Clarus

Identification and Discussion of User Needs

Submitted to:

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1 Purpose

This document presents a high-level discussion of the user needs for the Clarus system (the Nationwide Surface Transportation Weather Observing and Forecasting System). It is meant to be a reference and foundation for the Consultant Team, Project Administrators, and Initiative Coordinating Committee (ICC). It is a document with limited shelf life and applicability as the Clarus Concept of Operations (ConOps) takes shape. This Clarus User Needs document is the result of critical thought and much discussion at the early stages of the Clarus initiative to ensure that the Clarus ConOps development meets with the vision and needs of the Project Administrators and the ICC. The next step in the Clarus initiative will be development of a ConOps which will focus on how various users of the system will interact with Clarus for their specific application.

2 Overarching Goal and Background of Clarus

The goal of the Clarus initiative is to provide broader weather support for surface transportation system operators in their efforts to improve safety, reliability and security of transportation users. This will be accomplished through the design, demonstration and deployment of a national surface transportation weather data collection and management system. Observations from Clarus will not only serve the needs of the transportation system operators, but also the communities of surface transportation weather information providers and consumers. Clarus is a federal vision to leverage local and regional road and rail weather observing networks to serve a greater community and enhance 21st century transportation operations. To accomplish this it is proposed to include within Clarus:

- A one-stop Internet portal for all surface transportation weather related observations
- Continuous quality control with feedback to State DOT engineers and other users
- Data transferred in one common protocol with full metadata
- Management of user's rights to input or extract specific data components
- Data provided without post-processing, ready to be incorporated into value-added products including weather and traffic models as well as decision support systems
- A set of data retrieval tools
- Support for the inclusion of new technologies such as vehicle-based sensing technologies, surface visibility information from traffic cameras, and remote sensing technologies[1].

Clarus as used in the balance of this document refers to the surface transportation weather data collection and management system, which is part of the greater Clarus initiative. Substantial background effort has preceded Clarus and is pertinent towards the development of this Clarus User Needs document which will form the basis for the Clarus ConOps document. The Office of the Federal Coordinator for Meteorology (OFCM) "Weather Information for Surface

[1] *Clarus – The Nationwide Surface Transportation Weather Observing and Forecast System*. Pisano, Pol, Stern, and Goodwin. Submitted to TRB 2005, pp12.

Transportation: National Needs Assessment Report"[2], commonly referred to as the WIST Report, identifies six surface transportation sectors: Roadway, Long-haul Railway, Marine Transportation System, Rural and Urban Transit, Pipeline Systems, and Airport Ground Operations. Stakeholders are defined as those agencies and end users (i.e. data providers and data customers) that have needs with regard to their own data and other users' data, as well as value-added products generated from this data. Stakeholders include federal, state, local, academic, and private entities. The scope of Clarus is such that this document focuses only on the Roadway, Long-haul Railway, and Rural and Urban Transit sectors.

The scope of Clarus may be a new concept for system owners, maintainers, vendors, and primary users of the road weather observing networks. The successful deployment of Clarus will require extensive coordination from this group of data providers and users. Future practices and procedures will be affected by the operation of Clarus including how the data enters Clarus as well as how the data is quality controlled, managed and retrieved. Adoption of Clarus operations by these groups will be essential to the success of the Clarus initiative.

Recent reports indicate basic observations coupled with forecasted weather information could provide greater preparation for weather impacts on planning activities and on the operational decisions of travelers, commercial drivers, traffic operators, maintenance workers, and emergency or disaster planners[3]. Other work currently underway presents a foundational look at the integration of weather information in traffic operations across the U.S. and provides insight into the broad scope of weather information use outside of the historical winter maintenance domain[4].

