



Clarus Weather System Design

HIGH LEVEL

SYSTEM REQUIREMENTS

SPECIFICATION

DRAFT

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1 INTRODUCTION

1.1 Purpose

The purpose of this requirements specification is to provide a repository for the high level requirements governing the design of the Clarus system. These requirements capture the expression of general needs in the Clarus Concept of Operations and in meetings with potential users and participants. These requirements will be further refined and expanded as the project progresses and will form the basis for the design verification and validation of the system. The intended audience for this document includes decision makers, stakeholders, designers, and testers.

This document may be updated periodically to reflect changes in the system requirements, including changes reflected in subsequent versions of the system.

1.2 Scope

Clarus is an initiative sponsored by the Federal Highway Administration (FHWA) to expand surface weather observation capabilities in support of three primary motivations.

- 1) Surface transportation-based weather observations will enhance and extend the existing weather data sources that support general purpose weather forecasting for the protection of life and property.
- 2) National collection of real-time surface transportation-based weather observations will support real-time responses to observed weather.
- 3) Surface transportation-based weather observations integrated with existing observation data will permit broader support for models predicting impacts of weather on surface transportation safety and mobility.

The intent of the Clarus Initiative is to demonstrate how an open and integrated approach to observational data management can be used to collect, control the quality of, and consolidate surface transportation weather and pavement condition data to augment existing observations. The Clarus Initiative will address the necessary infrastructure to consolidate the data from a multitude of independent data collection systems. This process offers the prospect of enhancing data coverage, improving the performance of meteorological support services, and providing guidance to owners of these data sources regarding the quality of their data and performance of their data collection systems.

Clarus represents the next step in the union of weather data from disparate measurement sources and the first step in merging surface transportation weather data. Surface transportation weather data collected by the Clarus system will include atmospheric data, pavement data, and hydrologic (water level) data.

The Clarus Initiative consists of two development components.

- The first component is the development of the Clarus system – a network for sharing and exchanging surface weather data and relevant surface transportation conditions.
- The second component is the development of tools, models, and decision support items that make effective use of the Clarus system.

The addition of Clarus system data to national weather observations will further enhance general purpose weather forecasting, providing a wider range of benefits to the protection of life and property.

The Clarus system will have a wide variety of direct and indirect uses. Users having the most immediate 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 contained within the Clarus system. The following is an initial list — which will likely grow as the initiative progresses — of these stakeholders:

- Observation system owners including State DOTs, municipalities, transit authorities, rail carriers, and universities;
- Instrument and observation platform suppliers;
- Direct data users including system owners and their contractors;
- Surface transportation weather service providers;
- The National Oceanic and Atmospheric Administration;
- General weather service providers;
- Research community; and
- Climate data warehouse and other non-surface weather interests.

The deployed Clarus system is envisioned to include:

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

1.3 Definitions, Acronyms, and Abbreviations

This document may contain terms, acronyms and abbreviations that are unfamiliar to the reader. A dictionary of these terms, acronyms and abbreviations can be found in Appendix A.

1.4 References

The following documents contain additional information pertaining to this project or have been referenced within this document:

1. *Clarus – The Nationwide Surface Transportation Weather Observing and Forecast System*; Pisano, Pol, Stern, and Goodwin; TRB 2005.
2. *National ITS Architecture, Version 5.0*; FHWA, U.S. DOT; October 2003.
3. *Weather Information in the National ITS Architecture Version 5.0*; Meridian Environmental Technology, Inc.; August 2004.
4. *Clarus Initiative Coordinating Committee (ICC) Management Plan (Revision 1)*; James Pol, U.S. DOT; September 2004.
5. *Surface Transportation Decision Support Requirements, Version 1.0*; Mitretek Systems, Inc.; January 2000.
6. *Weather Information for Surface Transportation: National Needs Assessment Report*; Office of the Federal Coordinator for Meteorology; FCM-R18-2002; December 2002.
7. *Weather and Environmental Content on 511 Services*; ITS America; June 2003.
8. *NTCIP 1204:1998 NTCIP Object Definitions for Environmental Sensor Stations*; National Electrical Manufacturers' Association, American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; 1998.
9. *Where the Weather Meets the Road: A Research Agenda for Improving Road Weather*; The National Academies; BASC-U-02-06-A; 2004.
10. *Road Weather Information Systems (RWIS) Data Integration Guidelines*; Castle Rock Consultants; October 2002.
11. *Draft Report: Joint TMC/TOC System Integration Study for Emergency Transportation Operations and Weather: Baseline Conditions*; Battelle; 2004 (in review).
12. *Clarus Final Draft Concept of Operations*; Iteris and Meridian Environmental Technology, Inc.; May 16, 2005.
13. *IEEE Recommended Practice for Software Requirements Specifications*; Software Engineering Standards Committee of the IEEE Computer Society; IEEE Std 830-1998, 25 June 1998.

Some portions of the Clarus *Concept of Operations* have been incorporated in this document, both for continuity of concept, and to help identify the basis for the

high level requirements. Specific attributions of this content are only included where they enhance the context of the requirements.

1.5 Overview

The organization and content of this document is generally based on the IEEE standards for System Requirements Specifications. The requirements presented in this document represent the high level objectives, constraints, and desires for the Clarus system.

Each requirement is identified by a unique Clarus-specific identifier to allow the requirement to be referenced in future documents, providing traceability throughout the development process.

A requirements document states what must be accomplished to fulfill the vision described in a concept of operations. It does not state how it is to be accomplished. This document describes each requirement and the basis for inclusion of that requirement.

The remaining sections of the document contain the requirements for the system. The sections and their content are as follows:

Section 2 – General Description provides a general overview of the entire system. This section describes the general factors that affect the system and its requirements.

Section 3 – Specific Requirements contains the requirements developed from reference documentation and stakeholder communications. This section organizes the requirements into categories that facilitate the system development process. The categories in this document are: Functional Requirements, Performance Requirements, and Organizational Requirements.

2 GENERAL DESCRIPTION

This section provides an overview of the entire system and describes the general factors that affect the system and its requirements. This section does not state specific requirements, but instead is intended to make the requirements easier to understand by giving them context.

