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Core System Concept of Operations (ConOps)

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This document describes the Concept of Operations (ConOps) of the Core System for the United States Department of Transportation's (USDOT) next generation integrated transportation system. It includes a list of Needs for the Core System, a description of the Core system's 8 subsystems and their high level relationships, and a set of operational scenarios.

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1.0 SCOPE

1.1 Identification

This document describes the Concept of Operations (ConOps) of the Core System for the United States Department of Transportation's (USDOT) next generation integrated transportation system.

The Vehicle Infrastructure Integration (VII) program provided much of the research that led to this next generation system. The economic and technology climates have changed significantly since the VII program however; as a result much of what may have been considered viable during that program is no longer practical. For further information about VII's vision, please reference the VII Concept of Operations.

1.2 Document Overview

The USDOT initiated this Systems Engineering (SE) project to define the ConOps, requirements, and architecture for a system that will enable safety, mobility, and environmental applications in an environment where vehicles and personal mobile devices are connected wirelessly, hereafter referred to as the *connected vehicle* environment. This ConOps is a user-oriented document describing characteristics of a to-be-delivered system from the user's viewpoint. It includes a detailed description of how an operational concept is applied, with corresponding interactions and information flows between system elements and actors. It identifies the functions carried out by the system, users that interact with the system, their roles and responsibilities.

Figure 1-1 shows the process used for developing the Core System ConOps. This process began with the identification, analysis and documentation of user needs based on input collected and solicited from a wide variety of sources. Inputs to the ConOps activities include:

- Public stakeholder workshops
- One-on-one meetings with USDOT stakeholder representatives
- Project goals and objectives identified in the SE contract
- Interviews with VII program participants including members of the Crash Avoidance Metrics Partnership (CAMP), Vehicle Infrastructure Integration Consortium (VIIC) and the Booz Allen Hamilton (BAH) team
- Documents from the VII program, research, and international activities (see Section 2.0)

Research conducted under the VII program provides the basis for much of what has become the Core System. VII concepts such as probe data generation and collection, publish-subscribe and the 5.9 GHz Dedicated Short-Range Communication (DSRC) communications architecture provide much of the foundation for the Core System.

Figure 1-1 is an example of a type of figure used extensively in the ConOps to document processes. This style of figure comes from the International Council on Systems Engineering (INCOSE) *Systems Engineering Handbook V3.1*. It defines the actions of the actor in question (in this case the ConOps developers) in the center box. The inputs box represents the interactions and inputs of stakeholder workshops, one-on-one meetings, meetings with CAMP, VIIC and BAH. Enablers are those items that help achieve or influence an outcome. The outputs of the ConOps development process are captured in this ConOps document, most importantly by the needs defined in Section 4.0. These needs provide the foundation for traceability to the system requirements to be defined in the System Requirements Specification (SysRS).

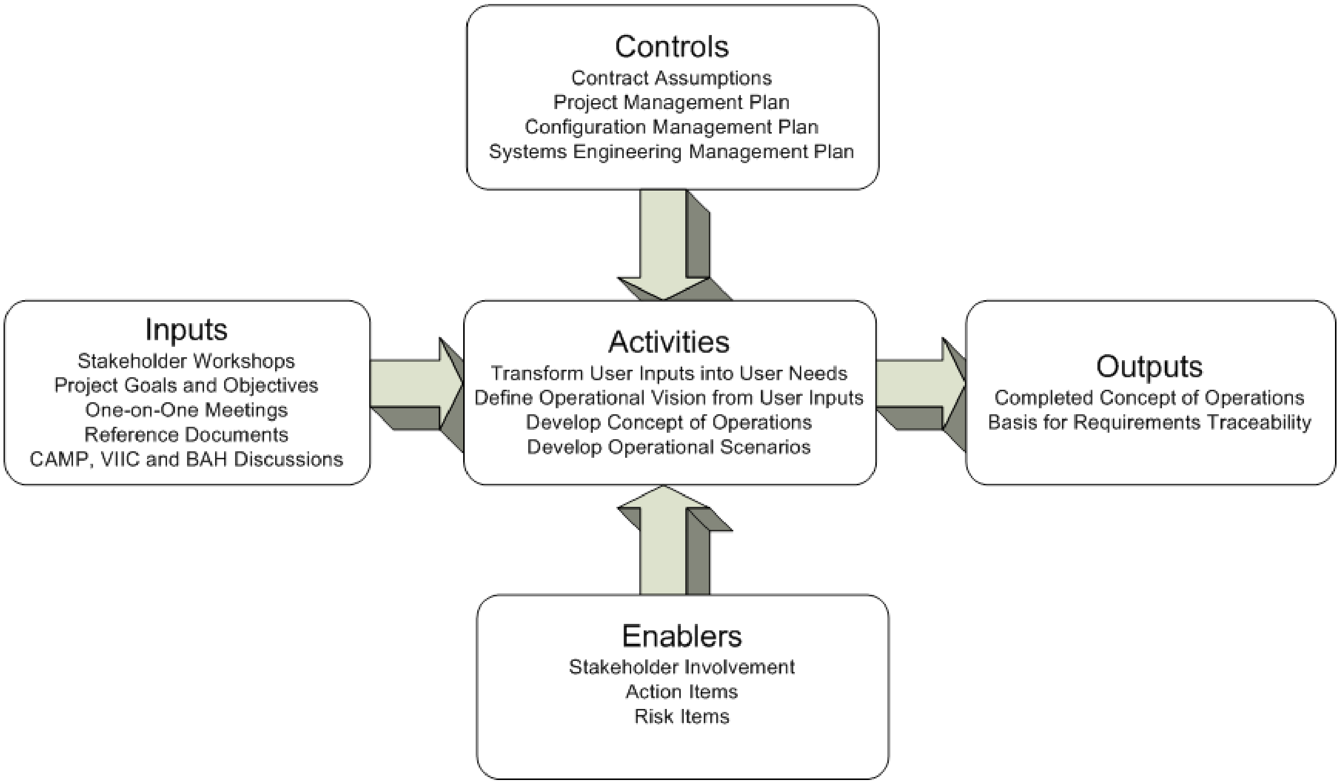

Figure 1-1: Core System ConOps Development Process

The Core System ConOps further reflects:

- Changes in assumptions and constraints identified by the USDOT and other key stakeholders
- Lessons learned and source material from the Cooperative Intelligent Transport System efforts from both Europe and Asia
- Customer (user) needs from which requirements can be developed

The structure of this ConOps document is based on Institute of Electrical and Electronics Engineers (IEEE) Standard 1362-1998 IEEE Guide for Information Technology, System Definition, Concept of Operations (ConOps) Document. The ConOps document consists of the following sections:

- Section 1.0 provides an overview of the Core System and an introduction to this ConOps document.
- Section 2.0 lists the documents used as background information or as a source of user needs. Many of these documents are artifacts from the VII program.
- Section 3.0 provides an overview of the current system. This is used as the basis for analyzing the needs and capabilities to be considered in the revised system.
- Section 4.0 discusses the Core System needs and the process followed to identify and define them.
- Section 5.0 describes the proposed Core System including its scope, operational environment, operational policies and constraints, major system services, interfaces to external systems and subsystems.

- Section 6.0 provides a set of scenarios developed to illustrate the Core System's support for the needs defined in Section 4.0. Each scenario includes a brief textual description of what the scenario discusses. Then a context diagram is presented, describing the inputs, enablers and controls that feed into the Core system, and what outputs are produced. Last, one or more activity diagrams describe the interactions between users and core subsystems.
- Section 7.0 provides a summary of the operational, organizational and developmental impacts of the proposed Core System.
- Section 8.0 discusses the improvements provided by the proposed system, its disadvantages and limitations, and any alternatives or trade-offs considered.
- Section 9.0 contains an alphabetical listing of acronyms used in this document.
- Section 10.0 consists of several appendices including a list of participants in each of the five stakeholder workshops, attendees at each of the one-on-one meetings, and the stakeholder input table.
- Section 11.0 contains a Glossary of terms in this document.

Within these sections, the Core System is discussed in terms of the environment within which it will operate, the services it provides, and the high-level design it supports. This foundation allows for the definition of requirements and system architecture that support the vision set forth in this ConOps. It provides the system boundaries and documents an understanding of the needs of the stakeholders who will participate in and benefit from its operation.

The intended audience for this ConOps includes: USDOT, transportation managers (including state and local DOTs), vehicle manufacturers, information service providers, fleet managers, commercial vehicle operators and regulators, application developers, and potential Core System acquirers, deployers, operators, and maintainers.

1.3 System Overview

The USDOT's *connected vehicle* program envisions the combination of applications, services and systems necessary to provide the safety, mobility and environmental benefits through the exchange of data between mobile and fixed transportation users. It consists of the following:

- **Applications** that provide functionality to realize safety, mobility and environmental benefits,
- **Communications** that facilitate data exchange,
- **Core Systems**, which provide the functionality needed to enable data exchange between and among mobile and fixed transportation users, and
- **Support Systems,** including security credentials certificate and registration authorities that allow devices and systems to establish trust relationships.

The Core System's main mission is to enable safety, mobility and environmental communications-based applications for both mobile and non-mobile users. The scope of the Core System includes those enabling technologies and services that will provide the foundation for application transactions. The Core System works in conjunction with External Support Systems like the Certificate Authority for Dedicated Short Range Communications (DSRC) security, as defined in IEEE Standard 1609.2. The system boundary for the Core System is not defined in terms of devices or agencies or vendors but by the open, standardized interface specifications that govern the behavior of all interactions between Core System Users.

The Core System supports a distributed, diverse set of applications. These applications use both wireless and wireline communications to provide:

- Wireless communications with and between mobile elements including vehicles (of all types), pedestrians, cyclists, and other transportation users
- Wireless communications between mobile elements and field infrastructure
- Wireless and wireline communications between mobile elements, field infrastructure, and back office/centers (Note: The terms "back office" and "center" are used interchangeably throughout this document. Center is a traditionally transportation-focused term, evoking management centers to support transportation needs, while back office generally refers to commercial applications. From the perspective of the Core System these are considered the same.)

The Federal Communications Commission (FCC) allocated 75 Megahertz (MHz) of spectrum in the 5.9 Gigahertz (GHz) frequency range for the primary purpose of improving transportation safety. In addition to safety of life and public safety applications, the FCC's Final Report and Order also allowed private and non-safety applications to make use of the spectrum on a lower priority basis. This allowed the VII program and associated research efforts to test the capabilities of 5.9 GHz DSRC for vehicular-based safety and mobility applications.

VII considered that some safety and mobility applications would be installed on all participating vehicles. Some safety applications would have been mandated to be installed on participating vehicles. Non-safety or mobility applications would have been installed on an opt-in basis however. The work following VII retains those possibilities that some applications may be mandated for safety while others would be optional.

A critical factor driving the conceptual view of the Core System and the entire *connected vehicle* environment is the level of trustworthiness between communicating parties. A complicating factor is the need to maintain the privacy of participants, though not necessarily exclusively through anonymous communication. The Core System is planning anonymity into the trusted exchange of data, using the existing Privacy Principles (see the VII Privacy Policies Framework v1.0.2) as guidelines, and balancing privacy against security and safety.

While the Core System is being planned for anonymity, it is also providing a foundation from which to leverage alternative communications methods for non-safety applications. These alternatives are typically available on the market today; however, the levels of anonymity and privacy inherent to these systems are typically governed by agreements between communication providers and consumers. So while privacy is not compromised for an individual, what happens between that individual and their communication provider (e.g., 3G service provider) very well may compromise privacy. Some application providers may require personal information in order to function which would require the application user to opt-in to use that application.

VII was conceived as a nationally deployed and managed system but the current thinking is that the *connected vehicle* program will likely include locally and regionally oriented deployments and it must be able to grow organically to support the changing needs of its user base. Deployments will likely be managed regionally but follow national standards to ensure that the essential capabilities are compatible no matter where the deployments are established.

Within the *connected vehicle* environment the Core System concept distinguishes communications mechanisms from data exchange and from the services needed to facilitate the data exchange. The functions and their relationship to each other are further defined in Section 4.0.The Core System supports the *connected vehicle* environment by being responsible for providing the services needed to facilitate the data exchanges. The contents of the data exchange are determined by applications unless the data exchange is used as part of the facilitation process between the user and the Core.

The Core System provides the functionality required to support safety, mobility and environmental applications. This same functionality may enable commercial applications but that is not a driving factor. The primary function of the Core System is the facilitation of communications between System Users and some of the communications must also be secure. The Core may also provide data distribution and network support services depending on the needs of the Core deployment. Section 5.0 describes the Core System in more depth and with more detail.

The Core System exists in an environment where it facilitates interactions between vehicles, field infrastructure and backoffice users, as illustrated in Figure 1-2.

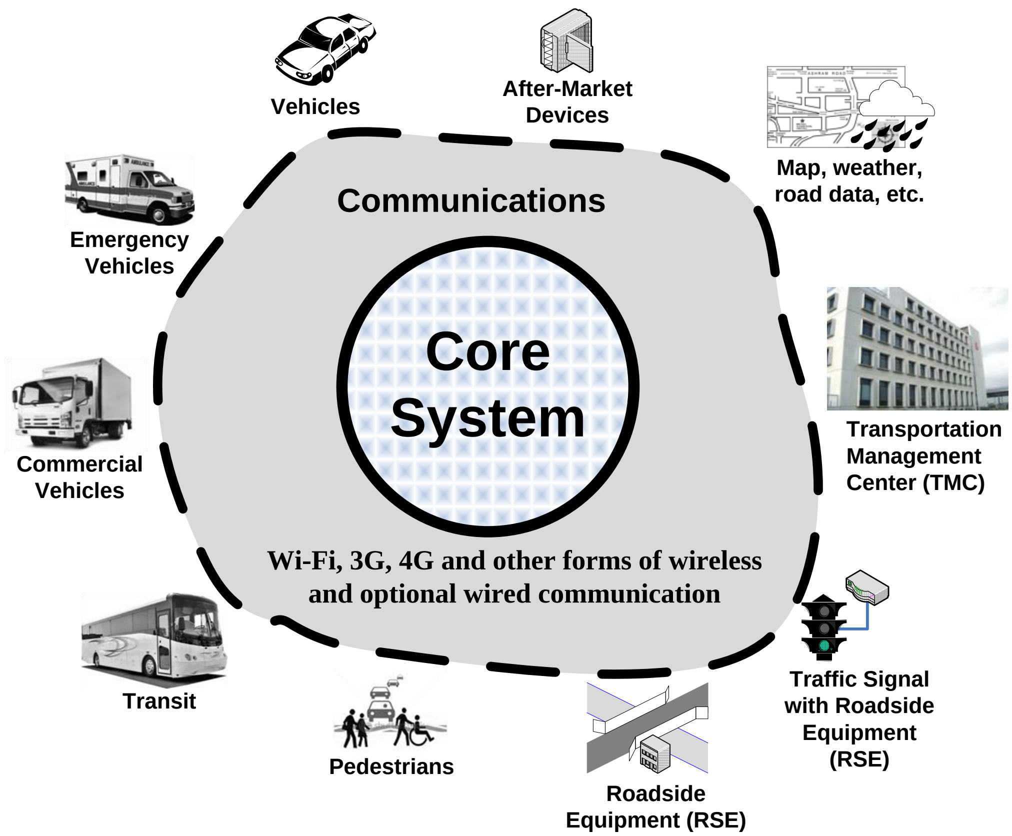

Figure 1-2: Core System Boundary Diagram

In Figure 1-2 above, the users, their devices, and software applications are outside of the Core System; the Core is still responsible for facilitating their security; this is chiefly done by providing digital certificate-based mechanisms to ensure trust between users. The Core also provides networking services to facilitate communications, though it does not comprise the communications network. Readers who are familiar with VII should note that the following are not part of the Core System:

- Mobile Users (e.g., vehicle devices, pedestrian smartphones) – any user device
- Roadside Equipment (RSE) – both public and commercial fixed devices
- Transportation Management Centers (TMC) and other public or private backoffice or centers

It is also important to note that the Core System is not meant to mandate or change existing transportation equipment, technology or transportation centers. The Core System provides mechanisms for efficiently collecting and distributing transportation data, but does not necessarily replace existing systems, though it is likely that many existing data collection mechanisms will be made obsolete by its data collection and distribution function.

1.4 Stakeholders

Core System stakeholders span the breadth of the transportation environment, including users, operators, deployers and maintainers of roads, devices and vehicles. Core System stakeholders include:

- Transportation Users, e.g., private vehicle drivers, public safety vehicle operators, transit vehicle operators, commercial vehicle operators, passengers, cyclists and pedestrians
- Transportation Operators, e.g. traffic managers, transit managers, fleet managers, toll operators, road maintenance and construction
- Public Safety, e.g. incident and emergency management, including fire, police and medical support
- Information Service Providers, e.g. data and information providers for transportation-related data, including traffic, weather and convenience applications
- Environmental Managers, including emissions and air quality monitors
- Original Equipment vehicle Manufacturers (OEMs)
- In-vehicle device manufacturers
- In-vehicle, personal handheld, roadside and backoffice application developers
- Communications Providers, including cellular network operators
- Federal regulatory and research agencies under the umbrella of USDOT or another government entity like the FCC
- Policy setting entities may include federal, state, and local level transportation agencies as well as standards development organizations and perhaps a consortium of public and private sector entities overseeing the development, deployment, and operation of a Core System.

2.0 DOCUMENTS

This section is divided into two portions. The first section lists the documents that are explicitly referenced as part of this document. The second section lists the documents or other resources that were used for background information and as a source for potential user needs during the development of this ConOps though there may not be a direct reference.

2.1 Referenced Documents

- Core System System Architecture Document (SAD), Sept 6 2011
- Core System System Requirements Specification (SyRS), Sept 06 2011
- IEEE Std. 1362 – IEEE Guide for Information Technology, System Definition, Concept of Operations (ConOps) Document, 22 Dec 1998
- IEEE 1609.4 Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-Channel Operations, Oct 2006
- INCOSE Systems Engineering Handbook version 3.1, August 2007
- Information technology—Open Systems Interconnection—Basic Reference Model: The Basic Model, ITU-T Recommendation X.200, ISO/IEC 7498-1:1994
- Vehicle Infrastructure Integration (VII) USDOT Day-1 Use Case Descriptions, v1.0, May 2006
- Vehicle Infrastructure Integration Consortium (VIIC) Standards Recommendations, VIIC Document SYS090-05, May 23, 2010
- VII Concept of Operations (ConOps), BAH, v1.2, September-06
- VII National System Requirements (NSR), BAH, v1.3.1, April-08
- VII Privacy Policies Framework, Version 1.0.2, February 16, 2007

2.2 Resource Documents

- A Provisional Technical Architecture for the VII, PB Farradyne, July 2004
- A Summary of European Cooperative Vehicle Systems Research Projects, Jun-09
- Achieving the Vision: Policy White Paper, 4/30/2010
- An Initial Assessment of the Ability of 4G Cellular Technology to Support Active Safety Applications, Final Draft, 11/18/2009
- Architecture Specification for the Vehicle and Certificate Authority Certificate Management Subsystems, VIIC
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- Certificate Management Concept of Operation, VIIC, SEC 110-01
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- Data Element Dictionary, BAH, v1.0, February-07
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- Enterprise Network Operations Center (ENOC) Subsystem Specification, BAH, v1.1
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- Final Report: VII POC Results and Findings – Infrastructure (Volume 3B), BAH
- Final Report: VII POC Results and Findings – Vehicles (Volume 3A), VIIC
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- IEEE 1609.2 Standard for Wireless Access in Vehicular Environments (WAVE) - Security Services for Applications and Management Messages, Jun 2006
- IEEE 1609.3 Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services, Apr 2007
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- IEEE Standard for Software Configuration Management Plans, 12 Aug 2010
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- Intelligent Transport Systems (ITS) Communications Architecture, ETSI EN 302 665 V1.1.1 (2010-09), European Telecommunications Standards Institute 2010.
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- OBE Subsystem Design Description, VIIC, SYS 112-02 (OBE), SYS 112-01
- OBE to RSE Interface Requirements Specification, VIIC, SYS 120-04
- POC OBE Subsystem Functional and Performance Requirements, VIIC, SYS 110-02
- POC Probe Data Collection Vehicle Application Requirements, VIIC, APP 220-01
- POC Trippath Generation Application Requirements, VIIC, APP 220-04
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- Potential Haul-In Aftermarket Device Suppliers, 6/11/2010

- Risk Management Plan for the Deployment of IVI Collision Avoidance Safety Systems, Draft Ver 1, 11/4/2004
- RSE Procurement Analysis, BAH, v1.0, June-06,
- Roadway Geometry and Inventory Trade Study for Applications, 7/1/2010
- RSE Software Requirements Specification (SRS), BAH, v2.0, July-07
- RSE Subsystem Specification, BAH, v1.2
- SAE J2735 - Dedicated Short Range Communications (DSRC) Message Set Dictionary, v2, Nov 2009
- SAE J2735 Standard: Applying the Systems Engineering Process, 6/30/2010
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- VII Architecture and Functional Requirements, PB Farradyne, VII Architecture version 1.1 2005_07_20
- VII Communications Analysis Report, BAH, v3.0, July-06
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- VII USDOT Day-1 Use Case Descriptions, BAH, Combined Final v1.0, May-06
- X-072 Interface Requirements Specification, SYS 120-02

3.0 CURRENT SYSTEM

3.1 Background, Objectives, and Scope

This section provides an overview of the current system. Identifying the current transportation system is not straightforward: while the VII program was never deployed, it did include a national system specification, prototype design and test-bed for a next-generation system enabling V2V and V2I wireless communications. Because of this applicable research-focused heritage, the current system baseline is defined in the VII National System Requirements (NSR) document.

The VII program's objectives were to seek significant improvement in safety, mobility, and commerce by deploying a communications infrastructure on roadways nationwide and installing DSRC radios in all production light vehicles. VII presented opportunities to take the next great step forward toward improving surface transportation. VII would provide safety features on vehicles that could prevent accidents at intersections, improve traffic management, enhance traffic mobility, optimize emergency response and keep vehicles from running off the road.

Under the VII program stakeholders worked together to explore the possible applications that would be enabled when vehicles could communicate directly with the infrastructure. VII stakeholders included vehicle manufacturers, Federal and State highway agencies, and engineering and communications support companies. USDOT's role included funding and fostering VII research, initiatives, applications and other related technologies. Other public transportation agencies provided experience, reference and the infrastructure foundation for the Proof-of-Concept (POC). Private companies, including vehicle OEMs, communications and other firms developed the NSR, other documents and constructed and operated the POC and ensuing test-bed.

For VII, all communications between vehicles and with vehicles were to use 5.9 GHz DSRC. In addition, the OEMs would install a DSRC radio only on new production vehicles; little consideration was given for aftermarket and retrofit devices (the NSR does include concepts for non-original equipment, but little other VII documentation addresses the use of aftermarket or retrofit devices).

DSRC uses 5.9 GHz in the US which is allocated into seven 10 MHz channels, four of which can be combined into two 20 MHz channels. This allows RSEs in local proximity of each other (approximately 1,000 meters) to provide services without causing interference. It also allows for use of some existing commercial IEEE 802.11 based radio components – the same standard interfaces that govern wireless networking access devices, e.g., Wi-Fi. Since it is critical for safety reasons to ensure that all OBE and RSE can hear each other, and the standards developers did not want to assume the use of multiple radio transceiver systems (or very wide band receiver systems), a method for channel management was developed and is described in IEEE 1609.4.

The concepts that were defined and tested during VII along with the standards that have evolved through VII and other related efforts around the world can be considered as stepping stones from stand-alone, proprietary technologies to a more integrated and open standards-based environment. The Core System engineering effort builds upon the results of the VII initiative. Its enabling capabilities may not necessarily replace any existing systems because of deployment strategies and budget constraints, but it will fit alongside and enhance existing Intelligent Transportation Systems (ITS).

3.2 Operational Policies and Constraints

The current system presumed a national deployment, operated and managed by a VII Operating Entity. It was envisioned to include a vast backbone and backhaul network distinct from existing ITS deployments; backhaul between VII field and management devices were not to be shared with existing ITS.

Traditional ITS systems are typically funded, built, and operated by either a single public agency (state, local) or by private industry. Occasionally a multi-agency organization is formed (e.g., as a collaborative role of multiple state and local entities) to run for example a traffic management center, but by and large ITS are single agency systems. Each entity decides where it deploys its equipment and for what purposes. In some cases these may conflict with the purposes or goals of the larger region, requiring agencies to work together to resolve the conflict.

3.3 Description of the Current System

VII focused on wirelessly linking vehicles with one another, with field devices and with transportation-related centers. Most VII work concentrated on light vehicles. The VII NSR does include a concept of public service vehicles, but there is no difference in how these vehicles are handled. VII does not explicitly recognize other vehicle types, such as transit or commercial, as the initial focus of the program was on light vehicles.

3.3.1 Current System Overview

The high-level logical overview of the VII system is represented in Figure 3-1.

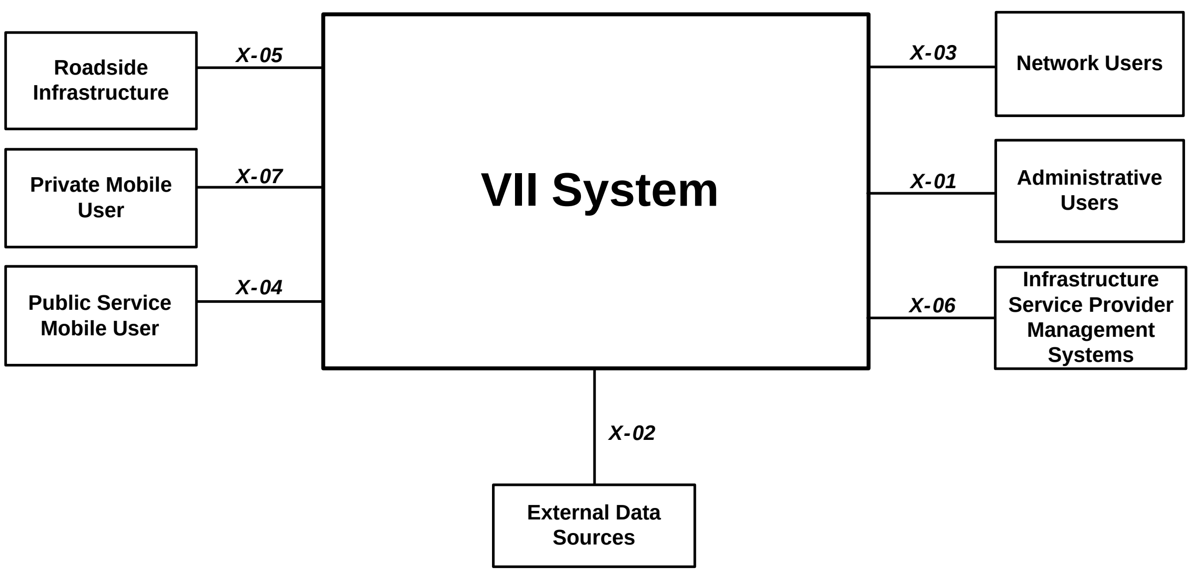


Figure 3-1: VII NSR Context Diagram

The seven user types that interact with the VII system are listed with abbreviated descriptions from the NSR document:

The Roadside Infrastructure User (RIU) includes traffic management or monitoring systems that interface with the VII System from the roadside as a:

a. Data Subscriber to receive data
b. Data Provider to provide data
c. Advisory Agent to send and receive advisory messages to and from the VII System
d. Transaction Agent to conduct informational transactions with vehicles or centers.