3 User Needs Identification

The identification of stakeholders is the first step in reaching consensus on user needs categories. Direct and indirect use of the Clarus system can be applied to a wide audience. Because a wide array of users can derive benefit from the Clarus system, it is necessary to focus upon those users that have the most immediate contact with the system components. ***Thus, the principal user whose needs are addressed by this Clarus User Needs Assessment are users who directly interact with the Clarus data system.*** These stakeholders include the owners and operators of the observing systems sending information to Clarus as well as the users directly accessing the data contained within the Clarus data system. An initial list of stakeholders whose user needs are considered includes the following:

- Observation system owners such as state DOTs, municipalities, transit authorities, rail carriers and universities
- Instrument and observation platform vendors
- Direct data users such as system owners and their contractors
- Surface transportation weather service providers
- General weather service providers

[2] *Weather Information for Surface Transportation: National Needs Assessment Report*, Office of the Federal Coordinator for Meteorology, FCM-R18-2002, pp 298.
[3] *Weather Information in the National ITS Architecture Version 5.0*, Meridian Environmental Technology, Inc., August 2004, pp. 58.
[4] *Draft Report: Joint TMC/TOC System Integration Study for Emergency Transportation Operations and Weather: Baseline Conditions*, Battelle, 2004, (in review).

- Research community
- Climate data warehouse and other non-surface weather interests

This list of direct users of data from the Clarus system is a subset of the entire population of stakeholders interested in the Clarus initiative. The requirements of the broader stakeholder community are essential to the Clarus initiative and these interests must serve as a framework for the core Clarus Data System. From information in the Surface Transportation Weather Decision Support Requirements (STWDSR), WIST, and 511 Deployment Coalition literature, it is possible to separate stakeholder groups into a condensed list based upon the user's interface or interaction with Clarus data. The users are viewed as defining layers in the process of transferring raw field observations to various levels of data use. The inherent layers in this transfer process include:

- the Autonomous Layer,
- the Service Providers Layer, and
- the Service Provider Customer Layer.

The Autonomous Layer is comprised of operational entities who utilize weather and transportation data to make plans, decisions and/or take action based upon sensor data within their control. These data include observations collected by Environmental Sensor Stations (ESS), mobile data acquisition platforms, cameras, and other transportation related measurement devices. The Autonomous Layer data comprises the vast majority of the raw input data to Clarus.

The Service Providers Layer is composed of both public and private entities that provide basic and valued added weather support services to support the weather needs of the broader surface transportation community. These support services rely on Clarus data (raw and processed) combined with other environmental or traffic information products to develop or provide road weather information and enhanced products. The Service Providers Layer is the principal user interacting with Clarus.

The Service Provider Customer Layer includes those groups who are direct consumers of products generated by Service Providers and are generally not a direct user of Clarus data. The members of this Layer can be from any user community, but are largely found within the surface transportation community. The support received comes from basic and/or valued added weather support utilizing a combination of Clarus and non-Clarus data. In some instances the Service Provider Customer Layer includes entities and agencies also found within the Autonomous Layer who receive quality control information of the data they originally provided to Clarus.

The Clarus Layer lies between the Autonomous and Service Providers Layers and represents the nationwide system and architecture to accomplish the previously outlined goals of surface transportation weather data collection and management. This is illustrated in Figure 1.

