Clarus Business Models Considerations

White Paper

October 2005

Submitted to:

ITS America
U.S. Department of Transportation,
Federal Highway Administration

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Executive Summary

This white paper was commissioned by USDOT, FHWA and ITS America to assist the *Clarus Initiative* Management team and the ICC in identifying relevant non-technical "business" issues that should be considered as design, testing and implementation move forward. This white paper is not intended to define, select or recommend detailed business models or implementation paths for the *Clarus System*. Rather, its purpose is to provide information to managers, decision-makers and stakeholders as they collectively move forward in the *Clarus Initiative* and implement the *Clarus System*.

In September and October of 2005, 21 short telephone interviews were conducted with key *Clarus* stakeholders. Individually, these stakeholders were identified by the *Clarus* management team as critical in their role and the organization and perspective they represent. Collectively the stakeholders interviewed spanned the full range of types of stakeholders critical to *Clarus System* development, implementation and success. There were a few areas where common themes seemed to have emerged from these diverse stakeholders that warrant highlighting:

- Strong agreement on the definition of the Clarus System.
- Agreement on latency as an issue; general agreement on latency requirements.
- Recognition of stakeholder self interest.
- Continued shared oversight desired as Clarus moves from concept to reality.
- NOAA/NWS most often mentioned as Clarus System operator.

In developing this paper, several analogous systems/concepts and current issues associated with the "Weather Industry Enterprise" were examined and are summarized herein. This research has led to two key conclusions that transportation officials need to recognize as the *Clarus Initiative* moves forward:

- The *Clarus System* business model will be influenced as much if not more so by the weather enterprise than transportation industry views of public/private/academic partnerships.
- Relationships between the sectors of the weather enterprise are equally or more fragile than those in the transportation industry.

This paper identifies and discusses several business models issues themes for consideration by Clarus managers and stakeholders:

- Implementation approach
  - Roll-out strategy
  - Incentives vs. requirements
  - Policy and funding emphasis
  - Evolution and expansion
- Funding
- Operations
- Governance
  - Management and Leadership
  - Guiding Principles
  - Data Sharing Agreements
  - Data Use Agreements
- Marketing
- Other Issues
  - Harnessing Enlightened Self-interest
  - System latency and its relevance to business models
  - Consistency

While this paper does not recommend specific models or the direction the *Clarus Initiative* should proceed related to the issues, it does offer some conclusions and recommendations on next steps:

- We believe strongly that it will be possible for the *Clarus* managers and stakeholders to establish a workable business model to implement, operate and maintain the *Clarus System*.
- We believe the time is right to begin developing consensus guiding policy and business principles that will underpin the *Clarus System*, as nearly all other business model decisions will flow from those principles.
- We encourage the *Clarus* managers and stakeholders to consider developing one or more business model scenarios that fit within the policy framework to fully address the issues identified above. We believe this should occur in parallel with development, or immediately after completion, of the guiding principles. The bundling of the issues and creating operating concepts that address them holistically will be most likely the quickest way to find the path to achieving stakeholder consensus on the overall *Clarus System* business model and implementation path.

Background

The *Clarus Initiative* is a Federal project that establishes a vision for the leveraging of local and regional surface transportation weather observations to serve a greater community and enhance 21st century transportation operations. The goal of the *Clarus Initiative* is to provide broader weather information support for surface transportation system operators in their efforts to improve safety, reliability and security of transportation users. This goal will be accomplished through the design, demonstration and deployment of a national surface transportation weather data collection and management system that complements the existing nationwide network of federal surface and upper-air weather observation systems (both *in situ* and remote sensing platforms) supplied through the National Oceanic and Atmospheric Administration (NOAA). Through this effort, surface transportation-based weather observations can be integrated with the existing NOAA data, thereby permitting broader support for surface transportation-specific operational needs and prediction models. The enhanced support capabilities offer the potential for greater safety and improved mobility for users of the surface transportation infrastructure.

The *Clarus Initiative* consists of two development components. The first component is the development of the Clarus System – a processing system for the collection, consolidation, quality control, and exchange of surface transportation weather data and related road and rail conditions. The second component is the development of tailored forecasts, models, and decision support tools that permit more effective use of the Clarus System and its processed data by the surface transportation community. By combining Clarus System data with NOAA data, the benefit will be extended to promote enhanced general purpose weather forecasting providing a wider range of benefits for the protection of life and property.

The Clarus System will impact the services of a wide audience, both through direct and indirect use of the Clarus System data. Users having direct contact with the Clarus System will include the owners and operators of the observing systems which are sending information to the Clarus System, as well as the users directly accessing the data processed within the Clarus System.

The *Clarus Initiative* is comprised of a comprehensive set of activities that will ensure efficient and effective design, development and deployment of the Clarus System. The following is a list of these activities.

- Development of the *Clarus* Vision and Management Infrastructure
- Creation of the *Clarus Initiative* Coordinating Committee (ICC)
- *Clarus* Concept of Operations
- Systems Design
- Proof-of-Concept Demonstration
- Research
- Evaluation during Multi-State Regional Demonstration
- Deployment Support and System Promotion

The *Clarus Initiative* is presently in the System Design phase. This white paper was commissioned by USDOT, FHWA and ITS America to assist the *Clarus Initiative* Management team and the ICC in identifying relevant non-technical "business" issues that should be considered as design, testing and implementation move forward.

Study Overview

PBS&J has conducted this study to assist ITS America in providing technical support to the U.S. DOT on the *Clarus Initiative* by developing this white paper that looks at prospective business models and paths to operations that could sustain a nationwide deployment of Clarus.

This study is not intended to define, select or recommend detailed business models or implementation paths for the *Clarus System*. Rather, its purpose is to provide information to managers, decision-makers and stakeholders as they collectively move forward in the *Clarus Initiative* and implement the *Clarus System*.

Study Process

The study proceeded with three primary tasks:

- Stakeholder Input – Over 20 key *Clarus* stakeholders, representing the full range of interests, were interviewed to obtain input on business model related issues from their personal and organizational perspectives. A summary of the findings are highlighted later in the paper, with the detailed input from each stakeholder provided in Appendix 1.

- Background Research – In parallel with the stakeholder interviews, an analysis of published materials related to several weather-related or analogous systems/concepts was completed to distill pertinent lessons learned from each relating to business model and implementation issues. Further, research into the general business issues associated with the meteorological community was conducted, primarily through careful study of the "Fair Weather: Effective Partnerships in Weather and Climate Services" report published in 2003 by the National Academy of Sciences. A summary of the research is contained in a later section of this paper.

- White Paper – The findings from stakeholder input and background research formed the material used in this White Paper. The white paper both summarizes the two foundation tasks and also synthesizes stakeholder input, lessons learned from research and our previous experience with business model issues, particularly related to travel information and transportation network status data, to identify business model issues that we believe are most relevant to *Clarus Initiative* leaders and stakeholders.

This study is intended to conclude with the completion of this White Paper.

Business Models: A Working Definition

The term "business models" is used often when describing companies, industries, markets, or enterprises. But while the term is often used, it is one that seems to have many different definitions.

A simple definition of business models focuses on revenue generation, such as Dictionary.com's definition: "a design of the operations of a business which focuses on how revenue will be generated." For our purposes of studying how to create and sustain a national multi-party system to collect and use observational weather data, this definition is far too simplistic.

More useful definitions for our purposes come from Masterliness.com. First, in defining a business model, elements beyond revenue and profits are highlighted:

> *"A business model (also called a business design) is the mechanism by which a business intends to generate revenue and profits. It is a summary of how a company plans to serve its customers. It involves both strategy and implementation. It is the totality of:*
>
> - *How it will select its customers*
> - *How it defines and differentiates its product offerings*
> - *How it creates utility for its customers*
> - *How it acquires and keeps customers*
> - *How it goes to the market (promotion strategy and distribution strategy)*
> - *How it defines the tasks to be performed*
> - *How it configures its resources*
> - *How it captures profit*[1]*"*

The site then highlights many different types of models. One in particular is of interest to us is the "collective" business model:

> *'A collective business system or collective business model is a business organization or association typically comprised of relatively large numbers of businesses, tradespersons or professionals in the same or related fields of endeavor, which pools resources, shares information or provides other benefits for their members. In the past, collective business systems such as the trade association, the cooperative and the franchise were created to allow groups of independently owned businesses with common interests to successfully compete in the marketplace.*[2]*"*

So, when considering business model issues related to the *Clarus System*, issues to be looked at include not only costs, revenues, fees, and profits but also organization and governance, marketing and promotion, customer service and response, intellectual property and data usage rights/terms, and liability. Also, the recognition that the *Clarus System* will exist in a complex multi-party environment, where even if a single organization becomes "operationally" responsible for the *Clarus System*, it will depend on scores of data providers and users for the system to be successful and sustainable.

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[1] See http://www.masterliness.com/a/Business.model.htm.
[2] See http://www.masterliness.com/a/Collective.business.system.htm.

When thinking about the term business models in general and how it applies to the *Clarus System*, there are at least a few areas in which the *Clarus System* falls outside the norm (it should be pointed out the *Clarus System* is not unique, just not a "business" in a traditional sense). For example, given that it is unlikely that revenue will flow back to the ESS owners, the *Clarus System* does not operate on a purely traditional business model. In "normal" business, raw commodity providers would be financially compensated for their commodity that gets transformed downstream into a product or service the customers pay for (e.g, mining companies provide commodities that get "monetized" when someone buys a car). In our study, it has not come up once to compensate ESS operators with revenue. Yet, ESS operators must clearly be incentivized to participate.

Another example is that business models are often discussed in purely private markets, where the revenue derived from customers must support the entire enterprise that creates the product or services (or it will not be sustained for long). With *Clarus*, it is likely that indirect funding support (e.g. taxes, grants, etc.) will fund a significant part of the enterprise and that end customers may only directly bear at most some of the costs of the enterprise.

Stakeholder Input

In September and October of 2005, 21 short telephone interviews were conducted with key *Clarus* stakeholders. Individually, these stakeholders were identified by the *Clarus* management team as critical in their role and the organization and perspective they represent. Collectively the stakeholders interviewed spanned the full range of types of stakeholders critical to *Clarus System* development, implementation and success. Figure 1 lists the stakeholders who graciously volunteered their time and provided candid input to the study.

These interviews were guided by five questions:

1. When you think of the *Clarus* "system," how would you describe it and what it does?
2. What factors do you think are key to establishing and sustaining *Clarus*?
3. Are there any particular issues or concerns you have regarding *Clarus*?
4. When we talk about business models, we basically focus on how something gets done, who does it, and how the resources are obtained to implement and sustain the "business," in this case the *Clarus System*. Do you have any ideas related to specific business models that you would suggest for *Clarus*? Any business models that you would suggest against?
5. What organization do you think would be best suited to operate *Clarus* and why?

Those interviewed were also able to provide additional input they believed to be relevant to the study. Some did provide this input and we have included it in the summaries as well. Appendix 1 contains the detailed input from each stakeholder to each question. These written summaries were reviewed and approved by each stakeholder following each phone interview.

- Dennis Belter, Program Support Manager, Indiana DOT
- S. Edward Boselly, President, Weather Solutions Group
- Mike Campbell, Chief of the Observing Services Division, NOAA
- Paul DeLannoy, Meteorological Service of Canada, Environment Canada
- Jan Dutton, Director of Weather Services and James Anderson, Director of Government Services, WeatherBug
- Joe Holt, Transportation Manager II, Tennessee DOT
- John Horel, Director, NOAA Cooperative Institute for Regional Prediction, University of Utah.
- Dan Krechmer, Principal, Cambridge Systematics
- Bill Mahoney, National Center for Atmospheric Research
- Patricia Miller, Chief of Scientific Branch, NOAA Forecast Systems Laboratory
- Renee McPherson, Acting Director, Oklahoma Climatological Survey
- Rick Nelson, Assistant Director, Operations, Nevada DOT
- Leon Osborne, President, Meridian Environmental Technology
- Curt Pape, RWIS Coordinator, Minnesota DOT
- Brooke Pearson, North America Business Development Manager, Vaisala
- Lee Smithson, Iowa DOT, SICOP Coordinator, AASHTO
- Michael Steinberg, Senior Vice President, Accuweather
- Jack Stickel, Transportation Planner, Alaska DOT
- Kathy Strebe, Director of Weather Data and Strategy, The Weather Channel
- Ron Sznaider, Vice President, Business Development, DTN-Meteorlogix
- Jon Tarleton, Marketing Development Manager/Meteorologist, SSI, Inc.