Private Mobile User (PMU) is the VII-enabled, personal or public vehicle or non-original equipment (aftermarket, portable, handheld, etc.) operated by the general public, agency, or corporation. PMU interacts with the VII System as a:

a. Data Provider to provide data
b. Data Advisory Subscriber to receive data
c. Transaction Agent to conduct informational transactions

Public Service Mobile User (PSMU) is a VII-enabled uniquely identifiable public mobile user, such as an ambulance, fire truck, police or road maintenance vehicle, or non-original equipment (aftermarket, portable, handheld, etc.). PSMU interacts with the VII System as a:

a. Data Provider to provide data
b. Data Advisory Subscriber to receive data
c. Transaction Agent to conduct informational transactions

The Network User is the public or private back office entity that uses VII System services. A Network User interacts with the VII System as a:

a. Network Subscriber to receive data
b. Network Advisory Provider to provide data
c. Network Transaction Agent to conduct informational transactions

The Administrative User manages VII System services; specifically it manages VII assets, enables or disables services, monitors VII System operations in selected domains, manages access and authorization of Network Users.

The Infrastructure Service Provider Management System is the telecommunications service provider customer service and network management systems. This may include the communications infrastructure provided by telecommunications companies.

The External Data Sources of the VII System include:

a. Global Positioning System (GPS) to provide positioning and timing information
b. Differential GPS (DGPS) Corrections providing enhanced positioning information to those VII subsystems that require more accurate positioning information
c. Roadway maps with sufficient accuracy to support vehicle safety applications

3.3.2 Current System Architecture

As part of the overall VII program a set of 100 use cases were developed by various stakeholder groups. The use cases provided insight into the needs and priorities of the various stakeholders. From the initial set of 100, 20 use cases were identified and articulated in more detail. These represented applications expected to be available at the initial deployment of VII and were known as the “Day-1 Use Cases.” It was from these 20 use cases that the VII services were developed.

The VII architecture provides ten services designed to support safety, mobility and commercial applications. The VII services are:

- Advisory Message Distribution Service (AMDS): provides a mechanism for the Network User and Roadside Infrastructure User to send messages to PMU/PSMU. For the Network User, this includes the ability to select from geographic areas and broadcast messages to all PMU/PSMU in the area. For the Roadside Infrastructure User, the communication is local to the vicinity of the RIU (generally within 1000m).
- Communications Service: Provides data exchange between PMU/PSMU and other PMU/PSMU, Roadside Infrastructure User and Network User.

- Information Lookup Service: Provides underlying network support capabilities enabling communications between users of all types.
- Management Service: Provides maintenance, monitoring, configuration of non-mobile system components.
- Map Element Distribution Service: Distributes small maps containing roadway geometry and lane features to PMU/PSMU.
- Positioning Service: Distributes positioning and position correction information to the PMU/PSMU and VII subsystems (Figure 3-2) that require it.
- Probe Data Service (PDS): Collects probe data from PMU/PSMU, distributes data to Network Users and Roadside Infrastructure Users using publish-subscribe methodology.
- Roadside Infrastructure Support Service: Provides compatibility and formatting for Roadside Infrastructure Users (e.g., Signal Phase and Timing (SPAT), tolling).
- Security Service: Security protection against unauthorized use or sabotage of internal systems. Also maintains authorizations, determining what permissions each user has.
- System Time Service: Distributes timing information to users and VII subsystems.

These services are implemented by the VII Architecture illustrated in Figure 3-2.

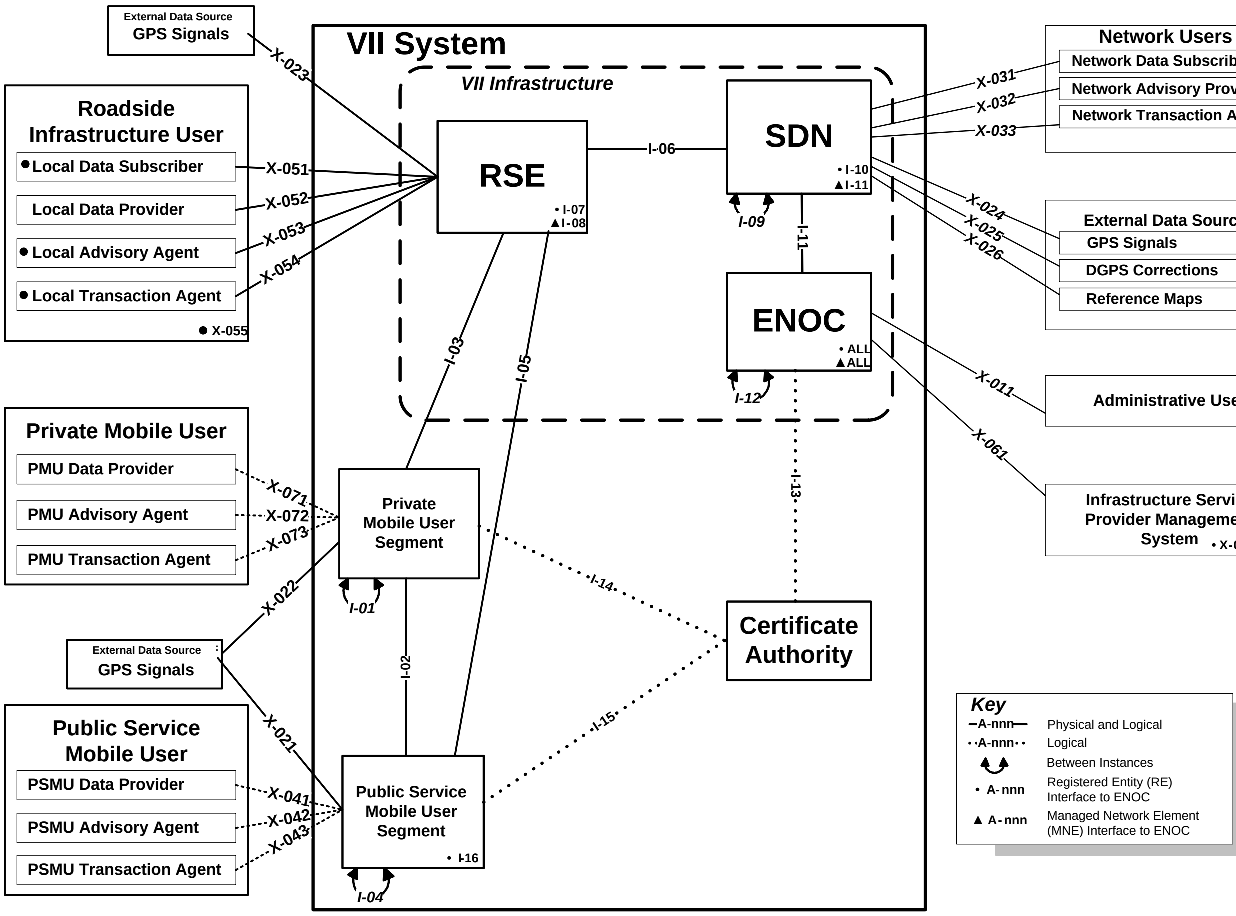


Figure 3-2: VII NSR Architecture Diagram

Roadside, Mobile and Network Users are further subdivided according to how they use VII:

- Advisory Providers use the AMDS to send advisories to the VII System.
- Advisory Subscribers use the AMDS to receive advisories from the VII System.
- Data Providers use the PDS to send probe data to the VII System.
- Data Subscribers use the PDS to receive probe data from the VII System.
- Transaction Agents (Local, Network and Mobile) use the Communications Service to engage in transactional communications with other Transaction Agents.

The VII Infrastructure includes the fixed installations that provide VII Services to Network Users and interface with Mobile Users and Roadside Infrastructure. The VII Infrastructure includes:

- The Enterprise Network Operations Center (ENOC) providing centralized monitoring and control of all VII Infrastructure components, as well as operations functions. Additionally, ENOC maintains a registry of all Network Users, Administrative Users, Infrastructure Service Provider Management Systems and selected Roadside Infrastructure and External Data Sources.
- The Service Delivery Node (SDN) communicating with the ENOC, other SDNs and an associated group of RSEs. The SDN provides the interface through which Network Users access VII services.
- The RSE communicating with a single primary and alternate backup SDN. The RSE provides the interface through which PMU/PSMU access VII services.

VII enables the following types of communication:

- Geo-cast messages from Network Users to PMU/PSMU
- Point-to-point messages between Network Users and PMU/PSMU, initiated by PMU/PSMU
- Uni-cast messages between PMU/PSMU
- Uni-cast messages between Roadside devices and PMU/PSMU

VII Services are implemented primarily at the SDNs, but the ENOC and RSE have roles implementing some parts of services. For example, the RSE provides proxies to access services, and can cache information locally. The ENOC provides aspects of the management and security services.

The Private Mobile User Segment and Public Service Mobile User Segment provide the mechanism whereby the PMU/PSMU interface with the VII System. The functionality for these subsystems is contained in a mobile system. This includes but is not limited to what is traditionally called OBE, but could also include aftermarket or handheld implementations. Communication with the RSE uses a DSRC radio.

The Certificate Authority (CA) issues keys and certificates to facilitate digitally signed and encrypted messaging. The CA also publishes lists of revoked certificates, so that users can verify that a particular message came from a valid, trustworthy source.

Section 4.2 of this ConOps includes a comparison of the services implemented by VII with the needs of the Core System.

3.3.3 POC and Test-bed

While VII was never fully deployed, various test-bed activities were carried out and in some cases are still active. One of the early implementations of VII was the deployment of the POC system that included 55 RSEs placed at various locations in the northwestern Detroit suburbs. These RSEs were linked to two SDNs, one in Virginia and the other in Michigan, using a variety of different back haul technologies including 3G cellular, Worldwide Interoperability for Microwave Access (WiMAX) and wire line communications. The POC deployment has since been migrated to a test-bed environment to be used to test the next generation transportation-related technologies.

Because developing and testing all 20 Day-1 VII Use Cases would have been impracticable, the POC program identified a subset of use cases that exercise the core functions. These were then implemented and tested in ways to assess both the functionality and the baseline performance of the system. The system would provide these core functions in the same way regardless of the specific details of the application.

3.4 Modes of operation for the Current System

The VII NSR document limited discussions on modes and states of the system, but it did identify requirements for failed and degraded services (which correlates with degradation modes and states). It also identified the need for restoration mechanisms to recover the system to an operational state.

4.0 JUSTIFICATION FOR AND NATURE OF CHANGES

This section discusses Core System operational goals, system needs and user needs. Operational goals establish parameters and targets for system performance. Needs identify what the system needs to do:

- System needs describe what the system needs to do in order to meet operational goals.
- User needs describe what the system needs to do in order to provide a foundation for applications.

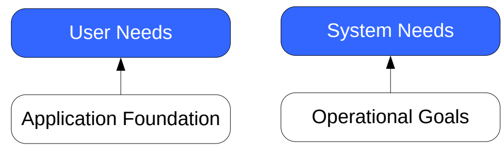


Figure 4-1: User and System Needs

Connected vehicle applications are not part of the Core System, but consideration of those applications drives the nature of the system. The Core needs to enable applications that meet the overarching USDOT goals of improving safety, mobility and the environment.

The existing VII system does not entirely meet these system and user needs, is not focused on environmental improvements, and thus does not enable applications as envisioned. It provides some of the basis for facilitating trust between users, but not in a sufficiently scalable way. It does not account for the differences between DSRC and other media, restricts publish-subscribe to internal applications (probe data, advisory messages) and does not account for varying policies, operations and maintenance capabilities and procedures that exist in different localities. VII also includes functionality and applications that are not necessary to meeting system needs, including provisions driven by the goal of improving commerce, which is no longer a program goal. All of these discrepancies are documented in the following section.

Typically a ConOps would proceed from this point with a justification of changes and descriptions of what those changes are, compared to the current system. As documented in Section 3.0, the current system is defined by the baseline documented in the VII National System Requirements. However, that system was not developed using the same systems engineering approach as the Core System. Comparing the document set that defines the Core System (this document and succeeding requirements and architecture documents) with documentation from the VII program is not a simple exercise as the contents of various documents are not easily aligned. Consequently, the Core System ConOps starts from a fresh examination of user and system needs, rather than starting from changes to the existing system. Documentation of changes to the existing system is completed in Section 4.2 by an analysis of which Core System needs are met by VII.

Subsequent to the user needs definition priorities are assigned among the suggested changes, including which capabilities must be included, which are desirable, and which are optional. Next is a discussion of functionality that was considered for inclusion but rejected for one reason or another (the reasons for rejection are included as well). Lastly, we document the various constraints under which the Core System will be developed, operated and maintained, along with the assumptions made with regard to those issues that could not otherwise be determined.

4.1 Justification for Changes

In the five years since the concept phase for VII, wireless access has become widely available at speeds sufficient to enable many VII-envisioned applications without the need for a dedicated transportation-focused communications network.

The VII system included communications as one of its underlying services. The communications service "…will provide communications facilities sufficient to allow Mobile Users to exchange information with [other users]…(see the VII NSR V1.3.1 2008-Apr-15, p 12).” The VII Infrastructure documented in the NSR includes definitions of communications interfaces between VII Subsystems and between VII Subsystems and external users; these definitions included specifications for the physical, data link, network, transport and session layers (as defined by the Open Systems Interconnection (OSI) Model (see Information Technology – Open Systems Interconnection – Basic Reference Model: The Basic Model. ITU-T Recommendation X.200)).

One of the significant changes since VII is the way in which mobile users access services. VII was based on DSRC for V2V and V2I communications, leveraging the low latency of the medium to enable time sensitive (chiefly safety) applications, while the additional available bandwidth would be used to deliver mobility and commercial services. Today however, cellular data services provide similar bandwidth to DSRC, making it a practical alternative for non-safety applications.

While V2V communications using DSRC are an integral part of the *connected vehicle* environment, V2I DSRC communications will be limited to those areas where DSRC-based field infrastructure is deployed. If a Core System operates in an area where there is no DSRC-based field infrastructure, it will not have to support V2I DSRC. This leads to multiple, disparate interfaces between Mobile and Core, depending on the media through which a user accesses the Core System.

For example, if a 3G user wants access to the Core System, his communications will be routed through his 3G provider. He will already have an Internet Protocol (IP) address and Internet connectivity. The interface between the Core System and his device will be between OSI layers 3 and 7 (from IP through application layer). If on the other hand a DSRC user wants access to the Core System, his interface would begin at the physical layer, encompassing layers 1-7. This would leave two different interface definitions, one for the 3G user, and one for the DSRC user. There are other wide-area and local area wireless technologies (WiMAX, LTE, etc.) that would require their own interfaces. Establishing these interfaces, ensuring the anonymity of users across different access technologies, and providing variations in Core system functionality to support these different technologies adds additional complexity to the definition of the Core System.

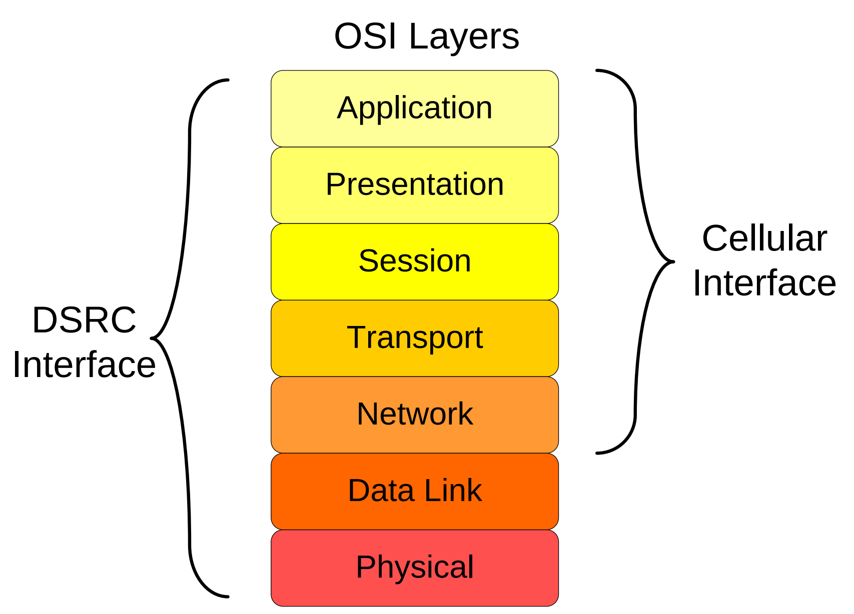


Figure 4-2: DSRC vs. Cellular OSI Model Layers Comparison

As a result, lower layer connectivity is distinguished as outside the Core System. The Core System provides a group of functions meeting needs aside from lower layer connectivity. The Core System must accommodate users of various access media, but is not managing those media or networks as part of its functionality. Figure 4-3 illustrates the major layers between and including the Core System and Users.

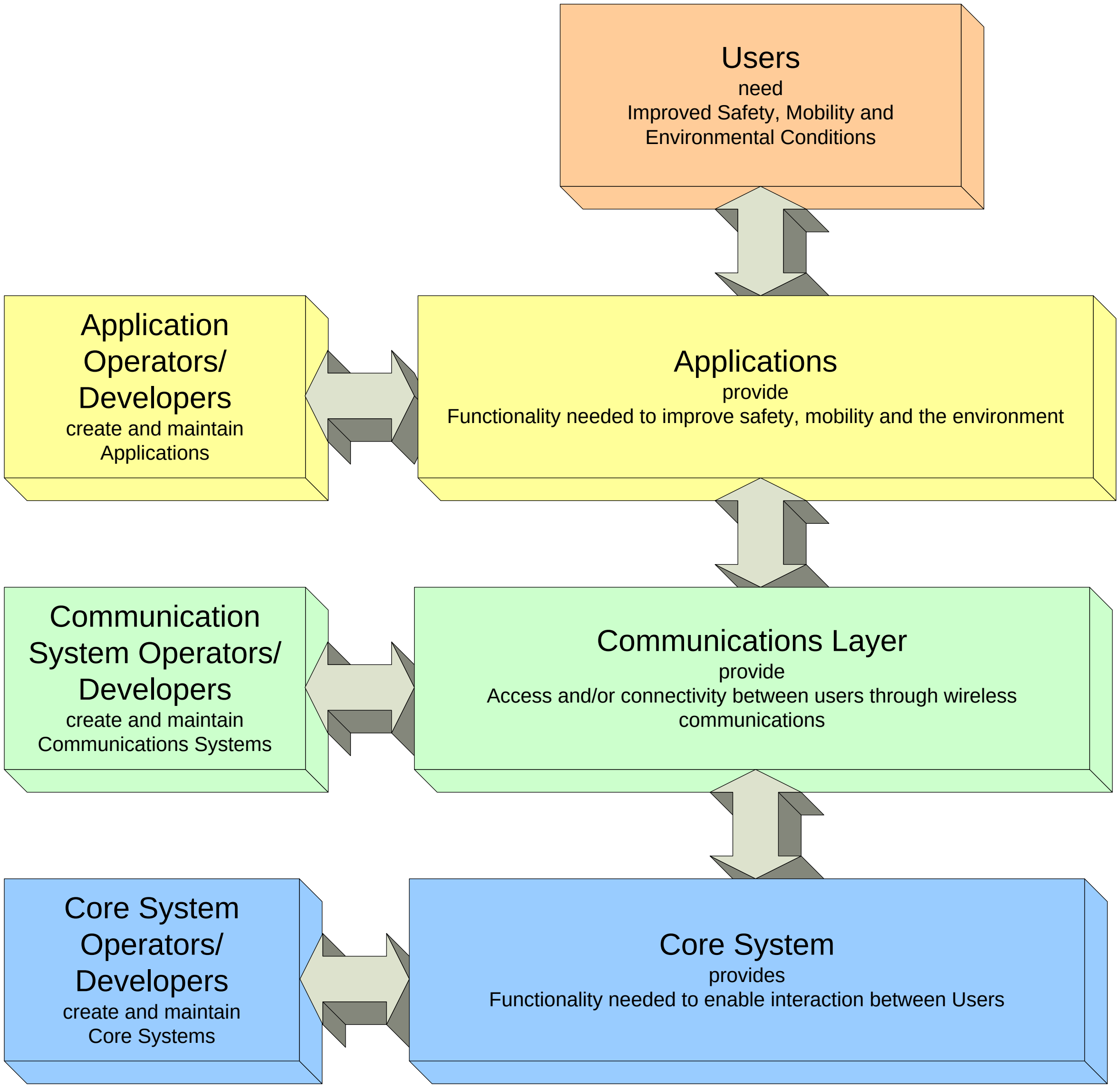


Figure 4-3: System Layers and Users

The **Core System** provides functionality enabling the trusted and secure exchange of data between users. Core System personnel operate, maintain, update and expand the Core System as necessary to provide services. They also implement local policies using Core System services where appropriate. The Core System provides interfaces to the services it provides, as defined in this and succeeding documents.

The **Communications Layer** provides wireless communications between Core System services and safety, mobility, and environmental applications. Which communications mechanisms are implemented at each deployment will vary. It could include cellular (e.g., 3G, 4G), WiMAX or other wide-area-wireless, or a network of short-range communications hot-spots based on DSRC 5.9 GHz. It could be privately operated, such as a typical cellular network is today, or publicly, like a municipal WiMAX solution. There is however, one primary function any such communications layer must include: access. The communications layer needs to provide logically addressable access to the Core System. How it does this, by short range or wide area, through public or private channels, is a question of implementation. Desirable communications performance characteristics will vary depending on the Core

System services offered at a given location; these will be further defined in the Requirements and System Architecture documents. Communications layer personnel operate and maintain the communications systems.

Applications provide benefits in the area of safety, mobility, or the environment to **Users**. Applications may include components in vehicles, handheld mobile devices, in back office environments and/or field infrastructure. Applications use the Core System services to facilitate their interactions with other applications or users. Applications are produced and maintained by **Application Operators and Developers.**

The **Interfaces** between layers include physical specifications, communications protocols and message set definitions, and vary depending on originator, destination and communications media chosen.

Figure 4-4 shows another view of the top level context in which the Core System resides, focusing on the communications enabled between the Core and users. This diagram includes notions of the entire *connected vehicle* transportation environment as defined below.

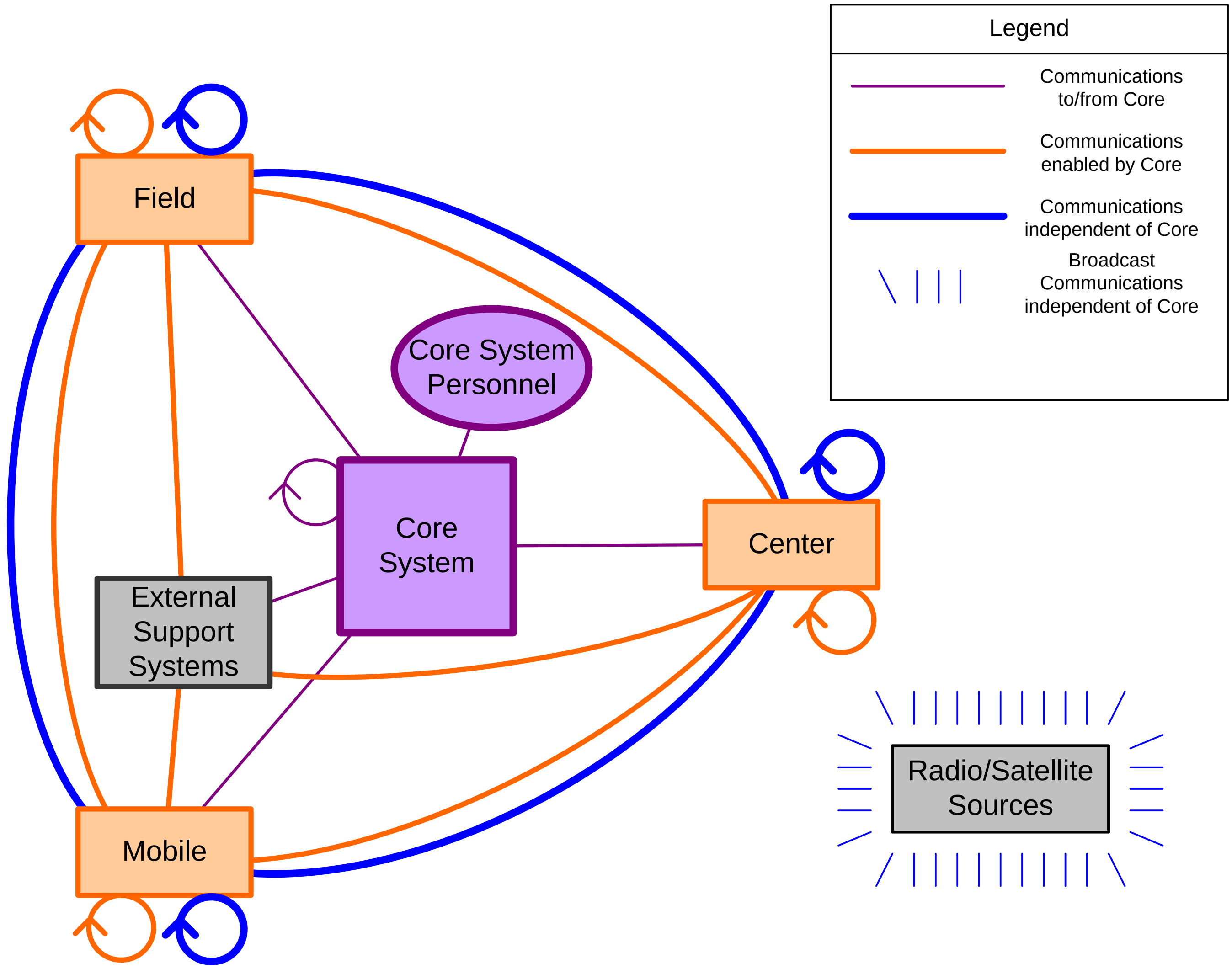


Figure 4-4: Core System Context Diagram

The Core System interacts with four types of entities:

- **Mobile** includes all vehicle types (private/personal, trucks, transit, emergency, commercial, maintenance, and construction vehicles) as well as non-vehicle-based platforms including portable personal devices (smart phones, tablets, etc.) used by travelers (vehicle operators, passengers, cyclists, pedestrians, etc.) to provide and receive transportation information. Mobile entities interact with other Mobile and Field entities (e.g. Dynamic Message Signs (DMS), Roadside Equipment (RSE)) in the Mobile entity's vicinity, and Center entities from any location.
- **Field** represents the intelligent infrastructure distributed near or along the transportation network which perform surveillance (e.g. traffic detectors, cameras), traffic control (e.g. signal controllers), information provision (e.g. DMS) and local transaction (e.g., tolling, parking) functions. Typically, their operation is governed by transportation management functions running in back offices. Field entities also include RSE supporting Dedicated Short Range Communications (DSRC), and other non-DSRC wireless communications infrastructure that provides communications between Mobile entities and fixed infrastructure.
- **Center** represents back office systems including public and commercial transportation and non-transportation systems that provide management, administrative, information dissemination, and support functions. These systems may exchange information relevant to the *connected vehicle* environment with other center systems. All of these systems take advantage of the Core System to provide or also make use of application data.
- **Core System Personnel** represents the people that operate and maintain the Core System. In addition to network managers and operations personnel, Core System Personnel also includes those that are deploying and provisioning Core elements. Other personnel interacting with the Core include developers of software services that, maintain, fix and expand Core services or extend the system as required.

