CLARUS WEATHER SYSTEM DESIGN

SYSTEM ARCHITECTURAL DESCRIPTION

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Prepared By:

Mixon/Hill, Inc.

12980 Metcalf Ave, Suite 470

Overland Park, Kansas 66213

913-239-8400

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1 INTRODUCTION

This system architectural description (SAD) describes the system components and their relationship to one another for the *Clarus* system. The primary functions of the *Clarus* system are to collect, quality control, and disseminate environmental information. The system architecture is described from multiple viewpoints to capture various perspectives of the distribution and interfaces between system components. The base system architectural viewpoint describes the architect's view (as the developer of the system), in this case describing the services provided by the system components. Network and hardware viewpoints describe the system in more physical terms. These viewpoints are followed by a description of how *Clarus* relates to the National ITS Architecture.

1.1 Purpose

The purpose of this system architectural description for *Clarus* is to reiterate the system concepts and define the system components and their relationship to one another.

The architectural description will subsequently serve as the foundation for more detailed architecture and design documents. The architectures are defined here using network-style viewpoints that model concepts, processes, and their relationships to one another. They are high-level and generally abstract relative to an actual system design.

This document is intended to be read and used by the U.S. Department of Transportation (USDOT), *Clarus* stakeholders, and the system development team members. This document conforms to the recommended practice for architectural descriptions as defined by IEEE Standard 1471-2000 (Ref. 1).

As indicated in Figure 1, the SAD is an intermediate deliverable in the larger context of the *Clarus* Weather System Design project, using criteria documented in the High-Level Requirements Specification to identify components and attributes") as input to the System Architectural Description.

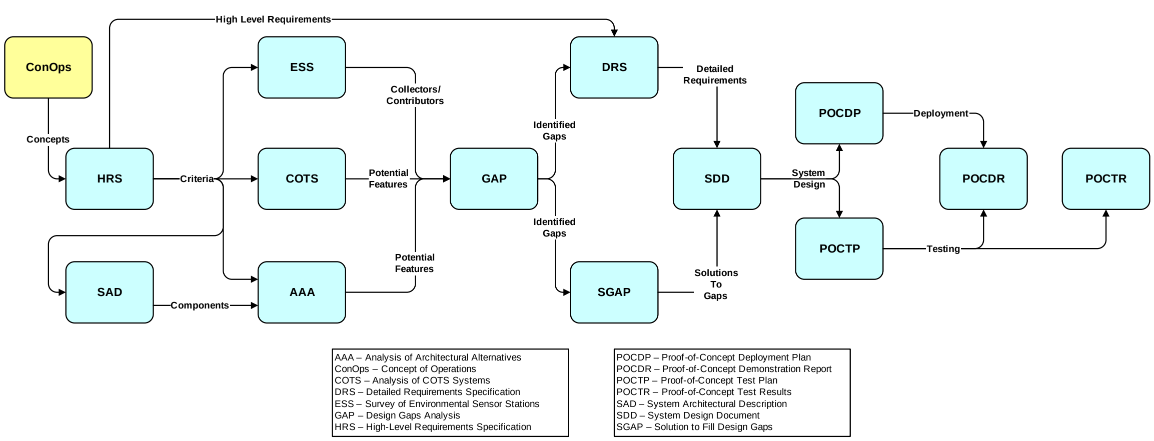

Figure 1 – System Architectural Description Context

1.2 Scope

The scope of this document is to describe the architecture of the *Clarus* system. *Clarus* will collect environmental information from environmental data sensors and mesonets. *Clarus*, using multiple quality verifying algorithms, will qualify the environmental information using a relative good and bad rating scale. *Clarus* will then format the qualified environmental information for presentation to end-users and for quality feedback to the information originators, responding to requests as they are received.

Clarus will be used by observing system owners and environmental equipment manufacturers to improve their assets and products. Transportation departments will use qualified *Clarus* information to enhance their decision making in traffic operations and road maintenance. Transit, rail and other entities will also use *Clarus* information to make operational and maintenance decisions. The National Oceanic and Atmospheric Administration (NOAA) and other weather service providers will use the high-quality environmental information to enhance their products for the public. It is envisioned that other public and private entities—such as the Department of Agriculture (drought monitoring), the Department of Interior (fire weather), the Environmental Protection Agency (air quality), the Department of Homeland Security (dispersion winds) —will also find value in *Clarus* system data.

This high-level architectural description is not an exhaustive examination of all possible architectures and implementations for *Clarus* as it may evolve. It is, however, a base description that guides the architectural description of any enhancements to be developed in future project iterations.

1.3 Definitions, Acronyms, and Abbreviations

This document may contain terms, acronyms, and abbreviations that are unfamiliar to the reader. A glossary of these terms, acronyms, and abbreviations is provided in Appendix A.

1.4 References

1. *IEEE Standard 1471-2000 – IEEE Recommended Practice for Architectural Description of Software-Intensive Systems*; The Institute of Electrical and Electronic Engineers, Inc.; Sept. 21, 2000.
2. *Clarus Final Draft Concept of Operations;* Iteris and Meridian Environmental Technology, Inc.; May 16, 2005.
3. *Clarus Weather System Design – High Level System Requirements Specification*; Mixon/Hill, Inc.; July 2005.
4. *National ITS Architecture, Version 5.0*; FHWA, U.S. DOT; October 2003.
5. *NTCIP 1204 – NTCIP Environmental Sensor Station Interface Standard*; National Electrical Manufacturers' Association, American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; v02.19b; 2004.

6. *ITE TM 1.03 – Standards for Traffic Management Center to Center Communications* (TMDD); American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; working draft v1.5; Dec. 15, 2003.
7. *ITE TM 2.01 – Message Sets for External Traffic Management Center Communication* (MS/ETMCC); American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; Rev. 1.1; Feb. 26, 1999.
8. *NTCIP 2304 – NTCIP Application Profile for DATEX-ASN* (AP-DATEX); National Electrical Manufacturers' Association, American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; v01.07; June 20, 2001.
9. *SAE J2354 – Message Sets for Advanced Traveler Information System (ATIS)*; Society of Automotive Engineers, Inc.; Nov. 1999.
10. *NTCIP 2306 – NTCIP Application Profile for XML Message Encoding and Transport in ITS Center to Center Communications* (C2C XML); National Electrical Manufacturers' Association, American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; v01.51; March 29, 2005.
11. *Canadian Meteorological Markup Language Specification* (CMML); Environment Canada; Version 2.0; August 24, 2005.
12. *OASIS Standard 200402 – Common Alerting Protocol* (CAP); OASIS; v. 1.0; March 2004.
13. *Standards for Traffic Management Center to Center Communications:* American Association of State Highway and Transportation Officials, and Institute of Transportation Engineers; v2.1 draft standard; June 30, 2004.

1.5 Overview

This document describes the *Clarus* system architecture. User needs for the system, upon which this architecture is based, are documented in the Concept of Operations and further developed in the High-Level System Requirements.

The remainder of this document consists of the following sections and content:

Section 2 Stakeholders and Concerns briefly summarizes stakeholders and their interests in *Clarus*, as more fully documented in the Concept of Operations.

Section 3 Operational Concept summarizes the Concept of Operations and identifies the major system elements.