Figure 1 – Interview List

While the individual input can be found in Appendix 1 and the collective input is a primary driver of the Business Models Issues and Considerations section later in the paper, there were a few areas where common themes seemed to have emerged from these diverse stakeholders that warrant highlighting:

- ***Strong agreement on the definition of the Clarus System***. All interviewed seemed to agree that the *Clarus System* is focused on surface weather and pavement condition observations, along with at least some level of quality checks. While the detailed responses used different wording and surely contained nuanced differences (and in at least one case, forecasts were believed to be included), the similarities of the input were far greater than the differences. This demonstrates that the *Clarus Initiative* leadership and stakeholders have done an excellent job in clearly defining the *Clarus System*, an essential element in achieving ultimate consensus on the business model and technical design/architecture.
- ***Agreement on latency as an issue; general agreement on latency requirements***. Most interviewed identified latency – the delay that users will incur through the *Clarus System* that would not occur if they had direct access to observing sites or networks – as a key determinant of the utility of the *Clarus System* to support real-time applications and products. Further, there seemed to be consensus forming that while no latency is desired, latencies in the range of 5 minutes or less would be acceptable.
- ***Recognition of stakeholder self interest.*** Many of those interviewed pointed out that the *Clarus System* must offer benefits to both users and suppliers of the data that moves through the System. Interestingly, much of the input was focused on the "other side's" view. Examples offered included data users identifying the need to make sure ESS operators obtain benefit for participation (via things such as QC feedback and technical assistance) and ESS operators supporting easy and low/no-cost access to the *Clarus System* by users.

- ***Continued shared oversight desired as Clarus moves from concept to reality.*** Many interviewed expressed support for the collaborative efforts in developing *Clarus* to date (though some expressed concern of limited private sector weather industry involvement) and indicated that continuing this collaboration is strongly desired as an operational *Clarus System* emerges and one or more entities become responsible for operations. Also, continuing to balance oversight between the transportation and meteorological communities, data collectors and users, and public and private sectors was identified often as key to long term support and success.
- ***NOAA/NWS most often mentioned as Clarus System operator.*** While not unanimous, a solid majority of interviewees shared the view point that NOAA, most likely through the National Weather Service, is the most logical and likely candidate to "operate" the *Clarus System*. In all cases, those interviewed indicated that whoever ends up the operator needs to have both the long-term commitment to operate the System and the ability to fight for, generate and obtain sufficient funding to support sustainable operations.

The interviews also uncovered some very good individual quotes that seemed appropriate to include in the body of the white paper:

- "Certain states in the U.S. have much greater density than others and the density of the weather stations represents the value of the information to that particular state highway authority and to the surrounding areas. It will be interesting to see what value others that are not local attribute to the dataset being that the U.S. is so vast."
- "The one hope is that RWIS Canada will be able to collect the meteorological data for all of Canada and feed this data to *Clarus* for use and dissemination, staying ahead of the curve for implementation so that the data is available when *Clarus* is ready to accept it."
- "It is important to establish clear roles and obligation, commitments and writing these up as data sharing agreements that identify a common understanding of everyone's roles and what will be provided as a result of these roles."
- "There's not a Mesonet that I'm familiar with that hasn't fallen on hard times. This model relies on the consortium or groups of individuals involved in the network constantly trying to get grants or program funds to keep the network operating. The end users are used to getting the data for free and become pretty unwilling to pay for it even when there is value added to the data."
- "The organization that is tasked with processing *Clarus* data should be stable, provide redundancy, have a successful history of processing and quality-controlling weather observations, and ensure that the data stay public domain."
- "It is also important to keep the data that is made available from *Clarus* to remain as raw data."
- "I feel pretty strongly that data should not be withheld if it's from a site that is not at the same level as other sites – rather that site should have some indicator that indicates the level of quality of the data, and users can then decide for themselves how much weight to give that data."
- "Compared project to 'herding chickens' in that there are so many different people out there operating these environmental sensor stations, and convincing them that they need to participate in *Clarus* is a milestone on the critical path."
- "Another concern is that when a system is designed for many customers, things are reduced to the lowest common denominator, and system might be 'dumbed' down to accommodate the less sophisticated systems (RWIS) and lose a lot of value from the more sophisticated ones."
- "You really have to take a look at the organization. Many have a good amount to contribute, but the determining factor would be who is going to be the champion of this system that will fight for the funding that is needed and the staffing that is needed to sustain *Clarus*, not just at the moment,

but for the long run. There are several places that it could be housed, but we need to make sure that the agency that ends up with it will work hard to sustain it in years to come."

- "My biggest concern with a system like this being operated within NOAA is that traditionally these major systems end up in parts of NOAA that don't interact well with the scientific community and remain in maintenance-only mode. There are parts of NOAA that are very forward-thinking and I hope that *Clarus* will be within a community where the various parties interact with each other."
- "NOAA - Under the NOAA umbrella, you have the national weather service, the regional climate centers, the research people and operations people that can do something with this data."

Research Summary

The *Clarus System* is not being developed and implemented in a vacuum. There are many examples of systems and services that offer parallels to the *Clarus System* that have identified and in many cases resolved issues similar to those faced by *Clarus* managers and stakeholders. Further, there have been over 100 years of federal meteorological-related policy development that has lead to the current "Weather Industry Enterprise Model", as one of the interviewed stakeholders called it, within which the *Clarus System* will likely need to fit to be successful over the long-term.

Analogous systems/concepts research

Again, resources and time requirements limited our assessment to those most logically appropriate to having lessons that are both relevant and potentially transferable to the *Clarus System*. The *Clarus Initiative* Management Team assisted in narrowing the candidates for study. In the end, we examined eight different systems, products, programs or studies:

- NOAA's Forecast Systems Laboratory (FSL) Meteorological Assimilation Data Ingest System (MADIS)
- NWS Observation Products
- National Lightning Detection Network (NLDN)
- WeatherBug
- Canadian Road Weather Information Network (RWIN)
- Various Mesonets
- Open Geospatial Consortium
- Aurora Program Project 2001-01: RWIS Data Integration Guidelines
- Aircraft Communications Addressing and Reporting System (ACARS)

In this section, we will provide a little background on each and some of the issues/lessons relevant to our focus on the *Clarus System*.

MADIS - The Meteorological Assimilation Data Ingest System (MADIS)[3] is dedicated toward making value-added data available from the NOAA Forecast Systems Laboratory (FSL) for the purpose of improving weather forecasting, by providing support for data assimilation, numerical weather prediction, and other hydrometeorological applications. MADIS subscribers have access to an integrated, reliable and easy-to-use database containing the real-time and archived observational datasets. While the entire resources of this study could be exhausted understanding and documenting the elements and features of MADIS, there are several areas that are of interest from a business models perspective:

- Quality Control (QC) – Observations are stored with a series of flags indicating the quality of the observation from a variety of perspectives (e.g. temporal consistency and spatial consistency), or more precisely, a series of flags indicating the results of various QC checks. Users of MADIS can then inspect the flags and decide whether or not to ingest the observation.
- Open Applications Programming Interface – MADIS includes an Application Program Interface (API) that provides users with easy access to the observations and quality control information. The API allows each user to specify station and observation types, as well as QC choices, and domain and time boundaries. The database and API are freely available to interested parties in the meteorological community.
- Data Access – MADIS users, or "subscribers," are expected to complete an application that both facilitates their electronic access (e.g., how and what they access) and indicates the subscriber read the disclaimer and usage information and agrees to comply with data restrictions.
- Multiple Data Distribution/Access Categories – FSL has established rules and procedures to manage datasets so that not all datasets are available to all subscribers, allowing those providing data to MADIS to have at least some level of control over how their data is utilized.
- Viral Marketing – To increase the exposure of MADIS and those data providers who feed MADIS, FSL encourages subscribers to publicize the use of MADIS and the data it provides. From the MADIS web site: "It would also be very helpful to the MADIS data providers, particularly the providers of aircraft and mesonet data, if publications and web pages that depend upon substantial use of their data acknowledge their contribution by including a statement similar to: This study was made possible in part due to the data made available to the Forecast Systems Laboratory by ---- (fill in the provider name or names, e.g. "the Kansas Department of Transportation", "MesoWest"…")."

As several interviewed stakeholders suggested, as MADIS evolves from a research endeavor to an operational system, it is a candidate to serve as the backbone of the *Clarus System*. Regardless of whether or not this occurs, several of the elements that have made MADIS a success to date are the proper identification and handling of these business model issues.

[3] See http://madis.noaa.gov/.

NWS Observation Products – The National Weather Service has several observation products that offer many analogies for the *Clarus System*. On the data ingest side, the Automated Surface Observing System (ASOS) and the Cooperative Observer Program (COOP) seem most relevant. On the data dissemination side, METAR[4] data access and the experimental Really Simple Syndication (RSS) and Extensible Mark-up Language (XML) weather observation feeds seem most relevant.

ASOS[5] serves as the nation's primary surface weather observing network. ASOS is designed to support weather forecast activities and aviation operations and, at the same time, support the needs of the meteorological, hydrological, and climatological research communities. There are just under 600 FAA-sponsored and just over 300 NWS-sponsored ASOS stations installed at airports throughout the country. Elements of ASOS of interest include:

- ASOS Data Acquisition System (ADAS) – Air Route Traffic Control Centers contain equipment that serves as hubs between the ASOS stations and the NWS servers.
- ASOS Operations and Monitoring Center (AOMC) – An office at NWS headquarters that monitors and tracks maintenance, provides site system support (including a time clock for synchronization of all ASOS stations), and technical assistance services.
- ASOS Requirements and Change Management – The NWS Requirements and Change Management Branch has formalized the process to request and manage changes to ASOS configuration. The process includes a Change Control Board and Program Management Committee

COOP[6] is a program in which over 11,000 volunteers take observations on farms, in urban and suburban areas, National Parks, seashores, and mountaintops. Observers record temperature and precipitation daily and send those reports monthly to the National Climatic Data Center (NCDC) or an NWS office. Many cooperative observers provide additional hydrological or meteorological data, such as evaporation. Data is transmitted via telephone, computer or mail. Equipment used at NWS cooperative stations may be owned by the NWS, the observer, or by a company or other government agency, as long as it meets NWS equipment standards. Equipment to gather these data is provided and maintained by the NWS. Observers send data forms monthly to NCDC in Asheville, NC, where data are digitized, checked and archived. While the type of data and the methods used for communications are simplistic when compared to the *Clarus* vision, one element is of interest. Modernization of the COOP is underway leading toward the establishment of a National Cooperative Mesonet[7]. This modernization will turn many sites into real-time reporting sites, establish baseline and enhanced sites and establish a mesonet platform for future growth of the observation network.

METAR Data Access[8] allows for interested parties to get computer to computer access to NWS observation datasets. METAR is the international standard code format for hourly surface weather observations which is analogous to the SA coding currently used in the U.S. Current

[4] The acronym roughly translates from French as Aviation Routine Weather Report
[5] See http://www.nws.noaa.gov/asos/index.html.
[6] See http://www.nws.noaa.gov/om/coop/index.htm.
[7] See http://www.nws.noaa.gov/om/coop/reference/PDP4COOP.pdf.
[8] See http://weather.noaa.gov/weather/metar.shtml.

and recent METAR observations are available as individual reports or in cycle files via anonymous FTP. In the U.S., METAR reports are taken once an hour between 50 minutes past the hour and the top of the (next) hour. All the observations taken within this time are considered to be for the same cycle. For example, observations taken between 1150Z and 1200Z are all considered to be 12Z observations. On 1 July 1996, when METAR took effect, the United States undertook the most significant change for observing, reporting, and coding surface weather observations and terminal forecasts in roughly forty years. The lessons from METAR include methods of using anonymous FTP access, defined directories and standardized codes to share observation data. Also the conversion to METAR from previous codes can provide lessons for a similar evolution that may be required for the *Clarus System* in the future.

The NWS is currently offering experimental RSS and XML data feeds for current observations[9] for about 1,800 locations across the United States and U.S. Territories. Though still in the experimental phase, these data feeds leverage current Internet computer-to-computer data exchange methods and offer approaches the *Clarus System* could model after or even directly utilize.

National Lightning Detection Network (NLDN) – The NLDN is a commercial service offered by the Vaisala Group.[10] The network utilizes commercial satellite communications to relay data from lightning sensors throughout the United States to the Network Control Center. The use of satellite communications to move data directly from more than 100 sensors to central servers that fuse, analyze and disseminate the data through various means could be a long-term model for ESS data. Also, the NLDN illustrates it is possible to create a private data collection network for specialty observation products.

WeatherBug – A brand name of AWS Convergence Technologies, the WeatherBug Network is the largest weather network in the world. More than 7,000 schools and emergency response facilities across the U.S. operate WeatherBug observations stations. Each station is connected to a users PC which then distributes collected data back to the WeatherBug network. Customers purchase the sensor station equipment, install it and share their data with the WeatherBug Network, and pay an annual fee to AWS to use enhanced software to view and analyze weather. In 2002 AWS formed a partnership with NWS called the Homeland Security WeatherBug Network. Through this partnership, AWS shares its weather data with NWS in times of emergency to support response activities that need live data about local conditions. WeatherBug sites must be certified to be designated as a Homeland Security WeatherBug Network site. The "tiering" and certification of a subset of sites is an element of interest when thinking of the *Clarus System*. Also of interest is the demonstration that "customers" find enough value in the enhancement of service to both purchase and operate sensor stations and pay yet again for interpretation of the shared data the collective network provides.

