What’s New with Clarus & FHWA’s Road Weather Management Projects

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The Clarus Initiative

• Clarus is an R&D initiative to demonstrate and evaluate the value of “Anytime. Anywhere Road Weather Information” provided by both public agencies and the private weather enterprise to transportation users and operators.

The Clarus Initiative: 4 Objectives

• Provide a North American resource to collect, quality check, and disseminate weather and road condition observations
• Demonstrate that these observations will support general purpose weather forecasting
• Demonstrate that the observations will support real-time operational responses to weather
• Support the enhancement and creation of models to improve forecasts at and near the earth’s surface

Clarus Sponsors

• U.S. Department of Transportation (USDOT)
  – FHWA - Road Weather Management (RWM) Team
  – RITA - Joint Program Office (JPO)
• Clarus Initiative Coordinating Committee
  – Transportation Community
    • Federal, State, & Local
  – Meteorological Community
  – Academic Community
  – Consultant Community
  – Vendor Community

The Clarus System

www.clarus-system.com
Over 75% of State DOTs Participate in Clarus

Clarus Connection Status
- Connected (38 States, 5 Locals, 4 Provinces)
- Pending (4 States, 5 Locals, 1 Province)
- Considering (3 States, 1 Local)

Clarus Users by Country - 2010
1. United States
2. Ireland
3. Japan
4. Canada
5. Israel
6. Great Britain
7. Spain
8. China
9. South Korea
10. Germany

Clarus Users in 2010
- 4993 unique addresses gaining access (3,524,702 hits) from 67 countries
- government agencies (federal, state, local)
- academic institutions
- weather providers
- TV stations
- private sector firms
- unknown sources (Internet providers, etc.)

Quality Checking Algorithms
Complete Flag
- All tests that can be run have completed
- Why wouldn’t a test run?
  - Not configured to run
  - Not enough data to run

Manual Flag
- Set by contributor to indicate “Don’t necessarily trust this value”
- Set by contributor to indicate “Out of Service”
### Quality Checking Algorithms

#### Sensor Range Test
- Observation compared to manufacturer’s published minimum and maximum values
- Example:
  - Air Temperature: 25°C
  - Spec: -20°C to 50°C
  - Test Passed

#### Climate Range Test
- Observation compared to historical climate minimum and maximum values per month by geographic area – gridded field
- Example:
  - Air Temperature: 25°C
  - Climate Value for January: -10°C to 20°C
  - Test did not pass

#### Step Test
- Observation compared to previous observations over a configured time range to determine if the rate of change (plus or minus) was acceptable
- Example:
  - Values: 10°C, 12°C, 15°C, 35°C
  - Test did not pass

#### Like Instrument Test
- Observation compared to the same observation types from the ESS

#### Persistence Test
- Observation compared to previous observations to determine if the values had changed at all over a period of time
- Example:
  - Values: 38.6%, 38.6%, 38.7%
  - Test passed

#### Dewpoint Test
- Determine the neighbors
- Calculate a dewpoint value based on the temperature & relative humidity
- Conduct a spatial test

#### IQR Spatial Test
- Neighboring ESS and ASOS/AWOS identified
- Eliminate the neighbors that are >350 meters
- Eliminate the highest and lowest neighboring values
- Observation compared to remaining neighbors to determine if they are similar
- Requires 5 initial neighbors for the test to run

#### Barnes Spatial Test
- Observation compared to neighboring ESS and ASOS/AWOS to determine if they are similar
- Requires 2 neighbors

#### Sea Level Pressure Test
- Calculate a sea level pressure from the station pressure and then conduct a spatial test
- Conversion based on current 700mb Rawinsonde observations or 30-year average gridded data

#### Precipitation Accumulation
- Applies to:
  - 3-hour
  - 6-hour
  - 12-hour
  - 24-hour
- Uses Stage II & IV precipitation files to accumulate the precipitation for comparison
Map display – timeout

