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EVOLUTION OF THE U.S. DEPARTMENT OF TRANSPORTATION CLARUS INITIATIVE: PROJECT STATUS AND FUTURE PLANS

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1.0 INTRODUCTION

The U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA) Road Weather Management Program, in conjunction with the Intelligent Transportation Systems (ITS) Joint Program Office (JPO) established the *Clarus* Initiative in 2004 to help reduce the impact of adverse weather on surface transportation users. The goal of *Clarus* is to create a robust data assimilation, quality checking, data management, and dissemination system that can provide atmospheric and pavement observations from the collective state's investments in road weather information system (RWIS), environmental sensor stations (ESS).

The Initiative has undergone rapid development using proven systems engineering practices and soliciting guidance from an active multidisciplinary stakeholder group. At the time of this writing (Fall 2006), the *Clarus* Initiative shifted from its initial development phase to a proof-of-concept demonstration, processing data from three State DOTs. In addition to systems engineering, there has been substantial work performed to optimize quality checking algorithms in the *Clarus* System for ESS observations and to define the final developmental phase. This phase, the *Clarus* regional demonstration, will test the ability of the network to perform as designed, and also challenge users to be innovative in the creation of new observational, forecast and decision support products. Such products are intended to ultimately create a safer and more efficient surface transportation system. This paper will review the development of the *Clarus* Initiative to date, and provide details about its future plans.

2.0 BACKGROUND

In 2004, the National Academy of Sciences, Board on Atmospheric Sciences and Climate (BASC) completed a visionary document that highlighted an important bridge between the meteorological and surface transportation communities with their report, "*Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services*" (National Academies, 2004). A key recommendation of this report highlighted the need for a nationwide resource to better utilize surface transportation weather observations that would ultimately provide a more comprehensive picture of current conditions on the surface transportation system (at the driver's level down to the pavement) and to energize efforts to improve forecasting for the roadway environment (Pisano, 2006).

With the recommendation of the BASC report resonating across the surface transportation community, the FHWA compiled a five year plan to create such a data management system. The new initiative was named *Clarus* which in Latin means "clear".

Engineering and development of the *Clarus* System was multifaceted and set to an aggressive pace. A team of companies led by Iteris, Inc. and Meridian Environmental Technology delivered the *Clarus* Concept of Operations in October, 2005 (DOT, 2005). Mixon/Hill, Inc. (MHI) was selected as lead of the development team and charged with requirements gathering, system design and implementation of a prototype system. A multidisciplinary stakeholder group, made up of subject matter experts from both public and private sectors and transportation practitioners from state and local DOTs assisted the FHWA in shaping the program.

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By the spring of 2006, the first components of the system implementation were completed. To provide preliminary system testing and to begin population of the metadata database, the FHWA began a proof-of-concept demonstration.

3.0 Proof-of-Concept Demonstration

State DOTs have made substantial investments in ESS. Figure 1 shows the deployment of ESS across the country. In many of these states, ESS data are centrally collected, however, the data may be used only internally. Some states provide their data to the National Oceanic and Atmospheric Administration (NOAA) as a way of making the data available to the greater community. One of the objectives of the *Clarus* Initiative is to collect all public agency ESS observations into one data management system, which now number over 2,400 stations.

The first step in evaluating the *Clarus* System was to conduct a proof-of-concept demonstration. Three state agencies were

selected to participate in the *Clarus* proof-of-concept demonstration. These were DOTs from Alaska, Minnesota and Utah (Figure 1. states with red ovals). These states were selected because they had robust systems in place, making the ESS data transfers to the *Clarus* System less complicated and allowing the focus to be on the *Clarus* system processes.

The proof-of-concept demonstration began during the summer of 2006 and successfully concluded by the end of the calendar year. The demonstration proved that the *Clarus* System was capable of ingesting atmospheric, pavement, and sub-surface data from State DOT ESS. The demonstration also showed that a web portal could be created through which potential users could access the system and download both observations and metadata. Prototype graphical user interfaces (GUIs) were created to make accessing the data easier. Figure 2 shows a prototype map-based GUI centered on southern Minnesota and displaying ESS air temperature data.