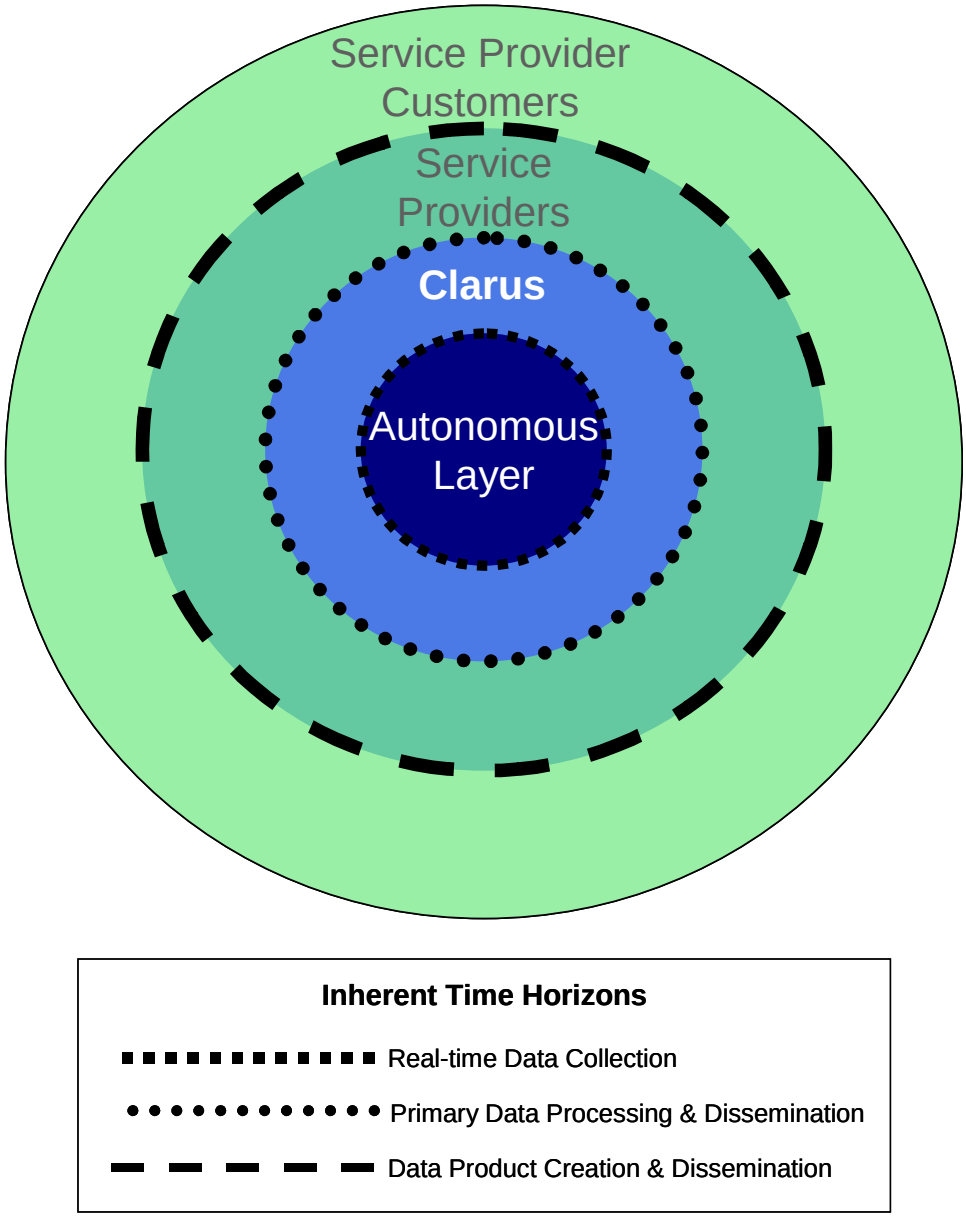

Figure 1. A conceptual diagram of the Clarus System and the data time horizons that separate the stakeholder groups.

Figure 1 contains an inherent time scale emanating from the center of the diagram outward representing the flow and processing of data through the Clarus system and between the layers. These not only represent the temporal limits of data collection, quality control, processing, and redistribution but also the period for which the Service Provider Customers have requirements. The design of Clarus will need to consider both these time horizons when considering the technical limitations of the system architecture. These data time horizons are illustrated in Figure 2. The average elapsed time for the Autonomous Layer varies as a result of configuration and communications latencies that are inherent within the operation of the system to collect the data. The Clarus Layer includes the time required to communicate data from the Autonomous Layer to the Clarus ingest process as well as the time required to process the input data into a database structure. Further, the variation in the Service Provider Layer includes the time required to add other data to the Clarus data and to perform the required human and/or machine based product

generation. The average data age grows as a result of the aggregated times required to move through the various layers and eventually to the Service Provider Customers. The Clarus system design must address how best to minimize these times to optimize the flow of data in a timely manner.