The **Core System** also interacts with other instantiations of Core Systems. More than one Core may exist, each providing services over given geographic or topical areas. Some may provide backup or standby services for others; some may provide more or less services than others.

> When referring to multiple Core Systems, this document will often drop the word System. In most cases Core System is used for the first reference in a paragraph, and Core used thereafter in that paragraph, though in those sections describing interactions between Cores or talking about Core subsystems the word System is usually left off entirely. This is strictly for readability. The title Core is a shortened version of Core System.

Radio/Satellite Sources refer to terrestrial radio and satellite broadcast, including Global Positioning System (GPS) broadcasts, and position correction broadcasts.

External Support Systems (ESS) provide services on behalf of and/or in support of the Core System. These services are provided by the ESS because it makes more sense to manage, maintain and share the service between multiple Cores due to overriding institutional, performance or functional constraints.

Throughout the remainder of this document, the term **System Users** refers to the combination of **Mobile, Field,** and **Center**. The term **End User** refers to the human user of the System User device. End Users do not interact directly with the Core System, but are referred to as the ultimate beneficiaries or participants in the *connected vehicle* environment.

Some other aspects of the transportation environment have changed since the VII program. The following additional considerations potentially affect the delivery of advanced transportation-related applications that rely on the Core System:

- Wide-area wireless (800 kbps and higher) communications paired with handheld devices capable of running sophisticated applications has become commonplace over much of the United States.
- Infrastructure-to-vehicle communication is not constrained to DSRC exclusively.
- Core System, Communications and Applications will likely be deployed locally and regionally, not nationally, in an evolutionary, organic fashion. There is not expected to be a single large national deployment. This leads to the conceptualization that the Core System exists in multiple instantiations. Further, Core Systems (and possibly Operators) will need to communicate with one another.
- VII's restriction to support OEM-sourced new vehicle solutions only has been removed. Aftermarket, retrofit and carry-in devices are all potential means for implementing mobile solutions.
- In addition to support for light vehicles, other vehicle types such as maintenance, construction, commercial and transit vehicles will access Core System services.
- Likewise, the mobile traveler including pedestrians, cyclists and transit riders will access Core System services.

4.1.1 Core System Operational Goals

As part of the user needs generation process (further defined later in Section 4.1.2) there were many meetings with stakeholders. Several themes came through consistently from those stakeholders that would be tasked with deploying, maintaining and operating Core Systems, Communications Layer systems and Applications. These themes are summarized by the following characteristics. These characteristics provide overarching goals and begin to define the performance characteristics that the Core System must demonstrate:

- Flexibility: The Core System design must be able to adapt to external change without requiring redesign.
- Extensibility: The Core System implementation must take future growth into consideration. Extensions may be achieved by adding new functionality or by modifying functionality that exists at the time extension is required.
- Scalability: The Core System must be able to handle growing amounts of work in a graceful manner or to be enlarged to handle growing amounts of work, without requiring redesign.
- Maintainability: The Core System must be maintainable in such a way so as to minimize maintenance time, with the least cost and application of supporting resources. More specifically, the figures of merit that must be defined are:
    - The probability that a given item within the Core System will be restored to operating condition within a given period of time when maintenance is performed as designed.
    - The probability that maintenance will not be required more than a given number of times in a given period, when the system is operated as designed.
    - The probability that the maintenance cost for the system will not exceed a designated value when the system is operated and maintained as designed.

- Deployability: The Core System must be able to be deployed in existing transportation environments, without requiring replacement of existing systems in order to provide measurable improvements.
- Reliability: The Core System must perform in a satisfactory manner when operated and maintained as designed.

4.1.2 Core System Needs Overview

4.1.2.1 Definition of a Need

A ***need*** is a capability that is identified to accomplish a specific goal or solve a problem, specifically to be supported by the Core System. It describes "what" is needed while avoiding the implementation specifics, or the "how." Each need is identified uniquely, contains a description and a rationale. Rationale may include examples of how the system capability may be exercised.

Two types of needs are identified for the Core System:

1. User needs that describe a capability required by a user in order for that user to accomplish a goal,
2. System needs that describe a capability required by the Core System in order to meet operational goals.

All needs are framed from the perspective of the Core System. "The Core System needs to…" or similar language modified to suit the need in question begin every need statement.

4.1.2.2 Needs Identification Process

Core System needs were identified as part of a 6-month process documented in Figure 4-5.

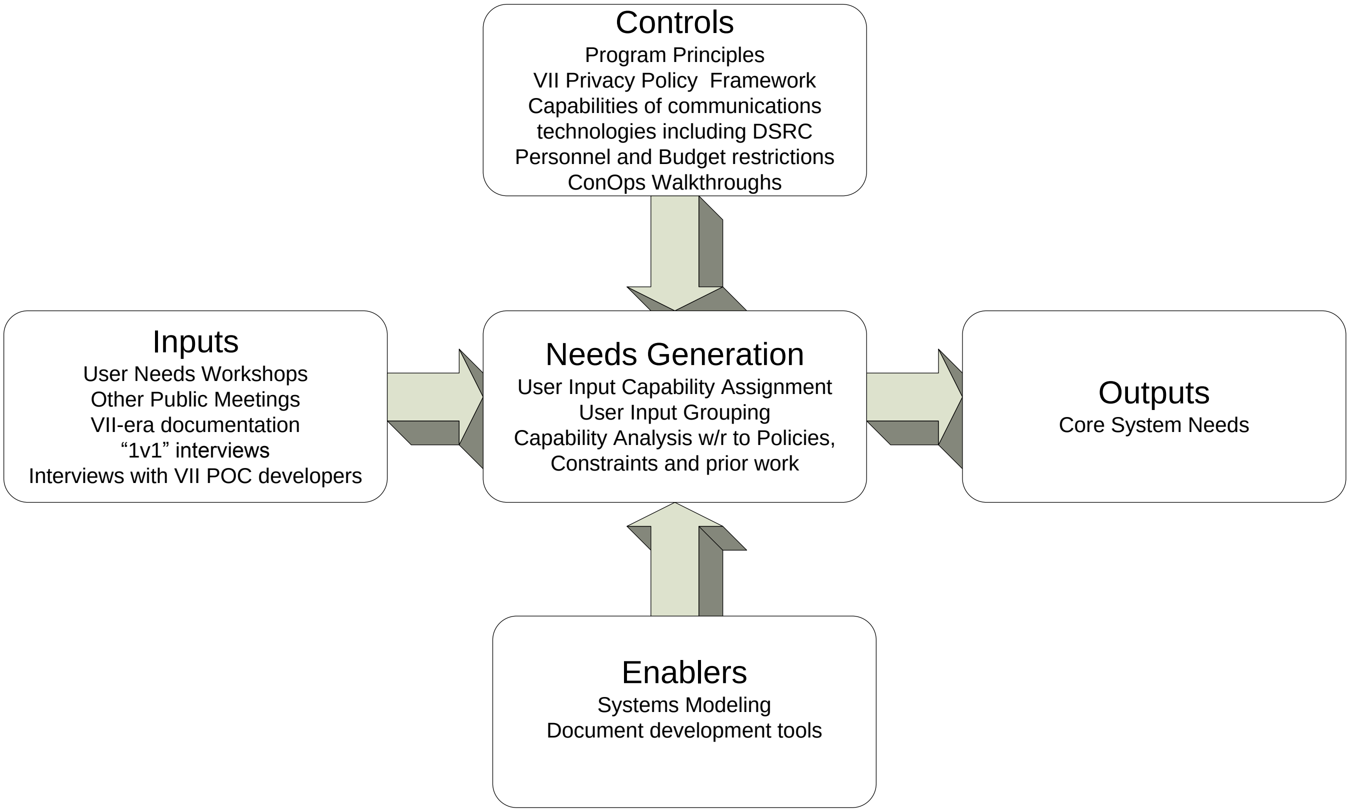


Figure 4-5: Needs Generation Process

Inputs to the needs identification process came from four major areas:

1. VII-era documentation listed in Section 2.0
2. Public workshops held with stakeholders
3. "1 on 1" meetings with USDOT program managers
4. Interviews with POC developers

All of these forums provided information that was used as part of the needs generation process. Most often the information provided was couched in the form of what a given stakeholder needed to support applications, i.e., as user needs.

While a large variety of stakeholders provided input to the needs identification process, there were practical limits with regard to schedule, the number of workshops and "1 on 1" interviews that could be conducted. Solicitation of needs information occurred at three large public workshops:

- Detroit, MI – August 25 & 26, 2010
- San Jose, CA – September 1 & 2, 2010
- Washington, DC – September 29 & 30, 2010

Two additional, more focused workshops were piggybacked on other meetings:

- Vancouver, BC – August 10 & 11, 2010, focused on signal controllers and traffic management at the Institute of Transportation Engineering (ITE) Annual Meeting

- San Antonio, TX – October 5, 2010, focused on public transit in conjunction with the American Public Transportation Association (APTA) Annual Meeting

Other public meetings including VII security workshops, SAE J2735 and IEEE 1609 standards meetings, Deployment Workshops, NAVTEQ NaviSmart Insurance, and an international Cooperative Intelligent Transport Systems standards meeting (CEN TC204/WG18 and ISO TC204/WG18 Joint Meeting in Zurich, Switzerland) served as sources for needs input.

Many one-on-one sessions were held with USDOT program managers to discuss their programs and how they might affect or be affected by Core System deployments. These included a wide variety of transit, policy, commercial vehicle and freight operations, standards, dynamic mobility, safety, collision avoidance, and transportation data programs.

Also, personnel responsible for various aspects of the VII POC, CAMP projects and a private DSRC implementation were interviewed:

- BAH personnel that designed and implemented the POC system, as well as the existing national system defined in the NSR
- BAH personnel that operate and maintain the test-bed in Detroit
- Members of the team that developed a Signal Phase and Timing (SPaT) implementation in Owosso, MI
- Representatives from CAMP and VIIC that were involved in various collision avoidance studies as well as the VII POC.

User input collected from the various venues was validated during the later workshops. Workshops ranged from one to two days and included a presentation of VII and more recent background material, new assumptions and plans forward, and guidelines for identification of needs. During breakout sessions, participants identified their problems, their needs, and the rationale behind their needs. During a second breakout session, participants were presented with specific scenarios and asked how they would leverage various capabilities (if those capabilities were provided).

Stakeholder inputs were organized according to what capability or capabilities they required. The inputs were then grouped by desirable feature, and those features analyzed in light of VII POC results and various constraints; the VII Privacy Policy Framework, capabilities of potentially applicable communications technologies, and the “soft” constraint on deployer/operator budgets and personnel. (This is a “soft” constraint for two reasons: 1) Localities or corporations may receive subsidies which would override their budget restrictions; and 2) Localities may team together or with larger entities that have available personnel/budget.)

The result of the needs generation process is presented in the following sections. Much of the user input from the workshops is included as justification for the individual needs, i.e. the rationale for the inclusion of a given capability.

4.1.2.3 Core System Needs

This section lists the needs that are driving the definition of the Core System, including the name, description, and rationale of each need. In many cases the rationale terminates with a statement referencing applications, often calling out specific examples of applications that drive the need. The reason for this is simple: without applications, the Core System accomplishes nothing. All Core System needs are focused on delivering services that will at some point be used to support applications.

1. **Data Protection:** The Core System needs to protect data it handles from unauthorized access. This is required to support applications that exchange sensitive information, such as personally identifying or financial information, which if intercepted could compromise the privacy or financial records of the user.
2. **Core Trust:** The Core System needs to establish trust with its System Users. Such trust relationships are necessary so that the Core System can be assured that System Users are who they say they are, and therefore trust the source and data it receives.
3. **System User Trust:** The Core System needs to facilitate trust between System Users. Such trust relationships are necessary so that System Users can be assured that other System Users "are who they say they are," and therefore trust the source and data they receive from other System Users.
4. **Core Trust Revocation:** The Core System needs to revoke the trust relationship it has with its System Users when necessary. A trusted System User may operate in a fashion that indicates it should no longer be trusted, in which case the Core System must have a way of revoking that trust.
5. **System User Trust Revocation:** The Core System needs to facilitate the revocation of the trust relationships between System Users when necessary. A trusted System User may operate in a fashion that indicates it should no longer be trusted, in which case the Core System must have a way of facilitating revocation of trust between System Users.
6. **Authorization Management:** The Core System needs to manage authorization mechanisms to define roles, responsibilities and permissions for System Users. This enables the Core System to establish operational environments where different System Users may have different capabilities in terms of accessing Core services and interacting with one another. For instance, some Mobile elements may be authorized to request signal priority, or some Centers may be permitted to use the geographic broadcast service, while those without those permissions would not.
7. **Authorization Verification:** The Core System needs to verify that System Users and Core Operations Personnel are authorized to perform an attempted operation. This enables the Core System to restrict operations to those users are permitted to use those operations. For example, geo-broadcast may be restricted to transportation or public safety agencies, so other users may be prohibited from performing geo-broadcast.
8. **Misbehavior Management:** The Core System needs to identify System Users acting as bad actors. Bad actors are not necessarily malicious; they could be malfunctioning devices that may interfere with other System Users, Communications Layer systems or the Core System. Identifying bad actors enables subsequent action to protect the integrity of all users sharing the transportation environment.
9. **Time Base:** The Core System and System Users need to operate on a common time base. Coordination of time between the internal systems that operate the Core System prevents internal synchronization errors and enables time-sensitive interactions with System Users.
10. **Data Request:** The Core System needs to provide a mechanism for data consumers to request data that is produced by data providers. This is a single request for a subscription to a certain type of data, and subsequent modification of the request to change data types or subscription parameters. Parameters include data frequency, type and location of where the data was generated. This enables the distribution of anonymously-provided data to interested data consumers, without requiring them to enter into a relationship with data providers. Request formats need to provide data consumers with the ability to differentiate and receive only the types of data they requested. For example this includes data type, geographic range, frequency and sampling rate. This request method supports a wide variety of user needs, from planners requesting all traffic data all the time,

to traveler information services requesting a subset of traffic data, to weather information services only interested in windshield wiper status for vehicles in a specific area.

11. **Data Provision:** The Core System needs to supply information to data providers enabling them to transmit data to interested data consumers. At a minimum, data characteristics need to include type, frequency and location where data was generated, so that users that have requested data (see need data request) can differentiate between available data. This need enables data providers to direct the data they create to data consumers, and serves as the provider-side corollary to the data request need. This supports a variety of applications, including those focused on the center provision of data to users. It also serves as the answer to the System User's question of "I have data, how do I provide it and to whom?"
12. **Data Forward:** The Core System needs to provide a mechanism to distribute data that is produced by a System User acting as a data provider and requested by another System User. The Core System needs to provide this distribution mechanism, rather than relying on individual provider-consumer relationships, because multiple consumers may want access to the same data. By having the Core System distribute the data, System Users are relieved of the need to transmit the data multiple times. Also, some data that may be critical to the proper functioning of mandatory applications, such as data supporting geo-location of users (position corrections), time base data and roadway geometry data, all of which likely comes from a single source and needs to be distributed to large numbers of System Users. Additionally, System Users may interact over resource-constrained communication links, so Core-provided data redistribution reduces the potential load on those links.
13. **Network Connectivity:** The Core System needs to connect to the Internet. This allows the Core to provide services to any System User capable of connecting to the Internet.
14. **Geographic Broadcast:** The Core System needs to provide the information necessary for System Users who wish to communicate with a group of System Users in a specific area to do so. This capability enables System Users to target those in a specific area for information they wish to distribute without having to send individual messages to each recipient. Examples of applications that might use this include Amber Alerts, traffic information, and air quality alerts.
15. **Core System Service Status:** The Core System needs to be able to monitor the status of Core System services and provide accurate status information to System Users. The Core System can then inform Core Operations Personnel when a service operates in abnormal or degraded fashion. Additionally, System Users may not be able to access a Core System service (because of their location for example) and would want to know where and when they could expect access to the Service.
16. **System Integrity Protection:** The Core System needs to protect its integrity. This includes defense against the loss of integrity from a deliberate attack, software bug, environmental or hardware failure. Protection of the Core System ensures that System Users have a high confidence in the security of the information they entrust to the Core System.
17. **System Availability:** The Core System needs to be available for System Users to access Core System Services. This includes both operational availability and the predictable return to normal operations after service degradation. Availability and a predictable return to normal operations ensures that System Users have a high confidence in the ability of the Core System to provide the services they require.
18. **System Operational Performance Monitoring:** The Core System needs to monitor its performance. This includes the status of interfaces, services, and metrics for the demand for services and the resolution of those demands. Monitoring the performance of Core System services

and interfaces is necessary to understand when the system is operating properly, and to gauge when the system may be nearing capacity so that action may be taken to prevent the system from failing to provide services, e.g. maximum number of transactions/second, or internal communication bandwidth.

19. **Core System Independence:** The Core System needs to be independently deployed and operated, providing Core System services to all System Users within its operational scope. This ensures that one entity's Core System deployment is not contingent on or dependent on another for basic functionality.
20. **Core System Interoperability:** The Core System needs to provide services in such a way that if a mobile user moves into an area of another Core System their interface to the Core System still operates. This helps manage user expectations and helps ensure that when a mobile user subscribes to a service or installs an application the user experience is consistent across multiple Core Systems.
21. **Core System Interdependence:** The Core System needs to operate in coordination with other Core Systems. This ensures that Core services deliver information that is consistent with information delivered by other Core systems, which will help avoid inconsistencies and incompatibilities between Cores and between System Users interacting with multiple Cores.
22. **Core System Data Protection**: The Core System needs to protect data it maintains from unauthorized access. This ensures that information held by the Core, which may include sensitive information about System Users, is accessed only by authorized users.
23. **Anonymity Preservation:** The Core System needs to preserve the anonymity of anonymous System Users that use its services. This ensures that System Users communicating with the Core who wish to remain anonymous will not have their anonymity breached as a result of communicating with the Core.
24. **Private Network Connectivity:** The Core System needs to connect to a private network. This allows the Core to provide services to any System User that provides a private network connection to the Core, which contributes to meeting the Deployability goal. It also allows Cores to establish dedicated connections between them, which contributes to the Cores collectively meeting goals of scalability, maintainability and reliability.
25. **Private Network Routing:** The Core System needs to route communications between other Cores and System Users, when one or both of the parties involved in the communication is connected to the Core by a private network. This enables System Users connected by private network to interact with Center-based applications, and also facilitates backup operations between Cores.

4.2 Description of Desired Changes

This section describes differences between the needs specified above and the needs that are satisfied by the VII architecture as specified in the NSR. Comparing the components of the VII architecture to the Core System illustrates major differences in how the Core System views users and internal components compared to VII:

Table 4-1: VII Components and Core System Concepts

VII Architecture Component	Core System Analog	Difference in Core System Concept
Roadside Infrastructure User	Field User	Field devices such as signal controllers and toll systems are still outside the system. They do not need to be integrated to a communications backhaul dedicated to the Core as they were in VII however.
Private Mobile User / Private Mobile User Segment	Mobile User	For VII parts of the Mobile User were considered to be inside the VII System. The Core System considers vehicles, aftermarket devices, handhelds, in fact any End User device to be outside the system.
Public Service Mobile User / Public Service Mobile User Segment	Mobile User	The Core considers all Mobile Users the same, potentially with different roles and responsibilities, but still using the same Core interfaces.
Network User	Center	Basically the same as VII.
Administrative User	Core System Personnel	Basically the same as VII.
Infrastructure Service Provider Management Systems	None	VII coupled services with communications. The Core System is strictly a provider of services, so the need for interfaces to separate communications management is unnecessary.
RSE	Field	The Core System defines the RSE as a Field User that has a DSRC interface. It is outside the Core System, and thus not responsible for implementing Core Services. In VII the RSE was the point of contact for Mobile Users, and provided proxies to many VII services. Some Core services may be accessed through proxies provided by the RSE, but RSE is not required to provide these proxies.
SDN, ENOC, Certificate Authority	Core System	The Core System includes most of the functionality of VII's ENOC, SDN and CA. VII assumed a national deployment would require hundreds or thousands of SDNs, but small numbers (1-10) of ENOCs and likely a single CA hierarchy. The Core views all of these as part of the Core System, and does not separate the provider of services from the administrative tools used to implement and manage those services at this level. The Core does consider the possibility of using ESS to provide some or most CA functions.

Table 4-2 lists the Core System Needs and the status of those needs in the VII design.

Table 4-2: Core System and VII Needs Comparison

CORE SYSTEM NEED	STATUS IN CURRENT DESIGN (VII)
Data Protection	Partially Satisfied. Distribution of certificates envisioned to facilitate encryption and decryption of data transmitted between VII entities was partially architected.
Core Trust	Partially Satisfied. Distribution of certificates envisioned to facilitate trust between VII entities was partially architected.
System User Trust	Partially Satisfied. Distribution of certificates envisioned to facilitate trust between VII entities was partially architected.
Core Trust Revocation	Partially Satisfied: VII reports indicate that distribution of Certificate Revocation Lists (CRL) for large scale deployments would require additional work in terms of scalability and performance analysis.
System User Trust Revocation	Partially Satisfied: VII reports indicate that distribution of Certificate Revocation Lists (CRL) for large scale deployments would require additional work in terms of scalability and performance analysis.
Authorization Management	Partially Satisfied: VII differentiated between user types, and included a notion of 'operational scope.' Insufficient detail is present in the NSR to determine if this includes restricting the roles and permissions for all System Users, or just VII Network and Administrative Users (akin to Centers and Core Personnel).
Authorization Verification	Partially Satisfied: VII differentiated between user types, and included a notion of 'operational scope.' Insufficient detail is present in the NSR to determine if this includes restricting the roles and permissions for all System Users, or just VII Network and Administrative Users (akin to Centers and Core Personnel).
Misbehavior Management	Partially Satisfied: The VII Management Service includes requirements for monitoring, detecting, logging and reporting abnormal behavior, as well as an "operational scope" concept that could be applied to Mobile users. It did not include a concept for receiving misbehavior reports about Mobile users from third parties. VII also did not include any concepts for multiple Core systems, where policies defining misbehavior might vary.
Time Base	Satisfied. The VII System Time service met this need.

CORE SYSTEM NEED	STATUS IN CURRENT DESIGN (VII)
Data Request	Partially Satisfied: VII includes a publish/subscribe mechanism that implements this and the two succeeding needs; however, it is limited to probe data and advisory message delivery. The new concept does not restrict the flow of data to vehicle-based probe data or center-based advisories. Further, VII presumed that all data would travel through the VII network; the effects of the addition of other communications media are unclear.
Data Provision	See Data Request
Data Forward	See Data Request
Network Connectivity	Partially Satisfied. The External Access Gateway, part of the VII SDN allows Network Users (Centers) to access VII services through the Internet.
Geographic Broadcast	Partially Satisfied: VII includes mechanisms for geographically-focused broadcasts using roadside equipment DSRC broadcasts, but does not address how to implement without DSRC communications.
Core System Service Status	Not satisfied. VII did not advertise the status of Core (SDN/ENOC) services.
System Integrity Protection	Partially Satisfied. The VII design documented in the NSR does not include environmental monitoring or mitigation. The POC implementation did include these aspects of integrity protection, but they are not fully documented.
System Availability	Not satisfied. The NSR includes system availability and maintainability requirements with unspecified values.
System Operational Performance Monitoring	Satisfied. The VII Management service specified management functions consistent with the Core System's needs.
Core System Independence	Satisfied. VII was envisioned as a single, nationally deployed system. As such it could operate independently by design.
Core System Interoperability	Partially Satisfied. VII included concepts for locally managed RSEs with different operational policies depending on local needs. It also required interoperability between regionally/locally deployed components (SDNs). Dependence on a single (or at most small number, certainly less than the number of SDNs) of ENOC(s) is a marked difference, as is the requirement for a "VII Operating Entity" that would make decisions affecting deployment and policy implementations.
Core System Interdependence	Partially Satisfied. VII was architected with SDNs and ENOCs working tightly together. However, variation between local management policies was not considered at the highest level.
Core System Data Protection	Satisfied. VII includes specifications for different types of users with configurable access, encrypted data storage and transmission necessary to protect the data stored and handled by the system.

CORE SYSTEM NEED	STATUS IN CURRENT DESIGN (VII)
Anonymity Preservation	Partially Satisfied. VII depends on a rapidly changing source identifier to obscure Mobile users. In some circumstances it is possible to track a single user providing probe data, but as DSRC device penetration increases this becomes extremely difficult.
Private Network Connectivity	Satisfied. The VII Network Subsystem provides dedicated connections to Network Users that require them.
Private Network Routing	Satisfied. The VII Network Subsystem routes data between SDNs to Network Users connected to one SDN but not the other.

VII includes some services that partially overlap with Core System needs such as the Probe Data Service (PDS). Additionally, there are services in VII that provide capabilities not reflected in the needs for the Core System. There are also services within VII that map to the Communications Layer, not the Core System services. The following are capabilities that exist in VII, beyond needs defined for the Core System:

1. The VII Communications Service includes a session management capability, which is not reflected in any needs of the Core System.
2. The VII Communications Service includes priority and levels of services concepts that are largely considered as part of the Communications Layer. The Core will have to maintain end-to-end class of service for communications that transit the Core however.
3. The VII Map Element Distribution Service maintained a store of map data. The distribution of map data is supported, and may in fact provide some storage if architecture analysis indicates it will be required, but that cannot be stated at this stage.
4. The VII Map Element Distribution Service validated map data based on probe data received from vehicles. Any such map data validation is outside the Core System.
5. The VII Positioning Service distributed positioning data to all vehicles. The Core System supports the distribution of position correction data, but does not provide it.
6. The VII Probe Data Service included mechanisms for protecting the identity of probe data providers. Since probe data is an application, management of privacy and anonymity as it is reflected within the contents of probe data messages is a task for the originating application, not the Core System.
7. The VII Probe Data Service included mechanisms for modifying probe data generation parameters. Since probe data an application, management of probe data generation is not a task for the Core System. Probe data generation management as it was envisioned for VII would include components at Mobile, Field and Center users all working together, with the Core facilitating trust but not transiting probe data generation messages.