Section 4 Prototype System Architecture describes the system architecture from several viewpoints: the services to be provided by the system, the network connecting the system components and external agents, the system hardware, and the National ITS Architecture.

Section 5 Standards provides a list of ITS standards applicable to development, deployment, and operation of the *Clarus* system.

2 STAKEHOLDERS AND CONCERNS

The stakeholders in the *Clarus* system are identified and described in detail in the *Clarus* Concept of Operations (ConOps) (Ref. 2). The initial list of stakeholders whose user needs are considered in that reference includes:

- 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;
- NOAA;
- Surface transportation weather service providers;
- General weather service providers;
- Research community; and
- Climate data warehouse and other non-surface weather interests.

The list further divides into those stakeholders who are providing data to *Clarus*, using data from *Clarus*, or both. Each of these groups has an interest in *Clarus* data specific to their particular organizational objectives and processes. The *Clarus* High Level System Requirements Specification (Ref. 3) documents these interests and provides the basis for determining what system features will be needed to meet the users' needs.

3 OPERATIONAL CONCEPT

The *Clarus* ConOps provides extensive discussions of the operational context, objectives, constraints, and system functions. These concepts are illustrated through discussion of an overall framework and operational scenarios for various user communities. Operational characteristics of the *Clarus* system itself are a subset of the overall framework and scenarios. The processes to be implemented in the *Clarus* system have been distilled from the framework in the ConOps and are shown in Figure 2 and Figure 3 below. This description focuses specifically on those functions to be fulfilled by the *Clarus* system and generalizes the interfaces based on the data types (rather than source types).

From the overall system perspective, the *Clarus* system will take in environmental data and metadata, and provide environmental metadata and qualified environmental data on request. The system will perform these operations based on data sharing agreements that define the terms of access and on quality control parameters used in assessing the incoming data. The system will need access to the environmental data networks and servers, and will need to provide network access for users requesting information.

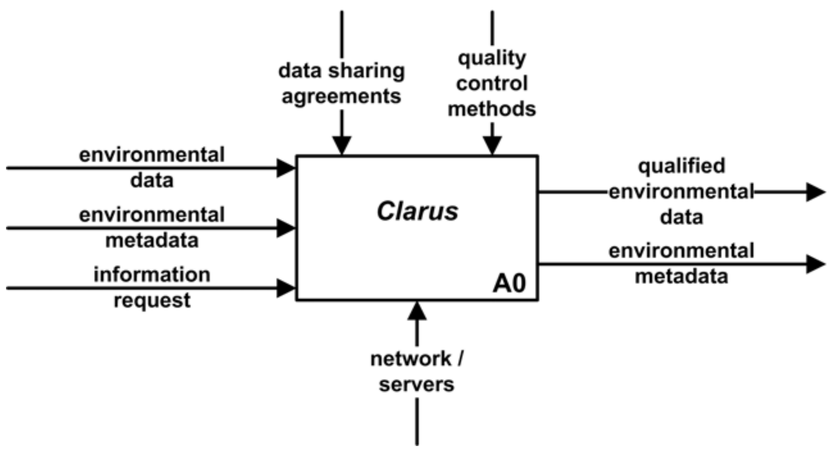

Figure 2 – *Clarus* System Process Context

Within the overall context, the *Clarus* system will collect, assess the quality of, and disseminate environmental data. The collection process locates, obtains, and stores the data in a common data structure, subject to access agreements. The quality control process applies one or more quality checks and associates quality flags with the data. The qualified data and the associated metadata are then available for dissemination, subject to any constraints specified in the data sharing agreements.

There will be multiple sources of data for the collection process, each potentially in its own format. Each source of data will also provide metadata describing the source and conditions surrounding the source. Terms under which data can be accessed from each source will be identified in data sharing agreements with the source organizations. Data are collected from the sources, interpreted from source formats, and stored in a common data structure.

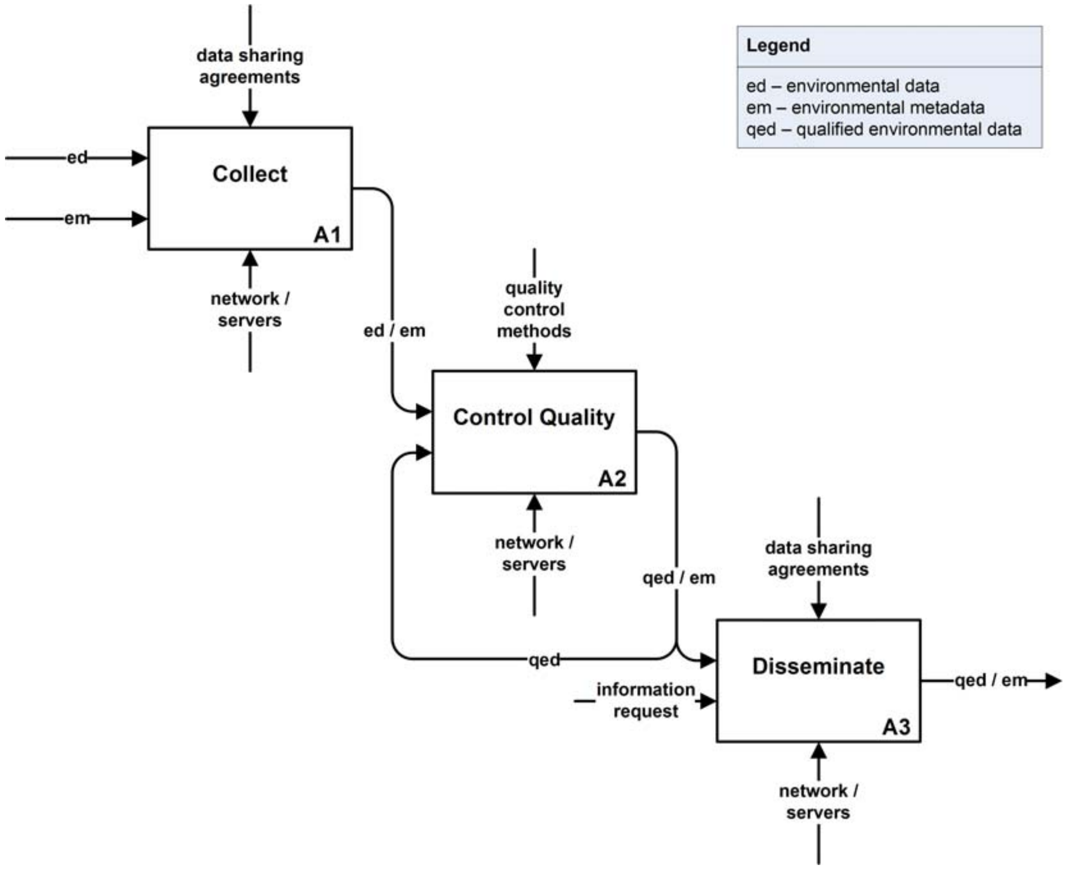

Figure 3 – High Level *Clarus* System Processes

The quality control process will implement one or more quality checks of the environmental data. Each quality check will be based on a set of rules for comparing the data to other models and data sets. Comparison data sets can include previously qualified data shown as a quality feedback loop in Figure 3. It may be necessary to derive or infer additional data from the original environmental data in order to complete some quality checks. Quality flags are assigned to the data according to the specific checks performed.

