SYSTEMS ENGINEERING
CONCEPT OF OPERATIONS (ConOps)

for:

ROAD WEATHER
INFORMATION SYSTEM

MINNESOTA DEPARTMENT OF TRANSPORTATION

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1.0 PURPOSE AND SCOPE OF APPLICATION PACKAGE

This document provides a ***Concept of Operations*** (*ConOps*) for Road Weather Information System (RWIS) installations. A Road Weather Information System (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. Often ESSs provide basic input to Minnesota's Maintenance Decision Support System (MDSS), an interactive system that assists maintenance supervisors with best management practices or techniques given predicted weather.

Figure 1 illustrates the range of applications of information collected from an ESS, while Figure 2 shows typical connectivity. This *ConOps* focuses on the field elements of ESSs that are fairly standard. Although communications and processing at central locations are required, they tend to be part of a larger network or are a specialized application.

Mobile sensing may become an integral part of RWIS networks in the future. The Minnesota Department of Transportation (Mn/DOT) now has over 160 vehicles with air and pavement temperature sensors. Plans are in place to equip Mn/DOT's entire snowplow fleet (830 vehicles) with Mobile Data Computers capable of collecting and transmitting data from these and other sensors and/or operator input. This *ConOps*, however, does not address these mobile units.

1.1 Basic RWIS Characteristics and Stakeholders

Regarding the three information types, atmospheric data (Figure 3) include air temperature and humidity, visibility distance, wind speed and direction, precipitation type and rate, cloud cover, tornado or waterspout occurrence, lightning, storm cell location and track, as well as air quality. Pavement data (see Figure 4) cover surface temperature, freezing point, condition (e.g., wet, icy, flooded), chemical concentration (amount of deicing material), and subsurface conditions (e.g., soil temperature). Water level data include stream, river, and lake levels near roads, as well as tide levels where applicable. Some ESSs are also used to collect traffic data such as vehicle speed, length, and classification. Wider employment of such vehicle data collection can be expected as implementers move towards using speed as a measure of level of service.

In addition, Minnesota is generally including closed circuit television (CCTV) cameras at ESSs to take images of the roadway for snow and ice control as well as for traveler information. RWIS installations may also be integrated with automated fixed anti-icing spray technology (FAST) installations to help proactively manage the pavement surface. This *ConOps* addresses only the RWIS.