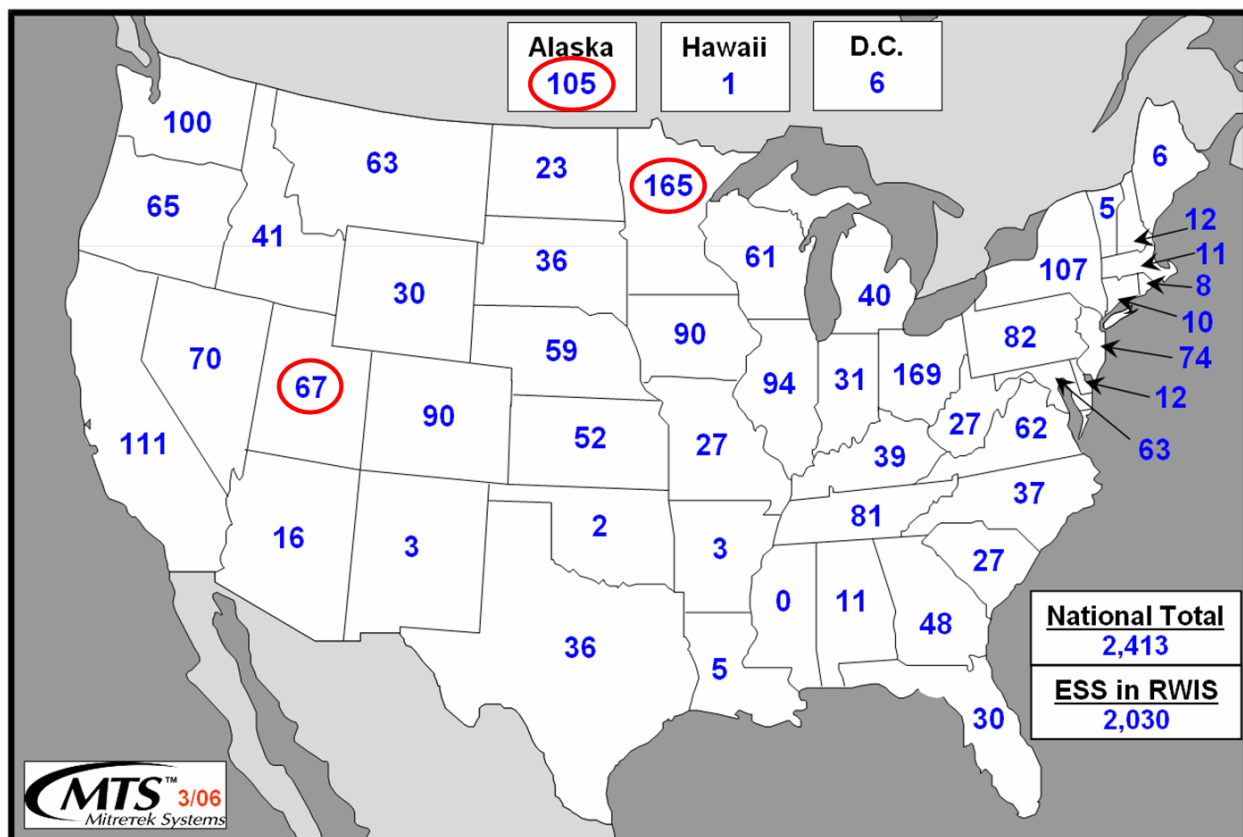


Figure 1 – ESS owned by State transportation agencies. An ESS is any site with sensors measuring atmospheric conditions, pavement and/or sub-pavement conditions, and/or water level conditions.