2.1 *System Perspective*

The Clarus Initiative is essentially a plan to create a “network of networks” much like the Internet. While the Internet is an interconnection of computer networks, Clarus will be an interconnection of weather data collection networks. Each of the weather networks will function autonomously; they will collect information and disseminate it internally without direction or dependence on the Clarus network.

Each participating weather network’s connection to Clarus will add two new possible modes of functionality. First, the participant will be able to share collected weather data with the Clarus network. This mode of operation is sometimes referred to as the “Autonomous Layer”. Second, participants will be able to receive weather information collected by the Clarus network. The primary recipients of this data will be Weather Service Providers, but any Clarus participants would be able to receive data if they so chose. This concept of autonomous data sharing is comparable to the World Wide Web layer of the Internet, where organizations can publish information on web pages, or browse and download information published by other organizations on the web.

The Clarus Initiative will add a third mode of functionality, which might be called “meta-librarian.” Like the Yahoo or Google web sites, the Clarus system will collect, organize, and qualify the weather data published on the Clarus network. The participant data will be collected from the participants, organized by location and type of data, and quality tags will be added. When this is done, the data will be re-published to the Service Providers and other participant/consumers on the Clarus network. Figure 1 shows the general process as data progresses from collection through publication to service providers.

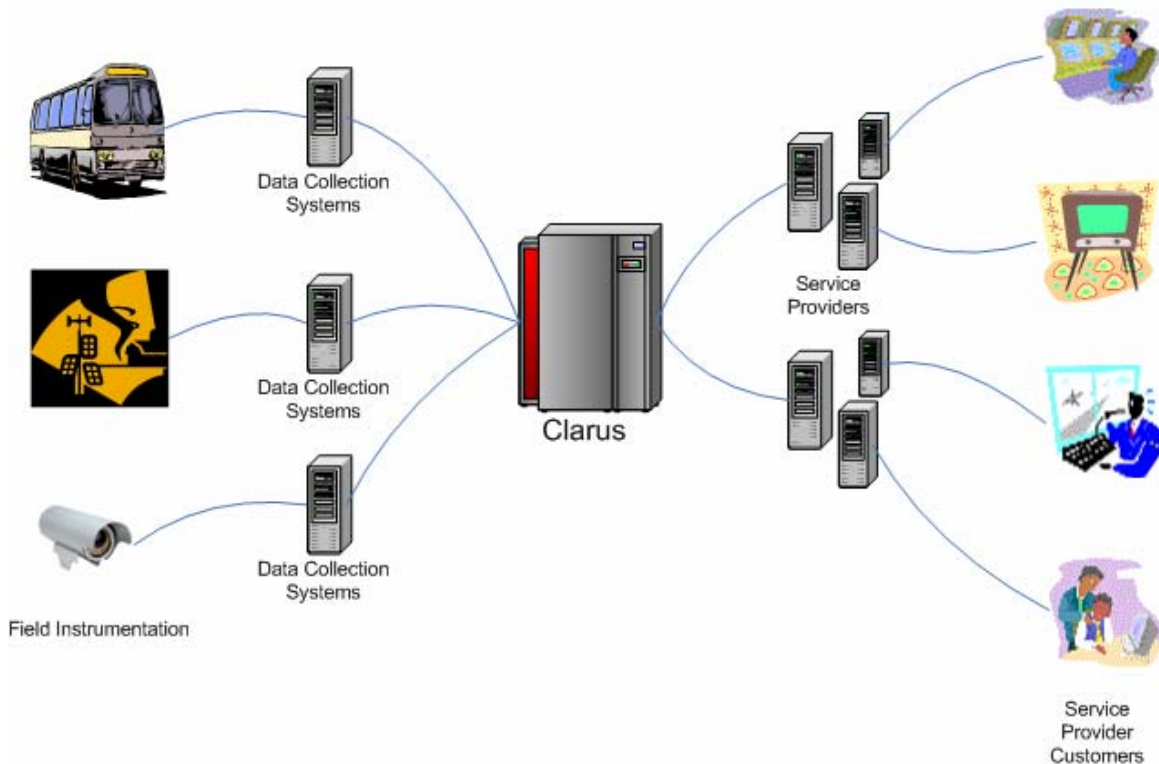


Figure 1 – Clarus Data Acquisition, Processing and Publication

The principal interfaces that will be critical to Clarus are the interface between Clarus and the participating collectors, and the interface between Clarus and the participating service providers. While the service provider interface is completely within the control of the Clarus Initiative, the interface(s) to the autonomous layer collectors may be influenced by what interfaces these systems can support.

While the participants want to access the network through “a one-stop internet portal for all surface transportation weather and pavement related observations” (Ref. 12), there is no requirement that the system be a single centralized system. Designers are free to explore centralized and de-centralized architectures so long as the interfaces with participants give the appearance of a “one-stop” portal.

The issues of data retention and archive are also not explicitly addressed. While some data retention is likely to be necessary to support the quality assessment function and the publication function, there is a clear recognition that as the data ages, it loses value to all but climatological investigators. This phase of development does not include directly archiving the large volume of weather data in Clarus. Considering the technical scope of such an effort, archiving may be externalized or be deferred until the Clarus network is operational and proven.

2.2 System Functions

The Clarus system will collect data from members of the Clarus network, organize and qualify the data, and then publish the data for use by Service Providers and other members of the network. These basic processes are shown in Figure 2 in terms of Clarus system objects and their interactions.

