabinet along with a visual inspection for water intrusion, etc.

4.3.2 Bluetooth Reader Reliability

The effectiveness of the system needs Bluetooth readers that will not limit system reliability. The Bluetooth readers need to function properly in all ambient conditions of temperature and humidity. Proper function includes being able to effectively read Bluetooth MAC addresses on a consistent basis. One reader needs to cover the entire intersection by identifying MAC addresses in all directions.

The object for reliability is a mean time between repair of 100,000 hours (to provide approximately 10 years of full-time operation).

4.3.3 Bluetooth Reader Reparability

Technicians need to be able to make a repair as soon as possible to avoid the repair activity having an effect on traffic management.

Orange County technicians perform board-level repair of system hardware rather than electronic component-level repair. When an electronic component on a circuit board fails, County technicians troubleshoot to determine which board failed, and then return the faulty board to the manufacturer for repair. The expected field-serviceable lifespan of the reader is 10 years.

4.3.4 Bluetooth Reader Maintenance Diagnostics

Technicians and TMC operators need to be able to quickly diagnose problems with the Bluetooth readers. The diagnostic information needs to include:

- Number of MAC reads
- Number of MAC matches
- Reader temperature
- Reader status

4.4 Integration and Configurability Needs

4.4.1 Bluetooth Operational Configuration

The TMC operator or the maintenance technician needs to be able to configure the Bluetooth reader for operation that supports all the purposes and activities defined in this document.

This configuration includes the latitude/longitude location of the reader, distance between individual reader sites, and the ability to create reader pairings in order to effectively calculate travel times between the reader pairs.

4.4.2 Bluetooth Reader Interface Needs

The Bluetooth readers will communicate over an IP network. The readers will, on a once per minute basis, send their associated MAC reads to an off-site server via the internet. The reader will need to be configured with an appropriate IP address, DNS address, and URL address (off-site server address).

This will allow the reader to send the entire MAC read information to the off-site server for travel time calculations.

4.5 Physical Construction Needs

4.5.1 Bluetooth Reader Positioning

As stated previously, positioning the Bluetooth reader is critical to proper system operation. When a travel time to a downstream signal is determined, the travel time starts at the upstream signal. Thus, the travel time sensing system must be able to measure or estimate travel times from one signalized intersection to another. However, the minimum distance between Bluetooth readers is quarter a mile. Therefore, Bluetooth readers at some signals may

not be installed to meet this spacing requirement.

5. System Overview

5.1 Bluetooth Reader System

5.1.1 Bluetooth Reader Equipment Locations

The Bluetooth reader locations will need to be determined based on the arterial road segments that travel time information will be calculated on. The majority of the installations will be at signalized intersections. However, some signalized intersections will be skipped to meet the quarter mile minimum spacing requirement.

5.1.2 Bluetooth Reader Communications

The Bluetooth readers will communicate with the ATMS using the existing fiber optic network. The current network infrastructure has spare Ethernet ports on existing network switches to accommodate the new reader equipment.

5.1.3 Bluetooth Reader Software

The Bluetooth reader software is web based. TMC operators and technicians log on using an Internet URL address and an assigned password. This eliminates the need for any special client software.

6. Operational and Support Environment

6.1 Personnel

Orange County Traffic Engineering staff will plan and design the project. County staff will utilize existing State and County contracts to procure the equipment. All of the equipment will be installed and integrated by County staff.

6.1.1 Staffing Requirements

6.1.1.1 Operations

Operations staff currently has 2 people dedicated to TMC ITS operations. The operations staff currently provides coverage to manage the system Monday through Friday from 6:30 AM until 6:30 PM. The impact of expanding the Arterial Travel System will be minimal on the operation due to the fact that the system is automated.

6.1.1.2 Maintenance

The Bluetooth readers will increase maintenance staffing needs linearly for preventive maintenance, but are expected not to significantly increase staffing levels for emergency maintenance.

6.1.1.3 Integration

Staffing requirements for integration will increase initially as new equipment is deployed. It is expected that only the initial implementation will impact integration staffing requirements.

6.2 Facilities

Devices will include existing sites and new high-priority sites to be identified.

6.3 Hardware and Software

The computer hardware and associated travel time software with adequate licensing for all of the devices required will be purchased as part of this project.

6.4 Operating Procedures

Standard Operating Procedures as currently followed by TMC operators will be followed.

6.5 Maintenance

Devices will be incorporated into Orange County Traffic Engineering's maintenance schedule. For new devices, the manufacturer will provide maintenance during the warranty period.

7. Operational Scenarios

7.1 Bluetooth Reader Design

In this scenario, The Bluetooth reader designer will determine the location of the reader. The designer will determine location based on the locations that travel time information will be referenced too. The designer will consider typical traffic flows and what travel time information will be useful to system engineers and operators.

7.2 Bluetooth Reader Installation and Configuration

In this scenario, the Bluetooth reader installer will determine the appropriate position of the reader on the signal support to ensure that the reader will satisfy all user needs, including proper operation and maintainability.

7.3 Bluetooth Maintenance

The maintenance technician will work with the TMC Operator to troubleshoot the reader and determine the most likely fault condition, either with the reader or in the supporting communications network.

The maintenance technician will then gain access to the reader. The technician will troubleshoot the problem, power down the reader, remove the defective modules, replace those modules with functional spares, and restore power and operation.

The technician will then communicate with the TMC Operator to verify the operation and programming of the reader. Once correct operation has been verified, the maintenance technician will leave the location.

8. Next Steps

8.1 Detailed Requirements

The stakeholder needs identified in the Concept of Operations are reviewed, analyzed, and transformed into verifiable requirements that determine what the system will do, but not how the system will do it. Working closely with the stakeholders the requirements are analyzed, validated, documented, and base-lined.

8.2 System Design

A system design is created based on the system requirements including a high-level design that defines the overall framework for the system. Subsystems of the system are identified and broken down further into components. Requirements are allocated to the system components, and interfaces are specified in detail. Detailed specifications are created for the hardware and software components to be developed, and the final product selections are made for off-the-shelf components.

8.3 Software / Hardware Development Field Installation

Hardware and software solutions are created for the components identified in the system design. Part of the solution may require custom hardware and/or software development, and part may be implemented with off-the-shelf items, modified as needed to meet the design specifications.

8.4 Unit / Device Testing

The components are tested and delivered ready for integration and installation

8.5 Subsystem and System Verification and Acceptance

The software and hardware components are individually verified and then integrated to produce higher-level assemblies or subsystems. These assemblies are also individually verified before being integrated with others to produce yet larger assemblies, until the complete system has been integrated and verified.

8.6 System Validation

After the ITS system has passed system verification and is installed in the operational environment, the system owner/operator, whether the State DOT, a regional agency, or another entity, runs its own set of tests to make sure that the deployed system meets original needs identified in the Concept of Operations.

8.7 Operations and Maintenance

Once the customer has accepted the ITS system, the system operates in its typical steady state. System maintenance is routinely performed and performance measures are monitored. As issues, suggested improvements, and technology upgrades are identified, they are documented, considered for addition to the system baseline, and incorporated as funds become available. An abbreviated version of the systems engineering process is used to

evaluate and implement each change. This occurs for each change or upgrade until the system reaches the end of its operational life.