A Primer on Concept of Operations Development

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1 Introduction

This document sets the context on how the concept of operations begins the systems engineering process. It defines the content and benefits of the concept of operations. This document serves to frame the discussion regarding the groundbreaking Clarus system and how all the stakeholders will be included.

2 Systems Engineering Process

The Concept of Operations is one of the initial stages in a system life cycle based on the Vee diagram widely used in the NHI Systems Engineering course (see Figure 1).

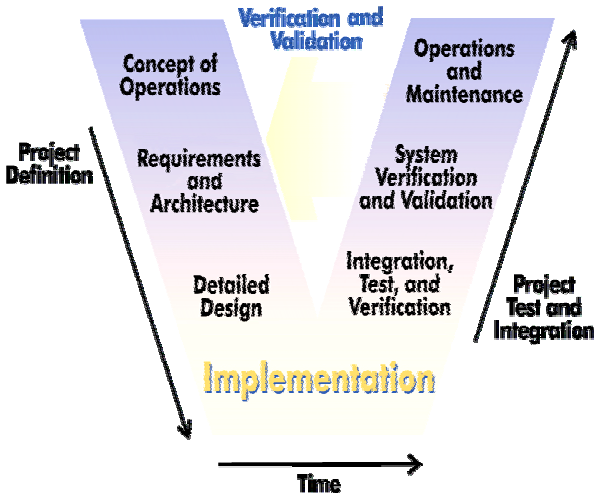

Figure 1. Systems Engineering Process

The Systems Engineering Process (SEP) provides a path for improving the cost effectiveness of complex systems as experienced by the system owner over the entire life of the system, from conception to retirement. It involves early and comprehensive identification of goals and a concept of operations that describes user needs and the operating environment, thorough and testable system requirements, detailed design, implementation, rigorous acceptance testing of the implemented system to ensure it meets the stated requirements (system verification), measuring its effectiveness in addressing goals (system validation), on-going operation and maintenance, system upgrades over time, and eventual retirement. The process emphasizes requirements-driven design and testing. All design elements and acceptance tests must be traceable to one or more system requirements and every requirement must be addressed by at least one design element and acceptance test. Such rigor ensures nothing is done unnecessarily and everything that is necessary is accomplished.

3 Concept of Operations

The Concept of Operations sets the stage for the development of the requirements, by defining the setting within which the system must operate. The Clarus Concept of Operations is a high level overview that will address three categories:

1. The system's fit into the agency's responsibilities,
2. The physical infrastructure, and
3. Expectations on how the system will work.

The Concept of Operations will define at a high level how the system works as well as all interfacing systems and people. The concept of operations will feature UML (Unified Modeling Language) use cases to show the visual connections and attributes among the pieces of the Clarus system and its external interfacing entities.

The Concept of Operations will result from review and research of the relationships within the system, between the system and the various agencies and stakeholders, the expectations for the system, and the physical environment in which the system operates. The Clarus Concept of Operations will support the design and establishment of a portal that allows access to:

1) Weather data relevant to the roadway,
2) Spatial databases of relevant road characteristics including pavement or concrete composition, road surface depth, and underlying soil type,
3) Real-time road surface condition information and
4) Traffic information accessible under the operational conditions and requirements identified from the data use stakeholders.

The overall objectives of the concept of operations include:

- Reference to the operational characteristics that the system needs to fulfill. It is not a reference to the functions of the system or its hardware and displays.
- Understanding of goals by encouraging an open discussion among stakeholders.
- A long-range view of the Clarus system's capabilities. This will serve as the basis for planning future enhancements.
- A mission for the system that is aligned with the missions of the stakeholder organizations.

3.1 System Environment

The data collected by the Clarus system represents three separate venues. Each venue plays various roles in the end uses of the data. Figure 2 is a Venn diagram of the Clarus database environment illustrating the overlap of three venues of input forming the core of the database, which is shown inside the dashed line. The database is populated automatically with weather, road, rail, and traffic observations. The roadway structure database is maintained manually by the agency operating or maintaining the route system.