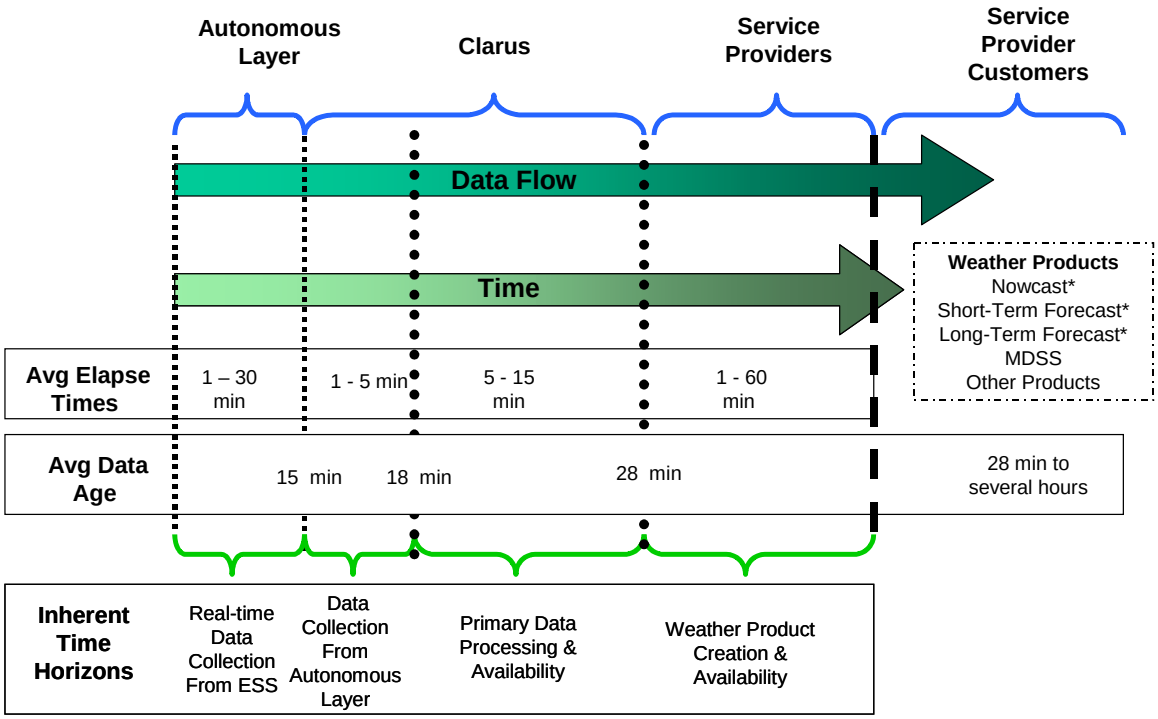

Figure 2. Inherent versus user needs time horizons along the temporal axis of data flow.

Definitions:

- Inherent Time is the estimated time for the process within that level to take place. It implies that observed records may have an age that represents the extremes of the time range.
- Average Data Age is the estimated average age of an observed value in each data component
- Desired time is the required time frame of the data or products within each layer to meet operational needs

Clarus provides the fundamental process of transporting data from members of the autonomous layer to a point where the Service Providers gain access to the data. However, Service Providers become an instrumental component in the total flow of the data within the Clarus construct because a large audience exists for the transportation weather data. These users want the raw form of the data transformed into more usable compositions. Service Providers perform this function by using the Clarus data in conjunction with data from other sources to create products that extend from reformulations of observations to forecasts out to several days. The STWDSR and the 511 Deployment Coalition Deployment Assistance Report #6 documents relate a time horizon definition to the fundamental type of transportation weather resource (see Table 1). The documents delineate the Service Providers that provide output or services within each category

or cell. The Service Providers defined in these two documents include the National Weather Service (NWS), National Oceanographic and Atmospheric Administration (NOAA), and surface transportation weather service providers (STWSP). The time horizon extends from real time on the left, near-term in the middle, and long term to the right corresponding to the microscale, mesoscale and synoptic spatial and temporal scales.