The data are disseminated in response to information requests directly from users with access to the data or automated processes based on data values and quality flags. In particular, data source organizations may be notified of data sets that do not pass particular quality checks. Data sharing agreements may constrain the data sets, formats, or distribution lists for data dissemination.

These essential *Clarus* functions provide the basis for developing the high level system architecture and design.

4 SYSTEM ARCHITECTURE

Any particular representation of a system's architecture is fundamentally just one view of the system itself. Different stakeholders in the system have different sets of concerns and expect to see specific sets of components and interfaces in the architectural model. This section of the SAD describes the *Clarus* system from services, network, hardware, and National ITS Architecture viewpoints.

Each of the viewpoints has its own context for the discussion. This helps establish a vocabulary and, consequently, the interpretation of terms used within the section. Viewpoints that include illustrations may use different styles of diagrams within that viewpoint and between viewpoints. Diagram styles are chosen specifically to define and communicate the concepts discussed in each viewpoint.

4.1 Services Viewpoint

This section describes the *Clarus* system services viewpoint. The services viewpoint identifies the relationship of environmental data to the *Clarus* system and what services are required to process that information. Two views are presented here: environmental data and its transmission into and out of the *Clarus* system and the environmental data handling services that reside within the *Clarus* system.

4.1.1 Context and Semantics

To speed the discussion and encapsulate comments, several abbreviations have been adopted for the different aspects of environmental data. The legends in the diagrams can be used to understand the meaning of the descriptions. The primary data flows are environmental data (ED), environmental metadata (EM), and qualified (or quality-controlled) environmental data (QED).

Collector and contributor are two terms that need further clarification. Environmental sensors, by themselves, generate electrical signals that are converted into specific environmental data. Sensor value interpretation is carried out by a data collector—commonly known as a data logger within the meteorological community. These basic functions are performed in the existing collectors, before sending information to the *Clarus* system.

Contributors are very similar to environmental data collectors. In this context, contributors are viewed as sets of environmental data collectors with a few additional attributes. Contributors typically have human organizations associated with them, have agreements with the *Clarus* program, and directly benefit from their data sharing with the *Clarus* system. Contributors may or may not own their set of collectors, but are assigned to operate them and may perform their own data processing on the information they collect.

Following this pattern, the *Clarus* system itself can be considered a contributor. It does not necessarily own or need to own any of its collectors, has a human organization associated with it, performs its own processing on the environmental data and metadata, and maintains data sharing agreements with other parties.

The diagrams in this section are simple block diagrams that use connecting lines with arrows to describe the direction of environmental data and to label the type of data moving throughout the systems. The blocks in the diagrams represent services that provide interfaces to environmental and system management data.

4.1.2 System Functions

The system functions from the environmental data flow viewpoint are very similar to the system functions from other viewpoints. Environmental data flows from the sensors, sensor data collectors, and contributors into the *Clarus* system. The *Clarus* system then qualifies and redistributes the qualified environmental data to environmental service providers upon request.

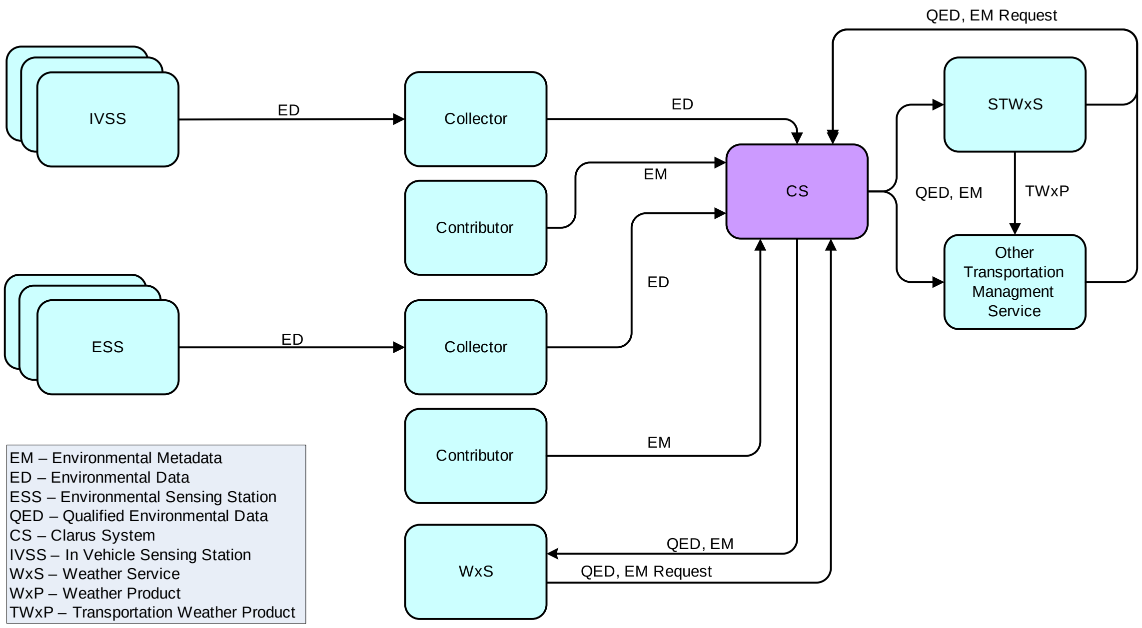

Figure 4 – Data Flows Into and Out of the *Clarus* System

Figure 4 illustrates the movement of environmental data and metadata from their origin into the *Clarus* system and out of the *Clarus* system to contributors and other environmental service providers. Environmental data (not quality controlled) originates from environmental sensors and is collected by environmental data collectors on environmental sensor stations and surface transportation weather sensors on vehicles. The environmental data (ED) is quality checked by the *Clarus* system and the qualified environmental data (QED) is made available to contributors and environmental service providers. While environmental metadata (EM) can be supplemented directly from collectors, the bulk of the metadata originates from contributors and is sent to the *Clarus* system to be made available for environmental service providers.

The activities that occur inside the interface boundaries of the *Clarus* system are shown in Figure 5. The diagram provides more detail about what operations the *Clarus* system is actually performing for the collect, qualify, and disseminate high-level description. The processes are modeled here as services.