- Microsoft
  - http://support.microsoft.com/kb/175500
- Firefox
  - https://wiki.mozilla.org/Firefox3_Timeout_Problem

Next Steps

- Continue to operate Clarus thru 2011
- Continue to support the Clarus to MADIS transition
- Update all metadata with contributors including, but not limited to:
  - Observation units
  - Surface sensor location (bridge, road, etc.)
  - Configuration elements (i.e. – file frequency, offsets from midnight, etc.)
- Reach out to local agencies
- Reach out to DOTs with observations on vehicles
- Include VDT observations into Clarus

Next Steps

- Update the user guide
- Create a configurable service to notify contributors when expected observations are not received
- Create a file format that can be used for Google Earth
- Investigate, implement, and test new quality checking algorithms
- Investigate, implement, and test new confidence value algorithm
- Create a collector service and dissemination method for mobile data

Clarus-enabled Services

Regional Demonstrations

Clarus Regional Demonstrations - Objectives

- Ensure the Clarus System works as designed
  - Demonstrate the ability of the Clarus System to process and provide data from large numbers of ESS
  - Promote/educate on metadata collection
- Foster proactive transportation system management
- Encourage improved private sector services for road weather information enabled with data from the Clarus System
  - New software will be GOTS/open source

Clarus Regional Demonstration

5 Use Case Scenarios

1. Enhanced Road Weather Forecasting Enabled by Clarus
2. Seasonal Weight Restriction Decision Support Tool
3. Non-winter Maintenance & Operations Decision Support Tool
4. Multi-state Control Strategy Tool
5. Enhanced Road Weather Content for Traveler Advisories

State Transportation Agency Partners

Mixon Hill Team
Scenarios 1, 3, 4

Meridian Team
Scenarios 1, 2, 3
Use Case #1 Evaluation

Regional Demonstration Evaluations

• Independent evaluation of the Clarus System & developed innovations
  • Two awards were made to perform independent evaluations of the Phase 3 innovations
• Use Case 1 Evaluation
  • Scientific/Statistical Analysis of improvements to surface transportation meteorology & operational forecasting awarded to SAIC Inc.; Due June 2011
• Use Case 2-5 Evaluation
  • Improvements to operations, tangible versus intangible benefits (mobility, productivity, safety) awarded to Battelle Inc.; Due in May 2011

Use Case #1 Enhanced Road Weather Forecasting Enabled by Clarus

• Two primary objectives
  – Assess the impact of Clarus data on weather and pavement predictions
  – Provide enhanced Clarus-enabled forecasts for the duration of the contract for utilization in the Non-winter Maintenance and Operations Decision Support Tool and the Multi-state Control Strategy Tool.

Methods

• For each test event, a WRF spatial forecast will be generated for each of the next twelve hours, with the forecast being rerun every six hours.
  – For Clarus simulations, Clarus QCh confidence flags will be used in WRF/ATEC.
• An RWFS/METRo point forecast will be generated for each hour for the next 8 days, with the forecast being rerun every hour.
  – For Clarus simulations, Clarus data will be ingested for several days prior so that the model is tuned with Clarus data.

Test 1 (June 6-7, 2008)

• Liquid Precipitation
  – Primary variable of interest is 24-hour precipitation total.
  – Air temperature, wind speed, wind direction, and relative humidity will also be assessed.
  – Clarus data will help to better define the surface wind patterns along with locations of major storm components (fronts, surface low, etc.) which ideally will help to improve the precipitation forecast.

Test 2 (Sep 12–15, 2008)

• High winds
  – Remnants of Hurricane Ike traveled through the study region.
  – Primary variable of interest is wind speed, although 24-hour precipitation totals will also be closely tracked.
  – Clarus data will help to better define the surface wind patterns and track the timing of Ike’s passage.
  – This also should improve the precipitation and temperature forecast.
Test 3 (May 14-16, 2009)
• Squall lines
  – Between 14 May 2009 and 16 May 2009 the study region was affected by a range of complex systems which formed two separate squall lines located along different fronts.
  – Primary variables of interest are wind speed, wind direction, relative humidity, and air temperature.
  – Specifically interested in timing of frontal passage.
  – Clarus data will help to better define the surface wind patterns, the availability of heat and moisture necessary for convection, as well as better track the timing of the passage of the cold front.