4.3 Priorities among Changes

Traditionally this section would define the priorities among changes. However, as documented above this is problematic considering the magnitude of changes between VII and the Core System. Consequently, Table 4-3 describes essential, desirable and optional needs in prioritized order. Essential needs are essential for each Core, or for the federation of all Cores. The latter category means that the need must be satisfied for any qualifying System User that requires a service met by that need, but that the provision of that service can come from any Core. Needs are categorized as follows:

1. Essential needs: Features that shall be provided by the Core System. The impacts that would result if the features were not implemented are explained for each essential feature. Essential features are those which are minimally required to enable V2V and V2I safety, mobility and environmental applications. Essential features that must be provided for all System Users by the federation of all Cores are identified as Essential-Sum. These are features that some Cores may not have to implement as long as the federation of all Cores together does provide the feature. Essential features that must be provided by every Core regardless of its scope are identified as Essential.
2. Desirable needs: Features that should be provided by the Core System. Reasons why the features are desirable are explained for each desirable feature. A feature may be considered desirable if it provides benefit, but is not minimally required in order to deploy safety, mobility and environmental applications.
3. Optional needs: Features that might be provided by the Core System.

Table 4-3: Priorities and Rationale for Core System Needs

Core System Need	Priority	Rationale
Data Protection	Essential	Without the ability to exchange data securely, privacy could be compromised, mobility applications that use financial data (e.g. tolling) would be more cumbersome to deploy, and any applications requiring the exchange of information that users would want to protect would be either easily compromised or never developed.
Core Trust	Essential	Without the ability for the Core to trust System Users, it cannot trust the information they provide. If the Core cannot trust information from System Users, it cannot facilitate trust between System Users.
System User Trust	Essential-Sum	Without the ability to trust another user, many safety and mobility applications requiring interaction between System Users are not viable. System User trust can be established by any trusted Core System; once a System User's trustworthiness is established by one trusted Core it will be acknowledged by all System Users.
Core Trust Revocation	Essential	Revocation is required to ensure trust; without revocation, many safety and mobility applications are not viable. The Core must revoke its trust relationship with a misbehaving System User to protect itself and the data it passes.
System User Trust Revocation	Essential-Sum	Revocation is required to ensure trust; without revocation, many safety and mobility applications are not viable. Relationships between System Users must be revoked to ensure that misbehaving System Users do not compromise the safety or privacy of other System Users. This may not be done by every Core System, but must be done for every misbehaving System User.
Authorization Management	Essential	Authorization management is necessary to control access to system services and controls. Without authorization management the Core would be insecure, jeopardizing the provision of any service.
Authorization Verification	Essential	Authorization verification is necessary to control access to system services and controls. Without authorization verification the Core would be insecure, jeopardizing the provision of any service.

Core System Need	Priority	Rationale
Time Base	Essential	Most applications require time coordination. While the Core System does not directly operate applications, it passes data that has time fields and that may support applications. Further, mechanisms used to ensure trust may use a time-based expiration mechanism. Without a consistent time base used by the Core System that is also available to System Users, success of time-sensitive applications will be limited and trust mechanisms constrained.
System Integrity Protection	Essential	Without the ability to ensure the integrity of Core System services, those services could be hijacked or corrupted, compromising service delivery.
System Availability	Essential	If the Core System isn't working, it can't provide services.
System Operational Performance Monitoring	Essential	Without operational performance monitoring, it will be difficult to know when the system degrades or fails; managing maintenance and repair activities will be extremely difficult, and overall system reliability will suffer. This will lead to a reduced level of service.
Core System Independence	Essential	Without Core System Independence, implementation of local policies will be difficult and control over Core System operations difficult to maintain.
Core System Interoperability	Essential	Without Core System Interoperability, a System User that moves from one Core to another may lose access to Core System services.
Core System Interdependence	Essential	Without Core System Interdependence, aspects of the Core that must be coordinated so as to avoid duplication or inconsistency between Cores would not function (e.g., System User Trust, System User Trust Revocation).
Network Connectivity	Essential	Network Connectivity is required for the Core System to provide services to any System User not able to provide a private connection to the Core System. It is thus an enabler for applications that pass data using the Core's services, and for applications that rely on the trust relationships between System Users that are facilitated by the Core's trust management services.
Misbehavior Management	Essential	Without misbehavior management, misbehaving actors could affect the operation of Core System services. Not including this service decreases the overall security and usability of a Core System service. Communications could still be enabled without Misbehavior Management, but the level of trust between users would be compromised. This should not affect safety, but may affect mobility convenience applications, particularly those requiring financial transactions.

Core System Need	Priority	Rationale
Data Request (partial)	Desirable	Many mobility and environmental applications will require data to be exchanged between System Users. A Core that does not include Data Request or Data Provision would not serve the needs of System Users that need data from other System Users. If the Core System does not provide a data distribution mechanism, applications will need to provide the data exchange. This includes all of the Data Request need except for the concepts parsing, sampling and data aggregation.
Data Provision	Desirable	Many mobility and environmental applications will require data to be exchanged between System Users. A Core that does not include Data Request or Data Provision would not serve the needs of System Users that need data from other System Users. If the Core System does not provide a data distribution mechanism, applications will need to provide the data exchange.
Data Forward (partial)	Desirable	Data Forward puts publish-subscribe inside the Core System, helping make the most efficient use of communications resources. Including data forwarding inside the Core System also simplifies administration of who can get access to data. For deployments operating over areas with significant DSRC infrastructure, publish-subscribe will further help manage communications resources, since those DSRC deployments are likely to be operated by the same entity that operates the Core. Without Data Forwarding, data distribution functions could still be accomplished through direct communication with Center data providers/consumers, but not as efficiently as if the need were met by the Core System. This includes all of the Data Forward need except for the concepts parsing, sampling and data aggregation.
Geographic Broadcast	Desirable	Without geographic broadcast, individual messages will have to be sent from System User to System User, or System Users will have to manage their own multicast or broadcast operations. This will make the provision of data to groups of System Users more difficult and less efficient than if the Core System provides geographic broadcast.
Core System Service Status	Desirable	Core System Service status helps set System User expectations. Without awareness of Core System service status, applications may attempt to access services that are not available, which could adversely affect communication resource use.

Core System Need	Priority	Rationale
Data Request (partial)	Optional	This includes only the aspects of the Data Request need required to support the concepts of parsing, sampling and data aggregation. It is optional because providing these services is an extra benefit beyond that which is minimally required to support Core System goals. Providing these concepts may make it easier for subscribers to leverage data because the data will come in smaller amounts but without loss of information.
Data Forward (partial)	Optional	This includes only the aspects of the Data Forward need required to support the concepts of parsing, sampling and data aggregation. It is optional because providing these services is an extra benefit beyond that which is minimally required to support Core System goals. Providing these concepts may make it easier for subscribers to leverage data because the data will come in smaller amounts but without loss of information.

4.4 Changes Considered but not Included

A feature that was considered, but not included, was long-term storage of probe data within the Core System. There was little input from workshops, and no input from any other forum indicating that the Core System must provide long-term storage. This is not to say that the Core System has no storage capability; many of the needs described above will require some form of storage in order to operate. Additionally, the Communications Layer may incorporate some buffering, which could include short-term storage of probe data, in order to accommodate various backhaul topologies.

Various “<user> must provide <data>” needs were considered, but ultimately rejected as they would result in the imposition of requirements on systems outside the bounds of the Core System. Instead, critical data provisions are identified as constraints on the ability to deliver application benefit, and reflected in discussion of policies.

A Core System service that maintained a listing of application availability across geographic bounds, with understanding of communications performance requirements was considered. This service would allow Mobile and Field users to determine where applications would function in advance of entering that area. It was not included in the Core because it is an application-centric function; the burden on setting user expectations for application performance is on the application, not the Core.

A Core System service that allowed a System User to query the Core to determine if another System User was permitted a specified action was considered. This could be used to support application permissions, for example determining if a Mobile User that sent a signal pre-emption message was entitled to do so. This functionality was not implemented because many of the applications that would use this service would require low-latency response that may make such a query impractical.

Lastly, the establishment of a back office brokerage function within the Core System was considered. This would allow Center data providers to advertise available data for acquisition by other Centers, and enable the establishment of a data exchange relationship between the two Centers. The rationale for including this functionality is that advertisement of available information is a sizeable barrier to information exchange between 3rd parties, and that providing this functionality would facilitate the development of data exchange standards (not the message sets, which are already mature, but how to set up the exchanges in the first place) and remove some of the barriers to interaction amongst users, providing a richer, more interrelated secondary data market. Ultimately, it was deemed that while this brokerage would be a valuable service, its inclusion does not help meet any of the USDOT’s transportation improvement goals. The provision of a center-to-center brokerage service is thus deemed a market opportunity, but not Core System functionality.

4.5 Constraints and Assumptions

This section describes any assumptions or constraints applicable to the changes and new features identified in this section.

A constraint is “a factor that lies outside, but has a direct impact on, a system design effort. Constraints may relate to laws and regulations or technological, socio-political, financial, or operational factors.” The following are Core System constraints:

1. Privacy limits the uses of personal information as defined in the VII Privacy Policies Framework. This framework documents concerns and policies relevant to securing, storing and handling

personally identifiable information that would be collected using or enabled by Core System facilities.

2. The IEEE 1609.x family of standards (including 1609.1, 1609.2, 1609.3 and 1609.4) as well as IEEE 802.11p will serve as the interface standards for 5.9GHz DSRC. This program will use of standards to document interfaces, and the existing IEEE 1609.x standards address many of the anticipated needs for DSRC communications. Developing a new set of DSRC communications standards would be a significant effort.
3. X.509 certificates will provide the basis for Core and System User non-DSRC certificates. Existing certificate management systems use X.509. Establishing new certificate formats, management procedures and implementations would be time consuming and expensive.
4. The SAE J2735 standard will serve as the basis for messages sent to and from Mobile users. The existing standard documents much of the messaging expected to Mobile users. It is the product of much intellectual capital applied during the VII program. While it may require revision to support Mobile cellular communications, it includes many of the concerns that are relevant for vehicles using DSRC.
5. Most existing public sector transportation agencies cannot afford additional personnel. This was consistent input from public sector personnel at User Needs workshops.
6. If a Core System service requires geo-referencing, the same geo-referencing capabilities must be available to all System Users. If not, it will be difficult or impossible to coordinate location references, jeopardizing safety and mobility applications that depend on accurate positioning data. POC positioning tests and CICAS-V testing both demonstrated the need for consistent geo-location references.
7. Service performance characteristics are constrained by the communications mechanism with which users connect to Core System. The Core can set minimum performance standards for usage of Core services, but is constrained by what is available. Unless DSRC field infrastructure is deployed at a pace sufficient to keep up with Core and Mobile deployments, usage of existing communications infrastructure, particularly 3G and 4G cellular, will be required to deliver services.
8. Core System Services must be accessible by System Users through interfaces defined in open standards. This was consistent input at the User Needs workshops.
9. IPv6 will provide the basis for communications between Mobile Users and the Core System. IPv4 will not be supported for Mobile User to Core System interactions, as it is being phased out in favor of IPv6, albeit slowly. IPv4 support to Mobile Users was included as part of the POC, and while functional did add significant complexity. IPv6 hardware and software should be readily available by the time the first Core is ready to deploy.

An assumption is “a judgment about unknown factors and the future which is made in analyzing alternative courses of action.” The following are assumptions made in the course of the development of the Core System:

1. The concept of regional and potentially overlapping deployments will be studied and concepts for management of Personally Identifiable Information (PII) in the context of overlapping deployments developed. The VII Privacy Policies Framework does not consider overlapping deployments. This study may result in guidance concerning agreements between Core Systems and how they handle data.
2. Communications between System Users and the Core System will be provided by System Users. Users are responsible for their own radio equipment (DSRC, 3G, etc.) and service plans necessary to use them.

3. Vehicles will provide probe data anonymously, including basic safety data, mobility data, emissions data, fuel consumption data, pavement condition data and weather data. The amount, quality and frequency of data will vary depending on vehicle capabilities and operator settings. Formats for probe data are reflected in the current version of SAE J2735. While there are currently no mandates or wide-ranging incentives for vehicles to provide this data, the application developer community has expressed the need to receive it at the User Needs Workshops.
4. Non-vehicular mobile users will provide probe data anonymously, including basic safety data and mobility data. The amount, quality and frequency of data will vary depending on device capabilities and user settings. While there are currently no mandates or wide-ranging incentives for non-vehicles to provide this data, the application developer community has expressed the need to receive it at the User Needs Workshops.
5. Anonymously-provided probe data will be made available to application providers. Probe data provides the foundation for many of the applications envisioned by participants at the User Needs Workshops; with anonymous probe data available, the application developers will be seeded with the foundational data they need to deliver mobility applications. Without anonymously provided, generally available data, the application environment will be constrained.
6. Some vehicle-based safety applications will be mandatory for new vehicles. All other applications will be Opt-in, based on the USDOT's policy research program.
7. In addition to 5.9 GHz DSRC, other forms of Wi-Fi and Cellular Communications will be used to provide communications between System Users and the Core System.
8. Deployment of Core System services and Communications Layer services will be regional and evolutionary. While no deployment plans have been finalized, this reflects the current analysis and feedback from potential deployers and operators.
9. Message Class of Service (CoS) will be managed primarily by the Communications Layer, depending on the class of service requested by the message request and message content. Service classes define ranges for the performance of communications resources, including bit rate and delay. By assigning messages to classes, communications resources will be able to better manage the delivery of messages using available resources. Delivery of a firmware patch for example, which may require a large amount of bandwidth, or safety data, which may require low latency between transmitter and receiver, are examples of the types of messages for which class of service could be important. Messages that transit the Core as part of publish-subscribe actions will have message CoS managed by the Core to the extent that the communications media used allow it.
10. Message priority will be managed primarily by the Communications Layer, considering factors such as the priority requested by a message, message content and available resources. Messages that transit the Core as part of publish-subscribe actions will have message priority managed by the Core to the extent that the communications media used allow it. Prioritization will increase the likelihood that more important messages are given access to communications resources, and increase the chance that they are sent and received relative to less important messages. Messages carrying safety information for example, would be prioritized higher than messages carrying probe data
11. IEEE 1609.2 certificates will be managed by a single ESS acting as CA. This CA will accept and act on revocation requests provided by the Core System.

5.0 CONCEPTS FOR THE PROPOSED SYSTEM

This section describes the Core System that will be developed to satisfy the needs defined in Section 4.0. The Core System may be thought of as housing the *functionality* to manage the *interfaces* between System Users.

The Core System includes eight distinct subsystems:

1. Core2Core, which manages interactions between Core Systems, coordinating backup and service handoffs between Cores.
2. Data Distribution, which informs data providers of how to provide data, manages data subscriptions, and provides data forwarding capabilities. This includes the notion of publish-subscribe.
3. Misbehavior Management, which identifies and suggests action against misbehaving System Users.
4. Network Services, which provides the information necessary to enable communications between specific System Users.
5. Service Monitor, which monitors the state of Core System components and makes the information available to System Users.
6. Time Synchronization, which keeps Core System services operating on the same time base as System Users.
7. User Permissions, which manages roles and responsibilities of System Users.
8. User Trust Management, which manages credentials of System Users.

Data Distribution, Service Monitor, Misbehavior Management, Network Services, User Permissions and User Trust Management provide services to System Users. Core2Core provides services to other Cores. Service Monitor provides additional services related to performance and operations to Core Personnel. The Time Synchronization subsystem offers no external services.

In addition, the Core System may procure services from ESS that provide services the Core needs to deliver, but make more sense to manage, maintain and share between multiple Cores due to overriding institutional, performance or functional constraints. The most likely candidate for external support is an external Certificate Authority, due to the need to coordinate certificate distribution and revocation activities between all cores. No other functions so plainly require all Cores to interact, so other ESS are less likely.

The reader is encouraged to resist the temptation to think of the Core System as some physical system purchased and installed once but rather a set of services, implemented in a distributed fashion, both in time and geography. The structure will be provided by the requirements on the system performance and through use of standardized interfaces.

As described in Section 4.1, the Communications Layer provides communications between the services provided by the Core System and System Users. The Communications Layer could be implemented by private or public operators, but in either case must support the privacy policies approved by USDOT which are documented in the VII Privacy Policies Framework.

The subsections that follow describe the proposed system starting with the background and overall scope of the Core System and some of the operational policies and constraints that will guide the use of the system. Then the system will be described in terms of its subsystems and how those subsystems interact with each other and the outside world. This will then be followed by a description of the various modes of operation supported by the Core System, the users or actors that interact with the Core System, and the support environment that surrounds and sustains the Core System.

5.1 Background, Objectives and Scope

This section describes the background and motivations that are behind the definition of the new system. What events have led to the formation of the new Core System? What changes have taken place in the industry and in areas of research that have driven the definition of the Core System?

Throughout this ConOps a distinction is made between the applications that are visible to users (travelers, operators, planners, advertisers, etc) and the services of the Core System that support those applications. To understand how the Core System is to be organized, this section looks at the evolution of the USDOT's programs that are related to the development of the *connected vehicle* environment.

When the USDOT re-branded the VII initiative in early 2009, it involved more than just changing the name of the initiative. The USDOT also changed some of the basic assumptions related to how mobile and infrastructure components of the system would communicate. The overall program is no longer focused on a name or brand, but the changes identified around the time of the re-branding remain. One major change relaxed the constraint that all wireless communications would use DSRC radios and protocols.

The technologies and applications that will be deployed as part of this program can transform travel as we know it. Combining leading edge technologies such as advanced wireless communications, on-board computer processing, advanced vehicle-sensors, navigation, and smart infrastructure can provide the capability for travelers to identify threats, hazards, and delays on the roadway and to communicate this information over wireless networks to provide alerts, warnings, and real time road network information. This program makes use of wireless communications networks that use both V2V and V2I communications to support the cooperative system capabilities necessary to support the applications. Within vehicles, four types of devices are supported: embedded devices (devices that are installed as part of the vehicle's systems by the vehicle manufacturer), retro-fit devices (devices installed after the vehicle leaves the vehicle manufacturer, but which connect to in-vehicle information systems), aftermarket devices (devices that are installed either at the time of vehicle purchase or later, that are not necessarily connected to in-vehicle information systems but can be, at the vehicle owner's option), and "carry-in" devices (devices that can be temporarily installed in vehicles and are not necessarily connected to in-vehicle information systems). "Carry-in" devices include the category of hand-held devices (e.g., smart phones) that could also be carried by pedestrians or other users of the roadways (e.g., bicyclists or wheelchair-bound travelers). Communications to and from each of these types of devices will be supported whether the communications is one-way or two-way and whether the communication is between any combination of vehicles, infrastructure and mobile devices.

The ability to collect, process and exchange real-time data provides travelers with an opportunity for greater situational awareness of the events, potential threats, and imminent hazards within their environment. When combined with technologies that intuitively and clearly present alerts, advice, and warnings, travelers can make better and safer decisions. Additionally, the *connected vehicle* environment will provide the opportunity to enhance the efficacy of automated vehicle-safety applications.

As a means of ensuring public acceptance of these technologies, the National VII Coalition developed a Vehicle Infrastructure Integration Privacy Policies Framework which is designed to protect the public from any misuse of PII (Personally Identifiable Information) that might be collected.

Since the USDOT's initiation of VII, international projects have provided different concepts and approaches to the wireless vehicle environment and the applications that are possible with *connected vehicles*. These projects include: Communications for eSafety (COMeSafety), Co-operative Systems for Intelligent Road Safety (COOPERS), the Cooperative Vehicle-Infrastructure Systems (CVIS) program, the Car 2 Car consortium, Japanese projects such as Smartway, as well as the Communications Access for Land Mobiles (CALM) standards effort in International Organization for Standardization (ISO) Technical Committee (TC) 204 Working Group (WG) 16.

The lessons learned from other parts of the world provide input to the definition of the transportation safety, mobility, and environmental applications for the US and North America. The Core System will also use the international efforts in the definition of the requirements and architecture, building upon their success in the vehicle to roadside wireless environment. The concepts for the framework of the Core System described in this ConOps are consistent with the high-level concepts and organization in the European Framework architecture. One difference that has already been shown is that the Core System merges the Vehicle and other mobile devices into the same category as it concerns the interaction with transportation applications. Other differences will come out as the system is architected in subsequent phases just as similarities will be manifested in architectural structures that build upon work already accomplished in previous work, including the international community.

5.2 Operational Policies and Constraints

This section describes operational policies and constraints that are to be considered for the Core System. Operational policies are predetermined management decisions regarding the operations of the system. Policies limit decision-making freedom but do allow for some discretion. Operational constraints are limitations placed on the operations of the system. This section will discuss topics such as "why should a System User provide data", interface standardization, data production, distribution vs. services, data ownership, and deployment policies.

While the policy and governance of the Core System is being considered as part of the architecture, most of the operational policies are being worked separately. See http://www.its.dot.gov/connected_vehicle/connected_vehicle_policy.htm for details on policy research sponsored by USDOT. A few policy issues that will directly affect the system architecture are reflected in assumptions or constraints in Section 4.5. There are also operational policies and constraints that will have to be considered as part of the architecture definition. These issues are shown here as a way to ensure they are considered throughout the system definition process but also so that readers considering the deployment of Core System components will be aware of them.

Certification:

- System User devices will have to be certified that they meet the specifications defined for interaction within the system. An entity or entities, granted authority by the USDOT and acknowledged by the state and local DOTs and vehicle manufacturers, will have to oversee this certification process.
- Similarly for software, there should be a means by which an authority can certify that the applications that are part of the *connected vehicle* environment meet national standards for application behavior wherever they are deployed.

- Exactly which devices and software need to be certified is uncertain. Safety of life devices and software almost certainly need to be certified, but which, if any, other devices and software need to be certified is uncertain. Mechanisms should be established to facilitate certification so that the actual practice of certification does not constrain the policy decision of what needs to be certified.
- Core Systems will also have to be certified. An entity or entities granted authority by the USDOT and acknowledged by the state and local DOTs and vehicle manufacturers will have to oversee this certification process. Core System certification should include some notion of monitoring and periodic recertification to help ensure that Cores maintain operational compatibility with one another. This will be especially relevant to managing software maintenance of Cores.

Operations and Maintenance:

- A constraint that will be particularly felt by the public sector agencies that will be hosting and operating Core System elements is that they may have limited ability to hire and train qualified staff. The operation of the Core System may become part of "other duties as assigned" to their existing personnel. It will be a challenge to ensure the system is functional without compromising system security and integrity. There may be a need to have additional staff, perhaps contracted, during the early phases of deployment until the Core System and the applications can replace services they currently run.

Security Management:

- The management of digital certificates required for wireless communications will need to assure national interoperability. Some entity or entities, granted authority by the USDOT and recognized by the owners and operators of System User devices, will have to manage these digital certificates. At a minimum this will include four different types of certificates: identity DSRC certificates, anonymous DSRC certificates, X.509 Core System certificates, and X.509 non-DSRC System User certificates. Digital certificates are issued by a CA and identify the owner (name and a serial number, or pseudonym for anonymous Mobile Users), expiration dates, a copy of one of the certificate holder's public keys (one key used for encrypting and decrypting messages another key for digital signatures), and the digital signature of the certificate-issuing authority so that a recipient can verify that the certificate is real. There is an ongoing research effort to define the certificate management policy. The benefit of having USDOT involved along with the public and private sector is that it increases the likelihood that a consistent practice can be established and this critical portion of the system will succeed.
- Identification of misbehaving users will require communication between every Core System, or at least a proxy communication with each Core communicating to the same certificate management entity. This will also require some coordination, as one locality's misbehavior may not be the same as another's. For example, one locality may wish to revoke permissions for misbehaving users, while another would not. This leads to a situation where a misbehaving user may still participate in the *connected vehicle* environment, might lose his permissions in one or more localities but maintain them in others.
- Definition of user groups will simplify operations, but if definitions vary between Core Systems, interactions between System Users and Cores could yield different results which could lead to end user confusion or dissatisfaction. User group definitions and permission sets should be coordinated between Cores operating where System Users may interact with both. Core2Core interactions should enable modifications to user group definitions once user groups have been agreed to by the entities operating their respective Cores.

Data Provision/Ownership:

- Determination of who owns data produced by mobile devices, including probe data, will affect deployments and secondary markets. This policy area may be addressed in ways that are consistent with current practices for data sharing agreements of ITS deployments in metropolitan areas today.
- Issues of ownership may also need to be settled via policy to ensure that public agencies seeking to manage their transportation operations have access to data while at the same time preserving the investment that other agencies or private entities may have put into the collection of that data.
- Incentives may be needed from the data collectors – those users that are seeking traffic conditions, weather, other traveler related data – in order for travelers to 'opt-in' to a service whereby they provide such rich information.

System Performance Management:

- Policies and procedures for revocation of certificates for devices that fall outside the standards of operation will have to be developed. This includes devices that are malfunctioning in some way but are still transmitting potentially erroneous messages to other System Users (e.g. Field Users transmitting incorrect weather data due to a faulty sensor, or Mobile Users transmitting incorrect safety messages due to a positioning error) or devices that have been deliberately tampered with that could cause confusion or threaten the safety and security of other users. The Core System will include functions to monitor the behavior of devices and applications interacting with and through the Core System to identify activity that might indicate a risk to the *connected vehicle* environment.
- The development of these policies and procedures must be nationally consistent and these policies and procedures need to be accepted and implemented everywhere the system is deployed. Otherwise security standards could vary depending on the Core which could compromise the environments managed by other more secure Cores.

Flexibility:

- The deployment strategy has not been finalized. System requirements, architecture, operational policies must all consider multiple deployment options.
- Economic conditions may dictate the deployment strategy and the architecture and governance constraints will need to be compatible with a wide range of deployment options.

5.3 Description of the Proposed System

The Core System exists among a federation of independently operated and managed Cores, working together to provide services. Each Core has its own scope, defining:

- The geographic area over which it provides services
- The performance of the services the Core provides
- The data types it supports
- The optional data distribution functionality (data sampling, aggregation, parsing) it supports
- The System User types it supports

In addition the operators and managers of Core Systems need to negotiate the terms of the relationships between Cores. The number and types of relationships between Cores will vary; relationships will depend on the Core's scope and the availability of other Cores that share scope boundaries with the Core. For example, a Core whose scope includes a large metropolitan area may have relationships with other Cores that cover adjacent areas while a Core that provides services in an isolated area may have no shared boundaries and few relationships with other Cores.

An individual Core System is composed of eight subsystems that provide all Core services and interfaces to System Users, Core System Personnel and other Cores, as shown in Figure 5-1. The logical interfaces that connect System Users to Core services will be defined later in this section. Subsystems are defined in section 5.3.2.