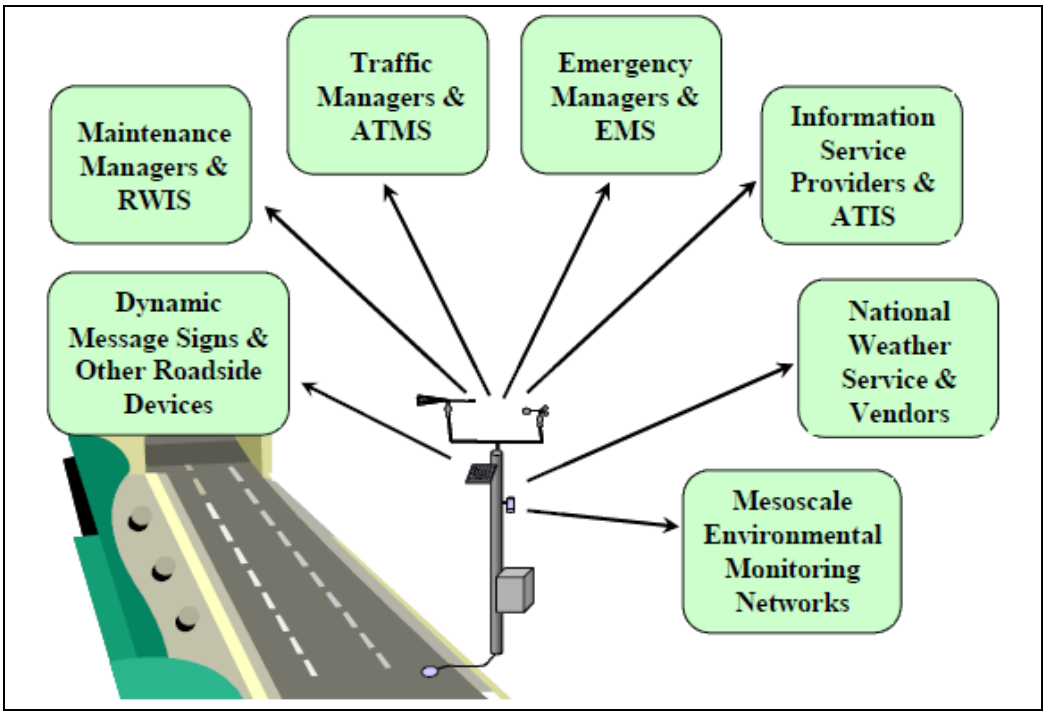

Figure 1 RWIS Uses and Customers
(Source: http://ops.fhwa.dot.gov/weather/mitigating_impacts/surveillance.htm#esrw)

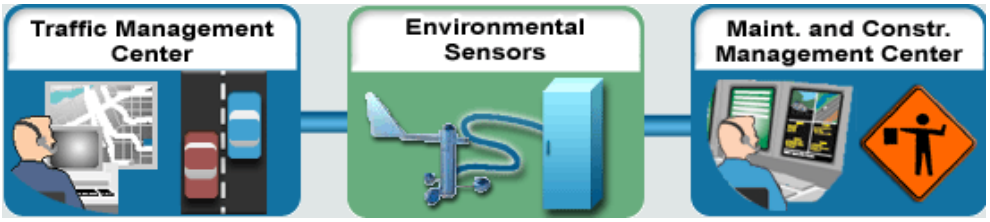

Figure 2 Typical RWIS Connections
(Source: *Best Practices for Road Weather Management*, Report No. FHWA-OP-03-081, available at http://ops.fhwa.dot.gov/weather/mitigating_impacts/best_practices.htm)

Figure 3 ESS Above Ground Sensor
(Source: *Road Weather Information System Environmental Sensor Station Siting Guidelines*, Publication No. FHWA-HOP-05-026, April 2005)

Figure 4 ESS Pavement Sensor
(Source: *Best Practices for Road Weather Management*, Report No. FHWA-OP-03-081, available at http://ops.fhwa.dot.gov/weather/mitigating_impacts/best_practices.htm)

The primary users of the information from RWIS installations are roadway maintenance, traffic operations, and weather service providers. The general public also may be a major user if the collected data are translated into useful traveler information, for example, by reporting on comparative conditions from several different sites.

The FHWA Clarus Initiative is a multi-year effort to develop and demonstrate an integrated surface transportation weather observation data management system, and to establish a partnership to create a Nationwide Surface Transportation Weather Observing and Forecasting System. Minnesota RWIS installations can be an input to Clarus.

Please see the corresponding *Minnesota Statewide Regional ITS Architecture and Systems Engineering Checklist* (*Checklist)* for the project locations.

Stakeholders, as per the *Minnesota Statewide Regional ITS Architecture* (March 2009; *Statewide Architecture* for short) for RWIS installations include some or all of the following depending on the site:

- Travelers: private vehicle drivers and passengers, transit operators and passengers, commercial operators, school bus operators and passengers, pedestrians (including those with disabilities), and bicyclists
- News media
- Minnesota Department of Transportation (Mn/DOT) and associated entities:
    - District Offices
    - RTMC (Regional Transportation Management Center), plus Transportation Operation and Communication Centers (TOCCs)
    - Office of Electronic Communications (OEC)
    - Office of Aeronautics (OA)
    - Office of Traffic, Safety, and Technology (OTST; formerly OTSO)
    - Office of Maintenance (OM)
    - Office of Transportation Data and Analysis (TDA)
- Local Agencies: counties, cities, towns, villages, and townships
- (Local) Traffic Management Centers
- Local Maintenance and Construction Management (MCM) Agencies
- Federal Highway Administration (FHWA)
- National Weather Service (NWS)
- Private Value Added Meteorological Services (VAMS)
- Minnesota State Patrol (MSP) and local law enforcement
- University of Minnesota Duluth Transportation Data Research Laboratory (UM-TDRL)