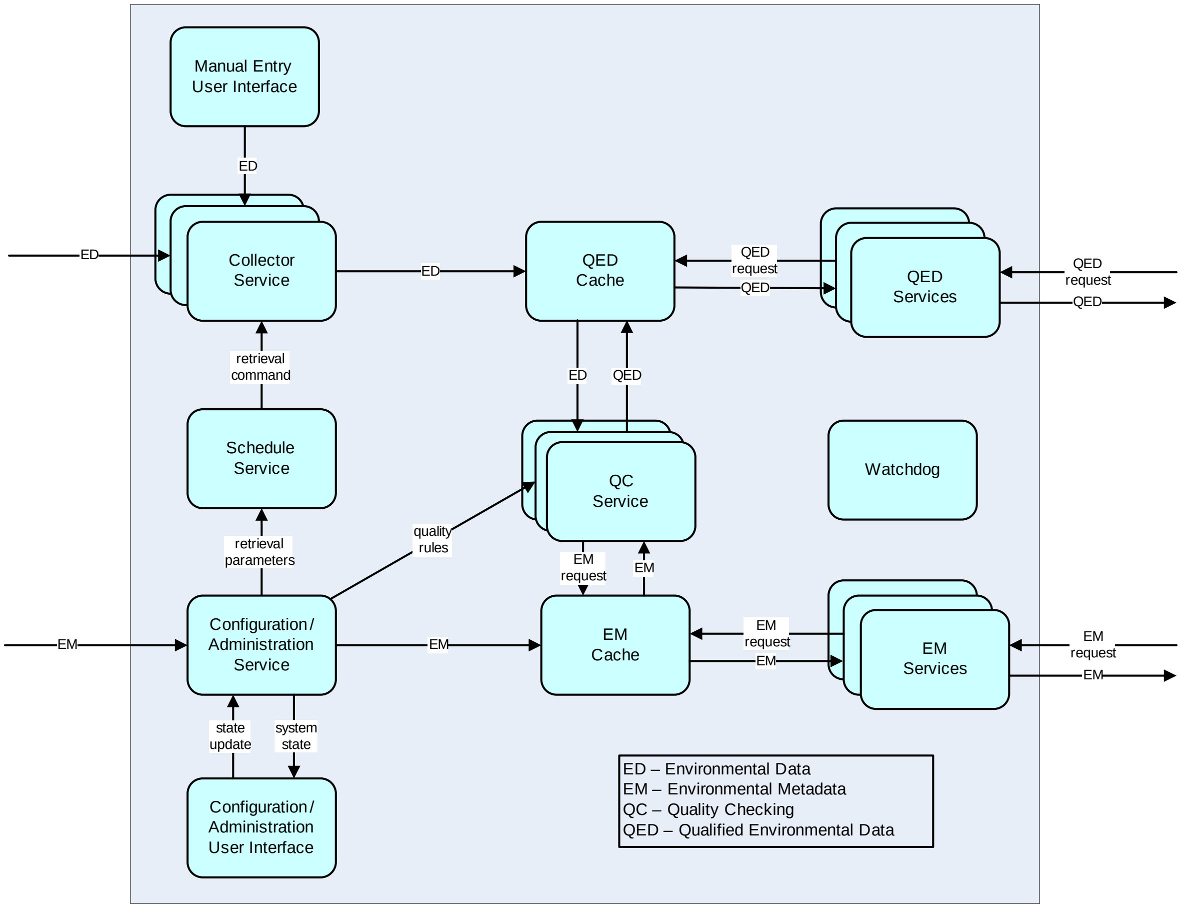

Figure 5 – Data Flows within the *Clarus* System

Four of the components in Figure 5 are modeled as sets of services: the collector, quality checking (QC), qualified environmental data, and environmental metadata services. The collector, QED, and EM services are sets of services because each individual service represents a particular data format interface. A set of services is required to properly interpret and transform all the incoming and outgoing environmental information. The particular collector, QED, or EM service performing a transformation depends on the origin and destination of the environmental data.

The fourth component modeled as a set is the quality checking service. It is a set of services because it represents in one component all the QC algorithms that can be applied to environmental data collected by *Clarus*. The specific algorithms and sequence in which they are applied are determined by quality rules established through the configuration/administration service. This arrangement supports flexibility in adding and removing QC algorithms to produce the best possible qualified environmental data in the *Clarus* system.

There are two services that keep the *Clarus* system operating: the watchdog and schedule services. The watchdog service monitors the overall system state and restarts unresponsive services as needed, thus preventing long-term service disruption. The schedule service prioritizes requests to receive environmental data from collectors and contributors. The schedule service will also prioritize and respond to subscription requests for environmental data (not depicted in Figure 5).

The set of collectors in the *Clarus* system receives environmental data from ED collectors and contributors through both push and pull methods. Each collector service is capable of understanding a particular data format and is responsible for extracting the environmental data and placing it into the qualified environmental data cache flagged as unqualified environmental data. The collectors also import environmental data from the manual entry user interface to override the automated environmental data and quality checks.

Quality rules set up by the configuration/administration service are executed by the quality checking services to apply sets of computations on the environmental data stored in the qualified environmental data cache. Flagging out-of-range values is one example of a quality rules. Other quality rules could be created to derive environmental conditions from existing information such as dew point. Multiple passes by the quality checking services on the QED cache information could apply grid algorithms sequentially to further qualify the environmental data. This allows constant access to qualified environmental data in-process. The QED is still valuable to end-users since it will always identify its level of quality and can be continuously delivered.

The QED services format the qualified environmental data to fulfill requests from and information subscriptions for environmental service providers and end-users. Similarly, the EM services format the metadata to meet requests from and metadata subscriptions for environmental service providers. Each of these components is a set of services, with each individual service supporting a particular data format.

The configuration/administration service supports both the *Clarus* system and program. It maintains information about data provider redistribution restrictions, and controls who has access to modify the system state, quality rules, and set ED retrieval schedules. The configuration/administration service also manages environmental metadata, formatting it for internal storage. Data transactions and system operational statistics are logged in the configuration/administration interface as well.

4.1.3 Interfaces

For environmental data to get into the *Clarus* system, the scheduling service sends a command to a collector service through its command interface to retrieve environmental data, or an external collector or contributor sends environmental data directly to a collector service through the collector's environmental data input interface suited for the arriving information. The environmental data is extracted by the collector service and sent to the environmental data cache using the collector service's common environmental data output interface.

Any environmental data within the *Clarus* system is inherently qualified. Environmental data that has not undergone any quality checking algorithms is flagged as being raw. Therefore, both environmental data from collector services and quality-processed environmental data from QC services enter the QED cache through the same qualified environmental data interface. Requests for qualified environmental data from QC services and QED services arrive at the cache through its request interface. Quality environmental data is delivered to QED services and QC services over the QED output interface.

Qualified environmental data is disseminated from the *Clarus* system through a QED service output interface that exports the data in an appropriate format for a specific request. Requests are received from environmental service providers and other end-users on the QED request interface. Requests can specify an immediate response or take the form of a subscription.

The QED service formats an immediate request for internal representation and sends it to the quality environmental data cache through its request interface. Subscription requests are stored in the quality environmental data service and specify a regular publishing interval or a data update event. When the allotted time is reached or data of interest is updated in the quality environmental data cache, the QED service generates an immediate QED request for the cache and the process continues as if an immediate request had been received.

Requests for information from the QED cache are compared against the publication rules defined by the configuration/administration service. Restricted data sets are determined and removed from the response. The QED service receives the resulting qualified environmental data in the internal format over its qualified environmental data input interface, formats it for dissemination, and sends it to the requestor/subscriber over the QED output interface.

A QC service requests environmental data from the QED cache through the QED cache request interface. The QC service then processes the response through its common qualified environmental data interface. The QC service applies configured algorithms to the received data and sends the further qualified environmental data back to the QED cache through its common qualified environmental data output interface.

Environmental metadata flows into the configuration/administration service through an EM input interface. There will be a specific EM input interface for each format of metadata supported by the system. The metadata is formatted for internal storage and sent to the EM cache through the configuration/ administration service's EM output interface.

The EM cache supports three interfaces. Environmental metadata in a storage format is received from the configuration/administration service through the EM input interface. An EM output interface is used to send metadata to environmental metadata services that convert the metadata for dissemination on-demand. The EM cache receives requests for metadata from the EM service handling a metadata request through its metadata request interface.