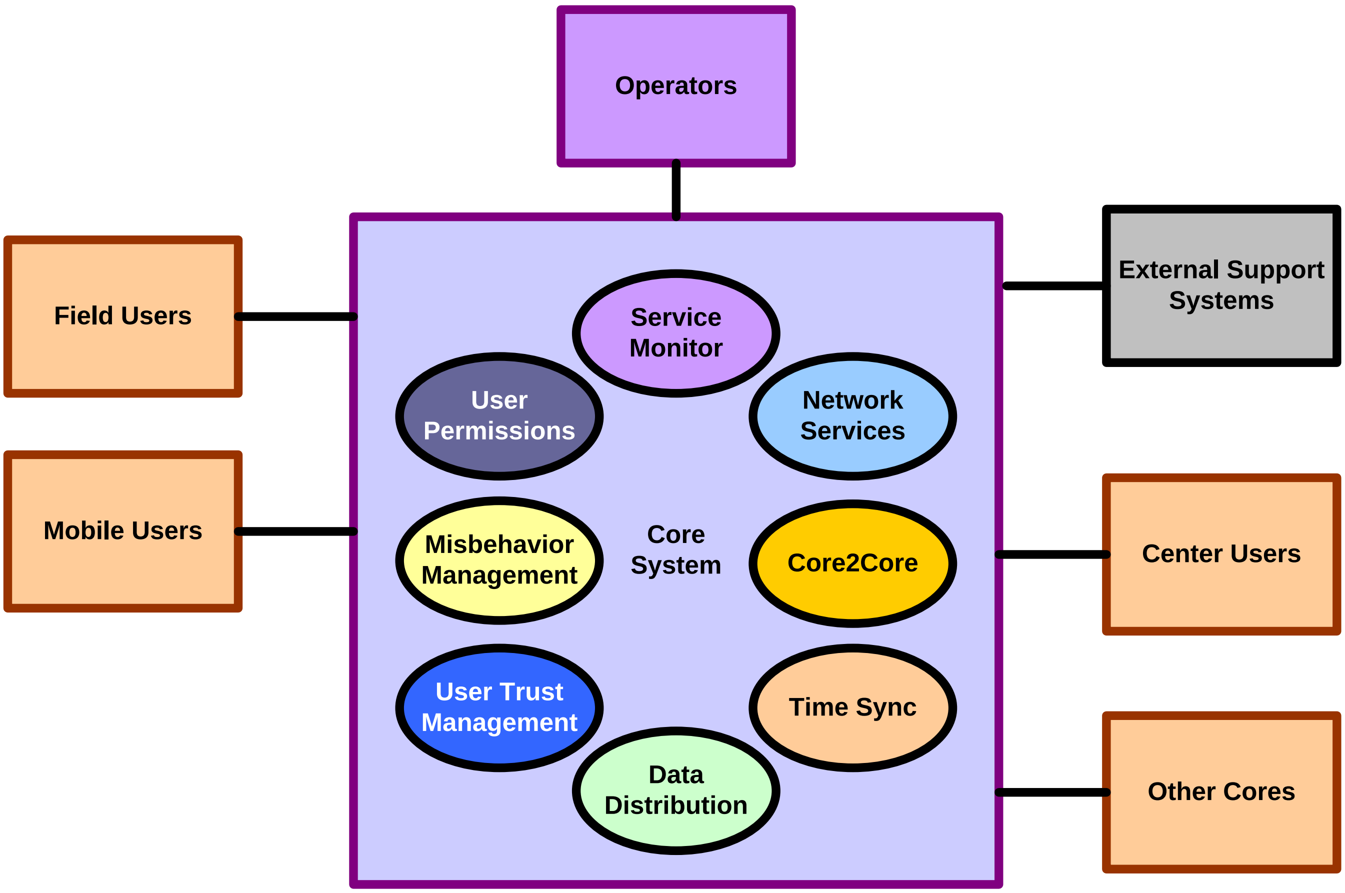


Figure 5-1: Core System Subsystem Context

5.3.1 The Operational Environment

The operational environment in which the Core System exists is a heterogeneous community of systems run by multiple agencies at different levels of complexity and various locations. Some examples of the operational environment can be gleaned from the representative scenarios in Section 6.0 of this document. The potential number of scenarios involving transportation-related System Users is unlimited but all will involve some sort of wireless communication. Applications may be deployed in complex configurations supporting a major metropolitan area or a minimal configuration to support a set of isolated rural road curve warning systems.

As Core Systems are deployed some may include just the essential functions to support a particular local area and rely on an interface to another Core to provide additional services. For instance, one Core could include the necessary hardware and software to manage a subset of the subsystems for their local area and rely on a connection to another Core's subsystems for additional services. A larger Core implementation may include instances of all of the subsystems, though that larger Core would still need connections to other Cores to support security services as for Mobile Users.

The Core System will not necessarily require a control center with large video screens or employ a large number of operators. A Core can function in an office or data center environment as long as there is access to a network that enables communications between System Users and the Core.

The Core System may have different deployment configurations:

- Standalone system – where the deploying agency (public or private) includes all hardware, software and communications necessary to support their services in an office or center environment that is dedicated to support safety, mobility, and environmental applications.
- Collocated with other transportation services – where the deploying agency (public or private) installs the hardware, software, communications in an office or center environment that is also used to house the operations for another transportation service such as a traffic management center or a traveler information service provider.
- Distributed across geographic locations, including remote hosting – where one deploying agency has the hardware and software for part of the services but uses Internet communications to run some Core System services remotely, either at another facility owned by the same agency, another similar agency, or a software as a service (SaaS) provider for some utilities.

A Core System's deployment footprint includes:

- The geographic area over which it provides services: this area may coincide with political boundaries, geographic features, communications deployments, or may be defined independent of any external factors by the entity deploying the Core.
- The performance of the services the Core provides: this includes identification of the services the Core provides as well as the performance of those services. Service performance will be a factor of several items: performance of the hardware and software on which the service operates, but most significantly the communication path over which the service is accessed by the System User. Hardware can usually be scaled to improve performance, but deployment of higher speed or lower latency wireless communications is a more lengthy process. Consequently, the performance aspect of service delivery will be primarily constrained by the performance of wireless communications available in the deployment area. This mostly affects Mobile users, since Field and Center users usually have access to wireline communications offering performance sufficient to their needs.
- The data types it supports: this defines the data types and associated message formats for all data accepted by the Core's Data Distribution subsystem. Since all Core interfaces are to be defined by standards, this should be expressed as a reference to applicable standards (e.g. SAE J2735).
- The optional data distribution functionality (data sampling, aggregation, parsing) it supports: these facilities must be characterized in terms of what data types are supported for each capability, ranges (e.g. sampling limited to between 1 in 10 and 1 in 50 and only over a specific geographic area) and any restrictions on the use of this functionality (e.g. aggregation limited to a particular group of System Users).

- The System User types it support: this explains if the Core has any group concepts for particular System User types (e.g., Transit vehicle Mobile Users). This could include a description of any particular functionality that is applicable to this group in the Core's geographic area (e.g., Transit signal priority).

The deployer must be able to describe the deployment footprint in a format that other parties understand so that this information can be communicated and understood by other Core deployers and interested System Users.

Further complicating the operational environment is the relationship between Core Systems. Cores may provide service backup for one another; i.e., one Core providing services in lieu of another, to support maintenance or emergency operations. Service backup requires institutional relationships between the Core operators as well as sufficient Core and communications capacities to fulfill takeover promises.

Institutional relationships must also address boundary conditions; i.e., what occurs when a Mobile User transitions between the deployment footprints of two Cores? The following examples of Core operational environments focus on the communications available between Cores and System Users, and the geographic boundaries between Core deployments.

Example 1: Isolated Core Deployment

Isolated Core systems provide the baseline for illustrating Core operational environments. In this example a single Core provides services for a given geographic area. This area has 3G cellular services available throughout, as well as two areas where DSRC-based roadside equipment is deployed. Core services are available through 3G everywhere, and through DSRC (to backhaul of some type, could be wired or wireless) in those two smaller areas. There are no conflicts or boundary conditions with other Cores. All Mobile User data distribution functions are provided by Core #1.

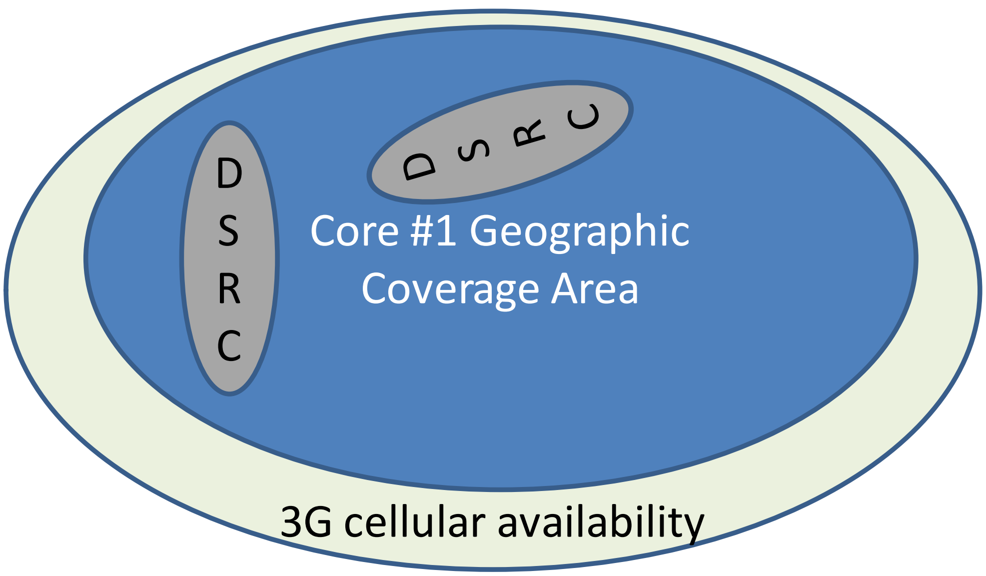


Figure 5-2: Single Core Deployment

Example 2: Two Adjacent Cores

Adjacent Core Systems require interaction between Cores and the entities that operate those Cores. In the example below, one Core overlaps coverage with another Core. In this example Core #2 provides all of its services in the red area, and all by 3G links. Core #1 provides its services in the blue area, some by 3G and some by DSRC. The adjacent area between the Cores requires agreement between the Core operators as to which Core provides services. Mobile Users that move between the areas serviced by the Cores would transition between Cores after they had left the boundary area between the two Cores' coverage areas. The size of the boundary area may be expressed in distance or time, and is a topic for further technical study.

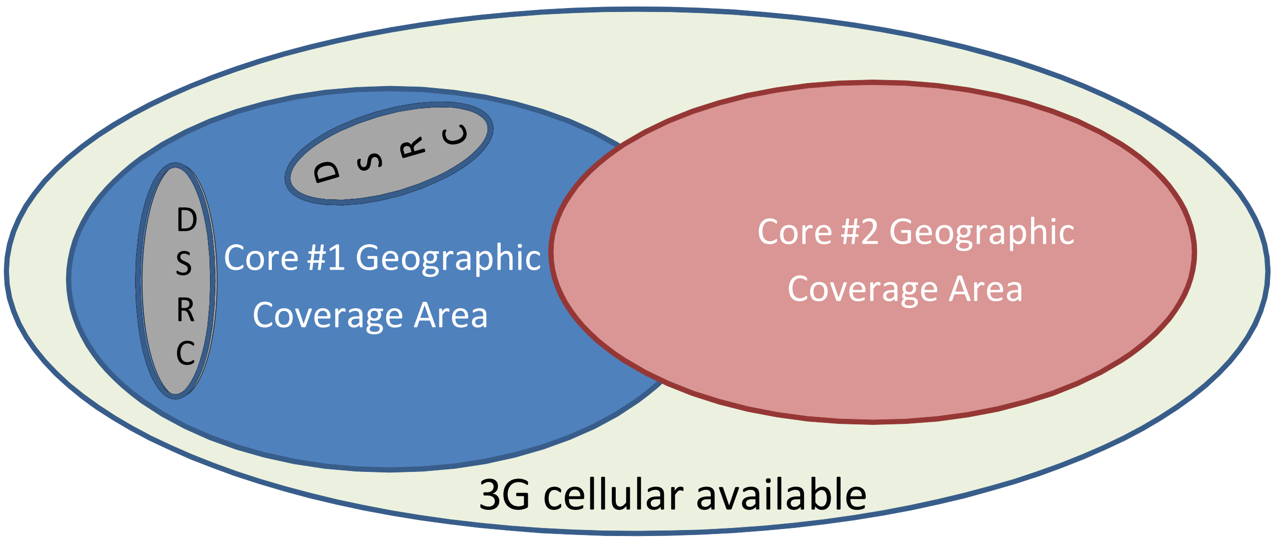


Figure 5-3: Multiple Overlapping Core Deployments

Example 3: Two Overlapping Cores

In Figure 5-4, the Cores share responsibility over an overlap area. They would have to negotiate agreements over data ownership and distribution; relationships could be as peers or one Core could be dominant for certain services while the other could be dominant for other services. Core #1 would provide some services in the area by DSRC, while both provide services in the shared area by 3G cellular. DSRC users would interact only with Core #1, while 3G users could interact with either Core depending on the nature of the data distribution agreement.

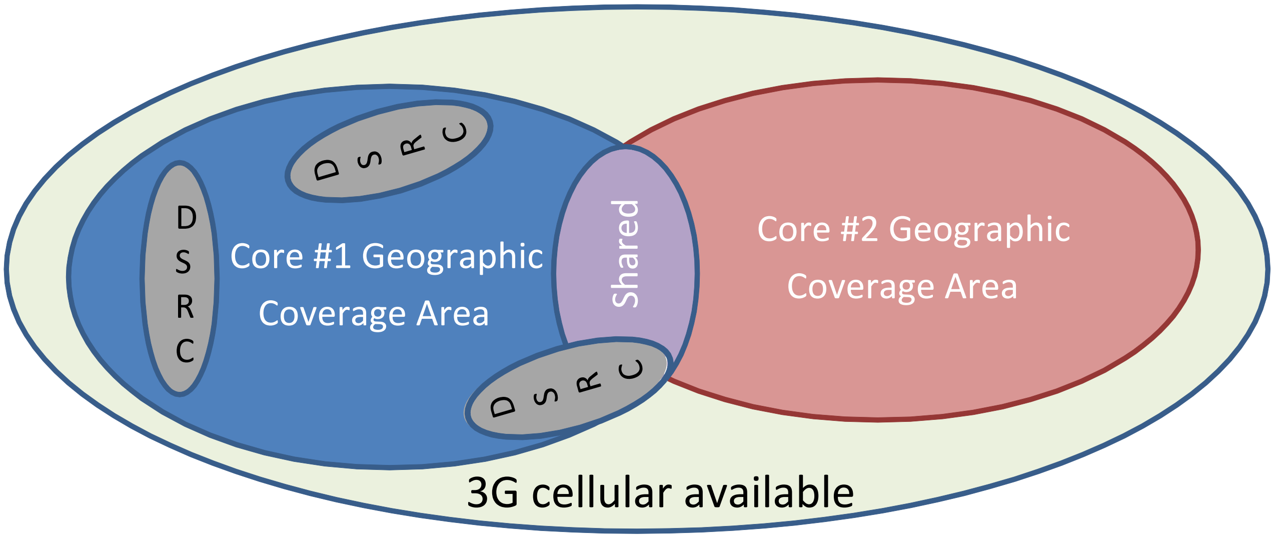


Figure 5-4: Multiple Overlapping Core Deployments with Shared Service

These examples illustrate some of the potential for overlap and shared service between Cores in a mixed communications environment. Interaction between Cores is necessary when Mobile users request services offered by one and not another in a shared space, and also when Mobile users move between coverage areas, at least to coordinate operational boundaries. These interactions will be more fully described in the System Architecture document.

One last result of this analysis illustrates a remarkable difference from the architecture conceived in the past: A *Core System can be deployed without DSRC field equipment*. DSRC field equipment will enable many applications including V2I safety applications, but V2V interactions rely only on the Core's facilitation of trust relationships. This does not necessarily require DSRC-enabled field equipment.

5.3.2 Subsystems

This section describes the subsystems of the Core System, how they relate to the Needs that were defined in Section 4.0, and how they relate to each other to support the overall operation of the Core System.

While at this point in the system engineering process it is premature to fully develop the major system components some high-level concepts can be related. The Core System is all about standardized communication that satisfies System User application needs. The Core System and the overall framework of applications need to be flexible to allow for staged deployments both large and small. The Core is really just enabling communications between System Users and as such is only comprised of standardized interfaces and the services required to make the interfaces work. The interfaces must be standardized in order to permit interoperability among the external systems described in Section 5.3.3.

The services will be further defined as the engineering process transitions from asking "what is it" to answering "how does it do it?"

Throughout the subsystem descriptions the term "System User" is used to identify the applications or external systems (i.e., Mobile, Center, and Field) that are interacting with the Core System. The only human users of the Core System are the administrative personnel that operate and maintain Core System services.

5.3.2.1 Subsystem Descriptions

This section provides a description of each of the subsystems of the Core System, arranged alphabetically. According to the INCOSE Systems Engineering Handbook v3.1, a subsystem is defined as “an integrated set of components that accomplish a clearly distinguishable set of functions with similar or related uses.” Some of these subsystems may use PII, in particular User Permissions and User Trust Management. Any PII collected is maintained as necessary to fulfill system functions but not shared outside the Core.

Core2Core Subsystem: The Core2Core Subsystem interfaces with other Core Systems, advertising its jurisdictional scope, offered services and services it desires from other Cores. The Core2Core subsystem will maintain knowledge base and services available from other Cores. In this way, the Core can act as a user to another Core, providing proxy services that it does not offer but another does. Additionally, Core2Core is responsible for compatibility between Cores, ensuring that it does not encroach on the scope of another Core, and similarly accepting error messages from Mobile Users that might indicate a cross-jurisdictional compatibility or scope coverage issue. Core2Core also manages backup of configuration data between Cores, restoration of backup data between Cores, and takeover of services between Cores (where one Core asks another Core to provide a service so that it may perform a maintenance action or other activity that renders it unable to deliver all services). Interfaces between Cores will be formalized in interface specifications. Conflicts and discrepancies between Cores will have to be resolved by agreements between the agencies responsible for the respective Cores.

Data Distribution Subsystem: The Data Distribution Subsystem interacts with System Users taking one of two roles:

- System User as Data Provider, where the System User provides data to the Core System for the Core to distribute to other System Users
- System User as Data Subscriber, where the System User receives data that was provided by other System Users but distributed by the Core

Data Distribution maintains a directory of System Users that want data (Data Subscribers) and facilitates the delivery of data received from Data Providers to those Data Subscribers. It supports multiple distribution mechanisms, including:

- Source-to-Points: The data provider communicates data directly to data consumers. In this case, no data is sent to the Core System, however the Core is involved to check User Permissions and provide addressing services through those subsystems
- Publish-Subscribe: The data provider communicates data to the Data Distribution subsystem, which forwards it to all users that are subscribed to receive the data.

Data Distribution allows data consumers to specify (and change the specification of) data they wish to receive using criteria including:

- Data type
- Data quality characteristics
- Data format requirements
- Geographic area
- Sampling rate
- Minimum and maximum frequency of data forwarding

Data Distribution maintains a registry of which data consumers get what data, according to the criteria defined above. Data Distribution does not store or buffer data beyond that which is necessary to complete publish-subscribe actions. If a given data consumer is unable to receive data that it has subscribed to because of a communications or other system failure, the data in question may be lost. The degree to which data distribution buffering accommodates connectivity failures will be up to the Core System deployment. Some Cores may offer “temporary storage” in this fashion.

Data Distribution repackages data it receives from data providers, stripping away the source header information while maintaining the message payload. It then sends the repackaged payload data to subscribers of that data. It may aggregate, sample or break data into individual elements (i.e., parse), depending on the deployment.

Data Distribution does not share or exchange data with other Core Systems. System Users that want data from multiple Cores need to subscribe to each Core.

Misbehavior Management Subsystem: The Misbehavior Management Subsystem analyzes messages sent to the Core System to identify users operating outside of their assigned permissions. It works with the User Permissions subsystem to identify suspicious requests and to maintain a record of specifically identifiable users that:

1. Provide false or misleading data
2. Operate in such a fashion as to impede other users
3. Operate outside of their authorized scope

Because most end users will rarely interface with the Core System, Misbehavior Management will also accept reports of misbehaving users from other users. Center, Mobile and Field users can send misbehavior reports that reference credentials attached to messages, and note the type of misbehavior in question. Misbehavior Management will record such reports, and according to a set of Core Personnel-controlled rules, determine when to revoke credentials from such reported misbehaving users. For anonymous users revocation is more complex, and may result instead in a lack of credential renewal. Regardless of the result, Misbehavior Management provides such revocation/renewal notifications to User Trust Management (which is responsible for managing certificates), and User Permissions (which is responsible for managing access to the Core System).

Large numbers of failed renewals could have a significant effect on operations; system requirements and design activities will need to ensure that renewal failures do not adversely affect system performance or user experience.

Also, since some Field Users could provide services that enable geo-casting to Mobile Users, Misbehavior Management must notify Data Distribution of misbehaving Field Users, so that they can be removed from any geo-casting distributions.

Network Services Subsystem: The Network Services Subsystem provides connectivity between the Core System and System Users. This includes both an Internet connection and any private network connections the Core supports to other Cores or System Users.

The Network Services Subsystem also provides management for Communications Layer resources. It will enable decisions about which communications medium to use when more than one is available, and take into account message priority when passing messages and choosing media. This requires identifying available communications methods’ current performance characteristics and applicable user permission levels. Permission requirements will be coordinated with the User Permissions subsystem.

Network Services is responsible for protecting the Core System from cyber threats. It examines all Core System network traffic to identify malicious activity, logs information about such activity, attempts to stop the activity and notifies Core System Personnel of the malicious action or attempt and its resolution.

Service Monitor Subsystem: The Service Monitor Subsystem monitors the status of Core System services, interfaces, and communications networks connected to the Core. It informs System Users of the availability and status of its services.

Service Monitor also monitors the integrity of internal Core System components and supporting software and mitigates against vulnerabilities. This includes periodic verification of the authenticity of Core service software and supporting software. This also includes monitoring for patches to third party components. Should a vulnerability be detected, or a component of the Core found to have lost integrity, Service Monitor takes steps to mitigate against damage and performance degradation.

The Service Monitor Subsystem ensures the physical security of Core System services by monitoring the environmental conditions that Core components operate in (temperature, humidity) as well as the condition of its power system. It takes steps to mitigate against system failures in the event that environmental conditions exceed operating thresholds. Actions could include the activation of environmental or backup power systems and/or the modification of Core service operations, as well as Core Personnel notification.

Service Monitor also monitors the performance of all services and interfaces and makes performance metrics available to Core Personnel.

Time Synchronization Subsystem: The Time Synchronization Subsystem uses a time base available to all System Users and makes this time available to all Core System services which use this time base whenever a time reference is required.

User Permissions Subsystem: The User Permissions Subsystem provides tools allowing Operators and other Core subsystems to verify whether a given System User is authorized to request or perform the action requested in the message payload. It also maintains the status of System Users and Operators, whether they have a specific account, their allowed behaviors (publish, subscribe, actions allowed to request, administrate, etc.) with defined permissions or belong to an anonymous group. User Permissions provides tools for Core Personnel to create new users and groups, modify existing users and groups, and modify permissions associated with users and groups. User Permissions accepts and acts upon user permissions change requests provided by Misbehavior Management.

User Trust Management Subsystem: The User Trust Management Subsystem manages trust between and among System Users and the Core. It does this by providing digital certificates that System Users can use to demonstrate to other System Users and Core Systems that they are legitimate System Users. The Core provides X.509 digital certificates to qualifying Field and Center users. User Trust Management works with an ESS to distribute IEEE 1609.2 certificates to DSRC-enabled Mobile and Field Users, and ensures that those certificates include the proper permissions for using applications whose use is governed by certificate permissions. User Trust Management accepts notification of misbehaving users from Misbehavior Management. For System Users using X.509 certificates, User Trust Management revokes the certificates of misbehaving System Users. For System Users using IEEE 1609.2 certificates, it requests revocation from the ESS.

User Trust Management maintains the Certificate Revocation List. It obtains a copy of the IEEE 1609.2 CRL from the ESS. It distributes both X.509 and IEEE 1609.2 CRLs.

5.3.2.2 Subsystem to Needs

Table 5-1 shows the relationship between the Core System Subsystems and the needs defined in Section 4.0. In most cases a subsystem will satisfy multiple needs and in some cases needs may be satisfied in multiple subsystems.

Table 5-1: Subsystem to Needs Traceability Matrix

Core Subsystem	Needs
Core2Core	Core System Independence, Core System Interoperability, Core System Interdependence, Core System Data Protection
Data Distribution	Data Request, Data Provision, Data Forward, Geographic Broadcast, Core System Interoperability, Core System Interdependence, Anonymity Preservation
Misbehavior Management	Misbehavior Management, Core Trust Revocation, System User Trust Revocation, Core System Interoperability, Core System Interdependence
Network Services	Network Connectivity, Core System Interoperability, Core System Interdependence , Core System Data Protection, Private Network Connectivity, Private Network Routing
Service Monitor	Core System Service Status, System Integrity Protection, System Availability, System Operational Performance Monitoring, Core System Independence, Core System Interoperability, Core System Data Protection
Time Synchronization	Time Base, Core System Interoperability, Core System Interdependence
User Permissions	Authorization Verification, Authorization Management, Core System Independence, Core System Data Protection, Anonymity Preservation
User Trust Management	Data Protection, Core Trust, System User Trust, Core Trust Revocation, System User Trust Revocation, Core System Independence, Core System Interoperability, Core System Interdependence, Core System Data Protection

5.3.2.3 System User - Subsystem Interfaces

The following diagrams and descriptions illustrate which subsystems System Users and other Cores interact with. The legend at right documents the color coding used on these diagrams.

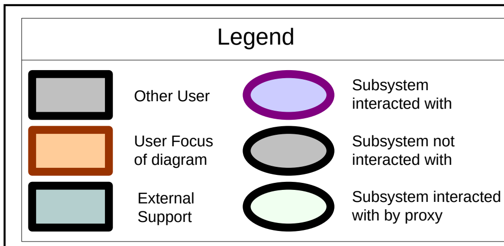


Figure 5-5: Subsystem Interfaces

Figure 5-6 shows the subsystems that Mobile Users interact with. User Trust Management provides Mobile Users with the information necessary to communicate with the ESS that distributes IEEE 1609.2 certificates. It also works with the ESS to ensure that the Mobile User obtains the proper permissions for its certificates, depending on locally managed application policies. User Permissions accepts credentials and permission change requests from System Users. Data Distribution accepts data provision requests, subscription requests and data from Mobile Users, and provides data to subscribed Mobile Users.