[9] See http://www.weather.gov/data/current_obs/.
[10] See http://www.lightningstorm.com/tux/jsp/discover/nldn/index.jsp

Canadian RWIN – Transport Canada and Environment Canada are currently working in partnership with provinces and territories on the development of an integrated cross-Canada Road Weather Information Network (RWIN). The national government will co-fund up to 50 percent of eligible costs relating to the acquisition and installation of environmental sensor equipment for priority stations along the National Highway System. The provinces and territories are expected to pay the balance of the total cost, as well as the ongoing operation and maintenance costs. As a condition of funding, provinces and territories are also required to enter into a data-sharing agreement with Environment Canada. Federal funding will be provided under the Strategic Highway Infrastructure Program, a $600 million program to improve highway infrastructure across Canada. The model of the national government using funding incentives to establish the network and ensure data is shared as part of the national network is of interest. Also of interest is the partnership of the national government agencies with lead responsibilities in transportation and meteorology to establish Canada's system essentially equivalent with the *Clarus System* in the United States.

Various Mesonets – Several mesoscale observation networks exist at present, with the largest being MADIS. Some networks are operated on regional or statewide basis. Examples include MesoWest and the Oklahoma Mesonet. MesoWest[11] is a real-time cooperative mesonet data exchange that provides access to weather observations from more than 180 government, educational, and commercial data providers at over 6,000 surface stations around the nation, with an emphasis upon the western United States. It provides access to surface observations in the western United States to operational forecasters, the research community and the public. Surface observations from a variety of federal, state and local agencies are combined into a common database. MesoWest is one of the activities of the NOAA Cooperative Institute for Regional Prediction (CIRP). CIRP's annual budget of close to $700,000 is provided by the National Weather Service, National Science Foundation, Bureau of Land Management, Department of Energy and other agencies.

The Oklahoma Mesonet[12] is a network of environmental monitoring stations designed and implemented by scientists at the University of Oklahoma (OU) and at Oklahoma State University (OSU), consisting of 116 automated stations covering Oklahoma with at least one station in each of Oklahoma's 77 counties. Measurements are packaged into "observations" every 5 minutes, and then the observations are transmitted to a central facility every 5 minutes, 24 hours per day year-round. The Oklahoma Climatological Survey (OCS) at OU receives the observations, verifies the quality of the data and provides the data to Mesonet customers. It takes 5 to 10 minutes from the time the measurements are acquired until they become available. The Oklahoma Mesonet is managed by the Oklahoma Mesonet Steering Committee and is funded by both universities, federal and state funds, grants, contracts, and user fees. User fees are at three levels, with the highest, at $400/month, targeted at private business users. Another revenue stream is fee-based access to the Mesonets' data archives. While many of the lessons to be gleaned from Mesonets are discussed in the MADIS section, these examples of regional Mesonets illustrate the dimensions of funding required to ingest observation data, shared governance and oversight, and user fees and multiple funding streams to sustain the network.

[11] See http://www.met.utah.edu/mesowest/
[12] See http://www.mesonet.org/.

Open Geospatial Consortium – The Open Geospatial Consortium, Inc. (OGC)[13] is an international industry consortium of nearly 300 companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications. OpenGIS® Specifications support interoperable solutions to make complex spatial information and services accessible and useful with all kinds of applications. A specific functional area that may have direct relevance to *Clarus*, is Sensor Web Enablement. OGC members are specifying interoperability interfaces and metadata encodings that enable real time integration of heterogeneous sensor webs into the information infrastructure. Examples of sensors envisioned include devices such as flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, Webcams, and robots as well as space and airborne earth imaging devices. Candidate specifications that have been developed and tested include an information model and XML encodings for discovering, querying and controlling Web-resident sensors, an information model and encodings for observations and measurements, a service to fetch observations from a sensor or group of sensors, a service to assist in 'collection feasibility plans' and to process collection requests for a sensor or group of sensors, and a service to manage dialogue between a client and Web service(s) for long duration asynchronous processes. While the technical elements of Sensor Web Enablement may have some utility in developing the *Clarus System* design, our focus is the ongoing collaborative process of developing solutions supported by both suppliers and end-users.

Aurora Program Project 2001-01: RWIS Data Integration Guidelines – The Aurora Program[14] is a pooled fund weather research program of several state DOTs and the Federal Highway Administration. In 2004, a project was completed that studied current practices in various states on how information is shared with the traveling public, other state agencies and other state weather systems. The study found that several states that have extensive ESS networks have established FTP sites that allow other states to download raw weather data at no cost to the recipient state. However, as of yet there is no consistent method by which the weather data is collected and formatted. The major barrier to overcome with the FTP site transfers will be the ability to interpret the raw weather data that is received from the corresponding DOT. Software incompatibility is often a factor in the ability of the recipient state to utilize the raw data. The relevance of this study is that (1) the states recognize the value of sharing information with adjacent states and (2) that the bottoms-up approach of sharing RWIS has yet to achieve the desired continuity of weather data on anything close to approaching a national scale.

Aircraft Communications Addressing and Reporting System (ACARS) – The Aircraft Communications Addressing and Reporting System, ACARS, is managed by Aeronautical Radio, Inc. (ARINC). ACARS is used by airlines to transmit a variety of proprietary air-to-ground communications. Many commercial aircraft operating in the world today are equipped with sensors that can provide real-time weather observations (primarily winds and temperatures) via radio downlinks. These data are routed by several cooperating airlines to NOAA's Forecast Systems Laboratory, which decodes and quality controls the data. The MADIS automated aircraft dataset provides data obtained through these cooperating airlines. There are approximately 140,000 wind and temperature observations available per day, 100,000 of which are over the continental United States. These data come from 4000 aircraft. The data arrives

[13] See http://www.opengeospatial.org.
[14] See http://www.aurora-program.org/.

continuously and is processed every 10 minutes. ACARS provides some interesting examples of the issues to be faced, and how they can be addressed, with environmental data from mobile sensors of the sort envisioned in the Vehicle Infrastructure Integration (VII) Initiative.

General Weather Industry Business Model and Political Landscape

While the *Clarus Initiative* is being led largely by transportation agencies to date, the *Clarus System* will operate within the confluence of the public, private and academic meteorological partnership that has evolved over more than a century. So when transportation officials examine business models and business-related issues, they would be wise to understand the relationship between the sectors in meteorology.

Just as the transportation industry faces issues such as how to pay for roads (tolls vs. gas tax), the roles of public agencies, consultants and universities in research, and the roles of the public and private sector in areas such as traveler information and congestion data, the meteorology industry has dealt for decades with issues over the federal role in weather observing and forecasting. In some cases, matters have been settled for over a century. In other cases, the situation is very fluid, changing with economic conditions and political leadership. In 2003, a major report was completed by the National Academy of Sciences that offers perhaps the most current and comprehensive insight into the general business issues associated with the meteorological community. "Fair Weather: Effective Partnerships in Weather and Climate Services" reviewed the public, private, academic weather "enterprise" and made several recommendations to strengthen this partnership. Several of the issues the *Clarus Initiative* faces have been faced in some form or another in other weather observation systems. While several interesting and useful items are found throughout the report, perhaps the easiest way to gain a glimpse of the issues being faced in the weather enterprise is by listing the report's 10 recommendations:

1. The NWS should replace its 1991 public-private partnership policy with a policy that defines processes for making decisions on products, technologies, and services, rather than rigidly defining the roles of the NWS and the private sector.
2. The NWS should establish an independent advisory committee to provide ongoing advice to it on weather and climate matters. The committee should be composed of users of weather and climate data and representatives of the public, private, and academic sectors, and it should consider issues relevant to each sector as well as to the set of players as a group, such as (but not limited to)
    - improving communication among the sectors,
    - creating or discontinuing products,
    - enhancing scientific and technical capabilities that support the NWS mission,
    - improving data quality and timeliness, and
    - disseminating data and information.
3. The NWS and relevant academic, state, and private organizations should seek a neutral host, such as the American Meteorological Society, to provide a periodic dedicated venue for the weather enterprise as a whole to discuss issues related to the public-private partnership.
4. The NWS should continue to carry out activities that are essential to its mission of protecting life and property and enhancing the national economy, including collecting

data; ensuring their quality; issuing forecasts, warnings, and advisories; and providing unrestricted access to publicly funded observations, analyses, model results, forecasts, and related information products in a timely manner and at the lowest possible cost to all users.

5. The NWS should make its data and products available in Internet-accessible digital form. Information held in digital databases should be based on widely recognized standards, formats, and metadata descriptions to ensure that data from different observing platforms, databases, and models can be integrated and used by all interested parties in the weather and climate enterprise.
6. The NWS should (1) improve its process for evaluating the need for new weather and climate products and services that meet new national needs, and (2) develop processes for discontinuing dissemination of products and services that are specific to particular individuals or organizations or that are not essential to the public.
7. NWS headquarters and regional managers should develop an approach to managing the local forecast offices that balances a respect for local innovation and creativity with greater control over the activities that affect the public-private partnership, especially those that concern the development and dissemination of new products or services.
8. The NWS should continue to adopt and improve probabilistic methods for communicating uncertainties in the data and forecasts where such methods are accepted as scientifically valid.
9. The NWS should retain its role as the official source of instrumentation, data, and data collection standards to ensure that scientific benchmarks for collecting, verifying, and reporting data are maintained. It should lead efforts to follow, harmonize, and extend standards, formats, and metadata to ensure that data from NWS and non-NWS networks, databases, and communications technology can be integrated and used with relative ease.
10. The commercial weather sector should work with the other sectors, using mechanisms such as those proposed in this report, to improve the techniques and processes by which the weather and climate enterprise as a whole can minimize friction and inefficiency.

Two points are worth noting as we end this section:

1. Transportation officials must recognize that the *Clarus System* business model will be influenced as much if not more so by the weather enterprise than transportation industry views of public/private/academic partnerships. The closer the *Clarus System* is tied to NOAA and the National Weather Service, as several interviewees have recommended, the more the *Clarus System* will be subject to the enabling laws, regulations, policy directives and Congressional oversight of federal weather and climatic services. Not that this should necessarily be avoided, it just needs to be recognized.
2. In understanding the fragile relationship between the sectors in the weather enterprise, one needs to look no further than the last sentences of the report's Executive Summary: "The committee notes that none of the sectors consistently recognizes and gives attribution of the contributions (i.e., data and models) of the other sectors. Such attribution is also important for gaining public support for the large investments required in the weather and climate information system."

Business Model Issues and Considerations

A handful of issue themes emerge from this study as the most critical when considering how to implement the *Clarus System*.

Implementation Approach

There are several issues that can be classified under the theme of implementation approach.

- Roll-out strategy – There is the issue of how to establish a *Clarus System* that is national in scope, where all or nearly all transportation agencies that deploy ESS feed their observations into the System. While it seems likely that the *Clarus System* will first be tested within one region of the country, the issue then becomes does the System go national immediately, or are regions added one at a time (of course, using the term "region" also begs the question of what it means: How big are regions? How many regions are there?) To roll out nationally, the issues identified in this study will likely need to be addressed up front, based upon the experience gleaned from the initial regional "test." If the System is established regions at a time, there could be opportunities to evolve the model as further experience is gained.
- Incentives vs. Requirements – A policy issue with major business model implications is the degree in which incentives (e.g., funding, recognition, assistance, guidelines) or requirements (e.g., regulations, criteria, rules) are used to create the *Clarus System*, particularly in obtaining a critical mass of quality ESS data. A wide range of models are possible, ranging, for example, from "mandates" where states could be required to implement specific types of ESS sensor suites, in defined numbers and locations, complying with a particular operational concept, by a certain date, to "carrots" where states would be encouraged to provide whatever ESS data they have, and given assistance and encouragement to improve both the quantity and quality of data provided, but the extent and timing of such improvements would be left totally up to the states. While it does not appear that anyone involved in the *Clarus Initiative* is strongly advocating "mandates" or "requirements," clearly articulated policy direction is needed to move forward. Though not as obvious, similar issues exist and should be addressed on the data use side. For instance, would users be required to only obtain the available ESS data through the *Clarus System* or would users be free to make the decision to go directly to one or more ESS data providers for data?
- Policy and funding emphasis – While the *Clarus System* is focused on being the one-stop national (possibly North American) shop for ESS data, the overall goal is to make transportation safer and improve the nation's overall meteorological capabilities. There are several areas where funding and policy emphasis can be placed to meet this overall goal, ranging from establishing and improving the performance of the *Clarus System* to improving the underlying quality of ESS observations to increasing the overall number of ESS observations to improving the tools that utilize the datasets. The relative amounts and timing of investments in these areas will be an implementation driver and needs to be established then, or if already established, clearly articulated to all *Clarus* stakeholders.
- Evolution and Expansion – Like most systems of this scale and complexity, *Clarus* stakeholders recognize that to be successful over the long-term, the System must be able

to evolve and expand as the number and types of observations grow and change. The most obvious example is the incorporation of mobile ESS data through concepts such as the Vehicle Infrastructure Integration (VII) Initiative. How the System is structured to accept and accommodate evolution is a business model issue. For instance, is the system going to be implemented using a "release" model approach, with clearly defined configuration and change management process? Or will such evolution not be accounted for upfront, making the system difficult to evolve?