Test 4 (Jan 15, 2009)
• Cold case
  – Strong northerly upper-level flow enabled a strong cold airmass from the Arctic to move into the Midwest.
  – The primary variables of interest in this case are air temperature and wind speed.
  – Clarus data will help to better forecast the timing and intensity of the cold air mass.

Test 5 (Jul 20, 2008)
• Warm case
  – Moderately high pressure with strong warm and moist (T~70°F) southwest flow.
  – Primary variables of interest are relative humidity, air temperature and (to a lesser extent) wind speed.
  – Clarus data will increase the accuracy of both temperature and dewpoint temperature forecasts.

Key Findings
• Inclusion of Clarus data provides small but statistically significant improvement in most meteorological variables in RWFS
  – Surface temperature
  – Air temperature
  – Dewpoint temperature
  – Wind speed
• Value of Clarus data in RWFS appears to be better in winter than summer (esp for pavement temp), based more on model deficiencies.

Temperature/Spatial

Precipitation
Forecast Observation
Use Case #3
Non-winter Maintenance & Operations Decision Support Tool

Objectives
• Expand decision support beyond snow and ice control
• Incorporate Clarus data to assist maintenance, operations, and construction-related scheduling decisions
• Provide the framework to bridge the current gap between the road weather information and the proactive decision-making process

Observation Map
• Data Sources
  – Near Real-time Observations
    • Clarus
    • METAR - NWS
    • Earthquake - USGS
    • Alerts - NWS
  – Gridded Forecasts
    • WRF - NCAR
    • NDFD - NWS
  – Site Specific Forecasts
    • RWFS - NCAR
    • Metro - NCAR

Observation Details
• Click on a station or forecast point
  – Observation Type
  – Value
  – Unit
  – Expires
    • The time that the system will no longer use the observation during processing
  – Miscellaneous
    • The station description

Show Observations
• Select one or more data sources
• Select one or more observation types
• Select Show Obs
• Current observations will appear next to the station, if available

Define Weather Related Practice

Dewpoint Temperature <= 30

Wind Average Speed <= 10

Air Temperature <= 30

Activity Duration
Define Weather Related Practice

- Define or select the activity group and activity
- Define the activity description and the default activity message
- Define the evaluation parameters

Plan an Activity

- Define location
- Define activity
- Define the activity duration
- Select “View Times”
- Select “Edit Emails”
- Select “Modify WRP”
- Repeat Activity

Schedule the Activity

Temporarily Modify the WRP

- View the schedules available for a number of activity types at a selected location
- A specific activity group can be selected to limit the number of schedules displayed
- All activity types in the system can be evaluated

View Active Plans

- Screen shows all of the plans that are active
  - Name of Plan
  - Start time of the plan
  - Description of the plan
- Links
  - view additional times
  - Edit the plan
  - Delete the plan

WRP Forecast
Objectives

• Provide data and strategies which will improve the coordination between agencies with respect to the imposition of controls and dissemination of associated advisories.
• This coordination will assist agencies in proactively responding to situations, allow for timely dissemination of safety-related information, and thus mitigate the impact to travelers.

Use Case #4
Multi-state Control Strategy Tool

Overview Map – WRF Gridded Forecasts

• Data Sources
  - Near Real-time Observations
    - Clorus
    - METAR - NWS
    - Earthquake - USGS
    - Alerts - NWS
  - Gridded Forecasts
    - WRF - NCAR
    - NDFD – NWS
  - Site Specific Forecasts
    - RWFS - NCAR
    - Metro - NCAR

NWS Radar

NWS Satellite
NWS Alerts

Set up a Conference

Define Strategy

- Verify Location
- Set up evaluation parameters
- Set up Action
- Set as “Active”
- Set as “Continuous” or not