Network Services passes all communications traffic between the Core and Mobile Users. Service Monitor provides the status of Core services. Misbehavior Management accepts suspicious behavior information from Mobile Users.

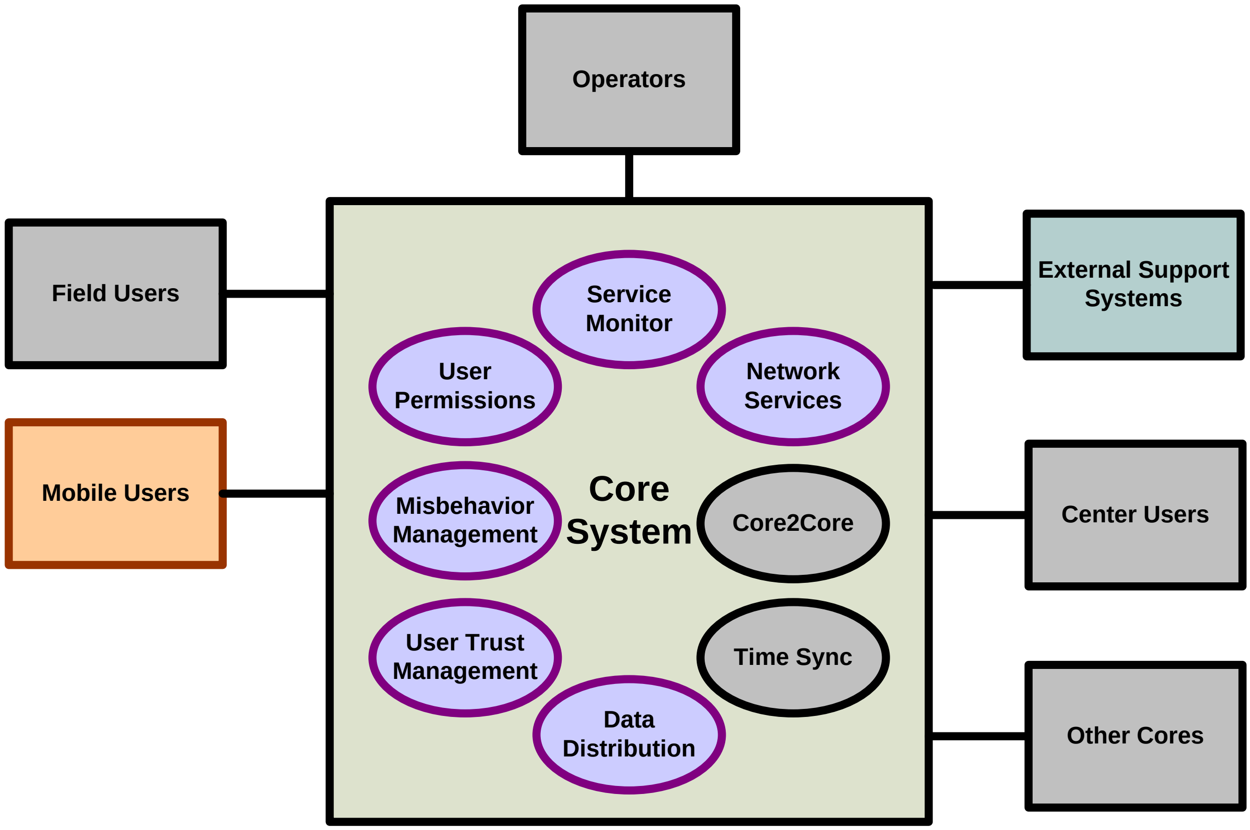


Figure 5-6: Mobile User Subsystem Interfaces

Figure 5-7 shows the subsystems with which Field and Center Users interact. Center and Field User interfaces are similar to Mobile User interfaces.

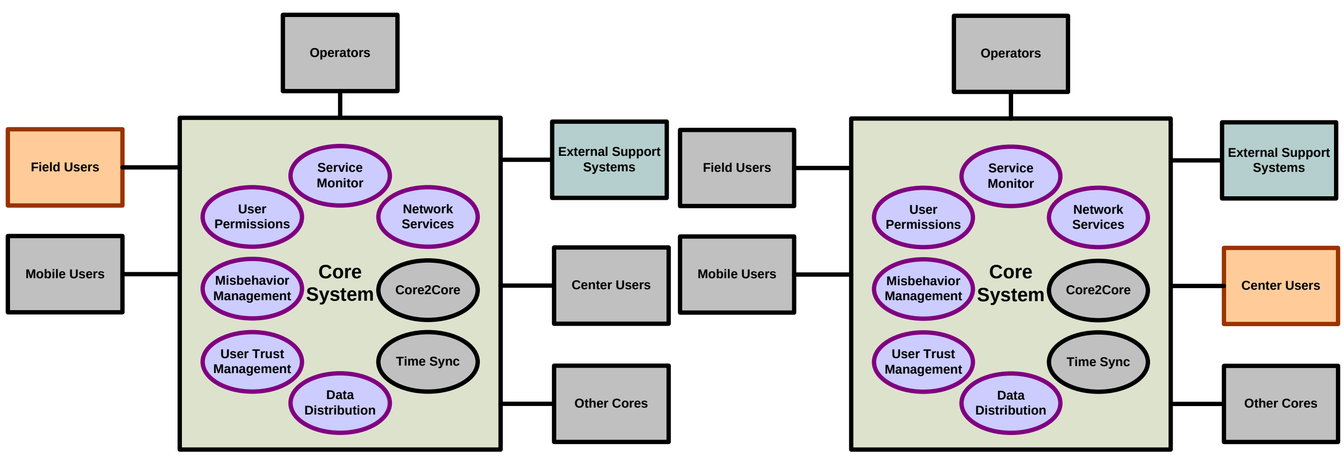


Figure 5-7: Field and Center User Subsystem Interfaces

As shown in Figure 5-8, Operators interact with all Core subsystems to some degree. The Service Monitor subsystem provides the interface over which performance and status information is sent. Operators interact with User Permissions to create and modify users, user groups and permissions. User Trust Management is used to configure and monitor the distribution of digital certificates. Misbehavior Management reports the identification of bad actors for Operator intervention if necessary. Data Distribution allows the manual adjustment of subscriptions and the management of data acceptance criteria. Core2Core interactions allow the Operator to update the locations and addresses of other Cores that this Core must interact with. Network Services provides security and status of network components to the Operator. The Operator can interact with any subsystem to configure, instantiate, update or restart any individual subsystem component.

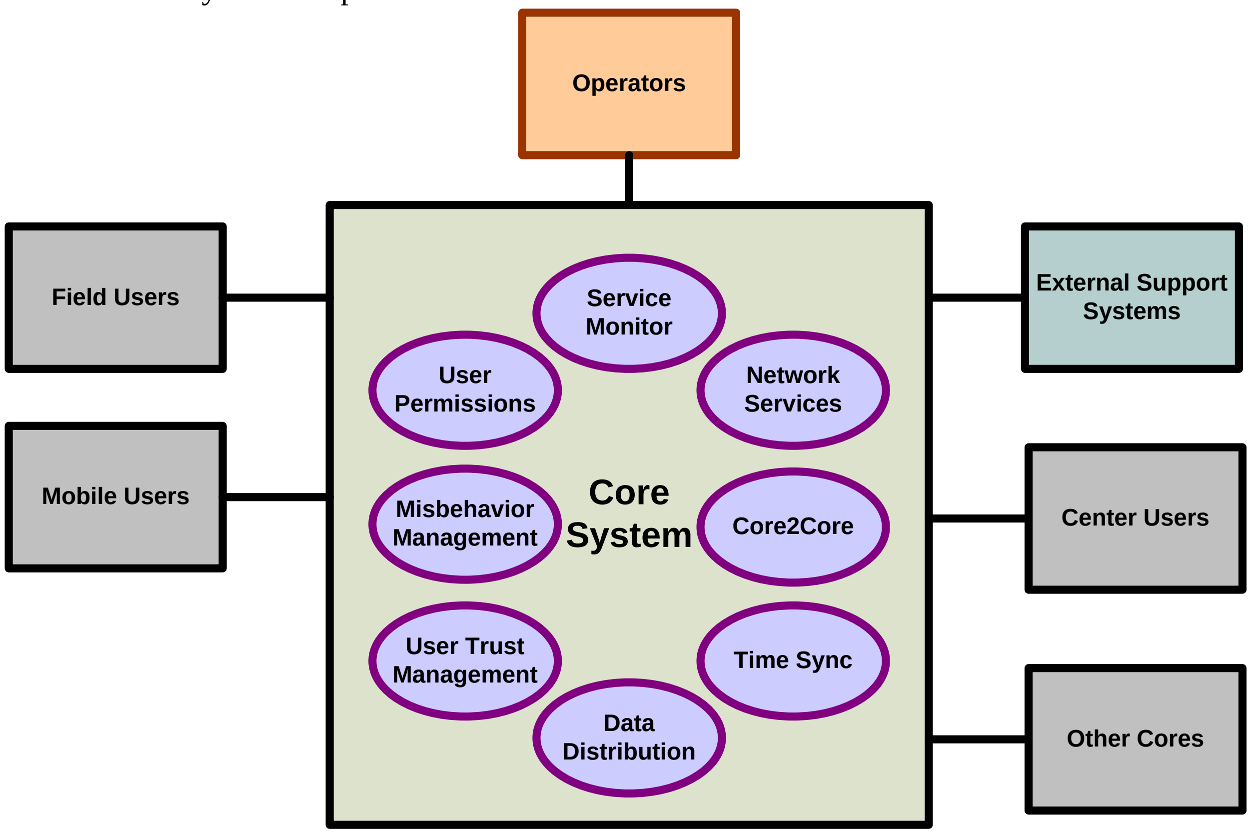


Figure 5-8: Operator Subsystem Interfaces

Figure 5-9 shows that other Cores interact directly only with the Core2Core subsystem. This subsystem manages interactions between Core subsystems and other Cores, serving as proxy for interactions with the other subsystems. All subsystems have interactions with other Cores. Data Distribution coordinates subscriptions and registrations for boundary conditions, so Cores are consistent in who collects and distributes data over what area (not propagating subscriptions). Misbehavior Management provides misbehavior reports and analysis results. Network Services shares cyber-security threat information. Service Monitor provides service status and performance information (see the discussion on states and modes later in this section). User Trust Management coordinates the revocation of certificates and ensures consistency among certificates that are distributed so that no duplications occur. All subsystems may provide configuration and backup information.

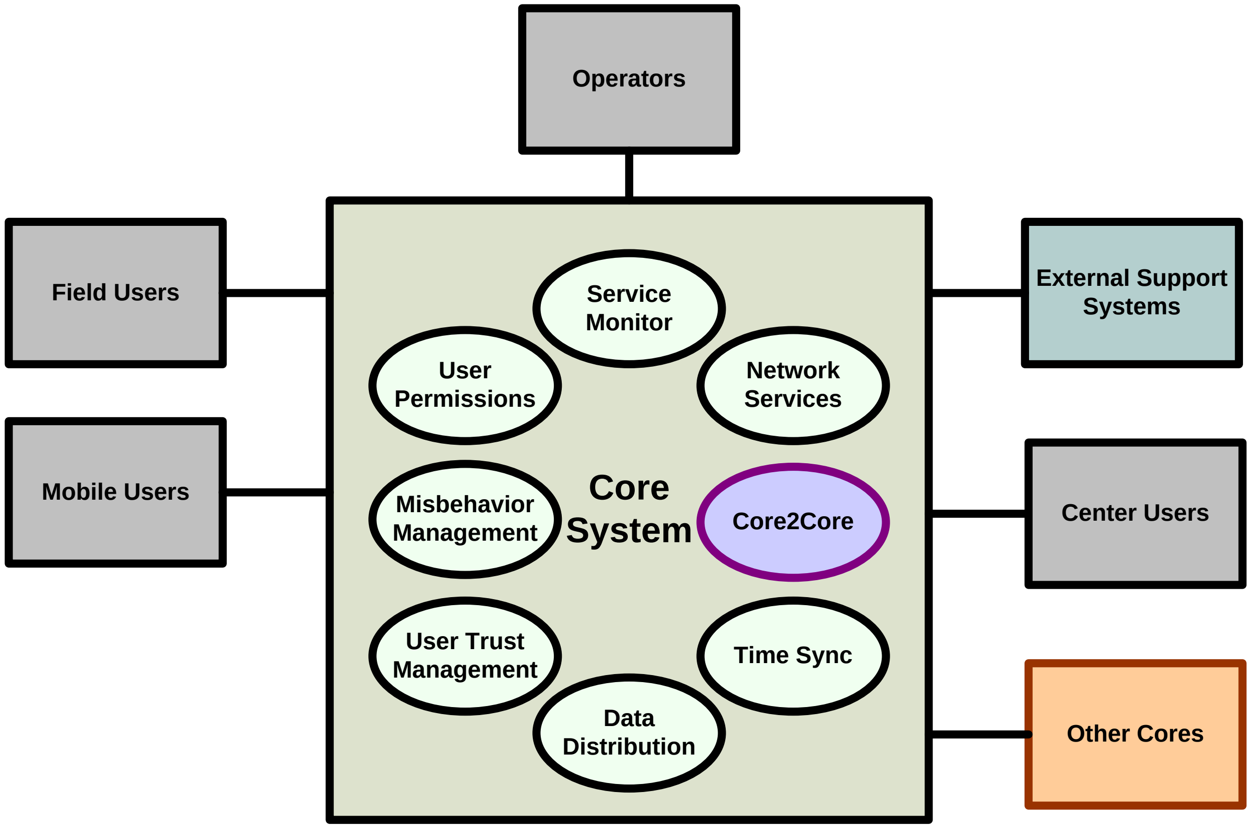


Figure 5-9: Other Core Subsystem Interfaces

5.3.2.4 Subsystem - Subsystem Interfaces

Core subsystems interact extensively. Interfaces between the Core subsystems include:

1. All subsystems provide configuration (including Data Distribution data acceptance and provision information) and backup data to Core2Core.
2. Core2Core provides restore data to all subsystems.
3. Core2Core exchanges CRLs with User Trust Management.
4. Data Distribution provides suspicious data (including geo-cast data) to Misbehavior Management for analysis.
5. Misbehavior Management provides System User misbehavior reports and its own misbehavior analysis results to Core2Core.
6. Misbehavior Management provides changes to geo-cast configurations to Data Distribution.
7. Network Services provides notifications of possible network intrusions to Misbehavior Management.
8. Network Services provides measures of Core System component (i.e., hardware) performance to Service Monitor.
9. Service Monitor provides Core performance information to Core2Core.
10. Time Synchronization provides time sync information to all subsystems.
11. User Permissions provide System User and Operator permission check results to all subsystems.
12. User Trust Management provides certificate distribution configuration information to Core2Core.

5.3.2.5 Data Stores in the Core System

The term Data Store is defined as "a permanent storehouse of data. The term is often used to lump the storage of all types of data structures (files, databases, text documents, etc.) into one generic category." (PC Magazine Encyclopedia, online definition, http://www.pcmag.com/encyclopedia; Copyright 1996-2011 Ziff Davis, Inc.).

While long term storage of data such as traffic probe data is not a service of the Core System, there will be data stores within the system to support and manage the system services. This will include the information necessary to communicate with other Cores, with ESS, Communications Layer systems, and will include data stores to organize misbehavior, states and modes, subsystem configurations, credential management, subscriptions, data acceptance criteria and System User information. For Mobile Users this information will only be collected and stored for as long as necessary in accordance with the Privacy Policies Framework. Specific details with regard to the exact types, locations and contents of the various data stores will be covered in SAD.

5.4 Modes of Operation

The states and modes of operation of the Core System are described in this section. Subsystems may be in one of four states, as illustrated in Figure 5-10:

- Installation
- Operational
- Training
- Standby

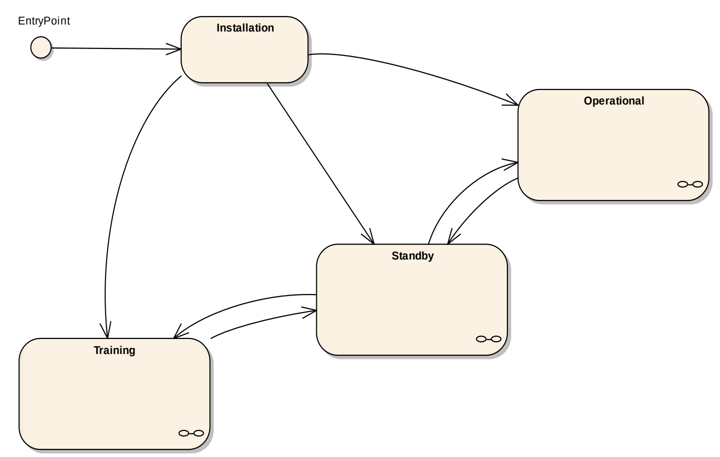


Figure 5-10: Subsystem States

A description of each of the states follows.

- Installation: This state includes all pre-operational activities necessary to plan, develop, install and verify the procedures and system configurations used to support the Core System.
- Operational: This state includes all activities during the normal conduct of operations.
- Standby: The Core System or subsystem operating in a Standby state will be providing backup to one or more other Cores or other Core subsystems. From the standby state the Core or subsystem may take over the functions of another Core or subsystem if required.
- Training: The Core System will be placed in a Training state when it is used for imparting training on the Core features. Certain features like real-time display of log messages and debug messages may be enabled in the Training state which may not otherwise be accessible under normal conditions.

While within the Standby and Operational states, each subsystem may be in one of five modes, as illustrated in Figure 5-11:

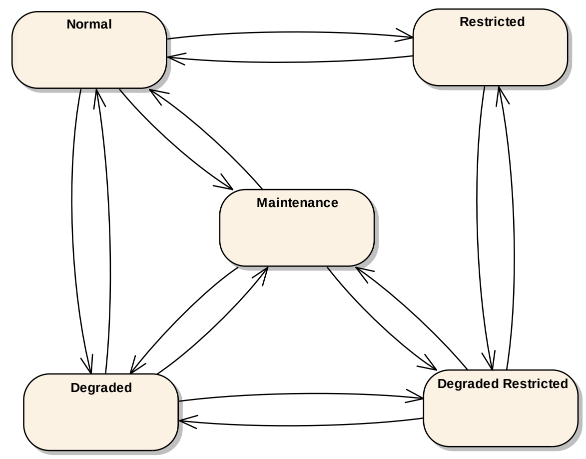


Figure 5-11: Standby and Operational Modes

- Normal mode: In the normal mode, there is little or no functional or performance impacts on the ability of the subsystem to provide its services.
- Degraded mode: In the degraded mode, the subsystem is impaired to a significant extent: its ability to provide services is greatly reduced or eliminated completely. Degraded mode is a reflection of conditions; it is not a mode that is voluntarily entered.
- Restricted mode: In the restricted mode, the subsystem is capable of performing as expected; however certain services or features are disabled to support a specific event such as an evacuation. The restriction is commanded by Core Personnel. It may also be implemented via a policy-based management system whereby policies (as specified by Core Personnel) are automatically implemented by the Core System in response to detection of events, behaviors or performance thresholds. In a restricted mode, the Core System could curtail the use of particular subsystems to privileged users, such as first responders and other emergency personnel.
- Degraded/Restricted Mode: If during the course of operating in a restricted mode there is a loss of functionality, or if while in degraded mode there is a need to enter restricted mode, the subsystem may enter the degraded/restricted mode. This mode is a combination of the restricted and degraded modes, where subsystem services are offered only to particular users, but performance is degraded.
- Maintenance Mode: Core Personnel may place a subsystem in maintenance mode to replace an impaired component or upgrade a component. Depending on the nature of maintenance planned, the impact on the subsystem's ability to provide services may be impacted. Also, its ability to manage itself and provide visibility into how it is performing may be impacted.

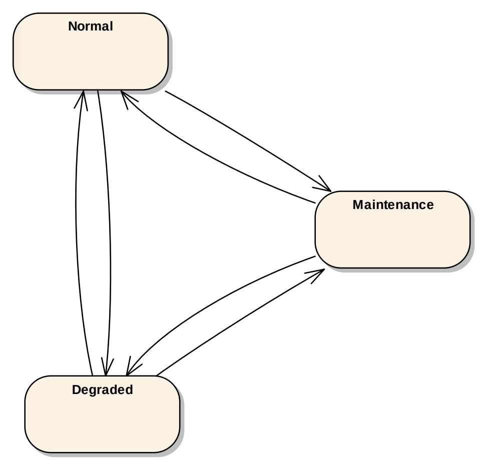


Figure 5-12: Training and Installation Modes

While in the Training and Installation states, each subsystem may be in one of three modes, as illustrated in Figure 5-12. Definitions of these modes are the same as those defined above under Standby and Operational.

5.5 User Types and other involved Personnel

This section discusses the users in terms of the types of actors and their interactions with the Core System, including support or operations personnel. These user types are used as part of the scenarios in the Section 6.0. In the case of the Core System the 'user' of the system or actors can be divided into 2 categories: System Users and Core System Personnel. Within those broad categories there are actors that can be considered based on the way they make use of the Core System services or operate and maintain those services.

- System Users (systems and applications that use/interact with the Core System), include the following:
  - Mobile Applications – These include applications running on vehicles of all types (private cars, trucks, buses, commercial vehicles, motorcycles). This also includes applications running on personal devices such as smartphones that allow pedestrians, bicyclists, or disabled road users to provide and receive data.
  - Field Applications – These include applications running on roadside devices collecting data about their surroundings, communicating with mobile devices, controlling and managing transportation systems such as signs or traffic signals. Accessing the services of the Core System allows these applications to participate in secure, authenticated data exchanges with mobile applications or other field applications. These could also include applications supporting transactions such as payment of tolls, parking, or reservation systems – again, using the services of the Core System to support the secure, authenticated exchange of data.
  - Center Applications – These include many types of central data systems or information services that support travelers, manage transportation resources, or provide more general applications that use or provide data to Mobile, Field, or other Center applications. Examples include traffic management centers, transit operations centers, archived data management systems, information service providers, emissions management systems, public safety or emergency management systems, and weather service applications.
- Core System Personnel, the human users that interact with the Core System, include the following:
  - Administrators – These are the operators that set control parameters, implement system policies, monitor system configuration, and make changes to the system as needed.
  - Operators – These are the day-to-day users of the Core System that monitor the health of the system components, adjust parameters to improve performance, and collect and report statistics of the overall system.
  - Maintainers – These users interact with the system to install updated software or to repair or upgrade hardware components to keep the system up to date and running efficiently.
  - Developers – These users are the actual software developers that build software enhancements for the system. They will be accessing the published interface definitions and configuration data about the Core System in order to develop additional features or expanded capabilities.
  - Deployers – These users represent the initial installers for a Core System. Their interaction with the Core System itself will be similar to an administrator or maintainer in that they will be accessing system configuration files, setting parameters and policies as part of the initial installation and check out of the system before turning it over to the other Core System Personnel for regular operations.
  - Testers – These users verify the Core System's operation when any changes are made to its operating hardware or software.

The operational context of where the application is located may affect the operations of that application. For instance, if a mobile application or its host device detects that it has boarded a bus, it may stop transmission of its location messages over DSRC until the device/application detects that it has left the bus and should start transmitting again. In other situations, the same application may be both a provider of data as well as a consumer of data from other sources of data.

5.6 Support Environment

This section discusses the systems, personnel, and processes that make up the support environment for the Core System. This system is different than other systems in that the support for the system is, to a large degree, part of the system.

Systems: The Service Monitor Subsystem provides support for the Core System by maintaining efficient operations of the system, alerting operators of issues, and providing mechanisms to isolate problems, fix them, and bring the system back on-line.

To some degree other subsystems such as Time, User Permissions or Core2Core also provide necessary functionality to complete the support environment. Beyond these subsystems that are part of the Core System there will be additional hardware and software to complete the support environment. In order to isolate, debug, fix, and test repairs to the system a Core System maintainer will need access to a hardware and software configuration representative of the configuration of the live system where the problem occurred.

The overall concept is that the Core System will be based on commercially available hardware and either commercially available software or software based on open source specifications. This will minimize the impact on the maintainers of the system to have to keep unique hardware/software sets just for the new framework of safety, mobility, or environmental applications. Specifics of the actual hardware and software will be defined as the Core System components are implemented.

Personnel: In terms of the Core System support environment, the personnel supporting the system will be the maintainers, administrators, and developers identified in Section 5.5. In deployments where a Core System is implemented by a public sector agency some of the same system administration or maintenance personnel may be called upon to support the Core System. Other configurations may involve private sector entities but again the same skills in computer system administration and maintenance would be required. A hybrid environment may exist where some devices and software are maintained by private or external agencies while others are under the control of existing organizations. In this case, agreements will need to be recorded that delineate the areas of responsibility for the maintenance of the system, including the coordination of resources to ensure that overall system availability is maintained.

Processes: The third component to a support environment is the establishment of processes to ensure that the systems are kept up to date and that adequate numbers of staff with appropriate skill sets are available to support the system. This includes the establishment of checklists for operators to be able to quickly isolate issues, development of repair or replacement criteria, establishment of maintenance levels and update cycles, as well as agreement on the storage, distribution, administration and supply of replacement parts or software updates.

As the Core System is deployed at different times with different configurations of hardware and software there will be local differences in the policies that govern the support environment. This is inevitable. The important consideration is that the support systems are in place, that personnel are trained and ready, and that processes are agreed upon by all of the stakeholders to maintain a functioning Core System.

6.0 OPERATIONAL SCENARIOS

The following scenarios describe how the system will operate, with an emphasis on Core System interaction. These scenarios are illustrative, showing how the system functions, not how the given scenarios should be implemented. They are broken down into four types of interactions, based on the entities involved:

- Exchange of data between System Users
- Interactions between System Users and the Core System
- Core-to-Core interactions
- Core System facilities operations and maintenance, including Core System Personnel interaction with the Core.

The scenarios described in the succeeding sections model twelve different cases, and sometimes multiple models are included for the same scenario depending on the operational state of the Core System or the System User. The multiple models may be in single or multiple diagrams but are always discussed in the accompanying text.

Scenarios are documented in several ways. Each includes a brief textual description of what the scenario discusses. Then a context diagram is presented, describing the inputs (data, existing relationships, user input), enablers (involved Core subsystems, Communications Layer, relationships between Core System and other entities) and controls (policies, constraints) that feed into the Core, and what outputs are produced. Lastly, one or more activity diagrams, drawn using Systems Modeling Language (SysML, an extension of Unified Modeling Language (UML)) describe the interactions between System Users, Core System Personnel and Core subsystems.

A sample diagram with notes describing constructs for the activity diagrams used in this document is shown in Figure 6-1.

