Systems Engineering Analysis for Road Weather Information System

System Requirements

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Revision History

This document will be used for design of MnDOT's new road weather information system. As the system is developed, changes to requirements will be tracked and this document will be revised as needed. The following table provides the date and a brief description of each revision to document revision history.

Revision Number	Date of Revision	Description of Revision
1.0	8/19/2019	Initial version
1.1	5/14/2020	Revisions per MnDOT comments

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Introduction

This document provides ***Functional Requirements*** (*FRs*) for Road Weather Information System (RWIS) installations. An RWIS uses Environmental Sensor Stations (ESSs) in the field with sensors and processors, a communication system for data transfer, and central systems to collect and disseminate field data from numerous ESSs. These stations measure atmospheric, pavement, or water level conditions, or combinations of these. Central RWIS hardware and software are used to process observations from ESSs to develop forecasts and display or disseminate road weather information in a format that can be easily interpreted by a manager to support decision making, or in a format for the general public to use, for instance, via a 511 information system.

Closed circuit television (CCTV) cameras are typically provided at the ESS to capture still images for observing field conditions on both weather and traffic. RWIS installations may also be integrated with automated fixed anti-icing spray technology (FAST) installation, and their data may be an input to the national Clarus weather system.

The concept of operations developed for this project presents an overview of the current environment, identifies the relevant stakeholders, translates current challenges into specific needs, outlines the envisioned operational concept, suggests likely roles and responsibilities, describes scenarios for operation of the new road weather information system, and presents potential risks and recommended mitigation strategies associated with this effort.

This system requirements document contains the requirements necessary for addressing the needs identified in the concept of operations. The requirements describe what the RWIS must do as the basis for further design, procurement, installation, testing and operation. It also presents an assessment of how RWIS fits within the *Minnesota Statewide Regional ITS Architecture.*

ITS Architecture Assessment

As an Intelligent Transportation System, it is necessary to assess where the RWIS fits within the Minnesota Statewide Regional ITS Architecture (Version 2018). As it is envisioned in the concept of operations, RWIS is part of the Weather Service Package Area (Volume 10). The system addresses numerous needs/potential solutions identified in the architecture and are noted below.

- WTR01: Provide automated monitoring of road weather conditions
- ATMS04: Provide cameras at locations with high incidents and areas of high importance for incident identification and verification
- ATMS12: Reduce clearance time for primary crashes

RWIS is further identified in Weather Service Package Area as a series of existing architecture elements within several service packages. Service packages represent slices of the Physical View that address specific services (i.e. traffic signal control). A service package collects together several different physical objects (systems and devices) and their functional objects and information flows that provide the desired service. Individual service packages and the system functions they perform can be found in the United States Department of Transportation National ITS Reference Architecture (ARC-IT). RWIS service packages

are provided in Table 1.

Table 1. Applicable Service Packages from Minnesota Statewide Regional ITS Architecture

System/Element	Service Package	Description
Advanced Pavement Condition and Visibility Warning System Roadside Equipment	• WX01: Weather Data Collection	The element represents the roadside equipment of the proposed automated warning system. The roadside equipment would consist of pavement sensors, visibility sensors, and either changeable message signs or static warning signs with flashing beacons located upstream from the problem area.
RWIS Central Control System	• WX01: Weather Data Collection • WX02: Weather Information Processing and Distribution	MnDOT RWIS Central Server collects, verifies, processes, and formats environmental and road pavement surface condition data. Data is then made available to the Condition Acquisition and Reporting System (CARS) database, maintenance personnel, law enforcement, vendors providing value-added services, and the general public via the 511 information system.
RWIS Roadside Equipment	• WX01: Weather Data Collection	MnDOT's RWIS Stations include 96 environmental sensor sites, designed to measure environmental conditions and road pavement surface conditions, and over 50 airport sites, designed just to measure environmental conditions, connected via statewide network. Environmental sensors are planned to be equipped with pan/tilt cameras to provide maintenance crews with additional road condition data. All data is communicated to the MnDOT RWIS Central Control System for verification, processing, and formatting. It is planned to upload camera images from RWIS stations to the MnDOT 511 Traveler Information Website (www.511mn.org).
Video Monitoring Roadside Equipment	• TM01: Infrastructure-Based Traffic Surveillance	This element represents video monitoring cameras deployed along the roadside by various agencies and municipalities throughout Minnesota.
RTMC	• TM01: Infrastructure-Based Traffic Surveillance	The RTMC is a unified communications center that houses State Patrol Dispatch, MnDOT Metro Maintenance Dispatch and MnDOT Traffic Operations. The Metro Maintenance Dispatch serves as a point of contact for incoming information. Staff handles phone calls and monitor electronic communications and the bridge de-icier system, roadway surface and sub-surface systems. Maintenance Dispatch coordinates and initiates traffic management systems with the RTMC, traffic management personnel and the State Patrol.