Funding

Typically, the most discussed business model issue is how revenue is generated to support the business or enterprise. In this case, the discussion is focused on how the *Clarus System*, not the ESS that feed observations, gets funded. The choices are relatively simple, though the decision is not. High-level options are:

- Users get free and unfettered access, with taxes or other funds supporting system operations.
- Users pay for access, either to fully or partially support system costs. If users don't fully support costs, then taxes or other funds would make up the difference. An example could be taxes fund implementation and user fees fund operations and maintenance costs.
- Tiers of services could be established, with the lower tier(s) being free and enhanced services (e.g., more data, better QC, quicker access, or some combination) made available for a fee.

Of course, there are several viable combinations and variants of these basic approaches. And while this paper provides many different examples of revenue models, both the research and stakeholder input point out that precedent and utility both lean towards at least some level of free access.

Operations

Another key issue is what organization or organizations operate the *Clarus System*. Based on research, the logical alternatives seem to be (1) a governmental organization, such as NOAA as several interviewees suggested, (2) an academic organization, or (3) a private company under contract or franchise. One item to point out is given the relevance of quality checks of data, whatever organization operates the *Clarus System* (assuming a single organization) will need to either already have or acquire the datasets necessary to properly execute timely quality checks. Clearly, whoever operates the System will do so under "rules" and expectations set forth by the *Clarus* stakeholders, as we discuss in the next section on governance.

Governance

An enterprise that requires so many different organizations to operate collectively needs clearly defined and understood rules and roles, a theme we call governance. In our experience, this may be the most important issue that will make or break the long-term success of *Clarus*. To date, the *Clarus Initiative* has made it a focus to seek broad stakeholder involvement. Inclusiveness will

be even more important as the *Clarus System* unfolds and becomes operational. We foresee several dimensions by which governance unfolds:

- Management and leadership – Systems with multiple participants typically require collective oversight. The first issue to address is who is "in charge." It could be a single organization that acts on behalf of the best interests of the System and its stakeholders. It could be a management body that represents stakeholders. It could even be an association or cooperative formed specifically to create, own, maintain and grow the System. Another important element of the enterprise model is how the different interests have input and influence on the direction of the System. If a single organization is in charge, stakeholder input could be through an advisory committee. If it is a "Board" of some sort that has legal responsibility for *Clarus*, its composition will be key to determining success of the System. However management and leadership is organized, key factors that will determine success are sound, responsible, consistent and transparent management, that is focused on seeking input from the full range of stakeholders, creates solutions that satisfy the collective interests of the stakeholders (including the public at large in the case of *Clarus*), while having the ability to defend, when required, the interests of the System as a whole, and its stakeholders against narrow self-interest. Further, configuration management processes and governance will need to be addressed.
- Guiding Principles – To make it clear to all potential participants, data providers, data users, the general public and organizations such as Congress who may provide funding for the System, the fundamental rules and guiding policy framework within which the *Clarus System* would be established and operated, and, importantly guide any future expansion of the System. Any of the issues discussed in this paper are candidates for inclusion, such as revenues and subsidies, access and ownership rights and responsibilities, etc. Without the agreement and establishment of such guiding principles, it may be difficult to continue to move forward with the concept, as those who are not completely satisfied with the general direction of the Initiative could continue to try to shift the policy framework more favorably towards their interests.
- Data Sharing Agreements – The *Clarus System* will depend upon the willingness of ESS owners and operators providing their data and joining the network. As interviews indicated, issues such as liability and uncertainty of the benefit of participation could impede efforts to gain ESS owner/operator support. One approach to overcome fears and codify the relationship between ESS owner/operators and the *Clarus System* is the establishment of a model *Clarus* Data Sharing Agreement. The agreement could, for example, contain elements that make clear that all users of the observation data do so at their own risk, no legal requirements for data quality or reliability, set the expectation that quality check feedback will be provided by the system to the operators and technical assistance and guidance will be freely available to assist the ESS operator in operating, maintaining, and improving the number, type and quality of observations.
- Data Use Agreements – The ultimate value of the *Clarus System*, assuming a critical mass of ESS observations are obtained, is the range and impact of improved products and services that result from one-stop shop access to QC'ed data. Thus, the development and encouragement of a user base for the data is critical. A model *Clarus* Data Use Agreement that should define the terms by which users gain access to the datasets, what responsibilities they have in terms of representation, acknowledgements, and usage rights

and roles of the *Clarus System* to ensure that all parties recognize, understand and accept the relationship between the System and the User. This agreement would go hand-in-hand with the model *Clarus* Data Sharing Agreement and be the principal "legal" mechanism that makes the *Clarus* Guiding Principles a reality. Such agreements are used often to codify the relationship between public agencies and traveler information service providers that allow the providers to obtain access to government traffic data. In those agreements, the intent is usually multi-fold: to eliminate or reduce the legal risk to the agency giving the data out, make clear the use gets the data as is (the quality and availability is not guaranteed), and describe what kind of acknowledgement the user will (or will not) use to indicate where the data was obtained.

Marketing

To be successful, the *Clarus System* must have both a critical mass of data providers and users. If the proper policy and governance framework is established, once critical mass is obtained, it is likely that it can be sustained (it may require effort, but the fundamental alignment of interests will be supporting its continuation). However, getting to critical mass is no simple matter. It will not be easy to recruit users if no data are available. Nor will it be easy to recruit data providers unless a significant committed user base for the data exists. Thus, the importance of "marketing" to the success of *Clarus* cannot be underestimated. In this case, marketing is focused on recruiting data providers, recruiting data users, and generally building support within the meteorological and transportation industries, as well as the political realm. Marketing, in hand with creative implementation, will be required to overcome the possible "chicken and egg" scenario of providers and users.

Editorial note: This seems an appropriate place to point out that if MADIS does evolve from an experimental, applied research initiative to an operational system, as is currently planned, with nearly half the states already providing ESS data, extending MADIS to act as the *Clarus System* "operator" would largely address the critical mass of data issue.

Other Issues

This study has uncovered several other business model related issues that should be understood and addressed as the *Clarus Initiative* moves forward. These include:

- Harnessing enlightened self interest – The U.S. economy is one of the most dynamic in the world because it largely recognizes and embraces the fact that most decisions are made in self-interest, whether it is individual consumers, businesses, or even public sector officials and organizations. Several of the stakeholders mentioned, in one form or another, the need to have something of benefit for all system participants, or the Initiative risks losing one or more constituent groups. We call it WI^{2}FM: What's in it for me? Common themes coming from ESS operators during this study are data quality feedback, access to guidelines and technical assistance, and "over the border" information access. Common themes from potential *Clarus* users are easy (and free or nearly free) access, consistency, better data quality, and more data. If benefits are provided, both users and providers may also be willing to do things beyond their narrow self-interest, so long as

it's relatively easy and does no harm to them or their organization. This is why we call it enlightened self interest. It is the "enlightenment" that those who create associations bank on, where a specific organization's interests get better satisfied by working with other organizations than working alone and may also result in some benefits to others of no value to that specific organization.

- System latency and its relevance to business models – No operational or design issue came up more in the stakeholder interviews than system latency. Given the "perishability" of weather data if one wishes to use it in real-time applications, it is easy to understand that the *Clarus System* cannot introduce significant latency if it is to support these real-time applications. As discussed in the interview summaries, there seemed to be reasonable consensus that 5 minutes or less latency from observation to having the observation available for use seemed largely desirable. However, like supply and demand, the lower the latency, the more useful the System will be. While this is clearly a design issue, the possible applications that could be supported and the overall value of the data – clearly business model issues – are tied to this issue.
- Consistency – Another topic that has popped up several times is consistency of data. Consistency has many dimensions, from the specific data elements, to metadata to siting and density to reporting processes. Users have expressed that in general, increasing consistency of the datasets in general will increase the value of the System. However, there is a recognition that the data available "as is" no matter how consistent, provides value as well. Further the more the *Clarus Initiative* focuses on "requiring" consistency, the greater the chance of disincentivizing ESS owners from participating. So, while consistency in general is good, the amount of emphasis, and how and when emphasis is placed upon creating consistency could have a significant impact on the overall value of the System.

Conclusions and Recommendations

To reiterate, this paper and the study that supported it, is intended to *raise*, not *solve*, business model and implementation issues associated with the *Clarus System*. As such, we have tried to shy away from recommending a business model, or the direction the in which *Clarus Initiative* should proceed related to these issues. However, we do have general conclusions and recommendations on where to go from here.

First, we believe strongly that it will be possible for the *Clarus* managers stakeholders to establish a workable business model to implement, operate and maintain the *Clarus System*. And in reading through the paper, one may be able to discern the most likely approaches to take on the issues identified. Second, we believe the time is right to begin developing consensus guiding policy and business principles that will underpin the *Clarus System*. Our belief is that nearly all other decisions will flow from those principles.

Finally, once guiding principles are in place (or even in parallel with principles development, to test out draft principles), we encourage the *Clarus* managers and stakeholders to consider developing one or more business model scenarios that fit within the policy framework to fully

address the issues identified above. The interdependence of the issues is so strong, that it is unlikely to be of much use to address the issues one at a time. Rather, the bundling of the issues and creating operating concepts that address them holistically will be most likely the quickest way to find the path to achieving stakeholder consensus on the overall *Clarus System* business model and implementation path. Further, how some issues are decided will largely dictate what other issues are of greater or lesser importance. For instance, if NOAA is identified as the *Clarus System* operator and all data will be available for free, then issues such as management and leadership to ensure stakeholder participation and support will be key. If the approach is chosen of a private company operating under contract or franchise with users being charged for data access, then recruiting ESS owners to participate may be a primary issue.

Appendix 1

Stakeholder Interviews

Dennis Belter, Program Support Manager, Indiana DOT

1. When you think of the Clarus “system”, how would you describe it and what it does?

A system that collects weather data on a national basis. There is RWIS in various states, none of it combined in one location, and that along with other sources of data would be centralized in one place. Hope that this data and a history of it for trending, will help us better forecast for highway operations.

2. What factors do you think are key to establishing and sustaining Clarus?

Someone on a national level will need to push for funding to sustain this system. Individual state funding will not be enough to keep this operational.
Would also like to see Aurora group involved in the initial role out / testing of Clarus. Several states interested in this issue and can provide good feedback.

3. Are there any particular issues or concerns you have regarding Clarus?

The magnitude of the project, the level of cooperation needed by all stakeholders and their level commitment to providing data is a big challenge.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Need to make sure that data availability is made, not only to the states that are contributing the data, but to vendors that the states are contracting with.

5. What organization do you think would be best suited to operate Clarus and why?

The size of the project warrants that this be operated by a larger organization. Not sure if it has to be centrally located or if it can be operated by regional centers, but possibly a large university or another group that has been funded for weather research, etc. (i.e. Purdue, Oklahoma) that have the large resource capabilities to operate it. NOAA would also be ideal since it is NOAA’s ‘buisness’. It would also help NOAA to have the additional weather information and the ability to trend the data for use in better, more accurate forecasting.

S. Edward Boselly, President, Weather Solutions Group

1. When you think of the Clarus "system," how would you describe it and what it does?

A system that collects, quality controls and archives weather data from various sources and across agency boundaries.

2. What factors do you think are key to establishing and sustaining Clarus?

See below.

3. Are there any particular issues or concerns you have regarding Clarus?

I attended the high level design review meeting in Kansas City and what bothered me was that I was the only weather person there representing the private sector so I'm concerned that the right players may not be in the process.

Timeliness of data? Need to be available within 10 to 15 minutes as a maximum latency and ideally 1 to 2 minutes.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

One of the issues with a business model for Clarus is that weather data have always been essentially free to users of the data. The only advantage that Clarus would have is that the data theoretically will have good quality control and good metadata associated with it compared with what you might get today where you don't know whether it's reliable or not.

5. What organization do you think would be best suited to operate Clarus and why?

There is a feeling or undercurrent of thought that FHWA and NWS are hooking up on this effort and that Clarus will be a subset of or a part of MADIS. In other words, there is concern that the private sector may not be a part of the operational Clarus system.

6. Do you think there's anything else we should know?

It will be a challenge to get the available information from 50 states and other agencies with a good level of cooperation. Some may not provide the data saying that they installed and own the sensors and do not want to share the data. The reason being that there is a legacy from the road weather business that the companies that have installed the sensors want to own the data.

There are some liability issues with how much of the data should be made available by the states. There are some states that will allow pavement temperature data to be available, but not other types of data.

There is also an issue on tort liability and having the public understand the data. Here in Washington State the pavement temperature data are available and there are always complaints and finger pointing that when the data may show freezing conditions why is the DOT not out taking care of it? When an incident occurs, the first thing then that people want is the pavement data.

Mike Campbell, Chief of the Observing Services Division, NOAA

1. When you think of the Clarus "system", how would you describe it and what it does?

Clarus is an integration of observational data sources in support of surface transportation. There is also a forecasting component of Clarus to support surface transportation as well.