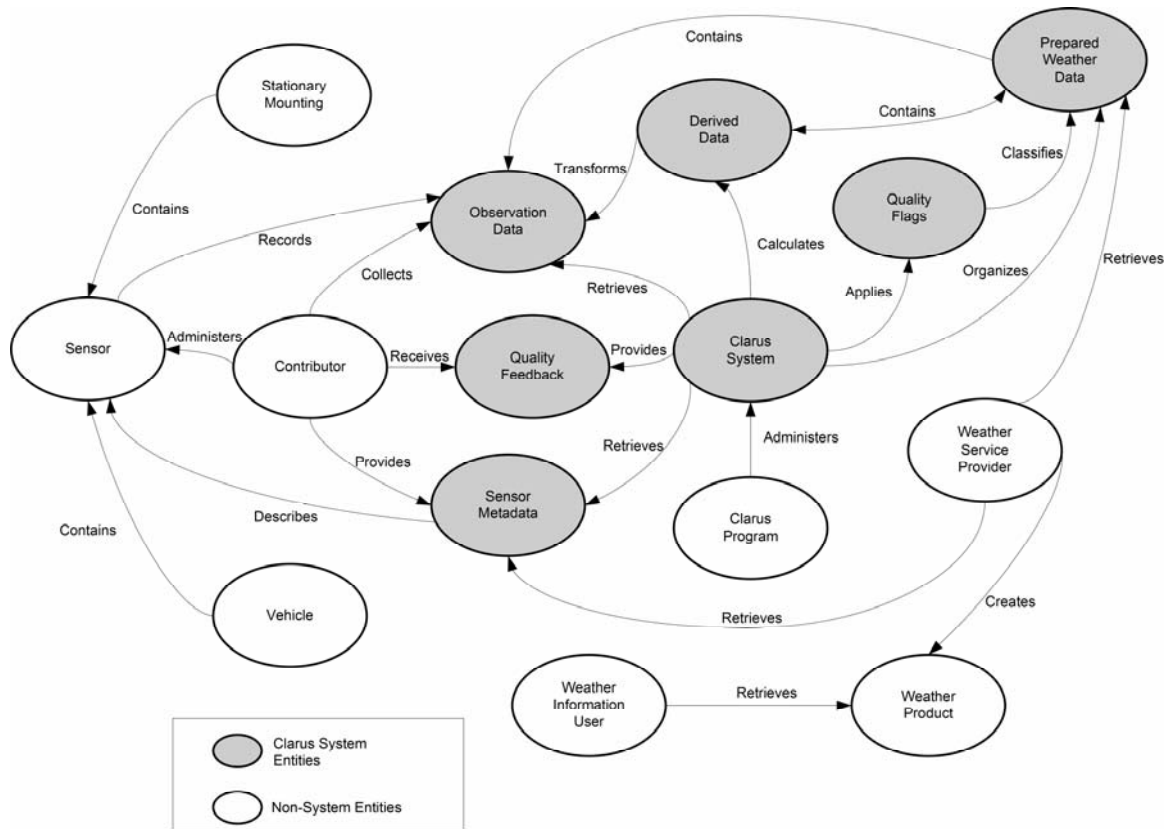


Figure 2 – Basic Clarus System Objects and Functions

The volume of data involved in this process is very large, which leads to a significant challenge in developing a system that can effectively gather, store, process, and disseminate the data. The Clarus system should be a data collection system capable of handling a vast range of data in a flexible manner that permits new data types to be added.

Determining data types will be a significant challenge. Proper understanding of the available data versus the required information will dictate how the data gathering processes and the database itself should be designed for greatest efficiency.

While there are many types of weather data that could be collected, the Clarus emphasis on surface weather and transportation puts the focus on those weather elements that have a direct bearing on surface transportation systems. These weather data elements are described in the NTCIP standard for environmental sensing station (ESS) interfaces (Ref. 8) and summarized in Table 1.

Table 1 – Potential Clarus Weather Data Elements

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

There are basic temporal limits for the data collection, quality control, processing, and publication of the weather data. There is also a period for which the Service Provider Customers have temporal-driven requirements. The design of Clarus will

need to consider these time horizons when planning the technical limitations of the system architecture. These data time horizons are illustrated in Figure 3.

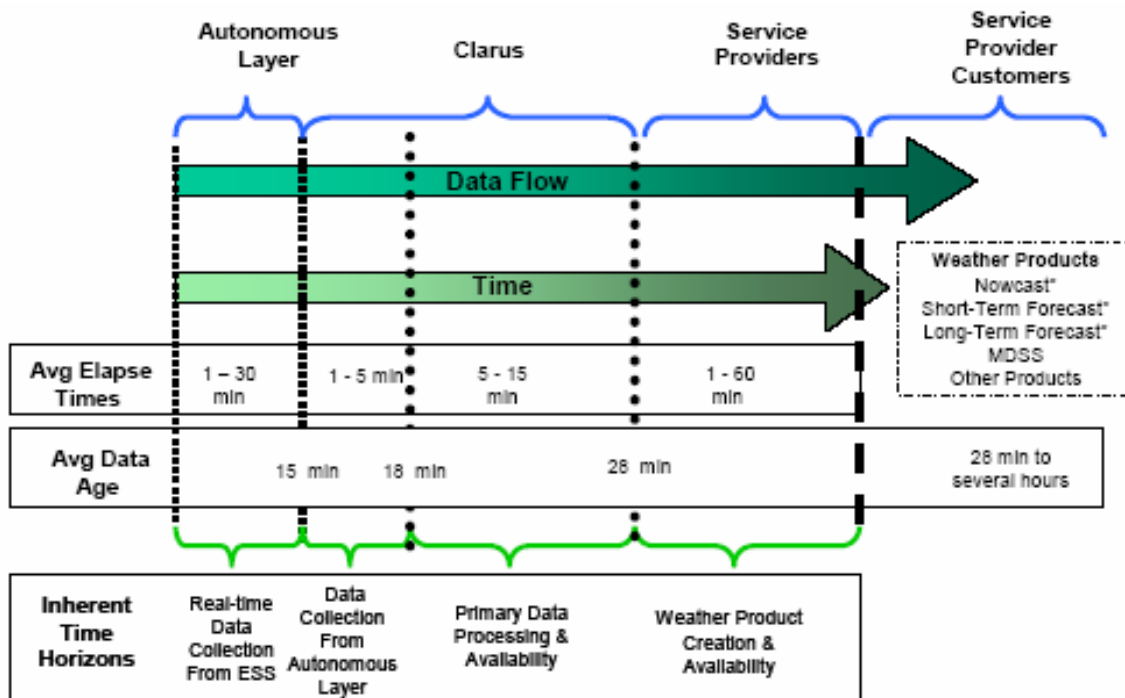


Figure 3 – Time horizons for weather data

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 component includes the time required to communicate data from the Autonomous Layer to the Clarus system import process as well as the time required to process the input data into storage structures. Further, the variation in the Service Provider component includes the time required to add other data to the Clarus data and to perform the required human- and 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.