Environmental metadata is disseminated from the *Clarus* system through an output interface of an EM service responsible for exporting the metadata in the format desired by a specific metadata request. Metadata requests are received from environmental service providers and other end-users over the EM request interface. The EM service formats the request in an internal representation and sends it to the EM cache through its metadata request interface. The EM service then receives environmental metadata in the internal format through its metadata input interface.

The configuration/administration service manages system administration access, environmental data retrieval schedules, environmental metadata, and quality rules for the quality checking services. The configuration/administration user interface presents the current state of the *Clarus* system parameters received from the system state interface. The user interface can update the system parameters through the system state update interface.

When the configuration/administration service receives system state update information from that interface it manages its own internal access control lists, sends retrieval parameters to the schedule service through the retrieval parameters interface, or modifies quality rules on the quality checking services through the quality rules interface. Access control lists manage the security groups and users who may administer the *Clarus* system. Retrieval parameters tell the schedule service what collector services to activate and which environmental data collectors and/or contributors from which to request information. The quality rules interface specifies what set of quality checking algorithms to apply under specified environmental data conditions. Consequently, quality checking services are made more robust and flexible.

The schedule service receives environmental retrieval parameters from the configuration/administration service through its retrieval parameters interface. The retrieval parameters are stored internally as trigger times, environmental data host lists, and collector service interface names. When a trigger time is reached, the schedule service determines what collector service is needed to retrieve environmental data and then sends a retrieval command to that particular collector service through its retrieval command interface. The retrieval command contains the lists of environmental collectors and contributors to poll for information.

Every service within the *Clarus* system will have watchdog interfaces. The watchdog service will send regular heartbeat requests to all services. If a service does not respond to the watchdog service within a specified period, the watchdog service will send a restart command to the service.

4.2 Network Viewpoint

The *Clarus* system collects, quality controls, and disseminates environmental data, and collects and disseminates environmental metadata. All of this information must be able to get into the system and also be able to be retrieved from the system. The network viewpoint discusses the communication network needed to support the system functions.

4.2.1 Context and Semantics

The network viewpoint represents the information connections between environmental data detection, collection, aggregation, and distribution. The diagrams in this section do not assume any underlying transport mechanism for communications to occur on the network. For example, TCP/IP and HTTP may be employed from environmental data contributors to the *Clarus* system but direct connections to data collectors may use some other mechanism such as a serial radio link or telephone.

In this section, participants in the *Clarus* program are grouped as logical units with high-level conceptual names that represent a particular interface to information. Environmental data contributors, for example, are not broken down into their constituent network routers, switches, computer servers, and storage arrays as the numbers and configurations of these systems vary by mesonet implementation. As far as the *Clarus* system is concerned, a contributor is simply another source of environmental data.

4.2.2 System Functions

The network viewpoint represents the system functions that move information from one point to another. Figure 6 represents a simplified network of connections between environmental data sources and qualified environmental data used by environmental service providers and other end-users.

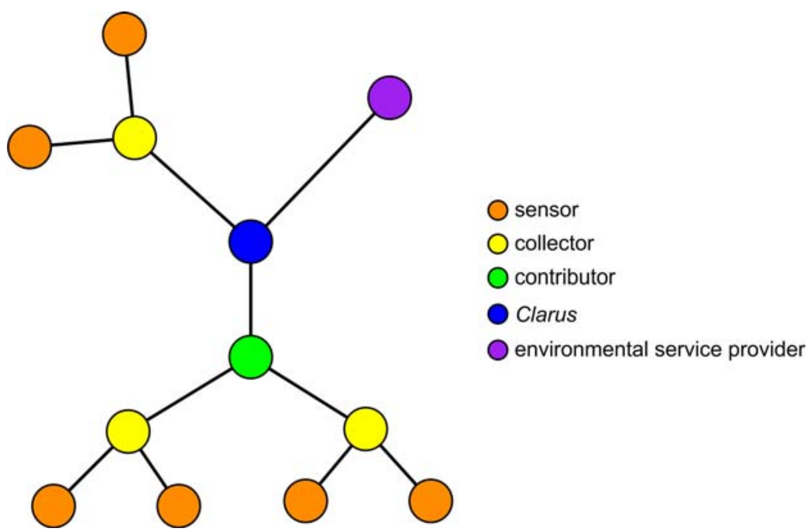

Figure 6 – Possible *Clarus* Communication Connections

Figure 6 is one view of a possible *Clarus* system within a network. That figure contains a pattern that can be repeated into ever larger *Clarus* networks. Figure 7 is an illustration of the *Clarus* system pattern replicated several times into a distributed *Clarus* system.

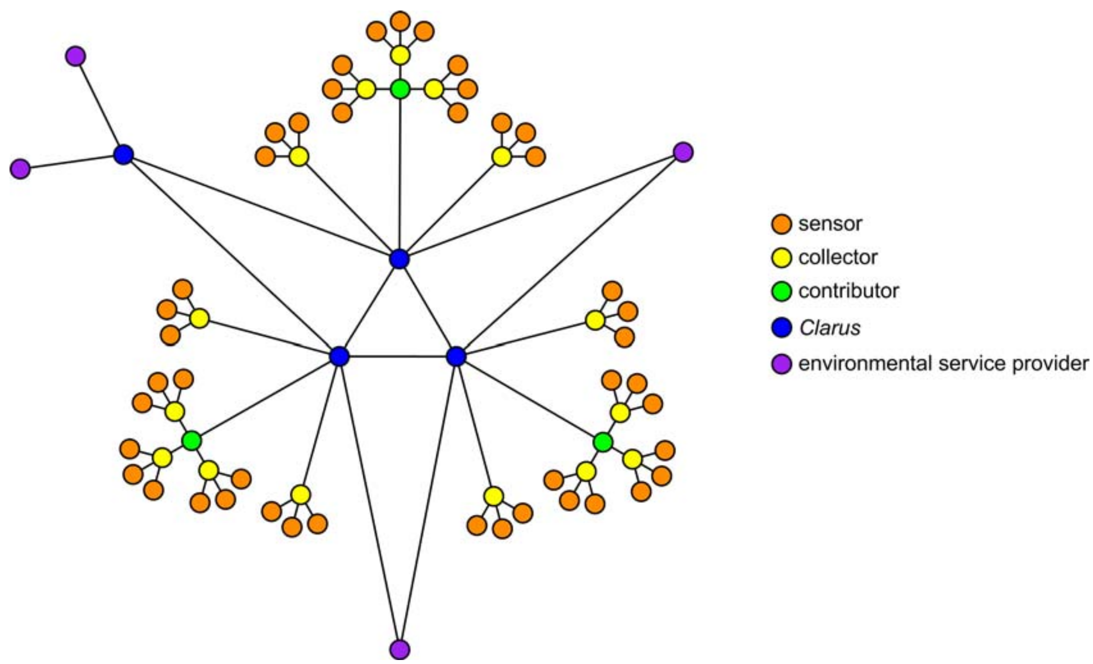

Figure 7 – Distributed Communication Pattern Example

The distributed pattern is enabled by logically switched communication networks such as the Internet that uses TCP/IP. *Clarus* system success will occur when quality and timely environmental information is made available to entities who are interested in such data and who are impacted the most by it.