Based on the architecture references identified, it is confirmed that the RWIS is adequately addressed in the *Minnesota Statewide Regional ITS Architecture*.

Functional Requirements

Functional requirements are verifiable details that define what the RWIS will do, how well it will perform or what conditions it must perform under. The requirements presented in this section are defined in relation to the needs that were identified in the concept of operations for the RWIS.

There are a series of functional requirements presented in Table 2 to describe the environment the system must operate within.

Table 2. Functional Requirements for RWIS Installation

ID	Functional Requirement
RWIS	**Road Weather Information System**
	Sensors
RWIS-1	The field element shall include surface and sub-surface environmental sensors that measure road surface temperature, moisture, icing, salinity, and other measures, as specified in the plans.
RWIS-2	The field element shall include environmental sensors that measure weather conditions including temperature, wind, humidity, precipitation, and visibility, as specified in the plans.
RWIS-3	The field element shall include sensors that measure water level and temperature, as specified in the plans.
RWIS-4	When specified in the plans, the field element shall collect traffic data vehicle speed, length, and classification.
RWIS-5	When specified in the plans, the field element shall include a pan-tilt-zoom CCTV camera.
RWIS-6	When specified in the plans, the field element shall share power and communications with other device subsystems such as CORS GPS stations, soil temperature/moisture grids, traffic information systems, and weigh-in-motion stations.
	Control and Monitoring
RWIS-7	The field element's environmental sensors shall be remotely controlled by a maintenance center, an RWIS control center, a traffic management center, or a maintenance and construction vehicle, as specified in the plans.
RWIS-8	The field element shall provide environmental sensor equipment operational status to the controlling center or maintenance vehicle.
RWIS-9	The field element shall provide environmental sensor equipment fault indication to the controlling center or maintenance vehicle.
	Data Flow and Interface
RWIS-10	When specified in the plans, the field element shall remotely aggregate environmental sensor data with environmental data collected from maintenance and construction vehicles.

ID	Functional Requirement
RWIS-11	When specified in the plans, the field element shall provide weather and road surface condition data via serial port or ethernet using standard protocols such as NTCIP 1204 or TCP/IP.
RWIS-12	The field element shall provide weather and road surface condition data to various centers and systems as specified in the plans. Data recipients may include the MnDOT MDSS, Minnesota 511, the national Clarus system, the National Weather Service, and Private VAMS.
RWIS-13	When specified in the plans, the field element shall provide traffic and weather data to the University of Minn. Duluth Transportation Data Research Laboratory and the MnDOT Office of Transportation Data and Analysis.
RWIS-CAV	**CAV Infrastructure Systems**
RWIS-CAV-1	RWIS design shall consider whether nearby CAV roadside units (RSUs) will require direct data feeds to and from the RWIS.
RWIS-CAV-2	RWIS design shall consider whether nearby CAV roadside units (RSUs) will benefit from shared structure, power or communications with the RWIS.
RWIS-CAV-3	When specified in the plans, RWIS shall communicate road conditions and alert messages to the applicable CAV Infrastructure System.
RWIS-CAV-4	When specified in the plans, RWIS shall receive BSM messages from applicable CAV Infrastructure System.
RWIS-Oth	**Other**
RWIS-Oth-1	[Develop as appropriate]

Table 3. Mapping of RWIS Needs/Services to Functional Requirements

Feature	Needs/Services	ITS Functional Requirements
Road Weather Information System	WTR01: Provide automated monitoring of road weather conditions	RWIS-1 thru -4, and -6 thru -13, RWIS-CAV-1 thru 4
	ATMS04: Provide cameras at locations with high incidents and areas of high importance for incident identification and verification	RWIS-5
	ATMS12: Reduce clearance time for primary crashes	RWIS-5
Other	[Develop as appropriate]	