For the purposes of defining the boundaries of these time horizons, the following definitions apply:

- **Average Elapsed Time** is the estimated time for the process within a given layer or layer sub-division to take place. The age of observed and recorded values can vary widely within these bands.
- **Average Data Age** is the estimated average age of an environmental sensor system (ESS) observation as it is transferred from the ESS to the end user.

2.3 *User Characteristics*

Direct and indirect use of the Clarus system can be applied to a wide audience. Because a variety of users can derive benefit from the Clarus system, it is necessary to focus upon those users who have the most immediate contact with the system components.

The primary user classes include the owners and operators of the observing systems collecting and sending information to Clarus, and the users directly accessing the data published by the Clarus system.

The following is an initial list of stakeholders whose user needs are considered:

- Observation system owners such as State DOTs, counties, municipalities, transit authorities, rail carriers, and universities;
- Instrument and observation platform vendors;
- Direct data users such as system owners and their contractors;
- NOAA;
- Surface transportation weather service providers;
- General weather service providers;
- Research community; and
- 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 system. From information in the *Surface Transportation Weather Decision Support Requirements* (STWDSR) (Ref. 5), *Weather Information for Surface Transportation* (WIST) (Ref. 6), and 511 Deployment Coalition (Ref. 7) documents, 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 data from raw field observations to various levels of data use. This is illustrated in Figure 4.

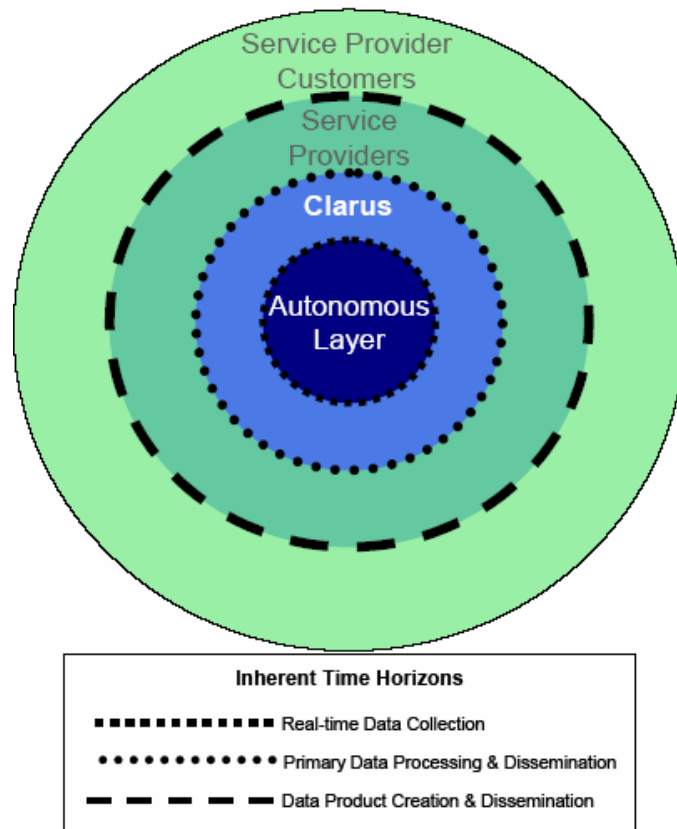


Figure 4 – Clarus User Layers and Time Horizon Relationships

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 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 the Clarus system.

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.

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

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 group could be anyone using weather information, but are largely found within the surface transportation community. The weather products received by these end users are built from 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.

Figure 4 can also be viewed as a depiction of the time horizons that separate the stakeholder groups. There is 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.

The context diagram in Figure 5 illustrates the relationship of the entities interfacing with Clarus. The diagram also describes the flow of data between the entities and the Clarus system. The data provider organizations maintain data collection systems. These organizations make up the Autonomous Layer — the primary contributors of surface transportation data to the Clarus system. These stakeholders can benefit from Clarus by receiving quality-controlled data from the Clarus system. This quality-controlled data are not value-added data, but data with flags indicating that elements do not meet quality assurance thresholds.