2. What factors do you think are key to establishing and sustaining Clarus?

Clarus needs to have a large scale system design, more of a national scope than a state by state or even regional design. It also needs to be supported by budgetary means. Clarus does not lend itself to a pay as you go system model but rather a federally partnered/supported system. The budgetary aspect of supporting the infrastructure that would allow for the Clarus functionality is the main objective.

3. Are there any particular issues or concerns you have regarding Clarus?

The only concern would be the operational support and infrastructure needed to support what Clarus is intending to provide. There is also some clear concern on the granularity of state RWIS data, as states have purchased their RWIS platforms from a variety of vendors. This results in a variety of QA/QC issues, issues with the robustness of each system, failure rates, maintenance, etc. Clarus would have to allow and develop a QC mechanism that would QC any type of platform data that is coming into the system, whether it be from each state's RWIS platform or other data supporting surface transportation.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

From a government perspective, it is crucial that we use our tax dollars as efficiently as possible. FHWA and NOAA have formally entered into an MOU this year which puts some burden on both agencies to work together efficiently in a business model perspective as far as developing an infrastructure that would support Clarus. Looking at things from the standpoint of the mission of both agencies, NOAA is in the business of ingesting, collecting, quality controlling, formatting and then disseminating environmental data. It is a logical partnership that should be brought up into the business model. FHWA is in partnership with another federal agency who's mandate is to do exactly what is being looked for in terms of a Clarus infrastructure.

5. What organization do you think would be best suited to operate Clarus and why?

NOAA's mission is to provide environmental information, not only observational data but forecast/model data as well, to support public safety. It also has a commerce and transportation facet to their mission where they support public safety and efficiency on the nation's transportation systems, including surface transportation. NOAA's expertise from ingesting data from diverse sources, quality controlling it, formatting it in common accepted formats and disseminating it as widely as possible at the lowest minimal cost. NOAA doesn't charge for the data – the precept of a government agency, they are funded by taxpayer dollars so they make the data available at either no cost or at a minimal recovery cost. NOAA partners with other federal agencies and with the private sector as well to accomplish this. NOAA has a history and has been in partnership with FHWA for some years. NOAA feels that they have an obligation to the private sector, the enterprise at large, to make the data available at minimal cost to benefit private sector opportunity as well.

Paul DeLannoy, Meteorological Service of Canada, Environment Canada

1. When you think of the Clarus "system", how would you describe it and what it does?

Clarus means the integration of all the desparate DOTs and private RWIS networks across North America into a nationally or continental wide integrated homogeneous network, ideally including RWIS information from Canada. The RWIS Canada initiative has been under development for some years now.

2. What factors do you think are key to establishing and sustaining Clarus?

Relating experiences from Canada, have found that 'good papers make good friends'. It is important to establish clear roles and obligation, commitments and writing these up as data sharing agreements that identifies a common understanding of everyone's roles and what will be provided as a result of these roles. Another overriding factor is a common data exchange protocol so that the same level of quality control is applied to all data received from all sources to make it fully interchangeable. Something FHWA as well as RWIS Canada have already done is to recommend basic instrument suite and installation recommendations for the agencies to use. The latency of this data, including the QC process, has to be real time. RWIS Canada has committed to latency of a matter of minutes; sometimes as much as 5 minutes, but never more than 10 minutes. Also, RWIS Canada becomes a central repository or clearinghouse for the data, they create an archive and the provinces designate recipients for the data. Otherwise, there are rigid controls over the dissemination of the data, and the data sharing agreements specify that the data is intellectual property of the provinces, that is easily shared through RWIS Canada if that approval is given.

3. Are there any particular issues or concerns you have regarding Clarus?

Clarus is an extremely positive move for the entire population, as transportation is linked to all facets of life, including the economy. The one hope is that RWIS Canada will be able to collect the meteorological data for all of Canada and feed this data to Clarus for use and dissemination, staying ahead of the curve for implementation so that the data is available when Clarus is ready to accept it. This is opposed to having Clarus collect the RWIS data in Canada as well. The meteorological data for Canada should be shared as our trade, transportation and tourism ties run deep and all of these are affected by weather and RWIS information.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

In terms of requirements definitions, when we talk about a nationally integrated network and a common standard for everyone, it is best if it is done by an impartial, non-profit agency or government department. Understanding is that the National Weather Service would be prepared to do that on behalf of FHWA, which is the same model used in Canada, where Meteorological Service of Canada who has obtained federal funding to bring in all of the provincial RWIS data. In terms of QC, the larger the database you have to work with, the better the QC process becomes. As in Canada, the National Weather Service has a large database to begin with, along with considerable expertise in QC of atmospheric data. A bigger benefit is that the National Weather Service can use the data internally, and forecasters can use it to refine the public weather forecast for everyone, an appropriate public benefit as the RWIS stations are typically paid for by public funds, at least in Canada. An additional benefit is that the data can also then be ingested and used in numerical weather forecasting, and refine the numerical forecasts used by the private sector to forecast road surface conditions and pavement temperature forecasts used in making winter maintenance decisions. A model that predicts road surface temperature is just a set of thermodynamic equations that

take into account all of the impacts of what is going on in the atmosphere – the quality of which is then determined by the quality of the atmospheric forecast.

While the Canada RWIS data is proprietary, and cost for access to the data as well as the access itself is controlled entirely by the provinces that collect the data, it is used internally by the Meteorlogical Service of Canada for various purposes. They can publish derivatives from the data, such as publishing climatological normals, but the integral data itself would not be recoverable. Effectively, the Meteorlogical Service adds value, through the QC process, to the data received by the provinces and thus become part owners of the data at this point. They give back the data to the provinces, and while they don't surrender their ownership of the data, they allow the provinces to use this data as they see fit, and don't expect payment in return if it is used for profit, as they have already been paid by the people of Canada. The primary goal is to make this data available as broadly as possible.

5. What organization do you think would be best suited to operate Clarus and why?

The National Weather Service! You want an organization that will be there for the long term, which will derive the maximum possible benefit while creating the least possible heartache for the vast majority of people that will be accessing this data. The private sector has a tendency to try to ensure continued business and revenue stream and will usually make access to the data more difficult. They also change hands, amalgamate, and running an archive becomes more difficult then.

You need an agency that is not aligned with any partnerships, a completely 'arm's length' organization. The National Weather Service is a national, impartial agency that runs a super-computer forecasting facility and is interested in providing QC to these data sources to normalize them for more valuable weather forecasting data. It is the most efficient way to operate Clarus. Private sector agencies will be willing to do it, but there is a premium attached to that service and a profit outlook will always be present, rather than an altruistic effort to make this data available to as many recipients as possible for the least amount of money.

Jan Dutton, Director of Weather Services, WeatherBug
James Anderson, Director of Government Services, WeatherBug

1. When you think of the Clarus "system," how would you describe it and what it does?

A central repository of weather information and related products for the surface transportation industry. It's role spans from ingesting data sources to the creation of products necessary for surface transportation decision makers.

2. What factors do you think are key to establishing and sustaining Clarus?

Funding is key to sustaining Clarus. We feel that for the roadway weather information market in general, WeatherBug has a relatively unknown and almost totally unutilized set of potentially very valuable assets

Generalized Statement: Would prefer that Clarus end up not competing with us. We have a unique perspective in that we are the only private nationwide centrally managed weather network in the United States. We'd like to find a way for us to participate in Clarus while still not denigrating our revenue models while at the same time not ending up competing with another nationwide centrally managed weather system.

3. Are there any particular issues or concerns you have regarding Clarus?

We see proposals frequently, that are either regional or national in scope, to develop weather sensing networks from scratch that are completely isolated and are designed to solve one problem or meet one set of users needs. The problem is that most of them are not sustainable. Most people like the idea of a weather network, but hate the idea of maintaining a weather network. They're also costly and take a good deal of time to set up. AWS has an existing national network of sensors which is at least a base level solution and has an economic model in place that will support and sustain it over time.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Public, private and academic partnership. There's always a conflict in the public and academic sector with the private sector because the private sector, by definition, is out to make a profit.
One potential business model is where the private sector maintains and operates the Clarus system. As an example, WeatherBug has experience and expertise in operating real time systems. One aspect of the Clarus system, in reviewing the requirements, is the data gathering and distribution system. WeatherBug just happens to have 800 servers that currently do that. The framework of this business model is to find the organization that will best and most efficiently operate the system.

The business model that I would like to see is one where the system is developed in research mode, but placed in the private sector when put into operation.

Another business model would be similar to Vaisala's National Lightning Detection Network (NLDN). They have a contract with the federal government to use their data and also sell their data privately to industry. Clarus could be operated similarly in that the federal government would partially fund the operation of the network for provision of data and services to the states, but the company would also be able to sell the data to the commercial sector.

Business models to advise against: An ad-hoc network set up to fulfill the needs of one fairly narrow use. If there were a consortium of universities and government agencies trying to pull together program dollars

to fund Clarus so that the data is distributed at little or no cost to the users then that's a losing proposition because the program funds will eventually go away. There's not a Mesonet that I'm familiar with that hasn't fallen on hard times. This model relies on the consortium or groups of individuals involved in the network constantly trying to get grants or program funds to keep the network operating. The end users are used to getting the data for free and become pretty unwilling to pay for it even when there is value added to the data. We see that with the NWS having a hard time sustaining the ASOS and AWOS networks. They are constantly fighting for budget dollars to do that. When you talk to stakeholders who are using the data, they are hungry for even more data. The expectation of free data has been around for so long that this data is seen as a public good. Perhaps the federal government should provide some base level of data for free?

5. What organization do you think would be best suited to operate Clarus and why?

In the end I believe there will not be a single organization that operates Clarus. It could be that the operations component is handled by a private group while the research and development component is handled by the public and academic sectors. The best incentives and the best knowledge to run Clarus would be in the private sector. Running a network of weather stations is in many ways a distributed asset problem; an operations and logistics problem. Private companies are much more suited to handle these types of problems in the long haul. Universities and/or the federal government pays the private company to operate and maintain the network for their purposes therefore the government and universities get unfettered access to the data for research and for their own projects. Then the private company has an opportunity to license that data for other applications (industrial applications, emergency management applications or other commercial non-essential application of the data).

Joe Holt, Transportation Manager II, Tennessee DOT

1. When you think of the Clarus "system", how would you describe it and what it does?

The intent is for Clarus to be a central, national warehouse of surface transportation weather data, including some sort of QC process that would eliminate erroneous data, and then processing it into some format that would be made available to users.

2. What factors do you think are key to establishing and sustaining Clarus?

Funding for Clarus in terms of long term sustainability will be a key factor. There is much demand for the data that will be made available through Clarus, so funding form various sources should be available, but it will be key in making it successful.

3. Are there any particular issues or concerns you have regarding Clarus?

Anticipating the model run to identify some of these issues. Some that come to mind would be that the data be made available in a format that is useful to users. Hoping that the QC process implemented as part of Clarus addresses any concerns with the quality of the data made available by the various sources.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Believe that the system should be centrally located, as the regional concept might lend to disagreement on the way things are operated and complicate things further. It is the understanding that all participants donating data to the Clarus system will have free access to the Clarus data. If these same participants need the data formatted in some way, there may be an element to Clarus that provides additional processing of the data for a fee.

5. What organization do you think would be best suited to operate Clarus and why?

NOAA. They definitely have the resources to process the data, and with the MADIS system in place, they have a similar concept and process that, while they have not been able to follow through on and have struggled with for several years as far as getting data, has provided a source of experience similar to what Clarus will require for operation. Tennessee will be providing RWIS data to MADIS in the near future.

John D. Horel, Director, NOAA Cooperative Institute for Regional Prediction, University of Utah

1. When you think of the Clarus "system," how would you describe it and what it does?

A way to provide some national structure to what has been a lot of independent efforts for collecting road weather information and other information for both public safety and for operations of highways.

2. What factors do you think are key to establishing and sustaining Clarus?

It's useful that Clarus is setting standards in terms of the types of equipment and reporting structures to be used within the system.

3. Are there any particular issues or concerns you have regarding Clarus?

The biggest issue is that there are tradeoffs that have to be made with siting of sensor stations. On one hand it's good to have overall program goals and national standards for sensor station locating, but on the other hand, especially in remote areas with difficult terrain, pragmatic decisions will need to be made by the local agency so that they get the information where they need it. However, siting the equipment in that location may never meet the national standards for locating that equipment (e.g. minimum distance to an obstruction, characteristics of the site, etc…).

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

With a decentralized model you must set up a structure so that there is success at the state and local level. What I've seen in working with a number of state agencies in the west is that they have the capability to do a lot of these things that Clarus will do and they just need some guidance and structure to make it so that it goes beyond just meeting their own direct needs since there are overarching national needs.

I would suggest against specific federal mandates that things have to be done exactly the same across the country and not taking into consideration local needs.

Timeliness of data – within 15 minutes would be acceptable.

5. What organization do you think would be best suited to operate Clarus and why?

State and local agencies. Having the system managed and operated by the people who are close to the scene makes sense from a maintenance standpoint. Even when you're operating on a regional basis you're getting away from who your customers are that will use the system. Here in Utah there are now meteorologists on staff who assist the maintenance personnel as well as interact with people in traffic operations.