	Information Time Horizon		
	Real time	Near term	Middle to long term
Events	Current conditions / Observations	Short-Term Weather Forecast (Nowcast)	Weather Forecast
Atmospheric weather (e.g. precipitation, general winds, etc.)	Observations from ESS, NWS, etc.	Nowcasts from Service Provider	Medium to longer term forecasts from Service Provider
Road weather (e.g. pavement temperature, winds at a bridge, fog at the road surface, etc.)	Observations from ESS, CCTVs, etc.	Nowcasts from Service Provider	Forecasts from Service Provider
Specific conditions (e.g. pavement or rail temperatures, icy, treated with salt, plowed, water depths, etc.)	Manual or automated observations (e.g. reported by field personnel or readings from sensors)	Reports from automated sources (e.g.. MDSS)	Predictions from decision support sources (e.g. MDSS) or contracted from Service Provider

Table 1. Relationship between the time of various weather data collection and forecast efforts and the information they provide to weather and road condition phenomena (modified from 511 Deployment Coalition, 2003).

The 511 Deployment Coalition and the WIST reports provide a basis in identifying the needs of Service Providers for the generation of these weather elements. These Service Providers will require real-time access to ESS data in order to satisfy the extensive demands by the surface transportation user community. However, because of the variable sources of transportation weather data, simple raw data must also contain substantial metadata information to permit Service Providers to selectively integrate data from the Clarus data stream.

The transportation weather product suites defined within each of the cells in Figure 1 are quite extensive and focus on a diverse set of parameters incorporated in the Clarus data stream. Table 2 identifies a basic list of data elements that constitute the user needs to be supported by Clarus. These data embody the range of ESS observations presently supported through the NTCIP ESS 1204 standard[5] for data collection. As such they represent the data collected through ESS for roadway, rail and transit activities. They also serve as the foundation data types, including metadata, that will flow into Clarus. Not shown here are conceptual new data elements that will continue to evolve as technologies progress for the collection of road, rail and transit information and as the users' needs become more sophisticated. An important user need of the Service

[5] *NTCIP 1204:*1998 *NTCIP Object Definitions for Environmental Sensor Stations*, published by the National Electrical Manufacturers' Association, the American Association of State Highway and Transportation Officials, and the Institute of Transportation Engineers; 1998.

Providers is that the ESS data provided in support of forecast weather element development is quality assured. This may take the form of data quality flags incorporated during the quality control process to be designed into Clarus.

Feature	Data or Metadata Type
Fixed ESS Metadata	Station Category
	Type of Station
	Location of ESS
	Location of sensors
	Sensor Configuration
	Pavement treatment information
	Time of Observations
Mobile ESS Metadata	Location of ESS
	Sensor Configuration
	Speed of Platform
	Direction of Platform
	Pavement treatment information
	Time of Observations
Atmospheric Sensor Data	Sensor Metadata
	Air Temperature
	Atmospheric Pressure
	Humidity
	Long and Short Wave Radiation
	Precipitation Occurrence, Type, Rate, Amount
	Visibility
	Water Depth, Road & Stream
	Wind Speed, Direction, & Gust
Pavement Sensor Data	Sensor Metadata
	Pavement Condition
	Pavement Temperature
	Pavement Chemical Solution Freeze Point
	Pavement Ice Thickness
	Snow Depth (off roadway)
Subsurface Sensor Data	Sensor Metadata
	Subsurface Temperature
	Subsurface Moisture
Air Quality	Sensor Metadata
	Air Quality Condition
Bio-Hazards	Bio-Hazards
Camera Imagery	Camera Imagery

Table 2. ESS data elements sumarized from NTCIP-ESS 1204 standards document.

The context diagram in Figure 3 illustrates the relationship of the entities interfacing with Clarus. Such a diagram also describes the flow of data between the entitites and the Clarus system. The data provider organizations (State Departments of Transportation, local traffic management organizations, and rail/transit systems) maintain data collection systems. These organizations define the Autonomous Layer and contribute the raw data to Clarus. These stakeholders can also benefit from Clarus by receiving quality-controlled data returned from Clarus. This quality-controlled data is not value-added data, but data with flags indicating that data elements do not meet quality assurance thresholds.