The environment, especially weather is an area effect. When there is a hurricane in Florida, the same hurricane is not in California. When it is snowing in Washington D.C., it is not likely to be snowing in Tucson. Architecting for a distributed *Clarus* system enhances the time and space usefulness of the qualified environmental data, improves the overall system processing capability, and creates a regionally, nationally, and internationally useful service. A distributed *Clarus* system is captured in the information flows as a *Clarus*-to-*Clarus* interaction.

4.2.3 Interfaces

The interfaces between elements connected to each other through one or more communication networks are discussed here at a conceptual level. National standards that exist for conveying environmental data and metadata will be used. SAE J2354 contains several useful environmental data elements. NTCIP 1204 ESS also applies.

The weather community has developed several data interchange formats over time. Contributors commonly use the most popular interchange formats because code libraries for multiple software development platforms are readily available to read and write them.

Direct communication between the *Clarus* system and environmental data collectors will have the most heterogeneous interfaces. Not all vendors of data logging equipment have implemented standards. When the environmental sensor station assessment is complete, a better understanding of the numbers and types of interfaces required will be obtained and a more detailed design discussion of the alternatives will be provided in the Architectural Alternatives Analysis.

Figure 6 depicts interface elements of participants in the *Clarus* program and their relationship to one another for the purposes of collecting and disseminating environmental data and metadata. Environmental sensors are connected to data collectors so that their electrical values modified by the environmental conditions can be interpreted into some meaningful environmental data. The environmental data is then aggregated by a contributor or directly by the *Clarus* system. The *Clarus* system quality flags the environmental data.

Environmental service providers request qualified environmental data from the *Clarus* system and the *Clarus* system provides the data it has that meets request filter criteria. The *Clarus* system also retrieves and stores environmental metadata from the data collectors and contributors and transmits it to environmental service providers who request it.

Environmental data contributors may be interested in the quality of their data in comparison to other data collected by the *Clarus* system. The contributors may request qualified environmental data in a similar fashion to environmental service providers from the *Clarus* system for quality feedback purposes.

Table 1 documents the origination and destination pairs of information moving across the *Clarus* system interfaces connected to a communications network. Information origins are listed in rows and information destinations are listed as columns.

Table 1 – Network Information Flows

From / To	**Collector**	**Contributor**	***Clarus***	**Service Provider**
Sensor	ED			
Collector		ED	ED	
Contributor			ED, EM, QEDR	
Clarus	EDR	QED, EDR, EMR	EM, QED, EDR, EMR	EM, QED
Service Provider			QEDR, EMR	

Where:

ED – Environmental Data
EDR – Environmental Data Request
EM – Environmental Metadata
EMR – Environmental Metadata Request
QED – Qualified Environmental Data
QEDR – Qualified Environmental Data Request

4.3 Hardware Viewpoint

The hardware viewpoint is the view of the *Clarus* system as it might be supported by a computing infrastructure.

This section is a short discussion of possible hardware configurations. There are a large number of ways in which computing and communication resources can be connected to establish an operating environment for the *Clarus* system. The actual needs and configuration of the *Clarus* system hardware will be determined during the analysis of architectural alternatives phase in Task 3 of this project.

4.3.1 Context and Semantics

The context of the terms used here refers directly to potential physical computing and communication hardware resources. Possible configurations of hardware and their communication connections will be explored as the system design becomes more detailed.

4.3.2 System Functions

From the Operational Concept described in an earlier section, the *Clarus* system will collect, assess the quality of, process, and disseminate environmental data. The system should accommodate infrastructural impacts such as communication and power disruptions within the *Clarus* system. Based on the expected amount of data flowing into and out of the system, high performance is also desired.

It is possible to divide the *Clarus* system into specific processes or services that make up the overall system function. These processes can reside and operate on single servers or clustered servers to add load balancing, failover, and increased performance characteristics. A communication infrastructure will be necessary to receive and transmit environmental data as well as support clustered computational arrangements. Additional information about the distribution of the *Clarus* system will be provided in the Architectural Alternatives Analysis.

4.3.3 Interfaces

From the hardware viewpoint, interfaces that need to be supported are the current standard protocols for logically switched network communications: Ethernet and TCP/IP. *Clarus* system servers will understand standard message transport protocols that operate using TCP/IP such as HTTP and HTTPS. The servers will also understand standard message encoding such as XML for encapsulation of standard message sets.

In a load balancing and clustering failover configuration the hardware will use the load balancing and synchronization mechanisms required by the underlying operating systems. Interfaces and message protocols that support the synchronization of hosting clusters will be employed.

4.4 National ITS Architecture Viewpoint

The Federal Highway Administration issued Part 940 of Chapter 23 of the Code of Federal Regulations (23 CFR 940), its final rule on conformance of ITS systems and projects to the National ITS Architecture and associated standards, in

January 2001. This section of the SAD allocates the components of the *Clarus* system according to the structure and viewpoint of the National ITS Architecture (Ref. 4).

The description of the National ITS Architecture herein is limited to those aspects of the architecture that are specifically related to the use of weather information. Broader and more detailed descriptions of the National ITS Architecture are readily available from the FHWA.

4.4.1 Context and Semantics

System functions in the National ITS Architecture are described in three representations: market packages, a physical architecture (in terms of subsystems, terminators, and equipment packages), and a logical architecture (in terms of processes and the data flows between them). A complete description of these representations and their associated object classes can be found in the referenced National ITS Architecture documentation.

Market packages are collections of functions (the "package") that can be used together to meet a related group of operational needs (the "market"). A market package does not necessarily correspond to a specific product or system. Version 5.0 of the National ITS Architecture describes eighty-five (85) market packages to represent the breadth of capabilities in the overall architecture. Table 2 identifies those market packages that include functionality provided by the *Clarus* system.

Table 2 – Market Packages Managing Weather Information

Market Package	Market Package Name
MC03	Road Weather Data Collection
MC04	Weather Information Processing and Distribution

The description of the system in Section 4 of this document most closely parallels the description of the physical architecture within the National ITS Architecture. Within the physical architecture, *subsystems* are used to describe collections of specific processing functions related to real-world transportation systems. *Terminators* are real-world users of and objects associated with the transportation systems; in the physical architecture, terminators interact with the subsystems, but are "outside the scope of" the transportation system itself.

Equipment packages are components or modules within the subsystems that accomplish a more specific function. In the real world, equipment packages correspond loosely to procurable components or software modules. Within the National ITS Architecture, equipment packages are the services or devices that actually perform the work.

4.4.2 System Functions

In general, weather-related functions play a supporting role in the National ITS Architecture. Weather information is both acquired from external services and generated within the system from Road Weather Information Systems (RWIS), but is provided for a specific transportation management purpose. Weather information is used by stakeholders across the transportation system.

Within the National ITS Architecture, management of weather information is focused within the Maintenance and Construction Management service area. There are, for example, eight (out of ten total) specific market packages within Maintenance and Construction Management that provide or use weather information. Of these, weather information is produced and processed for distribution in only two: Road Weather Data Collection (shown in Figure 8) and Weather Information Processing and Distribution (shown in Figure 9). The *Clarus* system will include provisions for functions found in both of these market packages.