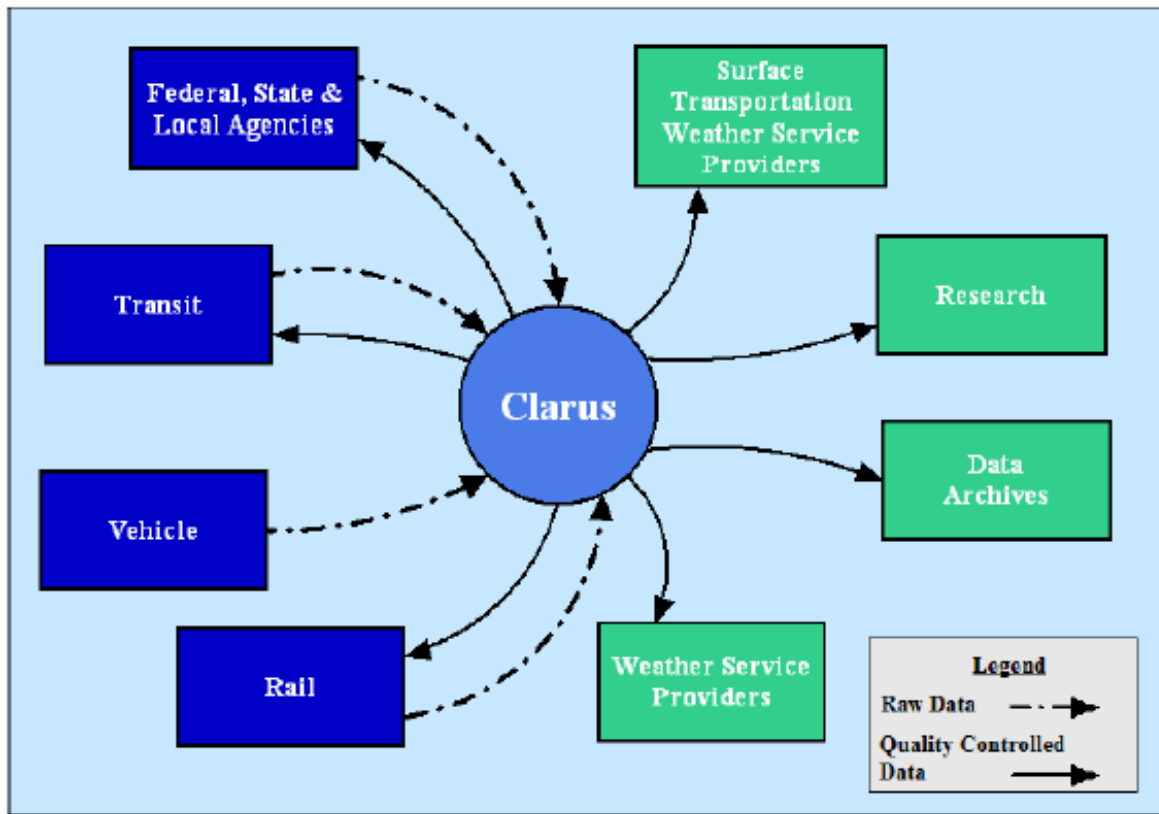


Figure 5 – Context Diagram of Clarus User Needs

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

Within the context of Figure 5, the following roles can be assigned to each group of users:

- **Federal, 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 users, primarily maintenance and operations personnel, are the principal consumers of information provided by surface transportation weather service providers. Additional data from this group may include CCTV images, road condition information, and records of treatment activities such as plowing and chemical application.
- **Transit** – These are the owners and operators of transit systems who contribute data to the Clarus system. 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 the Clarus system. This group places considerable emphasis on understanding weather conditions along designated routes plus weather-induced specifics such as rail temperatures, frozen switches, and drifting snow.
- **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 (STWSP)** – 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 value-added products and services used by the surface transportation decision-makers at state and local transportation agencies.
- **Weather Service Providers (WSP)** – These include the weather support services that are primarily interested in the meteorological and hydrologic components 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.
- **Archives 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 operational and non-operational interests who choose to include the Clarus data in their endeavors. The archiving of Clarus data will be most effective when

combined with other meteorological archives beyond the scope of Clarus, but is not restricted to such efforts.

2.4 *General Constraints*

Timeliness of information and reliability of the system are major constraints on the design. Both of these factors can be addressed through appropriate system architecture and implementation.

To address the timeliness factor, the system should be designed such that it can both retrieve and disseminate large volumes of data from a variety of sources and at potentially high rates. An architecture that spreads its data collection and dissemination processes across multiple servers and communication channels may address this issue. The inherent scalability of such a design may also enable the system to expand and add new data sources and end-users.

Reliability can be achieved through a variety of design and deployment considerations. Hardware, operating system, and development environment have significant impacts on the inherent reliability of the system. To maximize system uptime, redundancies may be required at both the hardware and software levels of the system. The primary challenge here will be the trade-off between the desire for reliability and the cost of redundancies.

While the availability of the system is covered in the Concept of Operations, the criticality of the system is not explicitly addressed. The system is not characterized as “critical” to any operation or transportation function. No adverse consequences are identified that would result if the system is unable to provide “good” data.

It is desirable that the system be “open,” using an architecture and communications interfaces that are non-proprietary and broadly supported within the information technology industry. The system should be standards based, where national standards are applicable. Special consideration should be given to the national ITS standards.

2.5 *Assumptions and Dependencies*

The usefulness of the Clarus system is dependent on participation by multiple weather data providers and multiple weather data consumers. While the system could be placed in operation with only data from the National Weather Service, there is no added value without the participation of other weather data sources. Likewise, participation by a small number of data consumers would not justify the cost of operating the system.

Several assumptions have been made about how long it will take weather data contributors to collect, process, and publish their data. If the data cannot be collected in a timely manner, it may be of no use to the data consumers. Assumptions have also been made about the accuracy of the data, and the ability of the contributing systems to provide adequate location, time/date, and data qualification tags. Accepting data from contributors who cannot provide these

tags with the data could seriously complicate the design of the data acquisition interfaces.

Even though the system will check the data and apply quality tags, consumers will need to understand that neither FHWA nor the contributing data providers will accept responsibility for the accuracy of any of the data.

Several requirements deal with “regional” needs, without specifying regional boundaries. It is unlikely that the regional boundaries from contributing systems will correspond with the regional boundaries defined within data consumer systems. It is even likely that participating data contributors will have different, though possibly overlapping, coverage areas for their networks. Data consumers will need to understand that data will be presented by geographic coordinates, not by regional boundaries. Consumers will also need to understand that coverage will not be uniform and will depend on sensor placement by the contributing organizations.

The availability, format, and precision of geo-reference coordinates for data collection points could present unusual problems for the data acquisition system. Data in the system database and in published data sets will likely include geo-reference coordinates in decimal longitude, latitude, and elevation.

The availability, format, and precision of time/date stamps could also present unusual problems for the data acquisition system, particularly if contributing systems cannot manage daylight savings time, span time zones, or span areas that do and do not participate in daylight savings time. Clarus time stamps for data in the database and in published data sets may need to be referenced to a standard time base such as Universal Time Code (UTC).

The base assumption regarding “database tools” is that the selected data storage software will include appropriate programming interfaces, query tools, and configuration and management tools. No special data tools will be developed as a part of the Clarus project.

3 SPECIFIC REQUIREMENTS

This section presents the high-level requirements for the Clarus system and the associated institutional program necessary to achieve the needs and goals described by the Concept of Operations. In this section, the requirements are divided into the following categories.

- **Functional Requirements** – Lists the characteristics that the system must support for each human interface. Identifies what is to be done by the system, what inputs should be transformed to what outputs, and what specific operations are required. The functional requirements further include:
 - **Data Requirements**, which describe requirements specific to the definition and management of data used and provided by the system; and
 - **Interface Requirements**, which describe the functional interfaces to the Clarus system from information providers and consumers.
- **Performance Requirements** – Specifies static and dynamic capacity for number of users, connections, and other performance related factors. Performance requirements further include:
 - **Design Constraints**, which identify constraints imposed by standards, regulations, software or hardware limitations; and
 - **Quality Characteristics**, which provide requirements which address the general quality, usability, extensibility, flexibility, and maintainability of the system.
- **Organizational Requirements** – Includes requirements for policies and procedures to support the implementation, operations, training, and institutional requirements to support the system. This category also covers database and data structure requirements. Details logical characteristics between the system and external data sources. Specifies level of integration with external systems and defines the interfaces with each user class. Specifies any communications interfaces and protocols that should be supported.