The private and public sector Service Providers are the principal Clarus users. These Service Providers generate value added services of road and rail weather information to the transportation community. Additional Service Providers having direct access to Clarus data resources include research organizations, archival agencies, and other related weather service providers.

The Clarus users shown in Figure 3 are summarized in the following descriptions:

- **State and Local Agencies**

  These are the transportation system and road weather information system operators and owners who directly provide the Clarus data. This group places considerable emphasis on the pavement specific component of the data at the observational level to make immediate decisions. These are also the individuals who are the principle consumers of information provided by surface transportation weather service providers. Personnel include those within maintenance, transit and traffic operations. Additional data from this group includes CCTV imagery and treatment activities such as plowing and chemical application.

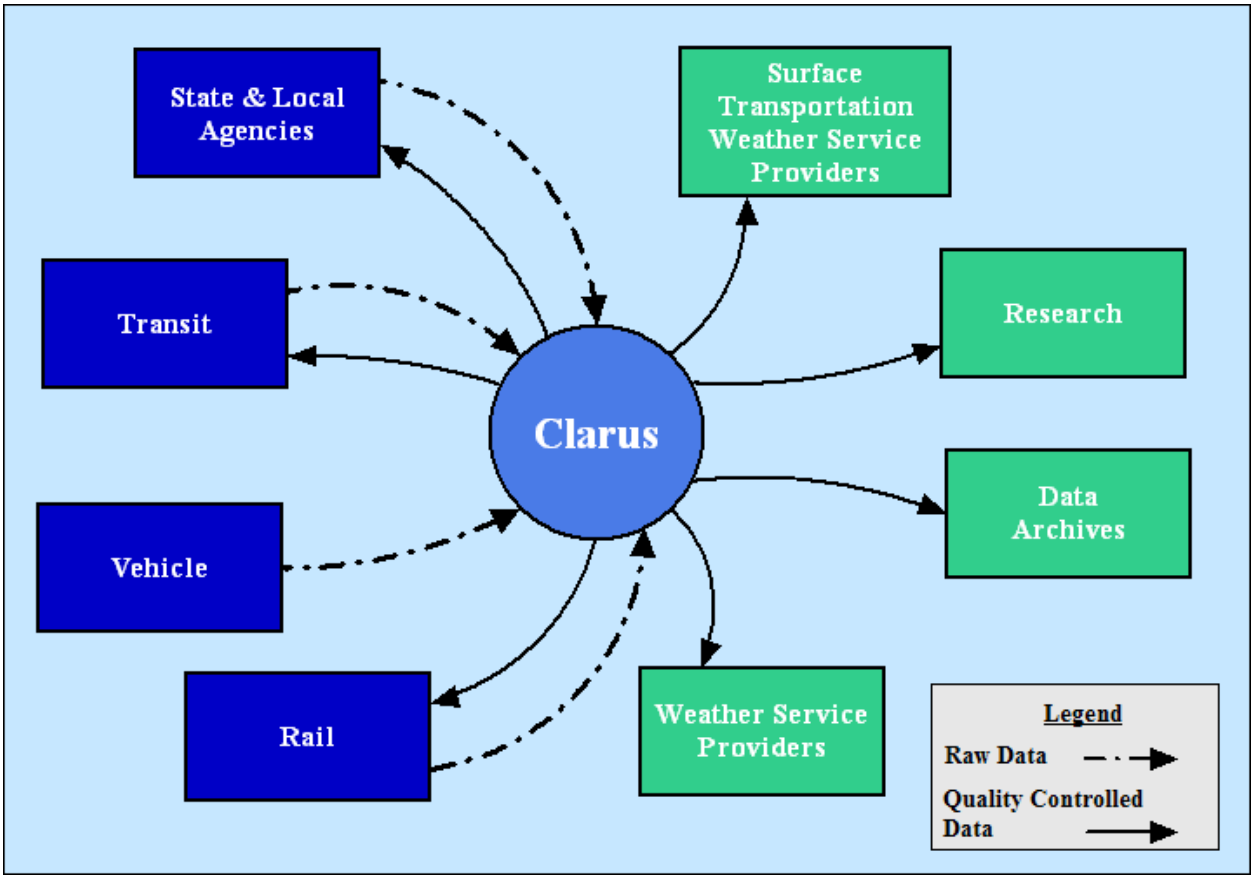

Figure 3. Context diagram of Clarus User Needs

- **Transit**

  These are the owners and operators of transit systems who contribute data to Clarus. This group places considerable emphasis on understanding road weather conditions along designated routes.