Notes to Stakeholder list:

- Only Travelers is listed in the *Statewide Architecture*, but has been expanded above to explicitly list the various types of Travelers.
- The list of Local Agencies has been similarly expanded from the *Statewide Architecture.*
- Local law enforcement has been added to the MSP group.

1.2 Other

[Reserved for new RWIS features and their characteristics. Please consult with appropriate Mn/DOT, FHWA, or local staff to develop needed scope description.]

2.0 REFERENCE DOCUMENTS

Reference sources, including traffic signal design and operation documents, follow. The latest adopted version of each document should apply.

- "Intelligent Transportation System Architecture and Standards," (*CFR 940*), Federal Highway Administration (FHWA) Final Rule, 23 CFR Parts 655 and 940
- *Minnesota Statewide Regional ITS Architecture*, March 2009
- *Mn/DOT Intelligent Transportation System (ITS) Design Manual*, Fall 2009
- Various traffic signal planning, design, and operations references cited at http://www.dot.state.mn.us/trafficeng/designtools/index.html
- Various RWIS reference documents cited at http://ops.fhwa.dot.gov/weather/best_practices/1024x768/menu_publications.htm
- Minnesota RWIS site information at http://www.rwis.dot.state.mn.us/
- *Maintenance Decision Support System Deployment Guide*, available at http://www.itsdocs.fhwa.dot.gov/JPODOCS//REPTS_TE/14439_files/mdss_dep_guide/14439.pdf
- Clarus Initiative information available at http://ops.fhwa.dot.gov/weather/mitigating_impacts/programs.htm
- *National Transportation Communications for ITS Protocol, Environmental Sensor Station (ESS) Interface Protocol*, NTCIP 1204 version v03.

3.0 BACKGROUND AND SYSTEM CONCEPT

3.1 Basic RWIS

RWIS development has progressed a long way in the last 20-30 years along with advances in electronic processing and communications system development. Weather obviously has always been a major consideration in transportation, affecting travelers' choice of travel time, mode, and route, plus operator management of facilities to keep them open under adverse conditions. Any information that allows operators and maintenance organizations to not only keep apprised of weather conditions system-wide but also to help forecast future conditions is valuable and helps agencies be more effective and efficient in performing their duties. ESSs to support the entire RWIS are the key connection with the travel environment, and as more are installed, the resulting performance can only improve.

ESSs provide basic inputs to Clarus, the Mn/DOT MDSS, and the Minnesota 511 Traveler Information system. RWIS installations typically use the NTCIP 1204: 1998 standard cited in Section 2.

3.2 Other

Future applications outside the scope of standard RWIS include potential center-to-vehicle communications of local conditions as a feature resulting from the national IntelliDrive program. A good deal of research and development will be needed before this can become a reality.

4.0 OPERATIONAL DESCRIPTION

The major operational aspects of RWIS have been discussed in Section 1.1 and 3.1. Each ESS is another data input that allows the stakeholders to implement and a wide area maintenance and management system for the sometimes harsh weather conditions in Minnesota.

5.0 OPERATIONAL NEEDS

The needs of RWIS for the various stakeholders are presented in Table 1.

The Needs and Services plus associated ITS Development Objectives, per the *Statewide Architecture*, are presented in Table 2. For reference, the complete list of ITS Development Objectives is presented in Appendix A.