Table 2 shows the general layout of the requirements tables, and explains the purpose or content of each column of the requirements table. The requirements in this document are a subset of the requirements information that will be tracked in the system “Requirements Matrix.” While this document is intended to record the requirements that apply to a particular implementation of the system, the Requirements Matrix tracks all proposed requirements for the system. The Matrix includes requirements that may apply to future versions of the system or which have been deferred due to cost or complexity.

Table 3 provides an explanation of the requirement identification numbering system.

Table 2 - Explanation of the Requirements Tables

ID	Requirement	Source	Comment
A unique identifier used to trace requirements from beginning to end in a system development process.	The text of the actual requirement.	Source(s) for the requirement; could be a reference document or a “parent” requirement.	Supporting text that may help explain the requirement, its priority, or the risks associated with implementing the requirement.

Table 3 – High-Level Requirement ID Format

High-Level Requirement ID Format	Explanation of Format
A-NNN	<p>A Represents the classification of the requirements within the requirements document. The following classifications have been used in this requirements specification:</p> <ul style="list-style-type: none"> D Design Constraints (Section 3.2.1) F Functional Requirements (Section 3.1.1) H Functional Data Requirements (Section 3.1.2) I Functional Interface Requirements (Section 3.1.3) P Performance Requirements (Section 3.2.3) Q Quality Characteristics (Section 3.2.2) X External Requirements (Section 3.3) <p>NNN Provides unique identification. Numbering is not necessarily sequential; gaps in the sequence leave room to add additional related requirements when they are discovered.</p>

3.1 Functional Requirements

This section lists the functional characteristics that the system must support. It also identifies what is to be done by the system, what inputs should be transformed to what outputs, and what specific operations are required. The functional requirements are broken into subsections by general functions, data functions, and interface functions.

3.1.1 General Functional Requirements

The general functional requirements apply to the system as a whole, without respect to specific functions or processes.

ID	Requirement	Source	Comment
F-100	The Clarus system shall collect, quality assure, and disseminate weather data.	ConOps	
F-201	The Clarus system shall be able to access in-situ weather observations from data providers.	OCS	
F-205	The Clarus system shall be able to access remotely sensed weather observations from data providers.	OCS	
F-207	The Clarus system shall be able to calculate derived weather values from observations.	OCS	
F-211	The Clarus system shall be able to receive roadway weather measurements derived from VII data.	OCS	
F-213	The Clarus system shall allow access to new surface transportation related observed weather data.	ConOps	Access could only be provided when new data sources are established and available.
F-214	The Clarus system shall accept weather data derived from images of atmospheric conditions.	MHI	“Images” would include CCTV and still images.
F-215	The Clarus system shall accept weather hazard reports containing the hazard type, location, and timeframe.	OCS	
F-221	The Clarus system shall be able to retrieve weather data directly from sensor stations.	OCS	

ID	Requirement	Source	Comment
F-222	The Clarus system shall minimize the time for data acquisition.	OCS	
F-223	The Clarus system shall process data as it is received.	ConOps	The Clarus system shall be able to automatically process and prepare data as it is received
F-225	The Clarus system shall collect surface transportation weather observations.	ConOps	
F-231	The Clarus system shall collect pavement related observations.	ConOps	“Pavement” observations could include precipitation accumulation or treatments
F-235	The Clarus system shall receive weather data from collectors.	ConOps	
F-241	The Clarus system shall accept weather data from rail-yard platforms.	ConOps	
F-245	The Clarus system shall accept weather data from railroad vehicles.	ConOps	
F-251	The Clarus system shall accept weather data from (roadway) vehicles.	Inferred from ConOps	
F-255	The Clarus system shall accept weather data from maintenance and construction vehicles.	ConOps	
F-261	The Clarus system shall accept weather data from service patrol vehicles.	ConOps	
F-271	The Clarus system shall accept weather data from transit vehicles.	ConOps	
F-275	The Clarus system shall accept weather data from emergency vehicles.	ConOps	
F-281	The Clarus system shall be able to receive weather data from weather service providers.	ConOps	
F-101	The Clarus system shall implement continuous quality control processes.	ConOps	
F-105	The Clarus system shall provide a Quality Assurance Service for weather data.	ConOps	
F-111	The Clarus system shall provide weather data quality indicators.	OCS	

ID	Requirement	Source	Comment
F-115	The Clarus system shall provide notification of data quality conditions to data providers.	ConOps	"Data provider" is not explicitly shown in the ConOps
F-121	The Clarus Quality Assurance Service shall detect out of range values.	ConOps	
F-125	The Clarus system shall not modify original observations.	OCS	
F-131	The Clarus system shall apply the Quality Assurance Service as data are received.	OCS	
F-135	The Clarus system Quality Assurance Service shall apply appropriate quality checks based on the quantity of received sensor station metadata.	OCS	
F-141	The Clarus system shall allow human intervention to override automatically applied quality assessment.	OCS	
F-145	The Clarus system shall apply quality control indicators to received data.	ConOps	
F-151	The Clarus system shall record the methods applied when deriving quality control information.	MHI	
F-155	The Clarus System Quality Assurance Service shall establish a set of rules for each weather parameter.	ConOps	
F-161	The Clarus system Quality Assurance Service shall implement quality rules for specific meteorological situations.	ConOps	The rules for setting quality flags on weather data elements may themselves depend on other weather data. For example, stormy conditions may allow more spatial and temporal variability in wind speed observations than under fair weather conditions.
F-165	The Clarus system Quality Assurance Service shall base its quality process on values from multiple observations.	ConOps	

ID	Requirement	Source	Comment
F-171	The Clarus system Quality Assurance Service shall be able to base its quality process on historical weather data.	ConOps	
F-175	The Clarus system Quality Assurance Service shall be able to use multiple transformation algorithms for its quality check.	ConOps	
F-200	The Clarus system shall be able to detect weather data observation submission errors.	MHI	
F-401	The Clarus system shall provide sensor equipment data to service providers in response to a request.	OCS	
F-501	The Clarus system shall minimize the time for data dissemination.	MHI	
F-505	The Clarus system shall be able to disseminate data based on spatial queries.	ConOps	Defining this as "spatial" allows coverage of custom regions.
F-521	The Clarus System shall maintain a dynamic library of data for at least two days.	ConOps	
F-525	The Clarus System shall make its collected data available as long as needed for service providers to retrieve and store it.	ConOps	
F-801	The Clarus program shall alert users to system modifications.	OCS	
F-805	The Clarus system shall not require approval to request weather data.	MHI	
F-805	The Clarus system shall enable system administrators to manage security groups.	MHI	
F-811	The Clarus system shall be able to restrict weather data publication based on source.	MHI	
F-901	The Clarus system shall record statistics about its operation.	OCS	
F-905	The Clarus system shall log data transactions.	MHI	

3.1.2 Functional Data Requirements

The data requirements identify and describe the management of information to be acquired, processed, and disseminated.