- **Rail**

  These are the owners and operators of rail systems who contribute data to Clarus. This group places considerable emphasis on understanding weather conditions along designated routes including such specifics as rail temperatures.

- **Vehicle**

  Emerging technologies are developing that will encourage a greater level of data collection from vehicles for the purpose of understanding the nature of the transportation system state including the impacts of weather. As this method of data collection matures, the information obtained on weather and pavement conditions from instrumentation on-board vehicles will be important Clarus data.

- **Surface Transportation Weather Service Providers**

  These surface transportation weather service providers are the private and public weather service providers who assimilate the Clarus data with other available data to generate products and services used by the surface transportation decision-makers at state and local transportation agencies.

- **Weather Service Providers**

  These include the weather support services that are primarily interested in the meteorological component of the Clarus data. This group includes the efforts in public forecasting by NOAA and the NWS along with private sector weather services and their value added support to markets such as agriculture, power utilities, and construction.

- **Archival and Research**

  This category incorporates federal, academic and private sector researchers who are working to improve the state of knowledge and practice through the research of surface transportation weather. Additionally, this category includes operations and non-operations interests who choose to include the Clarus data in their endeavors. The archival of Clarus data will be most effective when combined with other meteorological data archives, but not restricted to such efforts.

An evaluation of the linkages between stakeholders and road weather data sources within the National Intelligent Transportation System (ITS) Architecture has been completed for the Intelligent Transportation Society of America (ITS America)[6]. The findings of the ITS America Weather Services study are important in identifying user needs as the National ITS Architecture was derived based on architecture user needs that are linked to a set of ITS user services. However, at present there is no "weather" user service within the architecture, but rather weather information serves the decisions included in various ITS user services. The study investigated three key components of weather information applications within the National ITS Architecture:

[6] *Weather Information in the National ITS Architecture*, Meridian Environmental Technology, Inc., August 2004, pp. 58.

- Identification of Market Packages and ITS User Services within the National ITS Architecture that currently utilize any form of weather information,
- That spatial and temporal characteristics exist within surface transportation weather information; and,
- The application of the different combinations of spatial and temporal scales of weather information within a decision-making environment can enhance safety, mobility, productivity.

Specifically, Market Packages address service-oriented issues and are designed to operate individually or with other Market Packages. Taken overall, the architecture is a guide to assist jurisdictions in the development of plans, deployments and operations of new technology, while providing a standard design to support technology implementation within and across jurisdictional boundaries. The ITS America study identified a clear requirement for weather and surface transportation weather information within the framework of the National ITS Architecture with a recommendation that a designated ITS User Package be considered for Surface Transportation Weather.

4 Additional User Needs

Accessing pertinent data from Clarus represents the single largest user need. However, data alone does not define the complete list of user needs. The user needs of any data system extend beyond the data to include satisfactory method(s) of data access, support for customer service and resolution of any problems associated with the data and its accessibility. Figure 4 shows these different user needs and the affiliated Clarus subsystems that must be included to satisfy these needs.

As important as recognizing the user needs for information, it is essential for Clarus to meet the decision specific deployment requirements and constraints of the regional road weather observation network. It is this topic where successful deployment of Clarus will result from buy-in from the funding and deployment group of data providers and users. To accomplish this, an understanding of the high-level data formats, communications capabilities, and technical/functional concerns of each of the stakeholder groups will need to be catalogued and addressed.

5 Next Steps

Next steps in the Clarus initiative include the development of a ConOps document based on the findings of this User Needs document. Clarus ConOps will focus on how various users of the system will interact with Clarus for their specific application.