Table 1 RWIS Needs by Stakeholder

STAKEHOLDER	RWIS NEEDS
Travelers: private vehicle drivers and passengers, transit operators and passengers, commercial operators, school bus operators and passengers, pedestrians (including those with disabilities), and bicyclists News Media MSP and Local Law Enforcement	RWIS-1 Availability of wide-area weather information and forecasts based on ESSs as one of several inputs to other systems including the MDSS and Minnesota 511.
	RWIS-2 Access to ESS CCTV camera views as feasible and applicable.
	Other – *[Please consult with appropriate Mn/DOT, FHWA, or local staff to develop needed Needs and Functions]*
All Stakeholders share in above to varying degree. Additional Needs and Functions follow:	
Mn/DOT, Mn/DOT District Offices, Local Agencies	RWIS-3 Planning, design, and implementation of ESSs that meet agency design and performance standards, are reliable and easily maintained. Where appropriate, share power and communications with adjacent device systems.
Mn/DOT OA, RTMC, TOCCs, and OTST; Local Traffic Management Centers	RWIS-4 Communications links to RWIS management centers RWIS-5 Remote operation and control of ESSs per established hierarchy
Mn/DOT OM and OEC; Local MCM Agencies	RWIS-6 Oversight and maintenance of ESS devices
FHWA, NWS, Private VAMS	RWIS-7 Access to RWIS data for Clarus and for national/regional weather forecasting
UM-TDRL, Mn/DOT TDA	RWIS-8 Access to RWIS data for archiving and data analysis, including traffic data when available.

Table 2 RWIS Needs/Services & ITS Development Objectives by RWIS Feature

ID	Feature	Needs/Services		ITS Development Objectives
RWIS	*Road Weather Information System*	WZ04	Provide automated monitoring of road weather conditions	O-1, O-33
		TM04	Provide cameras at locations with high incidents and areas of high importance for incident identification and verification	O-4, O-15, O-16, O-21, O-24, O-26, O-27
		TM12	Reduce clearance time for primary crashes	O-4, O-15, O-16, O-26, O-27
RWIS-Oth	*Other*			

Needs/Services and ITS Development Objectives per *Minnesota Statewide Regional ITS Architecture* (March 2009).

Needs/Services Key:
WZ - Work Zone
TM - Traffic Management

See Appendix A for detailed list of ITS Development Objectives.

6.0 OPERATIONAL SUPPORT ENVIRONMENT

6.1 Basic RWIS

The operational support environment will be completed either by agency personnel or contracted private services. Specially trained technicians will operate and maintain the ESSs using standard supplier operational guidelines along with routine and emergency maintenance procedures that are well established. In general, trouble calls on ESSs are not as critical as with, by comparison, traffic signals or active grade crossing protection, except in the case of RWIS equipment integrated with a fixed anti-icing spray technology (FAST) system. In that case, response time requirements should be established and strictly enforced. Trouble calls will typically originate from alarms on the equipment transmitted to the RWIS control center.

Preventive maintenance on the equipment will be scheduled to occur as a part of routine maintenance. This would include periodic checking and recalibration of sensors.

Since field ESSs will connect to an RWIS control center, system architecture and communications system configuration will need to be developed, ideally including redundant network design. Communications may be either wireline or wireless.

6.2 Other

[Reserved for new features and their scenarios].

7.0 SUMMARY OF IMPACTS

7.1 Basic RWIS

Transportation managers can use roadway warning systems, interactive telephone systems (e.g., 511), and web sites to disseminate road weather information to travelers in order to influence their decisions. This information allows travelers to make choices about travel mode, departure time, route selection, vehicle type and equipment, and driving behavior

based on current and forecast weather conditions, and avoid severe weather conditions. The compiled information also can help to improve timeliness and efficiency of maintenance actions by way of the MDSS, such as when to snowplow or deposit anti-icing/de-icing chemicals on the highways. Such proactive facility management should result in safer roads with fewer weather-related accidents.

7.2 Other

[Reserved for new RWIS feature impacts.]

APPENDIX A. ITS DEVELOPMENT OBJECTIVES

Source: ***Minnesota Statewide Regional ITS Architecture*** *(March 2009)*

General Purpose: Create a system that enhances transportation through the safe and efficient movement of people, goods, and information, with greater mobility and fuel efficiency, less pollution, and increased operating efficiency in Minnesota.