ID	Requirement	Source	Comment
H-011	The Clarus baseline data types shall be defined by the NTCIP ESS 1204 standard for data collection.	ConOps	
H-021	The Clarus system shall manage atmospheric data.	ConOps	
H-022	The Clarus system shall manage pavement data.	ConOps	
H-023	The Clarus system shall manage hydrologic data.	ConOps	
H-121	The Clarus system shall manage atmospheric metadata.	ConOps	
H-122	The Clarus system shall manage pavement metadata.	ConOps	
H-123	The Clarus system shall manage hydrologic metadata.	ConOps	
H-151	The Clarus system shall require observation metadata to include location, timeframe, source, and quality.	ConOps	Appendix A includes a discussion of “metadata” in this context.
H-201	The Clarus system shall manage environmental sensing station data.	ConOps	
H-301	The Clarus system shall manage weather data from across the United States.	ConOps	The Clarus system shall be able to provide a mechanism to maintain a national clearinghouse of weather data

3.1.3 Functional Interface Requirements

The functional interface requirements describe the functional interfaces to the Clarus system from information providers and consumers.

ID	Requirement	Source	Comment
I-011	The Clarus system shall accept data through a Clarus standard interface.	OCS	Standard to be determined during design phase of this project

ID	Requirement	Source	Comment
I-012	The Clarus system shall be able to communicate with environmental sensor stations using the NTCIP ESS 1204 standard for data collection.	ConOps	
I-013	The Clarus system shall be able to communicate with RWIS databases through their native interface.	ConOps	
I-014	The Clarus system shall be able to communicate to individual ESS through their native interface.	ConOps	
I-015	The Clarus system shall be able to collect weather related data that is manually entered.	ConOps	
I-016	The Clarus system shall transfer data as efficiently as possible.	ConOps	
I-017	The Clarus system shall employ industry standards to minimize implementation impact to users and providers.	ConOps	
I-021	The Clarus system shall allow service providers to select specific desired data sets.	ConOps	
I-022	The Clarus system shall respond to queries for weather elements from the available data.	MHI	
I-025	The Clarus system shall enable weather data queries by timestamp.	ConOps	
I-026	The Clarus system shall enable weather data queries by location reference.	ConOps	
I-027	The Clarus system shall enable weather data queries by quality.	ConOps	
I-028	The Clarus system shall enable weather data queries by source.	MHI	
I-031	The Clarus system shall provide a user interface for system administration.	MHI	
I-032	The Clarus system shall manage users.	MHI	

ID	Requirement	Source	Comment
I-033	The Clarus system shall allow data users to create a weather data subscription request using an Internet browser.	ConOps	

3.2 Performance Requirements

The requirements in this section specify static and dynamic capacity for the number of users, connections, and other performance related factors. The performance requirements are divided into subsections and are provided in the form of design constraints, quality requirements, and system performance requirements.

3.2.1 Design Constraints

Design constraints apply existing rules or external conditions to the system. Examples of design constraints are communication standards, requirements for standardized hardware or software, and minimum needs for a system to be useful.

ID	Requirement	Source	Comment
D-011	The Clarus system shall be able to be hosted at multiple physical locations.	MHI	
D-021	The Clarus system shall use hardware that implements industry accepted standard interfaces.	MHI	
D-031	The Clarus system shall use software that implements industry accepted standard interfaces.	MHI	
D-041	The Clarus system shall be able to operate on redundant hardware.	ConOps	
D-051	The Clarus system shall disseminate data in response to a scheduled request.	OCS	
D-061	The Clarus system shall disseminate data in response to polling.	OCS	
D-071	The Clarus system shall disseminate data in response to a change notification request.	OCS	
D-081	The Clarus system shall be able to notify subscribers when data sets become available.	OCS	

ID	Requirement	Source	Comment
D-091	The Clarus system shall disseminate data using standard Internet protocols.	OCS	
D-101	All HTML coding shall meet FHWA requirements for web sites.	Contract	
D-111	The Clarus system shall support modular components.	OCS	
D-121	The Clarus system shall use latitude, longitude, and elevation (standard GPS) coordinates to specify location to the nearest fifty feet.	ConOps	
D-131	The Clarus system shall have at least one system administrator.	MHI	

3.2.2 Quality Requirements

These quality requirements pertain directly to maintaining a high level of service quality.

ID	Requirement	Source	Comment
Q-011	The Clarus system shall be able to mitigate communication denial-of-service attacks.	MHI	
Q-012	The Clarus system shall be able to automatically recover from an unexpected shutdown.	MHI	
Q-013	The Clarus system shall be able to respond to 99% of all requests for weather element data 99% of the time.	MHI	

3.2.3 System Performance Requirements

System performance requirements specify quantitatively what the system must do and in what timeframe.