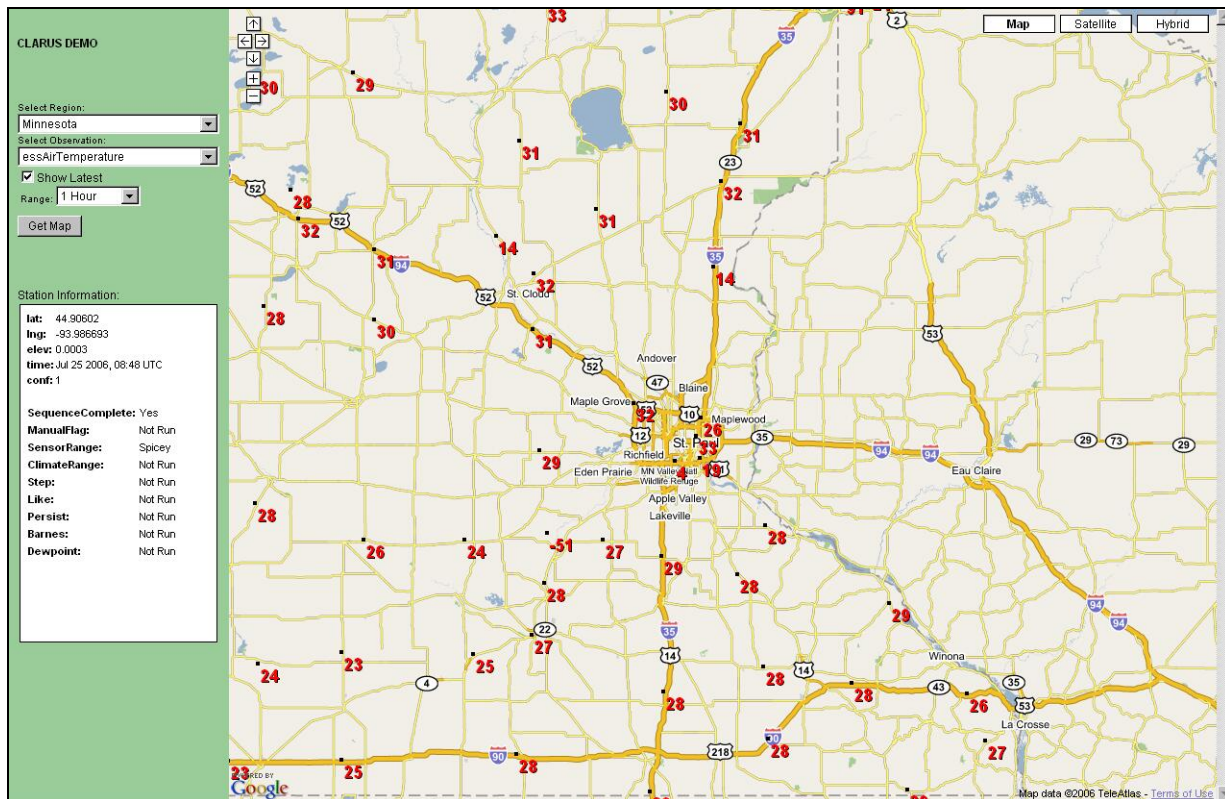


Figure 2 – A web-based graphical user interface for *Clarus*. ESS air temperature data from the Minnesota DOT network is shown on a map of highways and major arterials.

4.0 *Clarus* Task Forces

One of the most important aspects of the *Clarus* Initiative is stakeholder participation. From the beginning of the Initiative, the project has attracted an interested multidisciplinary group of professionals to participate as a member of the Initiative Coordinating Committee (ICC). The ICC has been brought together for four large stakeholder meetings through fall 2006. The ICC is used as a sounding board by FHWA and the Initiative Management Team (IMT) for shaping the direction of the project. When there are specific issues that need direct attention, a subset of the ICC is formed into a task force.

A task force is a short-lived subset of the ICC community that convenes to discuss an issue of relevance to the initiative. The group is selected to provide a sufficiently diverse cross-section of the community to represent weather and transportation interests as well as a mix from the public, private, and academic sectors. A task force typically meets only once, finishing

any business via teleconference or email. In most cases, a task force generates a deliverable which can be in the form of a report, spreadsheet, or a list of recommendations.

During 2006, *Clarus* leadership created two task forces. These were the Quality Checking Task Force and the Metadata Task Force which are discussed in the following subsections.

4.1 *The Clarus* Quality Checking Task Force

The need for a *Clarus* Quality Checking Task Force became evident during the requirements definition portion of the initiative during the fall of 2005. Through the detailed requirements process, the creation of the system design and the critical design review, there were many questions about how *Clarus* should approach quality checking for surface transportation weather data. These issues persisted into the third ICC meeting where there was a breakout session dedicated to this subject. During the spring of 2006, FHWA approved the creation of the Task Force which convened in late May 2006.