Set Up Evaluation Parameters

- Set up the observation evaluation up the same of use case #3
- Additional observations can be shown outside of the evaluation

Set up Actions

- Set up the messages that you want sent out when the parameters evaluate to true and to false

Conference Overview

- Displays all active conferences
- Ability to view all messages
- Ability to post additional messages
- Ability to view observations associated with message, if applicable
Monitor Results

Conference Details

Broad Agency Announcement

Additional Uses of Clarus Data

• Goal: develop more tools and apps beyond the five in the Regional Demonstrations
• Objective: Foster multi-disciplinary collaboration to use Clarus data to create:
  – New or improved surface transportation weather management/operations procedures,
  – Innovative user interfaces, and/or
  – New applications including weather-responsive traffic management tools
• Action: Award multiple contracts through a Broad Agency Announcement

Additional Uses of Clarus Data

• Received 15 proposals, made 8 awards (5 academic, 3 private)
• Period of performance: 12 months, thru Sept. 2011

AMEC Americas Ltd. Add Nova Scotia & New Brunswick to Clarus
University of Idaho Integrate Clarus data into Traffic Signal Sys. Ops.
GST Inc. Fuse Clarus data & MoPED Data for alerting & DST
University of Maryland Integrate Clarus data into Regional Integrated
Transportation Information System (RITIS)
Univ. of North Dakota Validate quality of mobile wx data from state
fleets: MN, ND & SD DOTs
Montana State Univ. Integrate Clarus data into Rural Travel Wx DST
Michigan Tech. Univ. Integrate Clarus data & Crash Data for travel DST
Telvent-NY Int. Road Segment Alerts with Clarus data; NY 511

Other Road Weather Management Projects
Connected Vehicles & Weather – Vision

- Obtain a thorough picture of current weather and road conditions by including mobile sources
  - Higher resolution observations that spatially augment fixed sensors
  - Take advantage of existing standards and on-board sensors
- Improve weather-related decision support tools to mitigate safety and mobility impacts of weather
  - Based on ability to better detect and forecast road weather and pavement conditions

The VDT Concept

- Functions
  - Parsing
  - Filtering
  - Quality Checking
  - Data integration
  - Statistical processing
  - Data export

Maintenance Decision Support System

MDSS is a winter maintenance decision-support system that combines:
- Advanced weather prediction
- Advanced road condition prediction
- Rules of practice for anti-icing and de-icing

The system generates winter treatment recommendations on a route-by-route basis.
Weather Responsive Traffic Management

- **Goal:** Develop strategies and tools to help agencies effectively manage traffic and highway operations during inclement weather.

- **WRTM Strategies**
  - Advisory, Control and Treatment

- **Current Research**
  - Weather Integration in TMC/TDC
  - Weather and Traffic Flow Studies

**RWMP Performance Metrics Project**

**Objective:** Develop performance measures to use for evaluating the success of the RWMP in achieving the following SAFETEA-LU Section 5308 goals:

1. Maximize use of available road weather information and technologies
2. Expand Road Weather R&D efforts to enhance roadway safety, capacity, and efficiency while minimizing environmental impacts; and
3. Promote technology transfer of effective road weather scientific and technological advances.

**Goal 1 Measures & Indicators**

- **Goal 1:** Maximize use of available road weather information and technologies

  - Measure 1: Number or percentage of agencies using information for advisory, control, treatment decisions
  - Measure 2: Number or percentage of travelers who use road weather information for making travel decisions
  - Measure 3: Number of ESS deployed and used by agencies to support decision-making
  - Measure 4: Number of states using ESS data for their operations
  - Measure 5: Number of agencies adopting MDSS
  - Measure 6: Number of states providing travel with Wx information

**Goal 1 - Maximize use of available road weather information and technologies**

- States providing travelers with Wx information increased 46% from 2004 to 2007.
- In 2007, 22 States reported providing route-specific weather forecasts, up 69% over 2004.
- In 2007, 46 States used atmospheric data, 45 States used pavement condition data for operations, and 30 States implemented traffic control strategies.
- In 2008, 30 agencies reported some use of MDSS, and 5 reported operational use.