- All activity diagrams include multiple columns called swim lanes. These swim lanes identify the entity or Core System subsystem that accomplishes the action in its swim lane.
- All activity diagrams begin from a start point represented by a black circle. There may be preconditions associated with this start point or with the first or any other action. Pre-conditions describe conditions that must exist prior to the start or action, e.g. System User has communications with the Core System.
- Lines with arrows indicate a flow of control. Often data is being passed. When the data is critical to the activity being documented, the line is labeled with an indication of what the data is.
- Boxes connected by lines represent actions by the entity or subsystem named in the swim lane in which the box is placed.
- Bold horizontal lines represent forks or joins of control. A fork is when a particular action initiates two or more other actions. A join is when multiple actions resolve to one action.
- A decision point is represented by a triangle. The result of the decision is described by the label of the lines exiting the triangle, e.g., [yes].
- End points are represented by hollow circles. A circle with an ‘x’ in the middle refers to the end of a given flow of control, but not the end of the activity. Such a flow is always one side of a fork. Final end points have a solid-circle middle, and represent the end of the activity.

- Italicized text refers to an artifact of the modeling tool, and has no bearing on the content of the diagram.

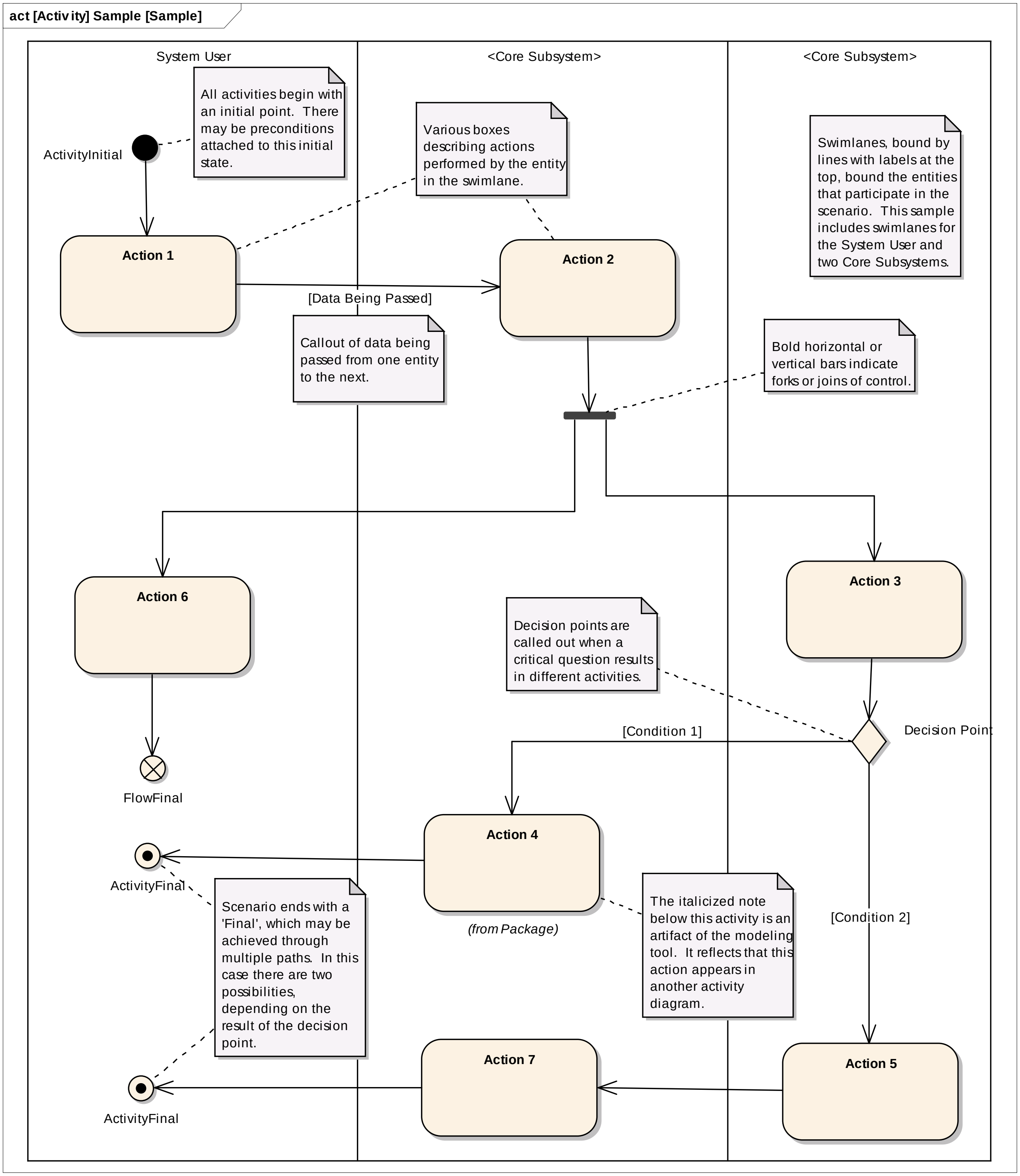


Figure 6-1: Example Activity Diagram

The diagrams are intended to illustrate scenarios and the actions that take place during those scenarios. From a SysML v1.1 compatibility perspective, the diagrams are partially compliant: they use legal constructs and connectors, but are not technically complete. In particular, use of ports and objects is avoided. This is a practical consideration, allowing the diagrams to fit within the page of the printed documents and still be readable, and also to simplify the diagrams so that readers would not have to be conversant in UML or SysML in order to understand them.

The Core2Core subsystem is involved in many of these scenarios, but is not always shown on the activity diagram to reduce clutter and contribute to readability. It is shown when it provides functionality beyond simple connectivity with other Cores.

Similarly, the Network Services subsystem is technically used in every scenario where a System User or other Core System interacts with the Core, but is not shown on the diagrams. Including it would not contribute to illustrating Core System operations, and would add another swim lane and many other objects on each activity diagram and context diagram.

Core trust relationships are listed as enablers for many of these scenarios. These refer to the relationships established between managers and operators of Core Systems which enable interactions between the respective Core2Core subsystems.

6.1 User Data Exchange

There are three basic types of data exchange:

- One System User uni-casting or geo-casting data it wants other Users to access
- One System User providing data to another User that it can specifically address, and
- One System User providing data to the Core for retransmission to a group of Users

System User data broadcasts are limited to Field and Mobile users broadcasting data using DSRC (5.9 GHz or other). This form of data exchange does not directly involve the Core System. However, messages that are signed or encrypted rely on credentials issued by the Core or an ESS. So while the messages do not pass through the Core, senders and receivers rely on Core services in order to encrypt, decrypt and/or trust the messages.

Data Providers providing data to more than one Data Consumer may rely on the Core's Data Distribution service to facilitate the distribution of data to multiple recipients. The Core does this through two distinct activities:

1. Provide a subscription service for a Data Subscriber, telling it what data is available, and if the Data Subscriber is qualified (again, according to Core local policies) to register the Subscriber to receive data. Data exchange could be through the Core or it could be direct from Provider to Subscriber, again depending on local policies, capacities and whether anyone besides this particular Data Subscriber wants the data. Section 6.5 describes a subscription scenario.
2. Provide a distribution service, where registered Data Providers send data to the Core, which publishes that data to one or more subscribed Data Subscribers. This is similar to the mechanism described in VII as "publish-subscribe." The context diagram describing this data distribution is shown in Figure 6-2.

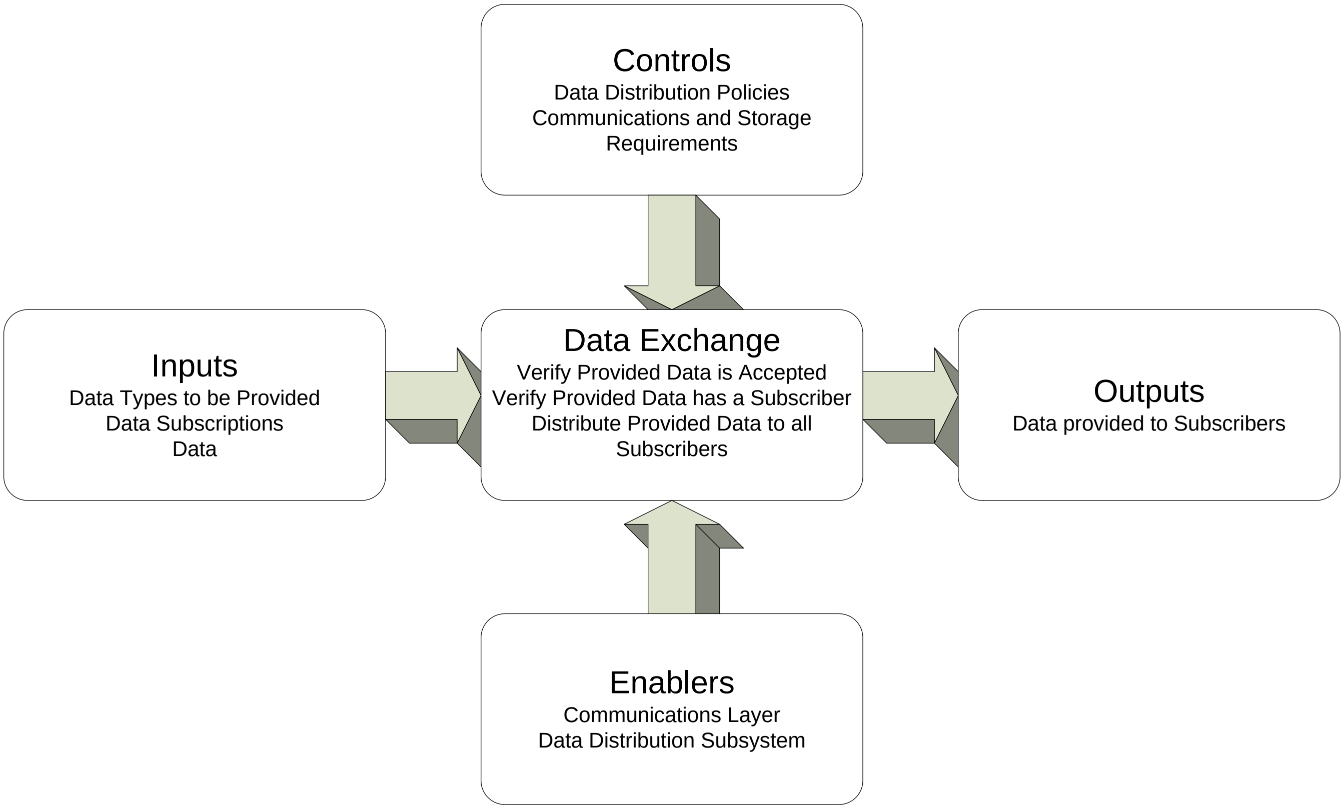


Figure 6-2: User Data Exchange Context Diagram

The activity diagram describing data distribution is shown in Figure 6-3. Data is provided to the Core by a System User. If the data is not of a type that the Core accepts, it provides a message to the System User indicating it does not accept this data. If the data is accepted by the Core, and if the Core has subscribers to this type of data, then it publishes the data to the subscribers. Data can be anything, but primarily:

- Data provided by Mobile Users will include probe data describing the operating conditions sensed by the vehicle carrying the Mobile User device or by the device itself. See SAE J2735.
- Data provided by Center Users will include advisory or alert information.
- Data provided by Field Users will be traffic or environmental data.

The publication step may include parsing, sampling, and aggregation functions. Parsing is where the Core examines each packet of data, extracts the elements that subscribers are interested in, and provides only those elements to the subscribers. Sampling is where the Core provides a percentage of the data that subscribers are interested in; for example a 1:10 sample would see the Core providing one data packet to a subscriber for every 10 received from providers. Aggregation is where the Core combines multiple like data packets, summarizes the data within, and retains all information but reduces the amount of data sent to each subscriber. For instance, if the Core received 5 speed measurements of 30 mph in a given area, it would provide a data packet stating that there are 5 instances of 30 mph in that area.

In the special case where a registered Data Provider is sending data directly to a 3rd party because the Core does not support distribution of the data that the System User provides, and the Core is upgraded to provide such distribution, there must be a mechanism for notifying data providers of this change. See Section 6.11 for an example of this case.

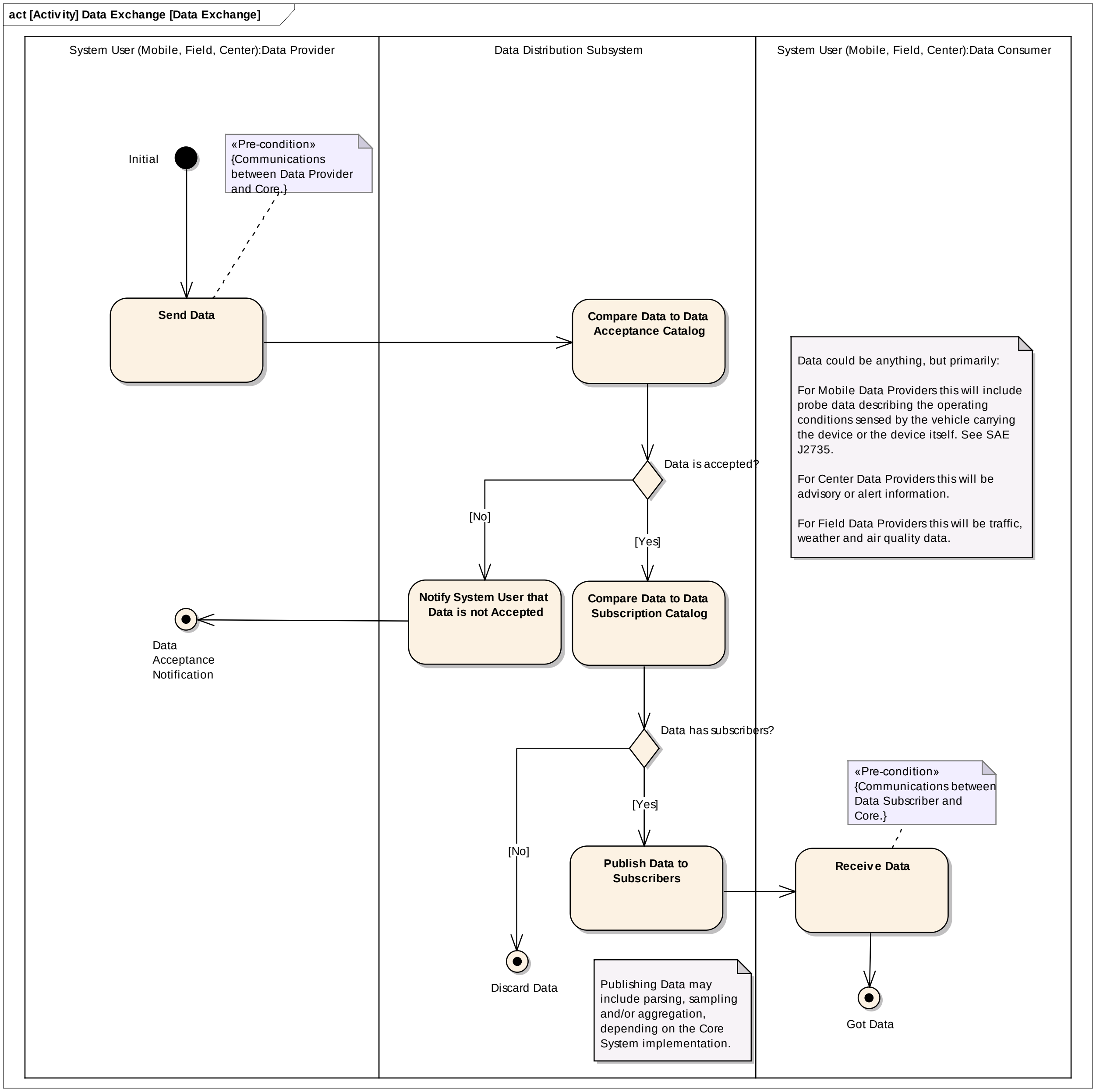


Figure 6-3: User Data Exchange Activity Diagram

6.2 Certificate Distribution

Certificates can be viewed as the “entry ticket” in order to use the system services. This scenario describes how System Users interact with a Core System to get a new certificate. This scenario addresses certificates distributed by the Core and also certificates distributed by an ESS.

As shown in the context diagram (Figure 6-4), the primary activities are verifying previous behavior, verifying permissions, and issuing new certificates. If the certificates are managed by an ESS, then the Core System’s involvement is limited to providing the System User with the contact information of the ESS.

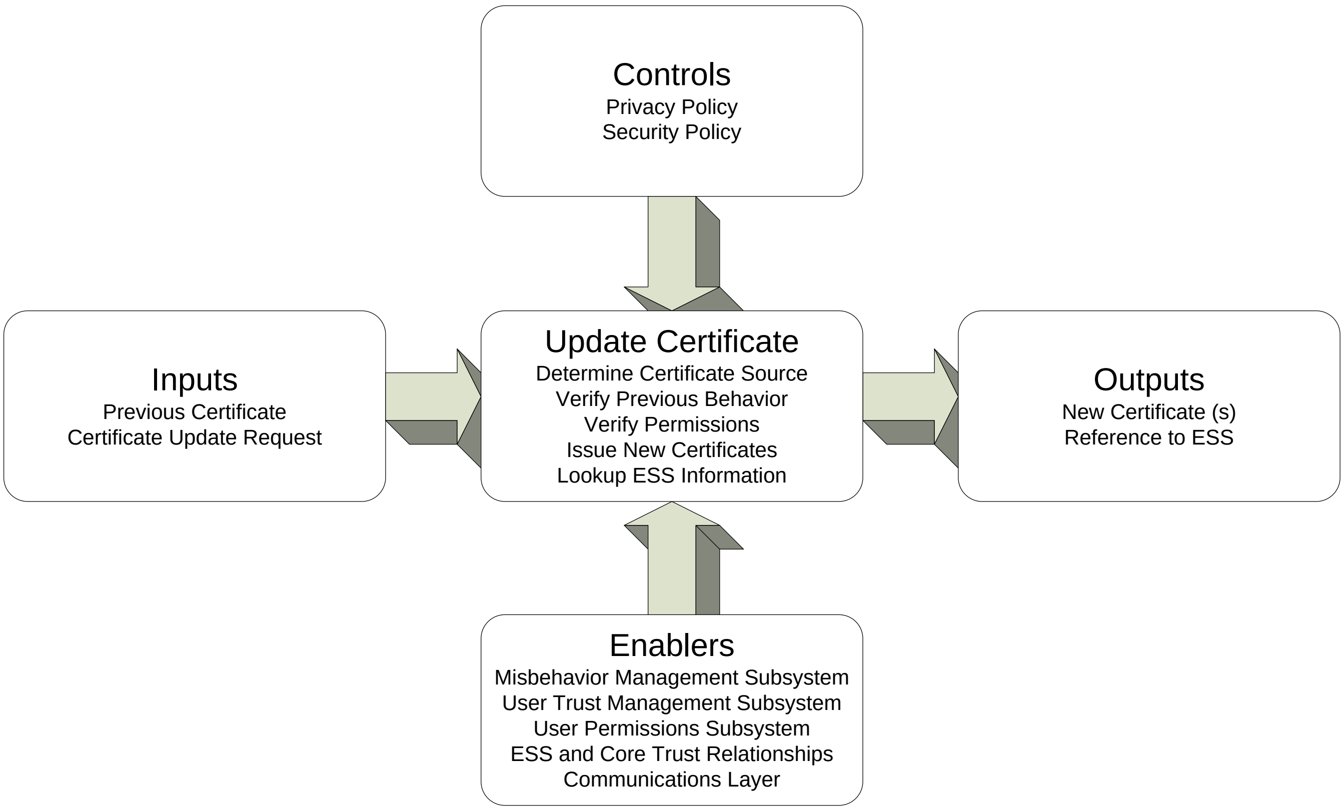


Figure 6-4: Certificate Distribution Context Diagram

The activity diagram shown in Figure 6-5 depicts the major steps in either rejecting a certificate update request or issuing a new one.

A System User provides a request for a certificate to the Core System, including any desired special permission information, its current certificate and a unique identifier associated with the request. All of this information may already be included in the certificate used by the System User, but if it is not must be included as part of the message.

If the Core System provides the type of certificate that the System User is requesting, it will service the request. An improperly formatted request will result in a misbehavior report and response to the originator but no certificate. A request sent using a certificate on the CRL will generate a misbehavior report and termination of the activity flow.

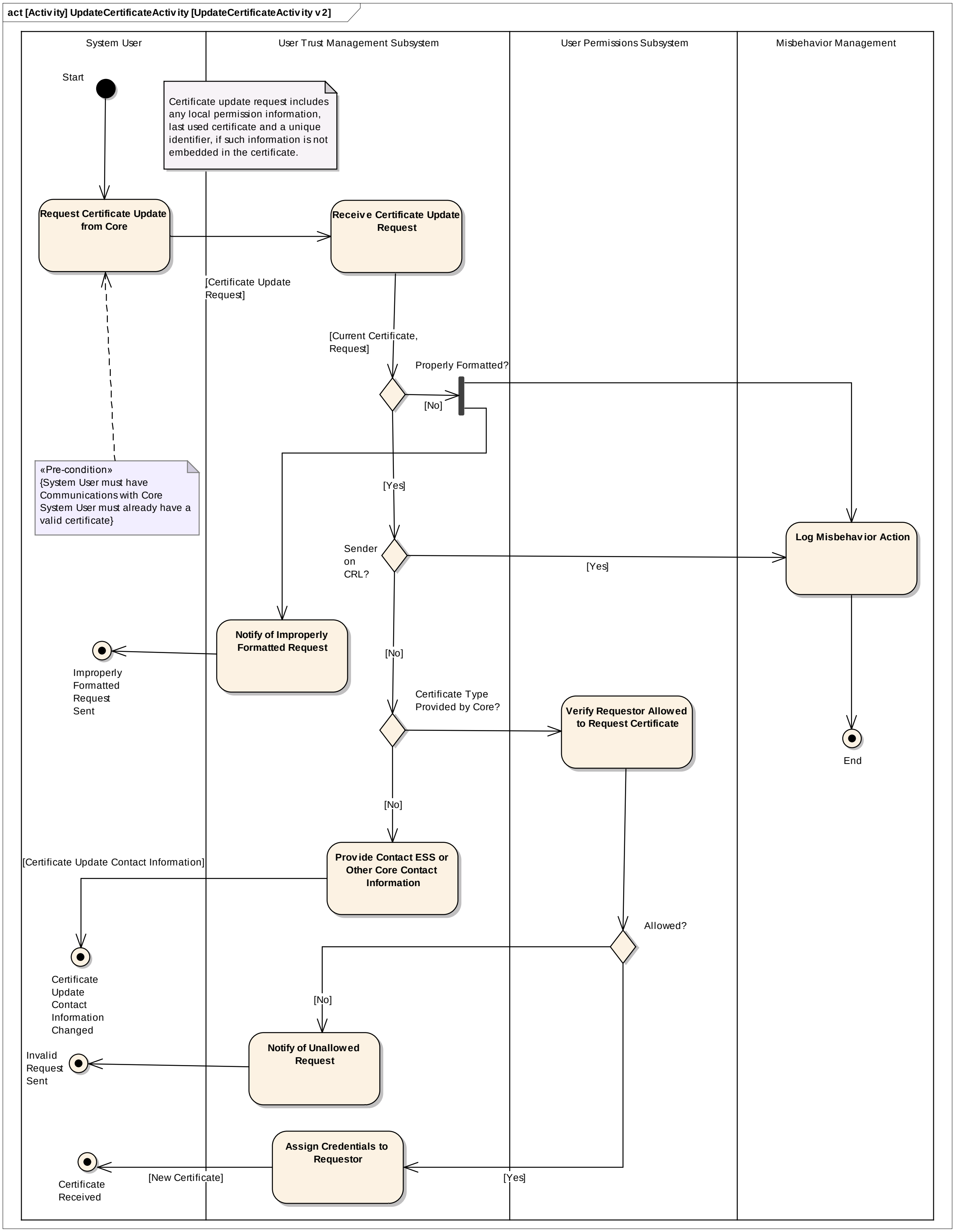


Figure 6-5: Certificate Distribution Activity Diagram

6.3 CRL Distribution

This scenario addresses the distribution of CRLs to System Users, including those maintained by the Core System, those maintained by other Cores, and those maintained by ESS.

The context diagram for Certificate Revocation List Distribution is shown in Figure 6-6.

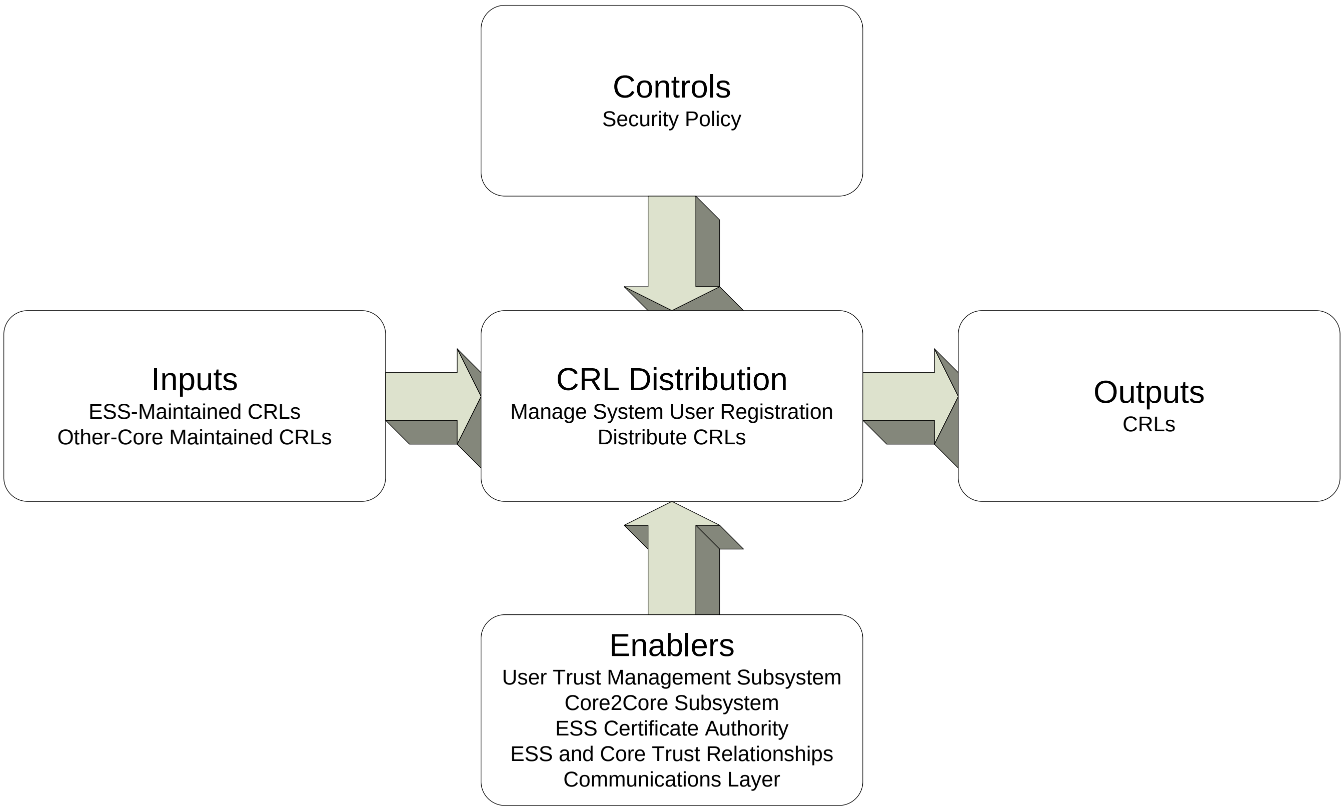


Figure 6-6: CRL Distribution Context Diagram

The Core System stores and distributes CRLs that it maintains as well as those it acquires from other Cores and ESS. System Users receive CRLs by registering with the Core to receive a regular distribution of CRLs. This means that anonymous users and Mobile Users that do not have persistent communications to the Core will not receive CRLs. Other mechanisms outside of the Core System are planned to provide this information however. DSRC-equipped Mobile Users can receive CRLs from nearby Field Users, as documented in IEEE 1609.2.