During the system design, a total of nine quality checking flags or algorithms were approved for inclusion within the *Clarus* System prototype. These included:

1. **Manual Flag:** The *Clarus* administrator would be able to manually change the value of this flag independent of an automated analysis according to information received from the State ESS engineer or if inspection of the data indicated that the values were obviously in error.
2. **Sensor Range Test:** Tests against hardware specifications or theoretical limits
3. **Climate Test:** Tests against local maxima and minima of climate extremes
4. **Barnes Spatial Test:** Tests the validity of the current observation using data from nearby ESS
5. **Step Test:** Comparison of the magnitude of the last observation change against predetermined thresholds
6. **Persistence Test:** Temporal test to check if observations failed to change over a set amount of time
7. **Like Instrument Test:** Comparison of observations between like sensors at the same site (e.g., multiple pavement temperature sensors)
8. **Dew Point Temperature Test:** Flags the dew point as failed if it fails the Barnes Spatial Test
9. **Sea Level Pressure Test:** Corrects observed station pressures to mean sea level and checks to see if the value passes the Barnes Spatial Test

The Quality Checking Task Force used these nine tests as a foundation to discuss ways to make the *Clarus* algorithms more robust. The task force focused on pavement-based algorithms which are generally much less mature than tests for atmospheric sensors. The group considered what kind of gaps existed in the current suite of algorithms and what technologies or complementary data sets could close these gaps. Finally, the task force looked at the content and format of the quality checking summaries and how these could be improved to best convey information to state engineers and end users about the status and quality of the ESS data.

In the end, the National Center for Atmospheric Research (NCAR) was tasked with taking the task force recommendations and combining them with their expertise in meteorology and data processing. The final result will be a document (due in December, 2006) which will contain recommendations for upgrading and enhancing the suite of *Clarus* quality checking suite of algorithms.

4.2 The *Clarus* Metadata Task Force

The FHWA has proposed creating templates for common sets of metadata elements that can be applied on a national scale for the description of ESS sites, sensors, and their observations. In response to the positive feedback received during the fourth *Clarus* ICC meeting (held in August 2006), the *Clarus* Metadata Task Force met toward the end of September, 2006. FHWA has found that the lack of nationally accepted models and templates for common sets of data elements can lead to inconsistent information. This, in turn, limits the usefulness and value of the data that is being generated by ESS across the country. This problem is compounded when attempts are made to integrate this inconsistent data into the *Clarus* System.

The primary goals of the *Clarus* Metadata Task Force were to develop a set of common metadata elements:

1. That satisfies the most basic requirements for essential metadata fields needed for the *Clarus* System to operate, and
2. Adds any additional critical metadata fields that would support the broader usage of ESS data on a national scale.

A complete metadata template includes not only the descriptions of the observational elements, but also the data fields describing those elements (e.g., numeric precision, data formats, and mnemonic names). By mid-October, 2006, the task force delivered the lists of critical and optional metadata fields. These can be found at the *Clarus* Initiative resource site (www.clarusinitiative.org).

5.0 CLARUS REGIONAL DEMONSTRATION

The next major step in the development of the *Clarus* System is the regional demonstration. The regional demonstration will provide a much better opportunity to test and evaluate the system design and to correct any deficiencies prior to operational deployment.

The regional demonstration seeks to validate the *Clarus* System design by:

- Collecting ESS data from numerous states and from many different types of networks
- Parsing and storing observations
- Populating and modifying the metadata cache
- Allowing interaction with the form-based and map-based prototype GUIs
- Validating the quality checking algorithms, and
- Testing the time (latency) that it takes to deliver requested data.

In addition to system evaluation, the regional demonstration will be the first opportunity for the greater community to participate in the *Clarus* Initiative. The regional demonstration is expected to:

- Enable proactive transportation system management through greater access and usefulness of ESS data
- Improve private sector products and services through *Clarus* data and quality checking flags
- Promote innovation and increase the value for surface transportation weather products, services, and new techniques

The regional demonstration will have three distinct phases; the Request for Applications (RFA), the Connection Incentive Program and the Request for Proposals (RFP).

5.1 Regional Demonstration Phase 1 - Request for Applications (RFA)

The RFA phase of the regional demonstration has two objectives. First, teams of state, municipal, or provincial DOTs will be funded to develop Concepts of Operations (ConOps) that describe innovative products, services, or techniques that are enabled through the use of *Clarus* data that results in new or improved "Business-to-Government" solutions. The ConOps will be evaluated by FHWA during the winter of 2006 and the selected concepts will move to the RFP phase (Section 5.3).

The second objective of the RFA is to hasten the population of the *Clarus* System with State ESS data. All participants in the RFA proposal must agree to provide their data and metadata for inclusion into *Clarus*. A discussion

of critical owner provided metadata fields was detailed in Section 4.2.

The RFA open period occurred during the fall of 2006. Selections of the winning ConOps will be made during mid winter 2007.