- From 2004 to 2007, the number of State DOTs using Wx information increased 31%.
- From 2006 to 2009, number of agencies contributing ESS data to CORS increased from 3 to 39.
- In 2008, 33 States had 41 operating 511 systems, and 25 offered road weather information.
Goal 2 Measures and Indicators

<table>
<thead>
<tr>
<th>Measure 1:</th>
<th>Number of agencies participating in Clarus initiative activities</th>
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<tr>
<td>Measure 2:</td>
<td>Percentage of time roadway meets safety and capacity LOS standards during and after weather events</td>
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<tr>
<td>Measure 3:</td>
<td>Reduction in agency costs (labor, equipment, materials) due to adoption of decision support systems</td>
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<td>Measure 4:</td>
<td>Reduction in user costs (e.g., delay, crashes, emissions) due to improved road weather strategies</td>
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Indicator 1: Reduction in crashes due to Clarus technology and operational deployment

GOAL 2 – Expand Road Weather R&D Efforts to Enhance Roadway Safety, Capacity and Efficiency while minimizing Environmental Impacts

- 88% of agencies participating in road weather R&D said they experienced moderate or substantial benefits, and 20 said they were involved in more than one RWMP initiative.
- 32% of agencies measure “time to wet/bare pavement;” 11% measure “time to pre-event travel speeds after a weather event;” and 18% measure “customer satisfaction with maintenance and recovery time.”
- Fog warning systems have reduced crashes by 70-100%; the use of RWIS increased by 17%; anti-icing strategies were up 83%; and wet pavement detection up by 39%.
- Low visibility warning systems reduced speed variability by 22% and increased speeds by 11%; variable speed limits reduced average speeds by 13%.

Goal 3 Measures and Indicators

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<tr>
<th>Measure 1:</th>
<th>Number of agencies contributing to MDSS stakeholder meetings</th>
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<td>Measure 2:</td>
<td>Rate of adoption of RWMP technology by agencies that participated in workshops or training</td>
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<tr>
<td>Measure 3:</td>
<td>Number of RWMP technology development, testing and deployment activities of the public or private sector</td>
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<tr>
<td>Measure 4:</td>
<td>Number of road weather technologies developed through partnerships reaching operational deployment</td>
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Indicator 1: Number of states adopting MDSS

GOAL 3 – Promote Technology Transfer of Effective Road Weather Scientific and Technological Advances

- State DOT participation in Clarus stakeholder meetings increased 68% between 2004-2008.
- 22 of 30 State agencies interviewed (73%) were involved in the Clarus Initiative, and 41 State DOTs have participated in one or more annual MDSS stakeholder meetings.
- 17 of 30 agencies (57%) are involved with MDSS, and 13 (43%) with both the Clarus Initiative and MDSS.
- 151 persons attended 6 road weather management training courses; 925 participated in 28 RWMP-sponsored MDSS Road Shows.
- 79% of State agencies interviewed have visited the RWMP web site; 12 downloaded materials, and 71 percent participated in an NTOC webcast.
- Between 2001 and 2008 - 90 projects have been initiated through federal, state and university sponsorship with RWMP input and support.

Conclusions and Next Steps

- Road Weather Management among agencies clearly advanced and improved over the last 5 years
- Performance measures and indicators useful for evaluating success of RWMP
- Difficult to attribute RWMP products and activities to specific measures
- Need to update the performance measures in 2011

Weather and Traffic – Highlights

- Weather Integration in TMC/TOC
  - Developed a self-evaluation guide to assist TMC’s with their weather integration activities
- Road Weather Advisory and Control Messages
  - Published design guidelines to assist traffic and emergency managers with the creation of weather-related messages
- Weather Module for Traffic Analysis Tool (TAT)
  - Develop guidance materials on the application of weather-sensitive tools
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