Dan Krechmer, Principal, Cambridge Systematics

1. When you think of the Clarus "system", how would you describe it and what it does?

A database that will collect and QC road weather observations from around the country and make it available to third parties for various purposes.

2. What factors do you think are key to establishing and sustaining Clarus?

Establish the quality and nature of the observations out there by conducting discussions with state DOT for establishing a process that generates meaningful data
National RWIS program needs to grow to add more observation stations in various states.
Feedback loop that communicates to data providers any issues or problems with the data being provided.

3. Are there any particular issues or concerns you have regarding Clarus?

Clarus is initially concentrating on DOT RWIS data, and these vary greatly between states. Some RWIS programs get a higher priority than others, and the future of these programs, particularly with funding, is uncertain. Do we fill in with other observations where good roadway data doesn't exist, or do we look towards a standard that requires all providers/states to have, for example, the same number of readers for x number of miles.

QC – 20 states already provide data to the MADIS system that has a QC process in place. Do we rely on the MADIS QC process which a lot of the states seem to be happy with and expand that process to all states, or do we establish a separate QC process for Clarus?

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Be careful with the agreements that we get into with private companies. It seems that Clarus is intended as a system that will be government owned and the information will be available to anyone who wants it, but as we contract with others to maintain and run the system, we don't want to over time and agreements, end up limiting the accessibility or dissemination of this information.

5. What organization do you think would be best suited to operate Clarus and why?

It is hard to give an opinion on this. It is not necessarily important who operates it, as long as the information is available to everyone. That outcome is more important than the operator, and if this accessibility is only guaranteed by a federal agency like NOAA or FHWA operating it, so be it, but don't think this is the case.

Bill Mahoney, National Center for Atmospheric Research

1. When you think of the Clarus "system", how would you describe it and what it does?

The Clarus system is a nationwide capability designed to ingest, process, quality control and disseminate road weather and road condition observations.

2. What factors do you think are key to establishing and sustaining Clarus?

- Ability to get concurrence from all state DOTs (and eventually other jurisdictions) to contribute their data to Clarus without restriction.
- Ability to process the data and redistribute the data with minimal delays (low lag time). The processing lag time should be no more than 5-10 minutes.
- The data should be public domain.
- Ability to obtain the nationwide dataset from a single location; not necessarily single physical location, but the ability to easily obtain data on a regular basis.
- Clarus should eventually include weather and road condition data gathered from vehicles, but the first priority is for fixed sensor data.
- The organization that is tasked with processing Clarus data should be stable, provide redundancy, have a successful history of processing and quality-controlling weather observations, and ensure that the data stay public domain (e.g., NOAA, well suited to administering a system like Clarus).

3. Are there any particular issues or concerns you have regarding Clarus?

The transition to operations (after the demonstration) needs attention. It is not clear how this will occur. It is also not clear how long-term funding to support this operation will be found. Who pays for fine tuning the system after the demonstration? (NOAA, FHWA, other?)

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Clarus system operations should be funded and maintained by the public sector to avoid conflicts of interest and avoid complexities of intellectual property. A public operation should be governed by an advisory group made up of the major contributors (e.g., state DOT representatives, possibly OEM involvement) with feedback from the broader stakeholder community.

5. What organization do you think would be best suited to operate Clarus and why?

NOAA has the most experience with weather data acquisition, processing, quality control, and dissemination. The weather community is also very familiar with NOAA and their procedures for acquiring datasets. NOAA is best positioned to take on this responsibility as it clearly dovetails with their mission and is consistent with their experience in acquiring and processing other weather observation datasets. NOAA also has the external (to Clarus) datasets necessary to properly quality control the Clarus data.

Additional:
Important that Clarus have strong participation from Federal Transit and Federal Rail and the marine side – not all marine operations are DOT operations, attention should be paid to other stakeholder groups that could contribute and benefit from the Clarus system.

Patricia A. Miller, Chief of the Scientific Branch, NOAA Forecast Systems Laboratory

1. When you think of the Clarus "system," how would you describe it and what it does?

It's the national collection, integration, automated quality control and distribution of road weather observations both meteorological and pavement observations to help in surface transportation.

2. What factors do you think are key to establishing and sustaining Clarus?

As far a long term establishment and sustaining Clarus we need NOAA buy in. Very similar to things that NOAA is already doing. Thinks we need to integrate not only RWIS observations, but also NOAA and non-NOAA observations and making them easily obtainable and usable.

NOAA buy in is critical.

Accepting observations from the individual state run networks or other networks via any format or communications techniques. i.e. don't make the data providers do the work. Also need to integrate other observations and give that back to the data providers so that they are getting something in return for sharing their data. QC statistics and other useful data are provided back to the data providers of MADIS, for example. This allows them to do things like calibrate barometers and find bad data sets and faulty sensor stations. MADIS does all of the data formatting work.

The data providers gain by joining the national data-sharing network. Gain station maintenance guidance in the form of QC statistics.

3. Are there any particular issues or concerns you have regarding Clarus?

Need better and more coordination with the existing government systems. Need to get the government buy in for the actual operation of the Clarus system. Should accept the data in any format instead of forcing providers to conform to a set format. Clarus needs a requirement to save the data. Seems to be a gap in the current requirements. Needs better metadata (some state DOTs don't even have elevation for their stations). This needs to be communicated back to the providers. Some concerns about the mobile operations (VII). Should they be handled the same as the RWIS or handled differently? There is a Clarus requirement to talk to each individual station. It might make more sense to have the individual networks talk to the local stations and the national system simply accept the data from the local networks.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

It's inherently a government function (a NOAA function) in that it helps with protection of life and property which is a main mission of the NWS. Another NWS mission is to gather the data and provide the national informational database for the rest of the meteorological community. The NWS has the existing infrastructure, experience and resources to do this. The current NOAA strategic plan includes integrating and gathering observations from all of these sources in several different places. Part of the existing NOAA plan is to form an integrated observation system and to provide a database.

5. What organization do you think would be best suited to operate Clarus and why?

MADIS currently has nearly 18,000 surface stations from over 100 individual mesonets which are run by many types of organizations (private companies, state and local government agencies, DOD organizations, etc…). In general, private companies will build and install the sensors including the

communications and will gather them to a central server. All that data is brought to a central location within a state DOT. MADIS then gathers all of that data, integrates it, puts it into a uniform format, performs automated quality control on all of the information once it's been integrated with the NOAA and non-NOAA data. The database is then built and distributed. Authentication procedures are built in since not everyone wants their data to be publicly available. There are three distribution categories:

- NOAA only
- Government research and education
- Fully Public integrated dataset

Data providers choose which category their dataset goes into. MADIS is currently run out of the FSL within NOAA and is transitioning to an officially operational part of NOAA. As part of the transition, agreements with data providers will be made official NWS documents. For people wanting to access the data there is a data application form. Bringing Clarus in to operate with/within MADIS is a logical step. They are continually working on bringing in more RWIS networks.

Timeliness of data: weather data is very perishable. Would probably be handled by tiered outputs for the national database. Several layers of outputs can be made with the datasets. The users can decide at what level of output they would like to receive data:

- 1st level: Bring data in and do quick reformatting and then output it; currently being done for the forecast offices. Data is brought in and distributed in ~ 15 seconds. This end-user level is very knowledgeable about meteorological data and have access to internal NOAA-specified QC systems, so there is little or no QC done to this dataset
- 2nd level: more integration and reformatting is done at this level
- 3rd level: First level of QC is performed at this level (quick QC results); Latency on output vs. receipt time is 3 minutes (mean time)
- 4th level: Full QC results

The basic idea is that different levels of outputs are made available for the different customers' needs. They are *very* focused on the timeliness of the weather observations.

6. Do you think there's anything else we should know?

Should think of the differences between Quality Control and Quality Assurance. QC – The automated checks. QA – Guidance being QC statistics that help maintenance personnel find bad sensors and fix them. Human in the loop. The individual networks do their own quality assurance and maintenance. NOAA could provide the QA guidance, but would leave the actual QA role to the data providers. Doesn't see the maintenance itself as a NOAA role, but sees it as a private sector role in that the private sector can provide the service to the state DOT's. The data provider's job is to focus on getting the data to MADIS and trying to keep the quality as best they can and taking any feedback provided to them by NOAA. NOAA provides automated feedback to them as an incentive to share their observations. The MADIS role is to do all of the integration, make the datasets available along with the QA guidance, but leave the QA itself to the data providers.

Dr. Renee A. McPherson, Acting Director, Oklahoma Climatological Survey

1. When you think of the Clarus "system", how would you describe it and what it does?

An ingest, data processing, data quality assurance and data delivery system that will integrate environmental data that are of use to the surface transportation community.

2. What factors do you think are key to establishing and sustaining Clarus?

The key factor is obtaining the legal agreements from the various data sources to acquire the data and then being able to share those data back to those agencies and others.

3. Are there any particular issues or concerns you have regarding Clarus?

The Oklahoma Mesonet currently acquires and quality controls data and generates products that are available five minutes after the measurements are taken. We are aiming to decrease that latency to one minute. So, one question I have is: Will Clarus customers get data even later than that via Clarus? Will that affect the reputation of our network?

Some networks don't take measurements during certain times of the year, don't take measurements on a regular basis or only take measurements when a specific event has occurred. Therefore you may be getting data from some states or regions of the country at a significantly delayed basis primarily due to their communications infrastructure and its associated costs.

There may be some training issues regarding how to use and how not to use the data with the users of Clarus (non-meteorologists mainly) who are not familiar with using this type of data. For the transportation officials, for example, there may need to be some guidance in how best to use the data in their daily activities. Instead of designing only the technological component of the system, there also needs to be significant thought about how users should be able to apply the data.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

The Clarus system could be integrated with NOAA's Integrated Surface Observing Systems Program. As long as the National Weather Service believes that ISOS is an important program to fund and continues to apply resources to it, then the NOAA/NWS could be a business model. Traditionally, customers feel comfortable getting data from the NWS because they've done it for decades.

Another model would be to contract out to a private company to run the Clarus system. The company would need to meet certain quality and timeliness standards which could provide more oversight for running Clarus than if it were operated by the NWS.

A potential problem with either of the above scenarios is that if the Clarus system, as it goes on, were to focus mainly on a "maintenance only" mode without an injection of new science and technology, then Clarus would soon be passed technologically by another system. I would like to see that there is a component of Clarus to keep it as technologically advanced as possible. This could be done through either the University research community or through the NOAA Laboratories. These advances could be new quality assurance techniques, new types of sensor data, advances in computing and communications, or other technological advances.

5. What organization do you think would be best suited to operate Clarus and why?

One organization that would do an excellent job would be the University of Oklahoma through its National Weather Center. We currently operate a number of operational units at the weather center, so we have experience in a 24x7, critical-operations environment. The scientists interact regularly with engineers and computer scientists so it's a good environment for ongoing technological input. My biggest concern with a system like this being operated within NOAA is that traditionally these major systems end up in parts of NOAA that don't interact well with the scientific community and remain in maintenance-only mode. There are parts of NOAA that are very forward-thinking and I hope that Clarus will be within a community where the various parties interact with each other.

6. Do you think there's anything else we should know?

FHWA should start to talk with some of the organizations that you think will be data providers as soon as possible. I've not been asked specifically if the Oklahoma Mesonet will be a data provider, and I suspect that most of the other providers have not been contacted. It may take a long time to get the data provider agreements put together with all of the potential state and local government providers, so I would suggest starting this process sooner rather than later.

Rick Nelson, Assistant Director, Operations, Nevada DOT

1. When you think of the Clarus "system", how would you describe it and what it does?

Perceives Clarus as a huge repository of weather data that is QA'd so that it has a degree of validity, and that is made available for use locally, which he believes is important. Realizes that there is some time that lags between data collection and availability because of the QA process (climacological data?). Still uncertain as how the data or system can be used operationally. Understands mission of Clarus to be the adjustment/QA of data from all of these environmental data stations from DOT and others to leverage them.

2. What factors do you think are key to establishing and sustaining Clarus?

Compared project to 'herding chickens' in that there are so many different people out there operating these environmental sensor stations, and convincing them that they need to participate in Clarus is a milestone on the critical path. There is a potential to end up with scarce data in some areas, and one critical factor is convincing people that have these sites that they do need to ingest, and if during the QA process we find that there are some issues with either sensors or sites, that they need to do something about it. Many states have built RWIS systems, and those that built them from the bottom up and might have more interest in maintaining their sensors, while others that have built them from the top down, might not have the interest in keeping up with their sites. One hurdle to overcome is dealing with the private value added MET people and the RWIS vendors. While there were several of them at the Clarus meeting in Vegas, but if they have not bought into the Clarus system, they can have considerable influence into the state's participation as well. Another thing that needs to happen is, when the Clarus program is presented to the states for participation, it is important to develop a business or marketing plan that highlights what is in it for them. Currently, we send data to three or four different places, Mesonet, climate center, university and national weather service because it was requested, and our philosophy has always been to share data for everyone's benefit. However, there are agencies out there protective with their data because of legal concerns, afraid of potential litigation, etc. and these could become stumbling blocks for getting people to participate, and a business plan that shows the importance of getting data into the system would help overcome these concerns. Data is not going to come back to hurt them, and that they can get value out of doing it.