A. Improve the Safety of the State's Transportation System

A-1. Reduce crash frequency (*ATMS, ATIS, APTS, CVO, EM, MCM & AVSS*)
- O-1 Reduce crashes due to road weather conditions
- O-2 Reduce crashes due to unexpected congestion
- O-3 Reduce secondary crashes
- O-4 Reduce incident clearance time
- O-5 Reduce crashes due to red-light running
- O-6 Reduce crashes due to unsafe drivers, vehicles and cargo on the transportation system
- O-7 Reduce lane departure crashes
- O-8 Reduce crashes due to roadway/geometric restrictions
- O-9 Reduce crashes at railroad crossings
- O-10 Reduce crashes at intersections
- O-11 Reduce speed differential
- O-12 Reduce crashes due to driver errors and limitations
- O-13 Reduce crashes involving pedestrians or non-motorized vehicles
- O-14 Reduce violation of traffic laws

A-2. Reduce fatalities and life changing injuries (*ATMS, ATIS, CVO, EM, MCM & AVSS*)
- O-5 Reduce crashes due to red-light running
- O-9 Reduce crashes at railroad crossings
- O-10 Reduce crashes at intersections
- O-11 Reduce speed differential
- O-15 Reduce emergency/incident response time
- O-16 Enhance emergency/incident response effectiveness
- O-17 Safeguard public safety personnel while they are at roadway incidents and emergencies
- O-18 Reduce speed violations

A-3. Safeguard the motoring public from homeland security and/or Hazmat incidents (*ALL*)
- O-15 Reduce emergency/incident response time
- O-19 Reduce security risks to transit passengers and transit vehicle operators
- O-20 Reduce security risks to motorists and travelers
- O-21 Reduce security risks to transportation infrastructure
- O-22 Reduce exposure due to Hazmat & homeland security incidents
- O-23 Enhance tracking and monitoring of sensitive Hazmat shipments

A-4. Reduce crashes in work zones (*ATMS, ATIS, EM & MCM*)
- O-4 Reduce incident clearance time
- O-11 Reduce speed differential
- O-24 Reduce congestion and delay
- O-25 Enhance safety of workers

B. Increase Operational Efficiency and Capacity of the Transportation System

B-1. Reduce overall delay associated with congestion *(ATMS, ATIS & MCM)*
- O-4 Reduce incident clearance time
- O-15 Reduce emergency/incident response time
- O-16 Enhance emergency/incident response effectiveness
- O-24 Reduce congestion and delay
- O-26 Maintain smooth traffic flow
- O-27 Reduce incident detection and verification time

B-2. Increase average vehicle occupancy and facility throughput *(ATMS & APTS)*
- O-28 Increase transit ridership
- O-29 Enhance transit operations efficiency
- O-30 Increase carpoolers
- O-31 Increase throughput of roadways

B-3. Reduce delays due to work zones *(ATMS, ATIS, EM & MCM)*
- O-4 Reduce incident clearance time
- O-24 Reduce congestion and delay
- O-26 Maintain smooth traffic flow

B-4. Reduce traffic delays during evacuation from homeland security and Hazmat incidents *(ALL)*
- O-24 Reduce congestion and delay

B-5. Enhance efficiency at borders *(ATMS, CVO, EM & AVSS)*
- O-32 Reduce delays at border crossings
- O-33 Keep travelers informed of travel conditions

C. Enhance Mobility, Security, Convenience, and Comfort for the Transportation System User

C-1. Reduce congestion and incident-related delay for travelers *(ATMS, ATIS & APTS)*
- O-4 Reduce incident clearance time
- O-15 Reduce emergency/incident response time
- O-16 Enhance emergency/incident response effectiveness
- O-24 Reduce congestion and delay
- O-26 Maintain smooth traffic flow
- O-27 Reduce incident detection and verification time
- O-34 Enhance parking facility services and management