MC03 – Road Weather Data Collection

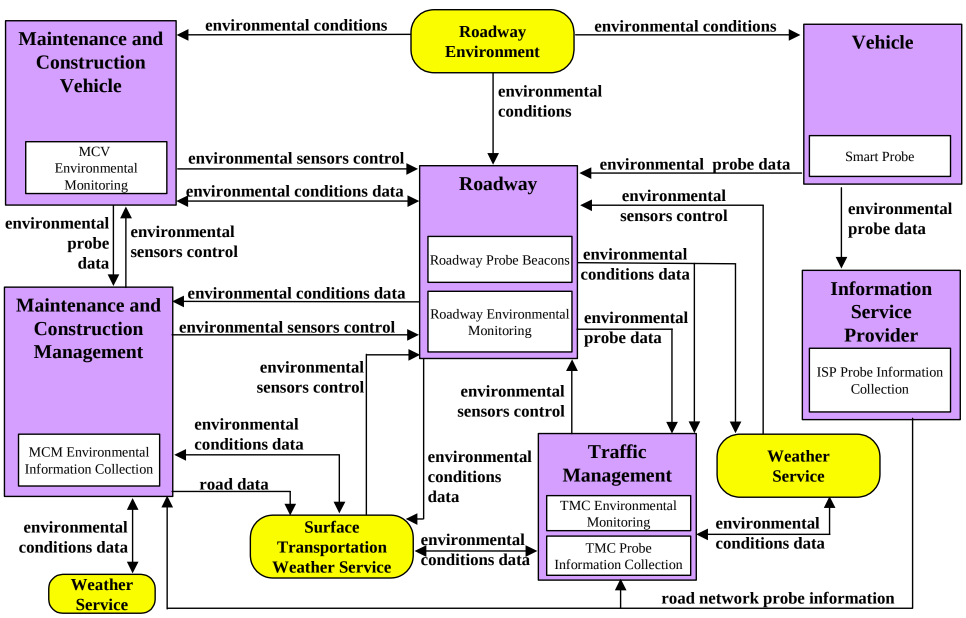

Figure 8 – Road Weather Data Collection Market Package (Ref. 4)

MC04 - Weather Information Processing and Distribution

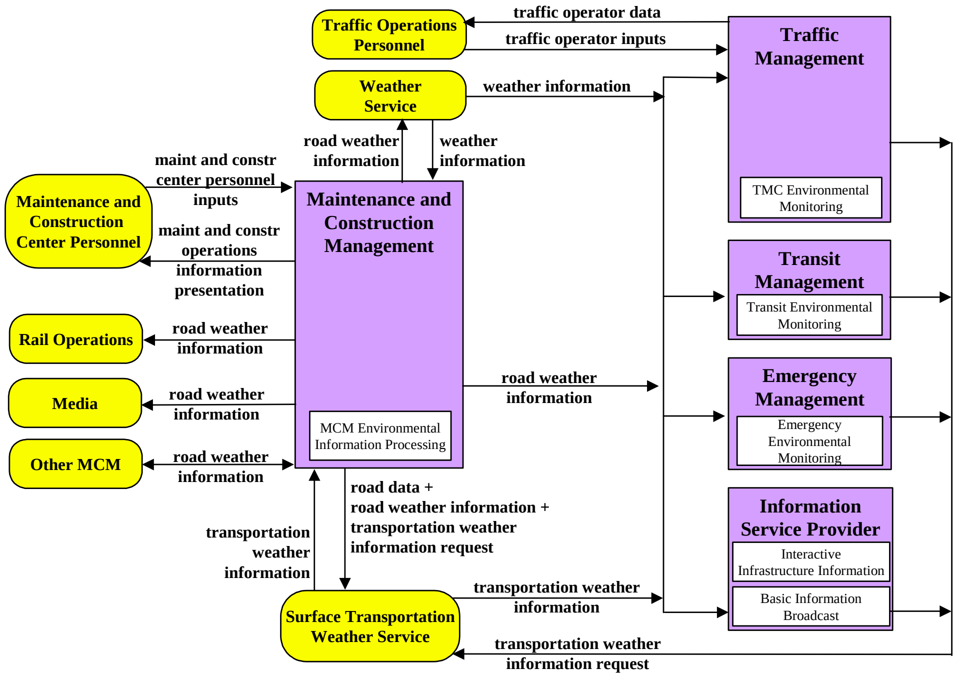

Figure 9 – Weather Information Processing and Distribution Market Package (Ref. 4)

The use of weather information occurs broadly across the transportation system and is explicitly identified in data flows within many of the market packages. These architectural data flows are identified variously as "weather information," "transportation weather information," "environmental conditions data," or "road network conditions," depending on the source and use of data. In many cases, weather information is offered as part of a more comprehensive message describing road and traffic conditions.

4.4.3 Interfaces

Interfaces, interconnects, and information flows for weather-related components of the National ITS Architecture are described in detail in the referenced National ITS Architecture documentation. Interfaces for the proof-of-concept *Clarus* system comply with that architecture.

5 STANDARDS

The usefulness and acceptance of systems depend on how well they implement their intended functions and meet expectations at the system interfaces. Standards are a means of documenting interface expectations for systems without prescribing the functional implementation. This is particularly valuable for systems with diverse user communities and complex information needs. The *Clarus* ConOps observes:

> "The national focus of the *Clarus System* will promote greater unity in the transportation community for data acquisition and integration. This will likely include better acceptance of standards for data exchange in the weather and transportation communities. Adherence to these standards will help to eliminate unnecessary complexities within the *Clarus System*. Until these standards are more widely adopted, the *Clarus System* will also need to communicate with the RWIS databases and/or their individual ESS through application programming interfaces (API) special to those systems. However, a successful *Clarus System* has the potential of fostering a much more rapid adoption of standards within the industry."

To that end, standards that may be applicable to *Clarus* are shown in Table 3. Specific implementations of applicable standards will be described in the detailed system requirements and the design documentation.

Table 3 – Applicable Standards

Standard Name	Relevance	Ref.	Specified in High-Level Requirements?
NTCIP 1204 Environmental Sensor Station Interface Standard	Basis for environmental data definitions throughout *Clarus*	5	H-011; I-011
ITE TM 1.03 Standard for Functional Level Traffic Management Data Dictionary (TMDD)	Governing standard for nomenclature	6	H-012
ITE TM 2.01 Standard for Message Sets for External Traffic Management Center Communication (MS/ETMCC)	Potential governing standard for message sets	7	No
NTCIP 1301 Weather Report Message Set for ESS	Development currently suspended; concept being evaluated relative to MS/ETMCC	n/a	No
NTCIP 1602 Generic Reference Model for Traffic Management	Similar to NTCIP 1301, development currently suspended pending review against MS/ETMCC	n/a	No

NTCIP 2304 Application Profile for DATEX-ASN	Reference document for DATEX-based message encoding rules	8	No
SAE J2354 Advanced Traveler Information Systems (ATIS) Message Sets	Overlaps MS/ETMCC; environmental data included in larger package of traveler information	9	No
NTCIP 2306 Application Profile for XML in ITS	Describes XML-based message encoding rules	10	No
Canadian Meteorological Markup Language (CMML)	Supplements environmental data descriptions in NTCIP 1204	11	No
CAP XML Common Alerting Protocol 1.0	Describes messaging for NWS watches, warnings, and advisories	12	No

APPENDIX A -DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

The following table provides definitions of terms, acronyms, and abbreviations to assist interpretation of this document. *The IEEE Standard Dictionary of Electrical and Electronics Terms* [B2], IEEE Standard 610.12-1990, or IEEE/EIA Standard 12207.0-1996 may be referenced for terms not defined here.