3. Are there any particular issues or concerns you have regarding Clarus?

Some challenges he sees are on the technical side. Not sure exactly if, once the data is made available either in an FTP site, pushed, pulled, etc., there may be a challenge with the compatibility of data. One of the concerns is going to be gathering the metadata associated with each one of these sites. We have dedicated one staff person for the summer to collect what they feel needs to be collected about the sites based on the siting guidelines put out by Paul. They have realized that they need better about where these sites are. We may need to do a pulled funds study to see what this data collection needs to be or a pilot study (business model issue) for data collection / data test where there is some assistance for agencies to go out and collect data. Some states might not have GPS system accuracy options (lat/long/elevation), so may need to strategize with AASHTO a bit, either on NCHIP work or pooled funds work to kick this off so that whoever is developing it gets a fairly clean data set to work with. Another thing to overcome is how to run the program, the sustainability issue. There will be overhead associated; someone will have to claim the data as their own to make sure that it is there and current. Whoever spearheads the Clarus initiative, FHWA or whomever needs to identify a transition plan from concept to small scale implementation to a full blown, sustainable, working environment system. Another thing to think about is how to use this data operationally. The people that operate the RWIS systems need to feel that it's important they participate in Clarus, and one way to do that is to make them feel that they are getting

something out of Clarus. One of the ways to do this is by showing some operational value in the short term, as opposed to just the climatological data that can be gone back to for reference, etc. The guys on the ground need to see a short term value for participating in data, and this will prompt folks to participate and work around liability issues and other things because of the trade off. Another concern is that when a system is designed for many customers, things are reduced to the lowest common denominator, and system might be 'dumbed' down to accommodate the less sophisticated systems (RWIS) and lose a lot of value from the more sophisticated ones. Hopes that we don't favor a particular vendor – many vendors out there for the equipment with different data formats. One of the greatest selling points for Clarus is NDSS and 511. If we can gather the weather data and hard link it into the MDSS program and 511, it just becomes part of the trinity. Also, there are at least 2 vendors (SSI to commercial vehicle folks, Vaisala pulling data and making it available to states) out there creating something similar to Clarus where they are aggregating data, pulling into databases and remarketing/reselling it. May run into obstacles from these folks who have invested time/effort into these systems and may see Clarus as a challenge to what they are already providing.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Thinking about who the logical agencies or groups to be involved, Clarus is going to end up being some kind of a distributed program. It might be that there is an umbrella agency that oversees the program, but NOAA has a role to play, if we think of it as the national regional climate centers, because they are a good agency to keep and QA the data since they do some of this already. The National Weather Service has a huge role to play as well – they have local knowledge in local forecast offices. They could have a real vested interest in getting hands on this ESS data because it can help them in their mission of protecting life and property. They have always bumped up against the vendors and value added meteorologists (VAMS). Some local forecast offices have worked a very close relationship with DOT's to get RWIS data and use it in forecasting, and forecast verification. Local DOT's can see the feedback of Clarus data into their operation if the local forecast offices get involved. Universities get engaged as well through research efforts, but the big 3 players are really NOAA, the local agencies that operate the RWIS systems and the national weather service regional forecast offices.

Concerned if the system focuses solely at a national level. If business model is that NOAA is creating a new repository for data administered out of NOAA's headquarters, without allowing the states to have a face to face contact with a Clarus representative, the local guys will not see the importance of feeding the data into Clarus. Without data, or if problems identified with data aren't fixed, it dilutes the benefit of the Clarus system. Need to make sure Clarus has a local flavor, not solely a national perspective. It will be difficult to start and/or sustain. It will be like the HPMS program where pavement condition data is collected, sent to a black hole in DC, and the only thing that comes out of it is a comparison rating. If federal funding wasn't tied to the HPMS requirement, it wouldn't be a worthwhile submission of data, and we don't want Clarus to take on a similar feel.

Local forecast office and national weather service plays a role; depending on the state and polling cycles, data gets submitted with varying time stamps. If they are the ingestion point of this data, the meteorologists can take a quick scan of the data, validate it and provide feedback back to the locals in an outcasting environment, and this provides value to the locals in submitting the data – creates operational value. This may compete with VAMS that have relationships with DOT's and provide them the same service, but that might not be a bad thing.

5. What organization do you think would be best suited to operate Clarus and why?
NOAA. Under the NOAA umbrella, you have the national weather service, the regional climate centers, the research people and operations people that can do something with this data. Considered if the

government should do this, the universities, or universities under contract to the government. His own personal experience is that generally, while there are universities out there that this doesn't apply to, there are universities out there that are not geared up to operate in an operational environment, focused on research and study – higher level thinking. To get operational value out of this data which is key to Clarus, we need to work with a group that is used to producing products in an operational environment – consistent, timely, routine data. Government is setup to do that, not so sure the university environment is.

Under NOAA umbrella is also the different forecast laboratories that provide a mechanism that, on a broader scale, can take this dense network of observations and get some value out of it in forecast modeling, etc., which would also benefit data that would feed to the 511 systems.

Leon Osborne, President, Meridian Environmental Technology

1. When you think of the Clarus "system", how would you describe it and what it does?

Clearing house of primarily ESS data collected from state/city/county areas. Not any forecasting or additional services other than some level of QC, just a data clearing house to expedite the flow of information from collectors to users. User is expected to provide their own level of final QC, so should consider Clarus data as essentially raw.

2. What factors do you think are key to establishing and sustaining Clarus?

There has to be an incentive for those who have data to participate in Clarus. This system hinges on states' participation in providing data and that will come from the value they perceive in providing the data. The long term benefit is improved support from the surface transportation weather service providers, who are currently on the outside looking in, not necessarily directly involved in Clarus. There has to be value for the users, the surface transportation weather service providers, to keep them involved in Clarus.

3. Are there any particular issues or concerns you have regarding Clarus?

The surface transportation weather service community has not been embraced by Clarus, and they are not going to pay money to attend the ICC meetings that have taken place, but are going to play an important role in the success of the system. The states are being supported to attend these meeting and participate, there is no incentive for the surface transportation weather service providers to participate, and this can ultimately backfire.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Will be determined by who will ultimately operate Clarus.

If NOAA houses and operates, it will follow its existing business model that works very well, where all the data is accessible by anyone in the community, which is what the Clarus ConOps envisioned early on. NOAA's MADIS business model is not only operational and most cost effective.
The business model has to provide for free and open access. If there is ever a fee for data, users will shy away from using it.

5. What organization do you think would be best suited to operate Clarus and why?

See above.

Curt Pape, Minnesota DOT

1. When you think of the Clarus "system", how would you describe it and what it does?

Clarus is an information clearinghouse for weather information collected nationally, to which some level of quality control is added before providing it to users in a light format.

2. What factors do you think are key to establishing and sustaining Clarus?

The first key factor would be to get the involvement of many states to provide weather data to Clarus. A second key factor is the fast turnaround and availability of this data. If data is collected and made available to users 6 hours later, it is of no value. This type of information has a limited shelf life of a ½ hour to an hour for it to be of any value to the DOTs, and this latency will also be affected by the varying state collection process times, some which pull data with less frequency than others. The QC process should also be limited to a level 2 or 3, not a full QC, but basic but valuable checks of the data in a short period of time, with caution to not speed the process up so much that we get junk data in a hurry.

3. Are there any particular issues or concerns you have regarding Clarus?

The only concern is a level of uncertainty that the Clarus system will be broad enough to cover information for and be able to provide benefit to all modes of transportation (rail, boat, etc.) in addition to road transportation.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

The only thoughts on components to a business model would be that the data should certainly be made available at no cost to end users. It is public data, and the process is being funded by public funds, so it should be made available to everyone! The system should also be centralized in one location.

5. What organization do you think would be best suited to operate Clarus and why?

NOAA. They are the experts in the weather arena, are certainly big enough to handle the requirements of operating the Clarus system, and the system fits in well with the mission of NOAA.

Brooke Pearson, North America Business Development Manager, Vaisala Inc.

1. When you think of the Clarus "system", how would you describe it and what it does?

A set of processes and systems that are linked together to take data from environmental weather stations, perform quality checks and make that data available to anyone who wants access to it.

2. What factors do you think are key to establishing and sustaining Clarus?

Presumably Clarus will be sustained if people want the data. If there is a sufficient requirement for it then Clarus will get FHWA funding on a regular basis.
North America has about 2,500 road weather stations. The U.K. has about 1,200 road weather stations so the density of stations in North America is relatively small. Certain states in the U.S. have much greater density than others and the density of the weather stations represents the value of the information to that particular state highway authority and to the surrounding areas. It will be interesting to see what value others that are not local attribute to the dataset being that the U.S. is so vast.

3. Are there any particular issues or concerns you have regarding Clarus?

Will there be enough interest to keep the momentum going on it long term? People must find something useful to do with the data. It's a national database and certainly it will be useful on a local level, but there must be a benefit for having a national database. It's also critical for other data to be coming into the database for it to be more useful.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

From a funding perspective, I believe Clarus will need funding from the central government. I don't envision that there will be enough revenue from selling the data to forecast agencies because they will want such small subsets of the data. Since the weather stations are so sparsely distributed there's not a lot of data available anyway. For example, Colorado DOT has about 80 road weather stations and Colorado is larger than the U.K. which has 1,200 weather stations. We looked at data sales in the U.K. and determined you would earn a certain amount on it but wouldn't make a living at it. It's a nice add-on, but only because we were doing other things.

I do see the data as having value, but not enough to be self-sustaining which is why I think it should be a part of a larger effort and probably be run by an agency like NOAA where it is run for the global good.

5. What organization do you think would be best suited to operate Clarus and why?

NOAA's Forecast Systems Laboratory since they're already running this type of system with MADIS.

Lee Smithson, Iowa DOT, SICOP Coordinator, AASHTO

1. When you think of the Clarus "system", how would you describe it and what it does?

A one stop shop for reliable data without importance of who is the recipient of this data. Reliable data right now is the biggest thing we're missing, and Clarus is the program that will help fix this issue.

2. What factors do you think are key to establishing and sustaining Clarus?

Need to start with the basics: identify and clarify the type of data that we are ingesting into Clarus to determine how reliable and accurate this data is. Start with basic environmental surface sensor stations in the state RWIS… there are thousands out there, but no metadata to identify what type of station this is. Over twenty years, these have been put in place with specific objectives in mind, but never with a centralized system like Clarus as a goal, so we need to index these stations to understand what kind of information we're dealing with. Does the station represent a bad accident area? Does it represent the coldest or warmest? We just don't know. This quality data should be the focus of Clarus. Right now, once the ESS is put in, very little is done to calibrate it, check to maintain that it stays calibrated all winter or during critical times.

3. Are there any particular issues or concerns you have regarding Clarus?

We've addressed many items of concern early on, such as communications standards and protocol for plug and play potential, etc. Presentation of the information put out by Clarus needs to be standardized as well so that it looks the same no matter who is the end recipient of the data.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

Clarus is so big in scope, that getting the stakeholders involved for input in the business models has been successful. It is critical to get input from these stakeholders for timeframe requirements on data. The existing business models that have been identified by FHWA all satisfy the needs of winter maintenance operations. There is another guiding report that should be looked at carefully, 'Where the Weather Meets the Road', put out by the National Academy. This might give insight to areas that we may have missed. Automobile industry is very important to us and they are really marketing the telemetrics right now, so keeping them and others in sight as a customer base is important. If they were identified as a customer in that report, does the Clarus business model selected meet that need – would be a great test to the substance of our business model and how it meets the market.

5. What organization do you think would be best suited to operate Clarus and why?

You really have to take a look at the organization. Many have a good amount to contribute, but the determining factor would be who is going to be the champion of this system that will fight for the funding that is needed and the staffing that is needed to sustain Clarus, not just at the moment, but for the long run. There are several places that it could be housed, but we need to make sure that the agency that ends up with it will work hard to sustain it in years to come.

Michael Steinberg, Senior Vice President, AccuWeather

1. When you think of the Clarus "system", how would you describe it and what it does?

Theoretically, Clarus is both a repository and a quality control mechanism for weather information – these are its two most important functions.

2. What factors do you think are key to establishing and sustaining Clarus?

The most important question is where Clarus' home will be, who will operate it, and how it will be funded. There are also issues related to data and the proprietary nature of at least some of this data.