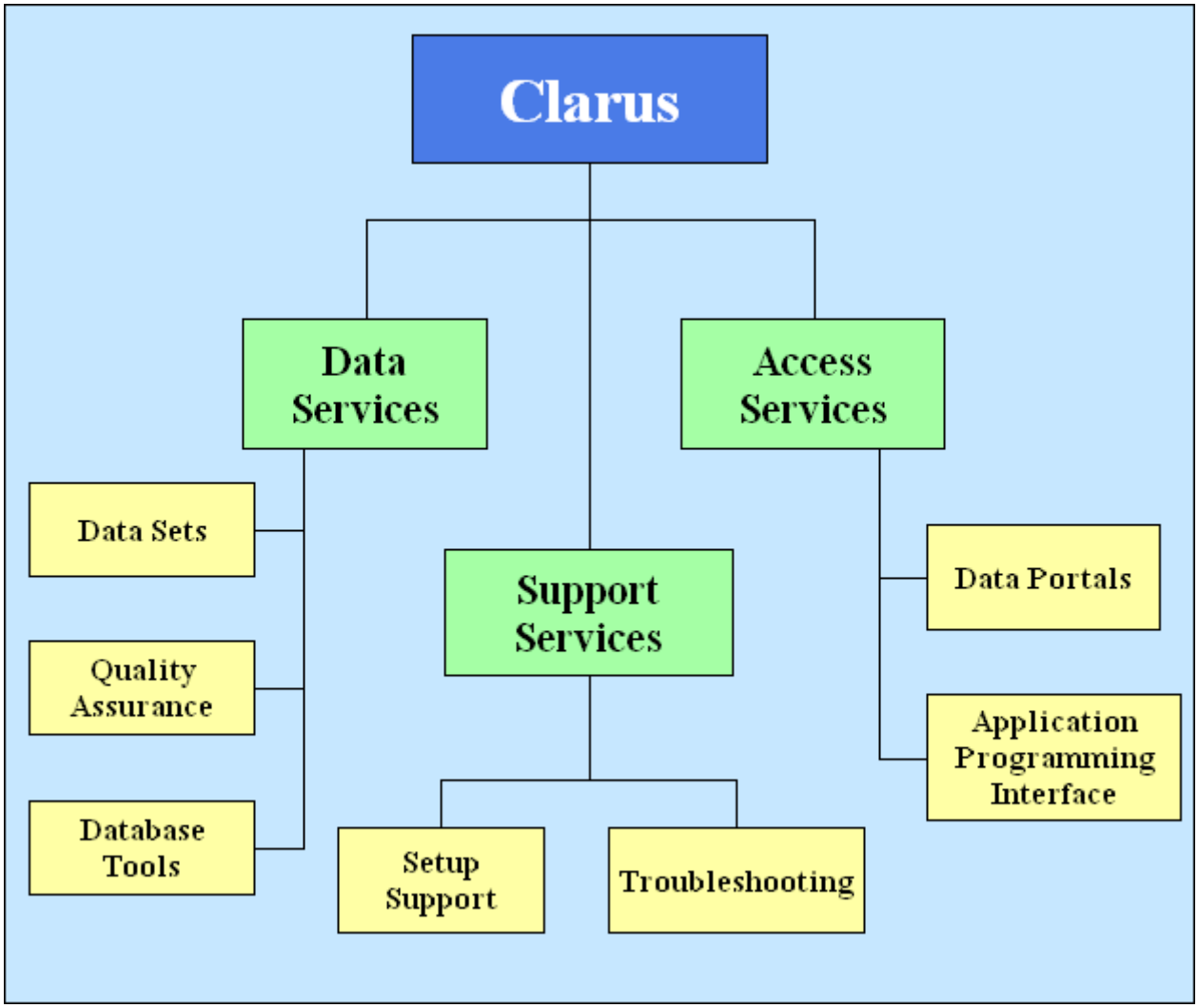

Figure 4. Organization of Clarus User Needs Categories and sub-categories