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
Acquirer	An organization that procures a system, software product, or software service from a supplier. (The acquirer could be a buyer, customer, owner, user, or purchaser.)
AMS	American Meteorological Society
API	Application programming interface. A well-defined set of functions commonly used by software to interface with libraries of reusable algorithms.
Architect	The person, team, or organization responsible for systems architecture.
Architecting	The activities of defining, documenting, maintaining, improving, and certifying proper implementation of an architecture.
Architectural Description (AD)	A collection of products to document an architecture.
Architecture	The fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution.
ASN	Abstract Syntax Notation
ASOS	Automated Surface Observing System
ATIS	Advanced Traveler Information Systems. A description for a group of interoperable services that enable dynamic management of transportation infrastructure and related activities. The project scope of the ATIS committee is to develop a minimum set of medium-independent messages and data elements needed by potential information service providers to deploy ATIS services, and provide the basis for future interoperability of ATIS devices.
CAP	Common Alerting Protocol. An open, non-proprietary standard data interchange XML format that can be used to collect all types of hazard warnings and reports locally, regionally and nationally, for input into a wide range of information-management and warning dissemination systems.
CCTV	Closed Circuit Television
Clarus	The *Clarus* system. An environmental data sharing system that collects, evaluates, and disseminates environmental data gathered from a geographically diverse set of environmental sensors.
CMML	Canadian Meteorological Markup Llanguage.
Collector	An electronic device used to convert environmental sensor electrical signals into environmental condition measured values and store them for retrieval.
ConOps	Concept of Operations

Term	**Definition**
Contributor	A managing agency or organization that owns and/or operates a set of environmental sensor collectors.
CSI	Cambridge Systematics, Inc.
DATEX	Data Exchange. A European standard effort for center-to-center data exchange.
DMS	Dynamic Message Sign
DOT	Department of Transportation
DSS	Decision Support System
ED	Environmental Ddata. This data has not been processed by any quality checking algorithms.
EDR	An Environmental Data Request sent to retrieve available environmental sensor information.
EM	Environmental Mmetadata. Information about an environmental sensor station.
EMR	Environmental Metadata Rrequest. A data request sent to retrieve information about environmental sensing stations.
ESS	Environmental Sensor Station
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration (U.S. DOT)
GRIB2	Gridded Binary data format, Edition 2. An information format used to transmit grid-based weather forecasts from contributing offices to the NDFD and also one of the primary forms used to transmit the NDFD grids to weather information customers and partners
HAR	Highway Advisory Radio
Heartbeat requests	A synchronous communication exchange used by a simple, continuously running (watchdog) process to verify at regular intervals that another process is still operating. The watchdog process will stop and restart an apparently non-responsive process.
Host Lists	A set of IP addresses or URLs that can be queried for environmental data.
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol. A communication standard for transmitting and receiving documents and other types of data over the Internet.
HTTPS	Secure Hyper Text Transfer Protocol.
ICC	(*Clarus*) Initiative Coordinating Committee
IEEE	Institute of Electrical and Electronics Engineers
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

Term	Definition
ITS America	Intelligent Transportation Society of America
Life Cycle Model	A framework containing the processes, activities, and tasks involved in the development, operation, and maintenance of a software product, which spans the life of the system from the definition of its requirements to the termination of its use.
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.
MS/ETMCC	Message Set for External Traffic Management Center Communication.
NASA	National Aeronautics and Space Administration
NDFD	National Digital Forecast Database. A database supported by the National Weather Service that contains gridded forecasts of several ground-based weather elements such as temperature, humidity, and chance of precipitation.
NHI	National Highway Institute
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration. United States National Oceanic and Atmospheric Administration. A governmental administrative body responsible for managing programs and resources for weather and oceanographic science.
NSWOS	National Surface Weather Observing System
NTCIP	National Transportation Communications for ITS Protocol
NWS	National Weather Service
OCS	Oklahoma Climatological ServiceSurvey
OMB	Office of Management and Budget
PDA	Personal Digital Assistant
PMP	Project Management Plan
Pull	A synchronous communication pattern where a request is sent to an information source and a response is generated before the communication session ends. Internet web browsing is an example of the pull communication pattern where web servers respond to URL queries.
Push	An asynchronous communication pattern that sends information to a recipient based on previously established rules used to initiate the transaction. Email is an example of this pattern. SPAM is an extreme case where the initiation rules are simply the existence of someone's email address.
QC	Quality Checking.

Term	Definition
QED	Qualified Environmental Data. Environmental data that has been evaluated by quality checking algorithms and contains a quality assessment flag.
QEDR	Qualified Environmental Data Request. A data request from environmental service providers and contributors to retrieve qualified environmental data from *Clarus* for value-added product delivery and quality feedback purposes.
RWIS	Road Weather Information System. Road Weather Information System. A unique system consisting of many meteorological stations strategically located alongside highways that allow the state Departments of Transportation to make more informed decisions during storms. Specialized equipment and computer programs monitor air and pavement temperature to make forecasts regarding how the weather impacts the operation and maintenance of the highways.
SAE	Society of Automotive Engineers. A group of engineers, business executives, educators, and students from more than 97 countries who share information and exchange ideas for advancing the engineering of mobility systems.
SEP	System(s) Engineering Process
STWDSR	Surface Transportation Weather Decision Support Requirements
STWSP	Surface Transportation Weather Service Provider
Subscription	A persistent set of rules that define an information query used in asynchronous communication patterns. The rules consist of a query, the event or events used to initiate an information exchange, and a list of locations. When the defined event or events occur, the query is executed and the results are sent to the specified locations. The information exchange in response to a subscription is often referred to as publishing.
System	A collection of components organized to accomplish a specific function or set of functions.
System Architectural Description (SAD)	A collection of products to document a system's architecture.
TBD	To Be Determined
TCP/IP	Transmission Control Protocol/Internet Protocol.
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary.
TOC	Traffic Operations Center
TRB	Transportation Research Board
Trigger Times	A one-time or recurring schedule that initiates an action based on a real-time clock. Trigger times are used by automated systems to execute pre-determined processes.
UML	Unified Modeling Language
U.S. DOT	United States Department of Transportation
UTC	Universal Time Code
View	A representation of a whole system from the perspective of a related set of concerns.

Term	Definition
Viewpoint	A specification of the conventions for constructing and using a view. A pattern or template from which to develop individual views by establishing the purposes and audience for a view and the techniques for its creation and analysis.
VII	Vehicle Infrastructure Integration
VSL	Variable Speed Limit
WIST	Weather Information for Surface Transportation
WRS	Weather Response System. A regionally-based service that electronically collects and processes weather forecast information into a coherent presentation for the purposes of traffic management and roadway maintenance.
XML	eXtensible Markup Language. A flexible text markup language used to create standard information formats that share both the format and the information to enable the interchange of structured data.