3. Are there any particular issues or concerns you have regarding Clarus?

There is a fundamental concern regarding maintenance and access. It will be important for FHWA to find someone to run Clarus operationally. It was suggested that it be run by NOAA. While this makes the most sense, there are questions on how this would interface with some of the other projects that NOAA is doing in terms of data, funding priorities and project priorities. There is also a concern with data availability. One would think that it would be essential that the data be freely available to anyone, government agencies, companies like AccuWeather that use the data to serve customers, or the end user public. If the data collection and storage is paid for by tax payer funds, it needs to be available to everyone. Data quality is also an issue of concern. Various levels of quality control would be required for data accuracy and data integrity before acceptance to ensure that data reads make sense and are not reporting great variations under stable conditions. Statistics can be developed in terms of the reliability of any individual site. Sites can be flagged or assigned a key based on their reliability and perceived accuracy, and this information should be made available along with the data that is being collected by that site. I feel pretty strongly that data should not be withheld if it's from a site that is not at the same level as other sites – rather that site should have some indicator that indicates the level of quality of the data, and users can then decide for themselves how much weight to give that data.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

The question of how will Clarus be funded is very relevant. If we assume that it has government funding, then whether the ultimate collector and distributor is a government agency or commercial company or university or consortium, the data has to be made available to everyone. If, on the other hand, a commercial company or a private university were to operate Clarus without government funding, then the data potentially is proprietary and would either need to be purchased or distributed under some type of arrangement. In terms of who collects and stores the data, the National Weather Service has effective mechanisms in place for doing this so they would be the logical choice, but clearly they would need additional funding for this. The determining factor is as much political as anything else. In terms of location – regional versus central, it would probably make more sense to have it in a central location/repository. Communication costs are relatively low, and would be lower if Clarus were in one location where people would go to one place to access the information. Centralizing the data would also make it easier to make the data available to end users, but you would need to be able to select criteria for the type of information that is desired… "a robust and flexible interface".

5. What organization do you think would be best suited to operate Clarus and why?

NOAA would be best suited to operate Clarus, since it is predominantly weather data that the Clarus system is dealing with and NOAA is the agency currently charged with weather information. If we are

including RWIS data, you could make a case that some other agency should operate it, potentially the state DOTs who currently have the RWIS information, and it wouldn't be a problem if NOAA didn't operate it. However, NOAA has an infrastructure in place and more experience in handling this type of data than anyone else; they would still have to get the funding to sustain Clarus.

Jack Stickel, Transportation Planner, Alaska DOT

1. When you think of the Clarus "system", how would you describe it and what it does?

Clarus bring three functionalities that it is bringing to stakeholders. The first is QC of other databases that support the surface transportation world, allowing the providers and users to be assured of quality in their data. The second is a system to provide weather data to traveler information services, forecast services, and the national weather service. The third would be to assist with technology development, particularly with field testing new ways of measuring or providing environmental weather support.

2. What factors do you think are key to establishing and sustaining Clarus?

Broad stakeholder input is one key factor. AKDOT represents the Aurora FHWA RWIS pooled fund, and have taken the opportunity to fund additional people to attend the Clarus ICC meeting this year out of one of their existing Aurora projects, and have put together and forwarded to FHWA a position white paper on what Aurora feels are the top ten issues that Clarus should address. Another key factor is for a sustained overall high level management involvement from NOAA, FHWA and other high level agencies as well. Will also need to see NOAA's and FHWA's involvement in this better defined; there was some question as to where MADIS was going, and while this has been somewhat clarified, it needs to be well documented. A final consideration is funding for the Clarus system.

3. Are there any particular issues or concerns you have regarding Clarus?

One concern is to secure good stakeholder participation for stake agencies and to have a good business model to fund their presence. It is even more critical to do that now because FHWA has tightened up on their allowable expenses in their work programs; don't think Clarus would be an allowable expense under anybody's work program. For state agencies, it is important to continue that type of financial carrot out there.

A balanced consideration of all weather impacts is also a concern so that Clarus data is valuable to all states. Aurora is developing a QC module that supplements the work that MADIS is already doing, as MADIS doesn't currently supply pavement temperature QC. Value added forecasting services are not as important to Alaska, but other elements of RWIS data are critical to them such as winter weather maintenance updates and weather data for the traveling public and commercial industry to use in making informed decisions on whether to make a trip or not as a result of weather.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

His participation in the breakout sessions at the ICC Meeting in Vegas covered two issues in terms of Clarus' business model. The first was what quality control MADIS would handle; the current level of QC is pretty basic, and is looking for a stronger business model in the QC arena and FHWA agreed with this point as well. The second was a question as to why Clarus was trying to duplicate, at a regional level, the databases and mesonets that already exist. It is important to make the decision on regional versus national.

It is also important to consider the value of integration with the Canadian RWIN. This doesn't necessarily mean bringing all of Canada's data into Clarus, but the data that affects Border States, since road weather doesn't stop at the border. For example, in southeast Alaska you often have to travel on US and Canadian land and marine vessels over several hours, travel that is affected by weather that RWIN has data on. The Clarus model contains marine data, but it doesn't have Canadian data, so if someone is trying to provide value added forecasting services or past forecasts, they are basically playing with incomplete data. The

Clarus model has to be adjusted to integrate Canadian data so that agencies like Alaska's can get it quicker, without dealing with the institutional proprietary issues that is characteristic of Canada's RWIN. If this isn't possible, the Clarus business model should address the issues that Border States face, and possibly identify the need for states like Alaska to have to deal specifically with Canada's data providers to access this data outside of Clarus.

5. What organization do you think would be best suited to operate Clarus and why?

Certainly MADIS is moving into NOAA taking it over NCAR; NOAA is best suited to operate Clarus. Even if it turns out to be a system that is turned over to the consultant community for them to operate, as the MDSS model where the labs and FHWA have taken it to a level where contractors can pick it up and pursue, there would still be a need for strong NOAA and FHWA involvement in fine tuning the business model as we go forward, learn from the regional deployment, learn from the national quality control database and consider factors like whether we move into QC of pavement temperature or not.

Kathy Strebe, Director of Weather Data and Strategy, The Weather Channel

1. When you think of the Clarus "system," how would you describe it and what it does?

A national and easily accessible ingest and quality control system for dissemination of surface data.

2. What factors do you think are key to establishing and sustaining Clarus?

Adequate funding, clear ownership and management with understood boundaries. Strong community support with a lot of private sector involvement.

3. Are there any particular issues or concerns you have regarding Clarus?

Concerned with the timeliness and reliability of the data and of the system itself. Would consider 5 minutes or less to be an acceptable latency for a consumer application. May need something with a much higher resolution for commercial products. What will be the boundaries between Clarus and NOAA? Availability of data. How much data will be open to all and how much will be protected and open to only a few?

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

One model to propose would be the Weather Industry Enterprise Model, comprised of a public sector, a private (commercial) sector, and a research/educational sector. The public sector, supported by public funds, would create the rich database and create some "direct to the consumer" products and services consistent with the public mission. The private (commercial) sector could acquire the data and drive some markets from it. The research/educational sector would spur innovation, improvements and archival needs. As this industry grows and develops, state and federal taxes would be fed back into the system to continue to enhance, grow and refine the system.

Propose a cross-sector board for management. When the National Science Foundation was established a few decades ago it was started with a National Science Board as the managing body. The board was made up of approximately 20 seats; each designated to be from certain areas and sectors of industry and academia. May be able to set up something similar for road weather information. The operational organization takes specific direction from the board and the overall management and strategic planning functions are carried out by the board.

5. What organization do you think would be best suited to operate Clarus and why?

It's important to have Clarus avoid evolving totally into a public sector entity without having a strong industry support component. The opportunity involves a specific interdependent partnership that creates the greatest value for the nation and does so by leveraging the skills and competencies that exist within each sector. Perhaps have a contracted private sector company be the operator?

6. Do you think there's anything else we should know?

With recent hurricanes as evidence that sensors do fail, usually precisely when you need them the most, it might be worthwhile to ensure that we are building and deploying stations to take this into account. Robust and hardened systems utilizing redundant communications, power and hardware should be deployed where appropriate.

Ron Sznaider,Vice President, Business Development, DTN-Meteorlogix

1. What you think of the Clarus "system," how would you describe it and what it does?

A federally sanctioned national surface weather collection, data archive, and information portal. A goal would be to seamlessly combine weather information from disparate sources into a common data warehouse. Data quality assurance (QA) will be important to provide confidence in the data. Common weather formats encourage interoperability with government agencies and the private sector. Clarus would eventually become operational and be the single source of weather data to federal and state government, educational institutions, and the private sector. A goal would be to allow more access to the weather information, foster value-added product development, and ultimately better serve the public.

2. What factors do you think are key factors to establishing and sustaining Clarus?

   - A viable business model that provides sustainable funding for the collection, quality assurance, and redistribution of the data sets. It is my understanding that FHWA is hoping to seek private sector involvement, yet retain data ownership.
   - A well defined and highly extensible system that provides a "plug-n-play" architecture to easily add new and expanded data sets from different sources. This may require definition of "standard" Clarus data formats and protocols.
   - Acceptance that Clarus will meet or exceed current and anticipated requirements (i.e. VII, next generation 511, mobile devices, etc.)

3. Are there any particular issues or concerns you have regarding Clarus?

Clarus will be more viable in an operational environment if the data collection and quality assurance is performed very quickly. Delayed weather data is of marginal value in operational situations. Clarus should adopt a QA process similar to the Forecast Systems Laboratory MADIS system. MADIS collects and combines data from public and private weather networks. The MADIS QA adds value. MADIS QA however introduces latency. Clarus with near-real-time QA provides value. Excessive latency however will relegate Clarus to be nothing more than a large historical data archive, of little value in real-time applications (including 511 systems).

It is not clear what type of weather data sets Clarus will collect or manage, nor the targeted applications. Although NCAR and other academic institutions offer much value, a design that also considers the operational requirements of commercial weather decision support systems would be preferable.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

This is a tough one. In fact it may be the biggest single issue that ultimately makes or breaks this project. We in private sector want to get paid for what we do. The public sector is willing to pay for it once, but then wants the flexibility to do what they want with it. What I would like to see is an architected solution that can support all of the users: public, government and private. The NWS Family of Services model seems to work reasonably well where the cost of data access is for recovery of cost of the access and communications. Most people seem to believe Clarus to be an "open source" type of initiative which would be no-cost or low cost to the end users.

Might be a good idea to design and promote Clarus as the new national weather data clearinghouse, with different levels of access. High redundancy, low latency, and well documented interfaces would be helpful.

5. What organization do you think would be best suited to operate Clarus and why?

The logical answer would be NOAA-National Weather Service, but their mission is to "protect life and property". Additional participation from other federal agencies, such as NOAA/FAA/DOD/DOT/DHS, would seem logical.

If it were a private company, I would suggest Vaisala, the company that deployed, maintains, and resells a complete national lightning data set. The system is called the National Lightning Detection Network (NLDN) and the data is resold to both the public and private sectors. It is possible that Vaisala, the world's largest instrument manufacturer, may be interested in funding (and maintaining data ownership) of at least a part of the Clarus system. The private group owning the sensors would then have the right to resell the real time data feed to mission critical or high value customers. The delayed or lower resolution data would be made available to the open market and would be integrated with the broader set of government-owned sensors.

A "core" set of Clarus data could be defined and made available at no or very low cost. One way that has been implemented before would be to introduce latency into some parts of a system.

A hybrid of Government and Private group participation and access may be the key to success. The NWS/FAA/DOD model for Nexrad seemed to work well. Another model would be similar to that for the 511 system with a working group that is overseen by AASHTO, but allows direct input, leadership, and hands on from all that are involved.

In a real-time operational mission-critical decision support system, what we're looking for is as close to real time, high quality and highly reliable datasets as possible. Meanwhile there's another group of users, typically in the research world, where historical archives are the main driver. Ideally, the Clarus design would take these two into account and serve both needs.

Jon Tarleton, Marketing Development Manager/Meteorologist, SSI, Inc.

1. When you think of the Clarus "system", how would you describe it and what it does?

Clarus is a national initiative to get a database of weather ESS type data together and organized in one central location, including some form of QC process, with the data made available to anyone interested in weather data, much like the NOAA family of services.

2. What factors do you think are key to establishing and sustaining Clarus?

From a meteorologist's perspective, the quality of the data is important. There are many weather stations out there, but are they sited properly to meteorological standards? The timeliness of the collection of the data would have to be acceptable for operational use. Once an hour would be a minimum, better than that would depend on the system, but certainly something that we would want to use in an operational timeframe. Downtime would also be a concern, how these systems will remain up and operational. Individual sites that are not working continuously would provide very little input into Clarus, and the system could become less useful to users if data isn't provided continuously.

3. Are there any particular issues or concerns you have regarding Clarus?

The only concern would be that the data from Clarus be made accessible to everyone, so that there aren't limitations placed on the data availability by any entity.

4. Do you have any ideas related to specific business models that you would suggest for Clarus? Any business models that you would suggest against?

One thing to factor in any business model would be to identify who is responsible for the system's uptime. Does it fall on the data provider or the agency operating the Clarus system? Who is responsible for paying to keep this data up and running? It is also important to keep the data that is made available from Clarus to remain as raw data; any processing would be handled by the private sector. This will help with latency of the data. An acceptable timeframe for data availability would be 5 minutes.

5. What organization do you think would be best suited to operate Clarus and why?

As a first thought, a third party would probably be best suited to operate and maintain the Clarus system, as opposed to NOAA or FHWA or some other stakeholder entity. The universities also handle weather data and were the leaders in getting the weather data to the internet for user access. It would be an opportunity for the universities to step up to the task and would be an acceptable candidate for the Clarus operation.