C-2. Improve travel time reliability *(ATMS)*
- O-24 Reduce congestion and delay
- O-26 Maintain smooth traffic flow

C-3. Increase choice of travel modes *(APTS & ATMS)*
- O-33 Keep travelers informed of travel conditions
- O-35 Inform travelers of travel mode options

C-4. Enhance traveler security *(APTS & EM)*
- O-19 Reduce security risks to transit passengers and transit vehicle operators
- O-20 Reduce security risks to motorists and travelers
- O-21 Reduce security risks to transportation infrastructure

C-5. Reduce stress caused by transportation *(ATMS, ATIS, APTS, EM & MCM)*
- O-3 Reduce secondary crashes
- O-11 Reduce speed differential
- O-14 Reduce violation of traffic laws
- O-18 Reduce speed violations
- O-24 Reduce congestion and delay
- O-29 Enhance transit operations efficiency

O-33 Keep travelers informed of travel conditions
O-34 Enhance parking facility services and management
O-35 Inform traveler of travel mode options

D. Enhance the Present and Future Economic Productivity of Individuals, Organizations and the Economy as a Whole

D-1. Reduce travel time for freight, transit and businesses *(ATMS, ATIS, APTS & CVO)*
- O-24 Reduce congestion and delay
- O-26 Maintain smooth traffic flow
- O-29 Enhance transit operations efficiency
- O-33 Keep travelers informed of travel conditions

D-2. Improve the efficiency of freight movement, permitting and credentials process *(ATIS & CVO)*
- O-33 Keep travelers informed of travel conditions
- O-36 Enhance asset and resource management
- O-37 Enhance credential process automation
- O-38 Reduce freight movement delays due to inspection

D-3. Improve travel time reliability for freight, transit and businesses *(ATMS, APTS & CVO)*
- O-26 Maintain smooth traffic flow
- O-29 Enhance transit operations efficiency
- O-33 Keep travelers informed of travel conditions
- O-38 Reduce freight movement delays due to inspection

D-4. Increase agency efficiency *(ATMS, APTS, AD, CVO, EM & MCM)*
- O-29 Enhance transit operations efficiency
- O-36 Enhance asset and resource management
- O-39 Enhance garage operations efficiency

D-5. Safeguard existing infrastructure *(CVO, EM & MCM)*
- O-21 Reduce security risks to transportation infrastructure
- O-36 Enhance asset and resource management
- O-40 Reduce commercial vehicle size and weight violations

D-6. Aid in transportation infrastructure and operations planning *(ALL)*
- O-36 Enhance asset and resource management
- O-41 Enhance planning with better data
- O-42 Enhance investment decision making

D-7. Reduce vehicle operating costs *(ATMS, APTS, CVO & AVSS)*
- O-24 Reduce congestion and delay
- O-26 Maintain smooth traffic flow

E. Reduce Energy Consumption, Environmental Impacts and Costs of Transportation

E-1. Reduce emissions/energy impacts and use associated with congestion *(ATMS, ATIS & CVO)*
- O-24 Reduce congestion and delay
- O-33 Keep travelers informed of travel conditions
- O-43 Enhance compliance of air quality standards

E-2. Reduce need for new facilities *(ATMS,CVO & MCM)*
- O-31 Increase throughput of roadways
- O-36 Enhance asset and resource management
- O-37 Enhance credential process automation

E-3. Reduce negative impacts of the transportation system on communities *(APTS, ATMS, EM & MCM)*

- O-14 Reduce violation of traffic laws
- O-28 Increase transit ridership
- O-30 Increase carpoolers
- O-44 Reduce environmental impacts of de-icing material use

AD:	Archived Data Management	AVSS:	Advanced Vehicle Safety Systems
APTS:	Advanced Public Transportation Systems	CVO:	Commercial Vehicle Operations
ATIS:	Advanced Traveler Information Systems	EM:	Emergency Management
ATMS:	Advanced Traffic Management Systems	MCM:	Maintenance and Construction Management