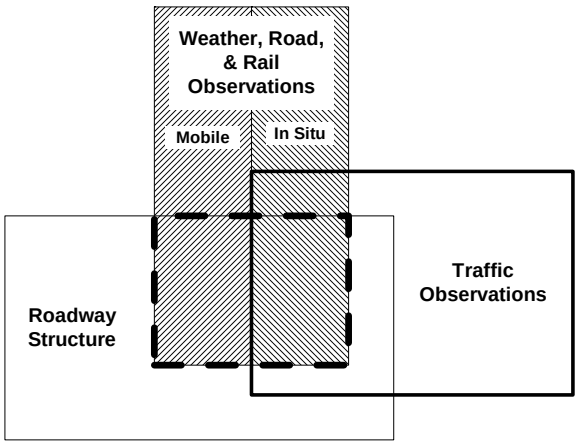

Figure 2. Venn diagram of Clarus database environment.

Roadway structure characteristics are important for the modeling and forecasting of current and future road surface conditions. The relational structure of this database must be flexible enough to accommodate slight variations of agency recording conventions, future standardization, and model initialization requirements.

Providing real time data and avoiding any latency in developing this information is a primary operational goal of the Clarus. Another goal is to ensure the data are accurate to the margin within which quality assurance measures can be statistically applied. One of the key steps in the development of a Concept of Operations is the establishment of a nationally accepted definition of what constitutes latent and less or non-valuable data at each tier of data user.

3.2 System Robustness

The primary considerations that need to be addressed from an information technology perspective for success of the Clarus system are **volume of data, timeliness of information, and reliability** of the system.

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, and process the data. The Clarus should be a data collection system capable of handling a vast range of data and in a flexible manner that permits new data types to be added.

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.

Timeliness of information and reliability of the system are the other critical factors of this system. To address the timeliness factor, the system should be architected such that it can both retrieve and disseminate large volumes of data from copious sources and at potentially high rates. The ability of the system to spread its data collection and dissemination processes across multiple servers and communication channels will address this issue. The inherent scalability of such a design will also enable the system to expand and new data sources and end-users to be added.

Reliability is achieved through a variety of design and deployment considerations. Choice of hardware, operating systems, and development environment has impacts on the inherent reliability of the system. To maximize system uptime redundancies can be built into the system at both the hardware and software levels.

3.3 Issues Involved in Developing the Clarus Concept of Operations

The development of the Concept of Operations will involve working hand-in-hand with U.S. DOT staff and various potential users including public-public and/or public-private partnerships of Clarus. In describing the operations of Clarus, the Concept of Operations must address the issues of:

- Deployment,
- Practices and Procedures,
- Performance,
- Utilization,
- Effectiveness,
- Life cycle and
- Environment.

The successful deployment of Clarus requires extensive buy-in from the data providers and data users.

The Clarus Concept of Operations, must address the following questions:

- Where will the system be used?
- What jurisdictions will use it?
- What geographic area will it cover?
- How will the system be used?
- What functions will the system be capable of performing?
- What system functions take priority over others?
- What performance expectations are there?
- Under what conditions will users interact with the system?
- What measures can be defined now to evaluate the post-deployment system?

The general answers to these questions are discussed below; however the key point is that the Clarus must be flexible in its conceptualization, requirements, design and implementation to serve a myriad of users

with unique needs. It is envisioned that a properly configured and administered Clarus can and will serve a very large and diverse user population. Reliable surface transportation weather data in greater density will facilitate increased reliance and improved efficiencies in a number of transportation and non-transportation related industries across the nation.

While Clarus' primary focus will be the facilitation of safer travel, it will also provide improved information for state-to-state highway maintenance activities, travelers, short- and long-haul trucking, rail, transit, power production facilitates, event planning, construction, educational systems and others whom will come to rely on the higher resolution information for decision making. For these reasons, Clarus should provide **multiple methods of access**, query devices and methods to facilitate data extraction.