5.2 Regional Demonstration Phase 2 – Connection Incentive Program (CIP)

For those states or local DOTs that do not participate in the RFA, FHWA is setting up a program to assist public transportation agencies in providing their ESS data and metadata to *Clarus*. To offset the costs for data access or metadata collection, FHWA will provide funds as an incentive for U.S. transportation agencies to participate in *Clarus*. The amount of assistance will be based on the number of ESS in the network, the agency networking capabilities, and the level of effort needed to obtain metadata.

The CIP will be presented to interested agencies as a Request for Expressions of Interest (RFEI). It is expected that the RFEI will be posted during the winter of 2007 and close during the spring.

5.3 Regional Demonstration Phase 3 – Request for Proposals (RFP)

The final phase of the *Clarus* regional demonstration is the RFP. Each ConOps submitted under the RFA will be evaluated. Up to five ConOps will be selected for implementation. FHWA will post a RFP for contractors to submit proposals to implement the solutions. The RFP process will be a full and open competition. The estimated period of performance for the RFP will be two years. Following this period, the selected contractor(s) will be asked to evaluate the performance of the *Clarus* System. This information will be used as input for future enhancements.

At the time of this writing, the expected posting date for the *Clarus* RFP is late spring or summer, 2007.

6.0 TRANSITION TO NOAA

FHWA has been working closely with NOAA's National Weather Service (NWS) on a plan for providing a sustainable environment for the *Clarus* System once development has concluded. At the time of this writing, NOAA was working to include *Clarus* into their new National Surface Weather Observing System (NSWOS) in the 2008-2009 timeframe. The transition to NOAA will provide a reliable, 24/7 operation for the nation's ESS observations.

7.0 CONCLUSION

The FHWA is almost half way through a five year plan to design, develop, and implement a data management system for the nation's road weather observations. *Clarus*, which is Latin for "clear", is a robust data assimilation, quality checking, data management, and dissemination system that can provide atmospheric and pavement observations from the collective state's investments in road weather information system (RWIS), environmental sensor stations (ESS).

The FHWA uses an interdisciplinary stakeholder group, called the *Clarus* Initiative Coordinating Committee (ICC) as a sounding board to provide guidance on the direction of the Initiative. Subsets of the ICC who are subject matter experts volunteer to participate on task forces that are focused on Initiative-specific issues. In 2006, task forces have worked on both quality checking algorithms and metadata for the *Clarus* System.

The *Clarus* System design contractor has completed its requirements, design, and development processes using proven systems engineering practices. During the summer and fall of 2006, a proof-of-concept demonstration was conducted where three State DOTs provided ESS observations and metadata to the system.

The next activity in the lifecycle of *Clarus* development is the regional demonstration. The regional demonstration consists of three phases that are designed to foster innovative use of *Clarus* data and metadata and to promote participation into the *Clarus* System. The first phase, the Request for Applications (RFA) will provide funding for the development of Concepts of Operations that describe innovative products, services, or techniques that are enabled through

the use of *Clarus* data that result in new or improved "Business-to-Government" solutions. The second phase is called the Connection Incentive Program (CIP). To offset the costs for data access or metadata collection, FHWA will provide funds as an incentive for U.S. transportation agencies not participating in the RFA to participate in *Clarus*. The final phase, the Request for Proposals (RFP), will provide funding for contractor(s) to implement the best Concepts of Operations that were submitted under the RFA. The regional demonstration activities began during the fall of 2006 and will conclude in 2008.

To provide a sustainable environment for the *Clarus* System once development activities have concluded, FHWA is working with the National Oceanic and Atmospheric Administration (NOAA) so that the *Clarus* System could be transitioned into an operational system hosted by the National Weather Service in 2008 or 2009.

8.0 REFERENCES

Department of Transportation (DOT), Federal Highway Administration (FHWA), 2005: "Clarus Concept of Operations," Publication Number FHWA-JPO-05-072; <http://www.clarusinitiative.org/documents.htm>.

National Academies Press, 2004: "Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services"; <http://www.nap.edu/books/0309091365/html/>.

Pisano, P.A., J.S. Pol, L.C. Goodwin, and A.D. Stern, 2006, "FHWA's Clarus Initiative: Concept of Operations and Associated Research", 22nd Conf. on Interactive Information and Processing Systems, Atlanta, GA, Amer. Meteor. Soc., Paper 13.4.