ID	Requirement	Source	Comment
P-011	The Clarus system shall be able to publish at least three times as many weather data elements as it collects.	MHI	
P-012	The Clarus System shall prioritize data processing for time-critical data.	ConOps	
P-013	The Clarus system shall support 26 million current observations.	MHI	2.6 million paved road miles in the US (10 weather parameters per each VII input)
P-021	The Clarus system shall collect data from sources within 5 minutes of its becoming available.	ConOps	
P-022	The Clarus system shall be able to receive all reported weather element data during a fifteen minute time interval.	MHI	
P-023	The Clarus system shall complete an automated quality assurance check and make weather data available within ten seconds of data receipt.	OCS	
P-024	The Clarus system shall be able to publish new data within twenty minutes of receiving it.	ConOps	
P-025	The Clarus system shall respond to a request for information within one minute.	MHI	
P-031	The Clarus system shall be able to handle two hundred simultaneous requests for weather element data.	MHI	Half of the concurrent users may be requesting data at any one time.
P-041	The Clarus system shall be able to support four hundred concurrent users.	MHI	An estimate of the number of concurrent potential weather service provider users of the Clarus system.
P-042	The Clarus system shall be able to support four thousand registered users.	MHI	An estimate of the number of individual users among the pool of weather service providers, ten per provider.

3.3 Organizational Requirements

Organizational requirements deal with policies regarding external parties involved with the system, personnel roles, training, and security needs.

ID	Requirement	Source	Comment
X-101	The Clarus system shall accept data only from approved sources.	MHI	
X-105	The Clarus system shall only accept observations that include measurement type, value, unit, location, and timeframe.	OCS	
X-205	The Clarus program shall maintain continuous 24x7 operations.	OCS	
X-207	The Clarus program shall provide an environment that has uninterruptible power for the Clarus system.	MHI	
X-209	The Clarus program shall provide an environment that has redundant communication for the Clarus system.	MHI	
X-211	The Clarus program shall provide network management tools.	OCS	Network management tools can be used to determine latency
X-215	The Clarus program shall provide setup support.	ConOps	
X-221	The Clarus program shall provide for customer service.	OCS	
X-225	The Clarus program shall provide a support staff.	ConOps	
X-227	The Clarus program shall properly train the support staff.	ConOps	
X-231	The Clarus program shall define data quality parameters.	OCS	
X-233	The Clarus program shall define data retention standards.	MHI	
X-235	The Clarus program shall provide standards documentation.	OCS	

ID	Requirement	Source	Comment
X-237	The Clarus program standards shall enable new sensor technologies to contribute to the Clarus System.	ConOps	
X-239	The Clarus program standards shall support multiple methods of data delivery to users.	ConOps	
X-305	The Clarus program shall maintain a comprehensive Clarus system test environment.	OCS	
X-311	The Clarus program shall test all software changes in the designated test environment before deployment to production.	OCS	
X-315	The Clarus program shall test all hardware changes in the designated test environment before deployment to production.	OCS	
X-601	The Clarus program shall operate the Clarus system according to its published IT Security Plan.	Contract	
X-605	The Clarus program shall operate according to Government IT security requirements as outlined in OMB Circular A-130, Management of Federal Information Resources, Appendix 111, Security of Federal Automated Information Resources.	Contract	
X-611	The Clarus program shall operate according to Government IT security requirements as outlined in the National Institute of Standards and Technology (NIST) Guidelines, Departmental Information Resource Management Manual, and associated guidelines.	Contract	
X-615	The Clarus program shall operate according to Government IT security requirements as outlined in DOT Order 1630.2B, Personnel Security Management.	Contract	

ID	Requirement	Source	Comment
X-805	Weather service providers shall be able to use Clarus data to provide localized special weather products.	ConOps	
X-811	State DOT maintenance and construction personnel shall be able to use the Clarus system to obtain weather conditions.	ConOps	
X-815	Rail system personnel shall be able to use the Clarus system to obtain weather conditions.	Extended from ConOps	
X-821	Traffic management personnel shall be able to use the Clarus system to obtain weather conditions.	Extended from ConOps	
X-823	Transit personnel shall be able to use the Clarus system to obtain weather conditions.	Extended from ConOps	
X-825	The freight community shall be able to use the Clarus system to obtain weather conditions.	Extended from ConOps	
X-905	The Clarus program shall maintain information about data providers.	OCS	
X-910	The Clarus program shall maintain metadata about each data provider's network.	OCS	
X-915	The Clarus program shall maintain information about data provider redistribution restrictions.	OCS	
X-921	The Clarus program shall maintain information about service providers.	OCS	
X-925	The Clarus program shall maintain information about service provider communications.	OCS	
X-931	The Clarus program shall maintain information about service provider access to data.	OCS	
X-935	The Clarus program shall allow potential weather element data providers to request permission to submit weather information.	MHI	

APPENDIX A - DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

The following table provides definitions of terms, acronyms, and abbreviations to assist interpretation of this document.

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
AMS	American Meteorological Society
ASOS	Automated Surface Observing System
CCTV	Closed Circuit Television
ConOps	Concept of Operations
CSI	Cambridge Systematics, Inc.
DMS	Dynamic Message Sign
DOT	Department of Transportation
DSS	Decision Support System
ESS	Environmental Sensor Station
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
HTML	Hypertext Markup Language
ICC	(Clarus) Initiative Coordinating Committee
IMT	(Clarus) Initiative Management Team
in situ	From Latin, "in situ" means "in place." As applied to meteorological data, it refers to data specific to a (fixed) point of observation.
ISP	Information Service Provider
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
ITS America	Intelligent Transportation Society of America
MADIS	Meteorological Assimilation Data Ingest System
MDSS	Maintenance Decision Support System
MDT	Mobile Data Terminal
metadata	In common information systems use, "metadata" is "data about data." Within the meteorological community, this use has been extended to include data about objects related to weather observations. For example, location data for an ESS becomes metadata for the observation data.
MHI	Mixon/Hill, Inc.
NASA	National Aeronautics and Space Administration
NHI	National Highway Institute

Term	Definition
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NTCIP	National Transportation Communications for ITS Protocol
NWOS	National Weather Observing System
NWS	National Weather Service
OCS	Oklahoma Climatological Service
OMB	Office of Management and Budget
PDA	Personal Digital Assistant
PMP	Project Management Plan
RWIS	Road Weather Information System
SEP	System(s) Engineering Process
STWDSR	Surface Transportation Weather Decision Support Requirements
STWSP	Surface Transportation Weather Service Provider
TBD	To Be Determined
TMC	Traffic Management Center
TOC	Traffic Operations Center
TRB	Transportation Research Board
UML	Unified Modeling Language
UTC	Universal Time Code
VII	Vehicle Infrastructure Integration
VSL	Variable Speed Limit
WIST	Weather Information for Surface Transportation