The **geographical boundaries should be definable by the user**, whether it is local, regional, statewide, multi-state, a multi-jurisdictional region or national. Tracking weather events across a multi-state region without regard for political boundaries affords both maintainers and users the ability to take a proactive approach to both their safety and travel time concerns.

For Clarus to become a reliable source of data, **performance measures must be tracked** and system functionality must be maintained at a very high level. System tracking of data flows, equipment status, access records and quality of data will require processes to monitor and evaluate overall system performance. These and other metrics can provide information necessary to predict system upgrades and required maintenance, increased national, regional, and state focus of resources, necessary changes in database configurations, or locations that require increased emphasis of surface transportation weather data collection resources within the system.

Examples of use by transportation sector stakeholders will highlight the importance of the above requirements. While accessing their own RWIS systems and other weather reporting sites within their state or district, a jurisdiction requires immediate access to adjoining systems in the next political subdivision to assist planning needs for personnel and materials for an approaching weather related event. This event requires access to real-time data from all available weather reporting locales.

To facilitate similar activities for differing industries, (such as regional short- or long-haul companies, power companies, etc.) regional overlapping of real-time data processes must be available to the user. The data provision must allow for rapid update within effected regions to facilitate user access, while maintaining data delivery to archival systems for future use within research, training, and policy development by local, regional, state and federal agencies.

To ensure quality user and system access, Clarus must be viewed as a surface transportation weather information portal behind which is an efficient interlocked system of equipment, telecommunications, power, database management, operations and maintenance. Metrics designed to identify the location and extent of problems will be required to minimize manpower in the detection and reduction of the overall effects of problems encountered to both the entire system and the community of users.

3.4 Audience of the Clarus Concept of Operations

A concept of operations is useful to many audiences and will constitute a broad range of stakeholders important to the concept of operations development:

- **Owners:** Facilitate understanding of objectives and form a basis for system acceptance criteria
- **Users/operators/maintainers:** Technical attributes related to human-machine interfaces, interactions among systems, sequences, functions, etc.
- **System engineers and architects:** Establish system context particularly as it relates to interfaces
- **System implementers:** Insight into the role of the system within the overall environment
- **Testers:** Understand operational philosophies to ensure proper test focus; Understand operational attributes of external interfaces to ensure their thorough testing
- **Managers:** Understand and agree to system objectives; Understand role of system in overall regional integration/strategic plan; Use Concept of Operations to manage expectations for everyone, particularly users and managers/decision makers/executives.

3.5 Benefits of Developing the Clarus Concept of Operations

Development of a concept of operations realizes these benefits:

- Ensures that users and supporters have same understanding – By writing a description of operations, misunderstandings should be minimized. Expectations can also be managed.
- Conditions for use are clearly defined – A written description will clarify who may use the system(s) and the associated information/data under what conditions.
- Describes the operational needs of users (and other stakeholders) without getting bogged down in the technical issues that belong in other systems analysis activities.
- Documents the operational needs and the proposed characteristics of the system such that the user can verify these without needing any more technical knowledge than that required to perform normal job functions.
- It is a place where the users can state what they'd like to see in the system without having to provide testable, quantified requirements.
- It lets the users state their needs in broad terms, e.g., "highly reliable" as opposed to a measurable value for reliability.

4 How will the Stakeholders be Involved in the Development of the Clarus Concept of Operations?

Clarus stakeholders play an important role in the development of the concept of operations. Their participation in the development of the concept of operations offers the stakeholders the opportunity to provide input into the Clarus system based on their previous experience with weather-related information activities. Stakeholders' participation could be in, but is not limited to, the following areas:

- Defining Clarus goals and objectives.
- Validating user needs
- Identifying technical and institutional issues
- Developing alternative concepts and solutions
- Developing alternative project architectures
- Consensus building