The activity diagram illustrated in Figure 6-7 shows the activities involved in distributing CRLs. There are three distinct processes involved:

1. The Core System acquires CRLs from external sources. This acquisition may be a query-response or a periodic distribution, depending on the other Core or ESS implementation.
2. The Core System provides a registration interface to System Users and other Cores, enabling the System User or Core to register for CRL distribution.
3. The Core System distributes CRLs to all Cores and System Users that are registered to receive them.

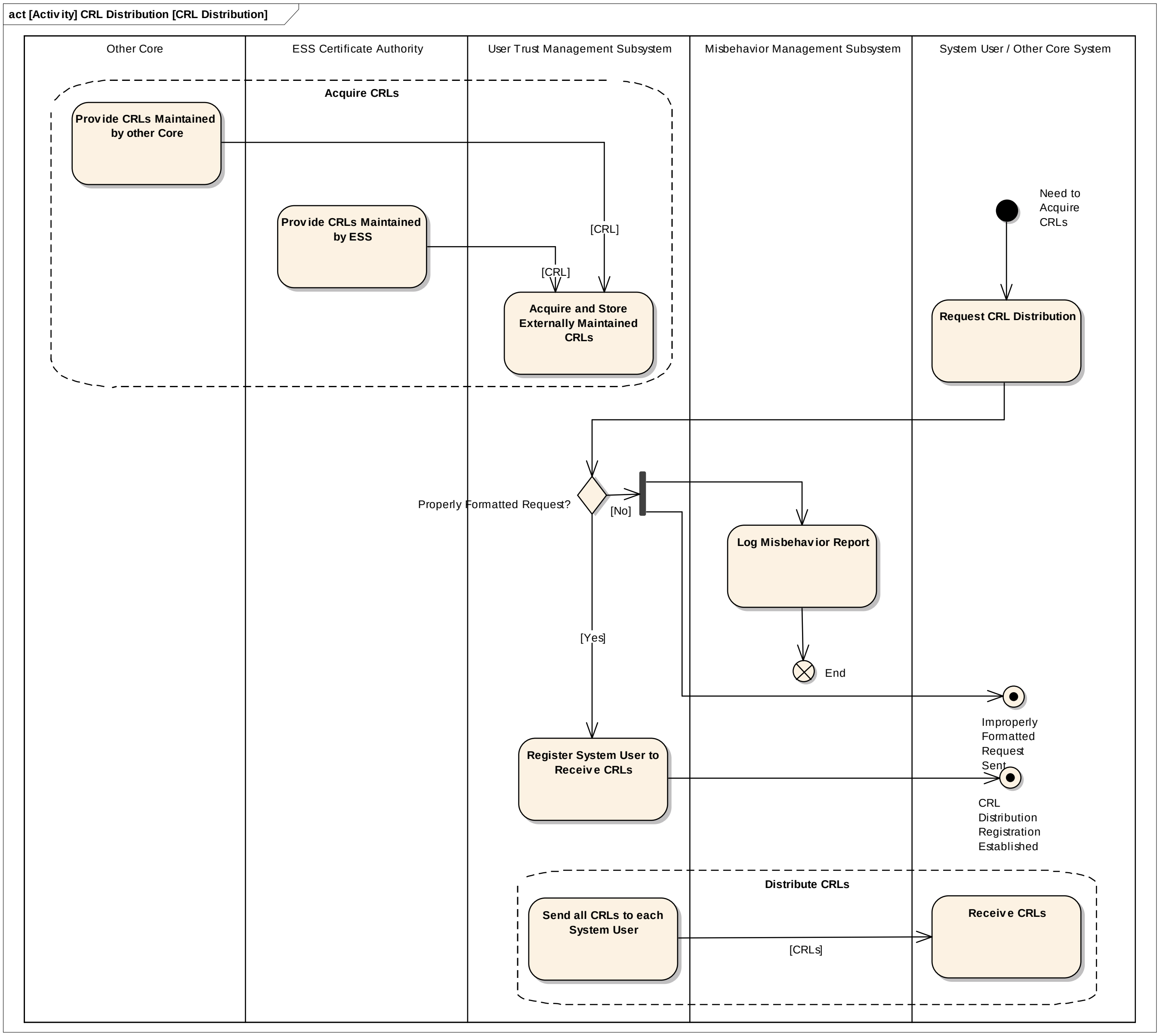


Figure 6-7: CRL Distribution Activity Diagram

Note that the Core2Core subsystem is involved in establishing and maintaining the relationships the Core has with other Cores. It is not shown on the activity diagram because it acts as a pass-through for certificate registration and CRL distribution.

6.4 Misbehavior Action: Certificate Revocation List Addition

Certificates can be revoked if the Core System determines they are being used in a fashion incompatible with approved uses. There are two ways to have certificates revoked: (1) Core System Personnel can manually revoke a certificate by placing it in the certificate revocation list, (2) the Misbehavior Management subsystem can automatically revoke certificates based on a policy. If the certificate in question is managed by an ESS, then the Core notifies the ESS to place the certificate in the CRL.

The context diagram for Certificate Revocation List Addition is shown in Figure 6-8.

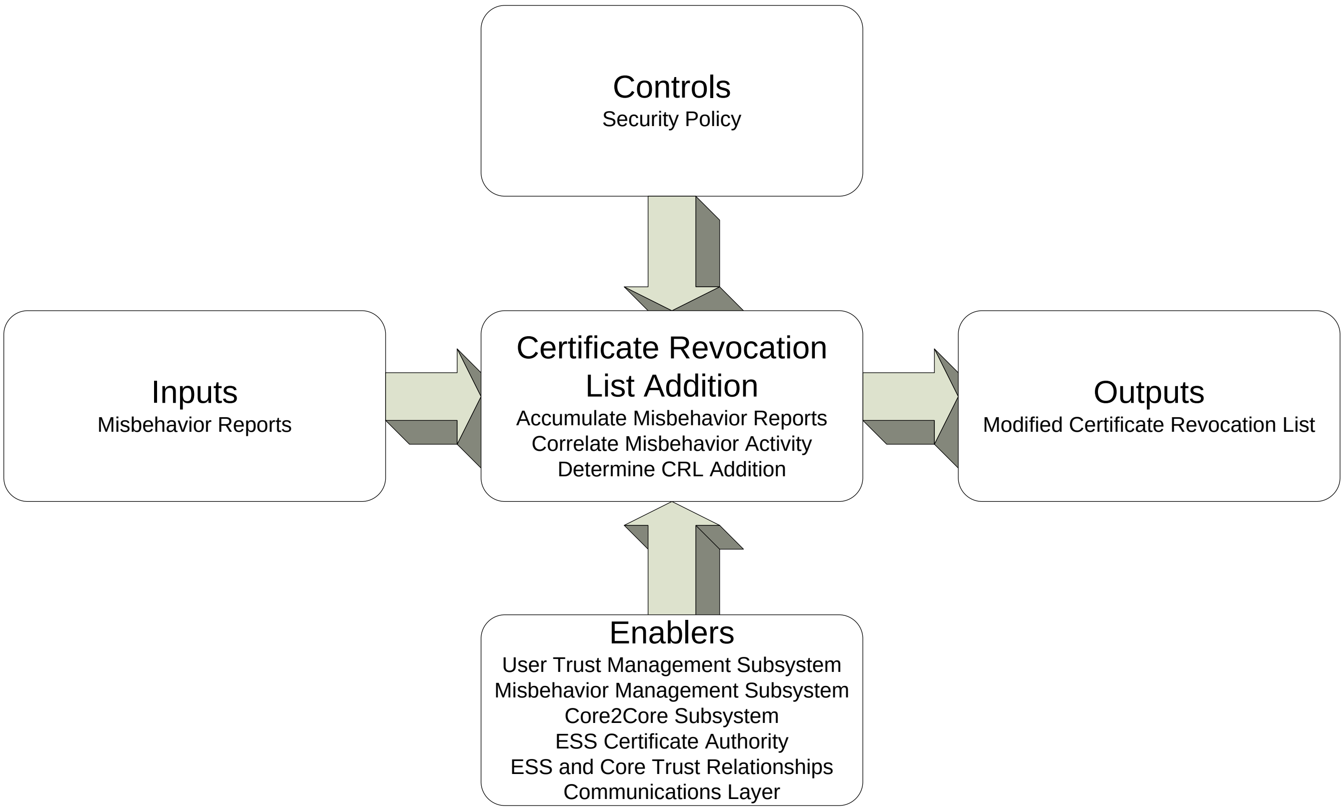


Figure 6-8: Certificate Revocation List Addition Context Diagram

The activity diagram for Certificate Revocation List Addition is shown in Figure 6-9. Misbehavior Reports are received from System Users and generated by all Core subsystems (not shown for clarity). Those reports of interest to other Cores are distributed to those Cores. Misbehavior reports are organized and analyzed continuously. When a misbehavior report analysis concludes that a System User’s certificate must be revoked, the Core determines the entity responsible for revocation and either performs the revocation or forwards a request for revocation.

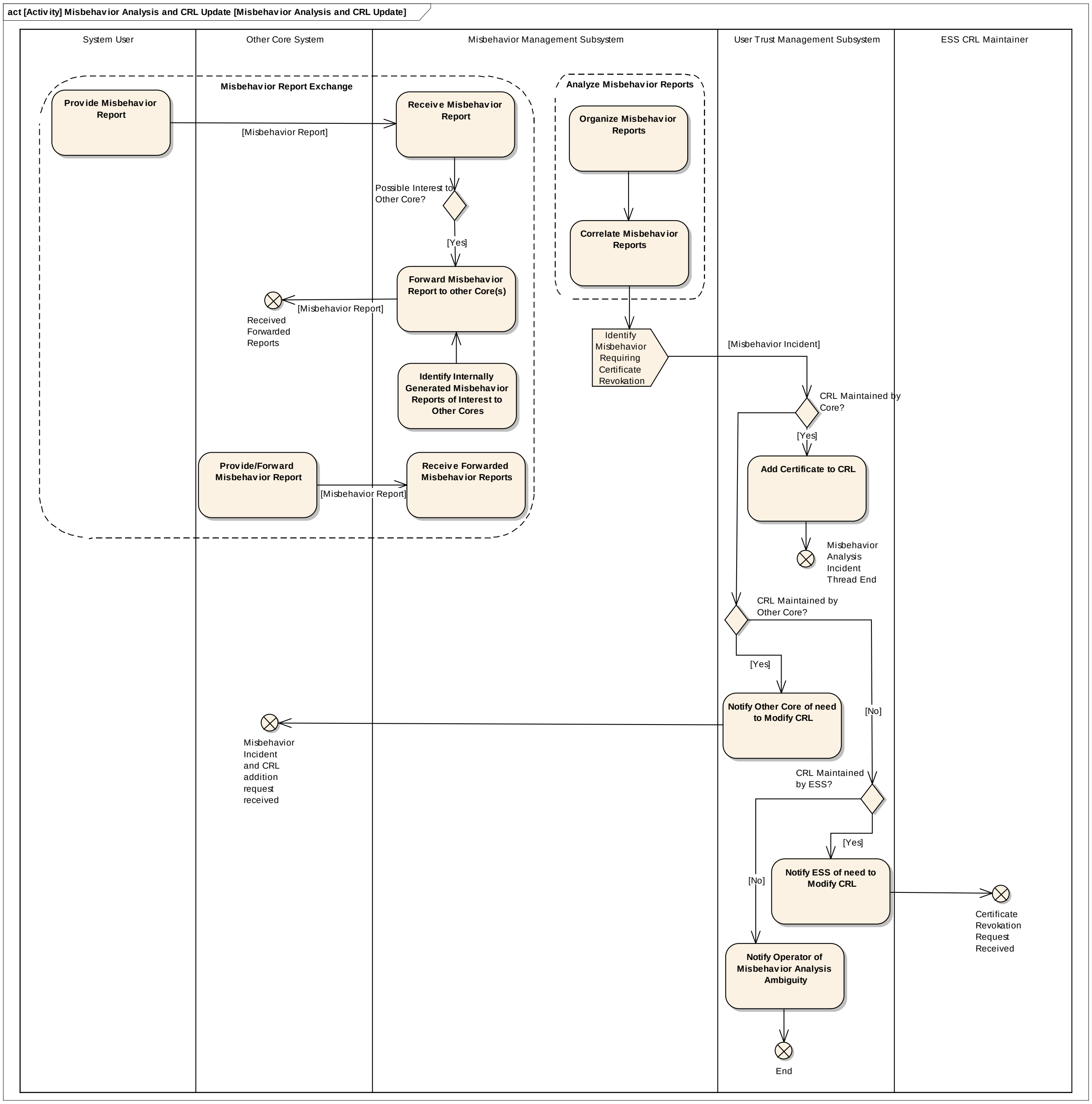


Figure 6-9: Certificate Revocation List Addition Activity Diagram

6.5 Data Subscription

In order to receive data from other users without establishing individual relationships, System Users register to receive the kinds of data they are interested in. This scenario describes the process by which System Users subscribe to data distributed by the Core System.

The context diagram shown in Figure 6-10 illustrates the inputs, controls and enablers that are involved in the process of data subscription. Data subscription involves a single data consumer (Mobile, Field or Center) and a single Core System.

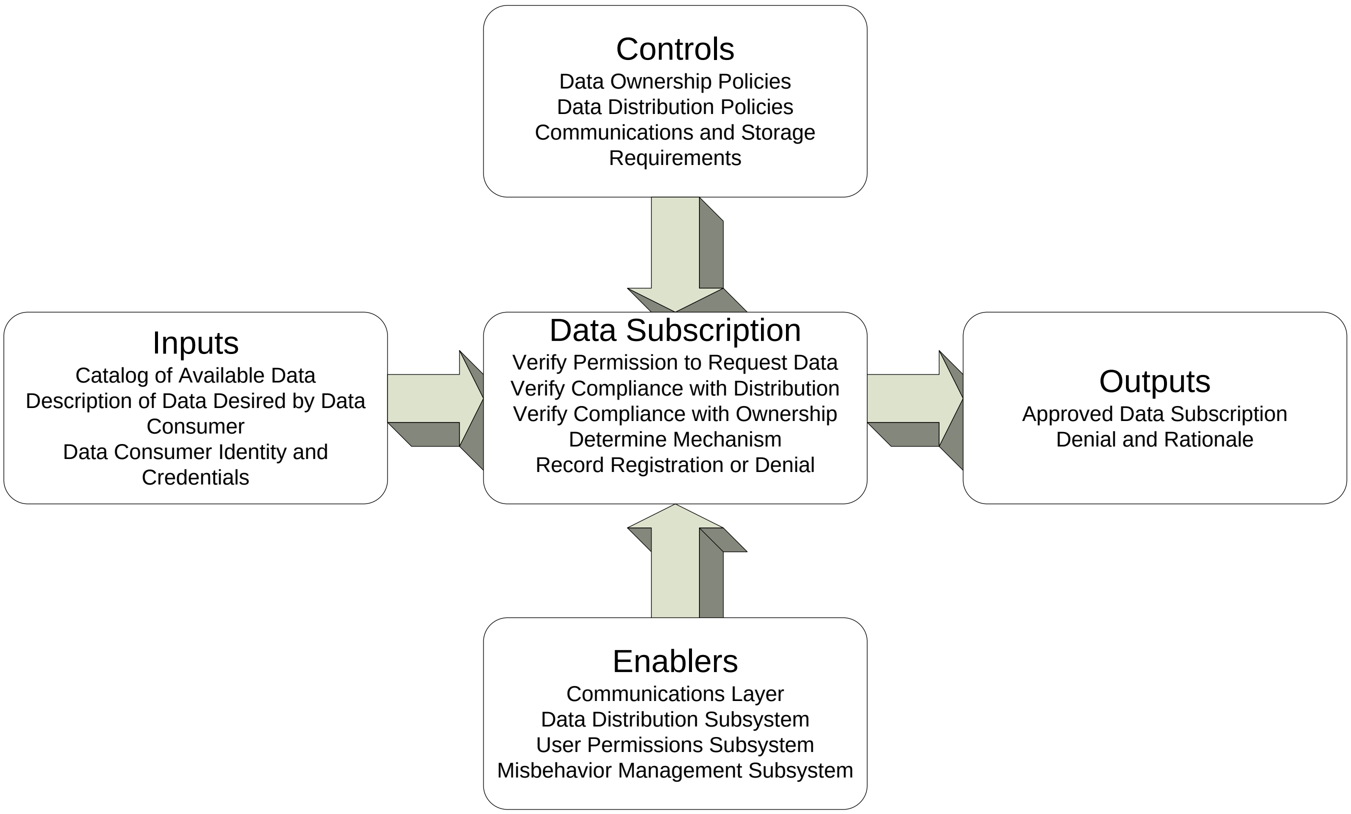


Figure 6-10: Data Subscription Context Diagram

The data subscription process involves the Data Distribution, User Permissions and Misbehavior Management subsystems. The System User requests a catalog of data providers and data types from which it requests a subscription and provides its user credentials. While some data will not require a subscriber to provide credentials, some data may be restricted depending on policies governing data distribution and ownership. The Data Subscription activity diagram is shown in Figure 6-11.

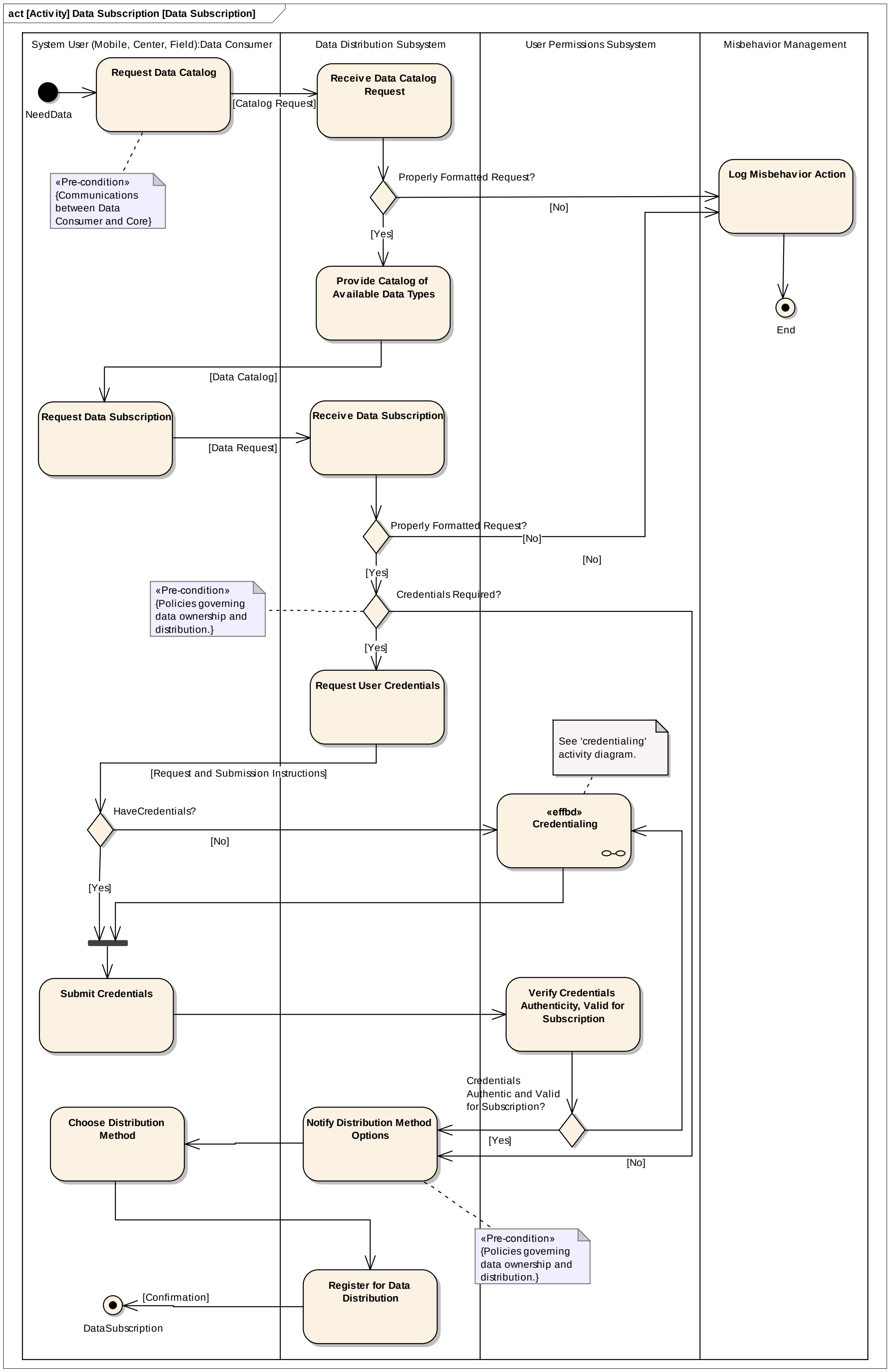


Figure 6-11: Data Subscription Activity Diagram (1 of 2)

During the subscription process, it is possible that the User Permissions subsystem will engage the data consumer in a dialog regarding credentialing and permission to subscribe to data. In this case, Core Operations Personnel may be involved, as illustrated in the Credentialing Activity (Figure 6-12).

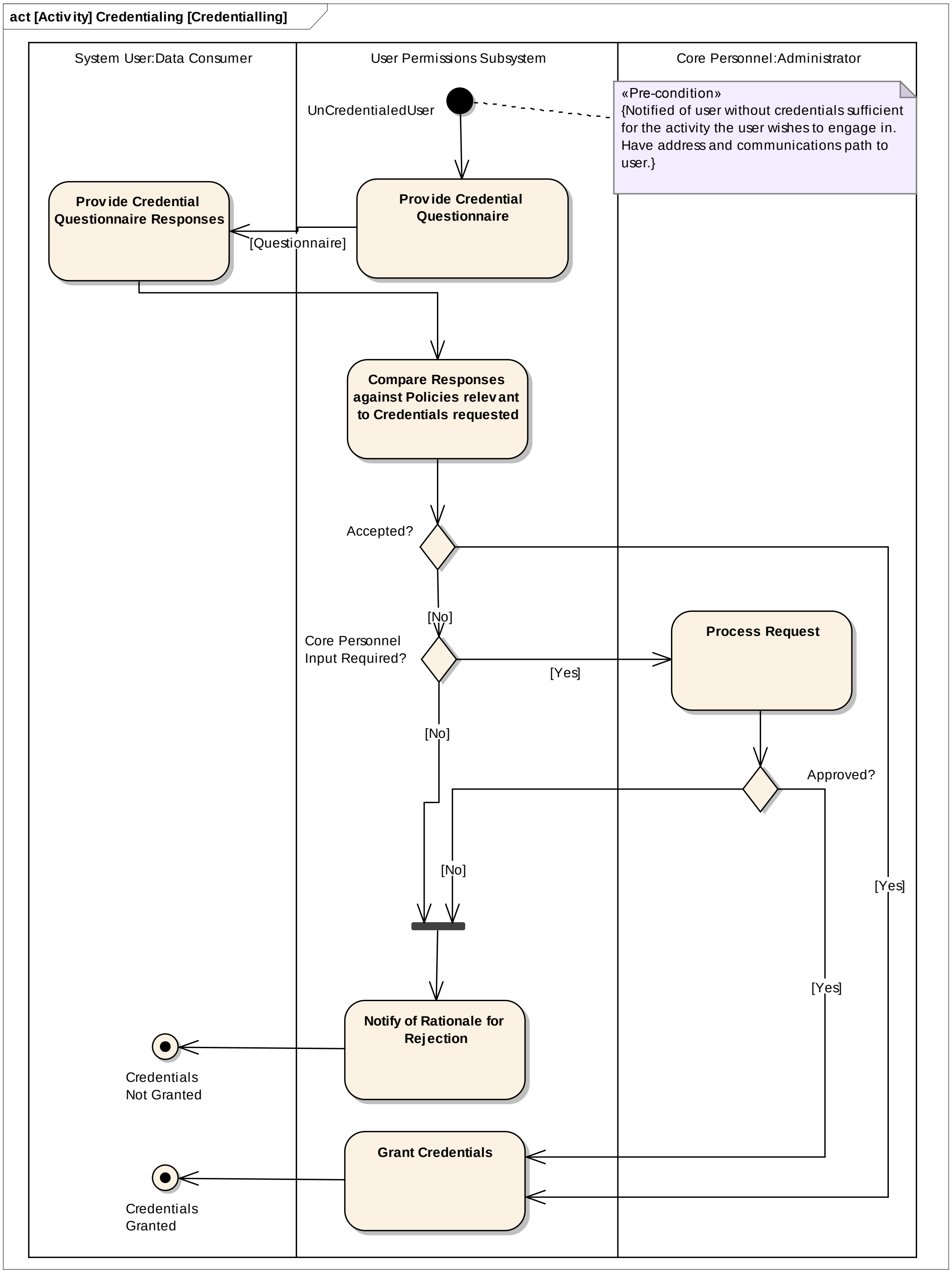


Figure 6-12: Data Subscription Activity Diagram: Credentialing (2 of 2)

6.6 Remote Services

There are several circumstances that may require Cores to cooperate.

- Exchanging CRLs (see Section 6.3)
- Providing Service and Data Backup (see Section 6.11and Section 6.12)
- Cooperating with other Cores to proxy services, so even if one Core does not provide a given service it can "reach back" to another to provide that service. This supports Mobile Users that move from Core to Core and expect or require a service provided by a remote Core.
- Providing services to a Mobile User that it does not have direct communications with. In this case one Core is acting as service router between the Mobile User and a Core.

This scenario covers the two latter cases.

Figure 6-13 summarizes the remote services scenario for a case where the System User does not have communications with the Core or other System User it is trying to contact, and the Core provides that connectivity.

Figure 6-14 summarizes the remote services scenario for a case where the System User wants a service not offered by the Core it contacts (in this case a Data Distribution service).

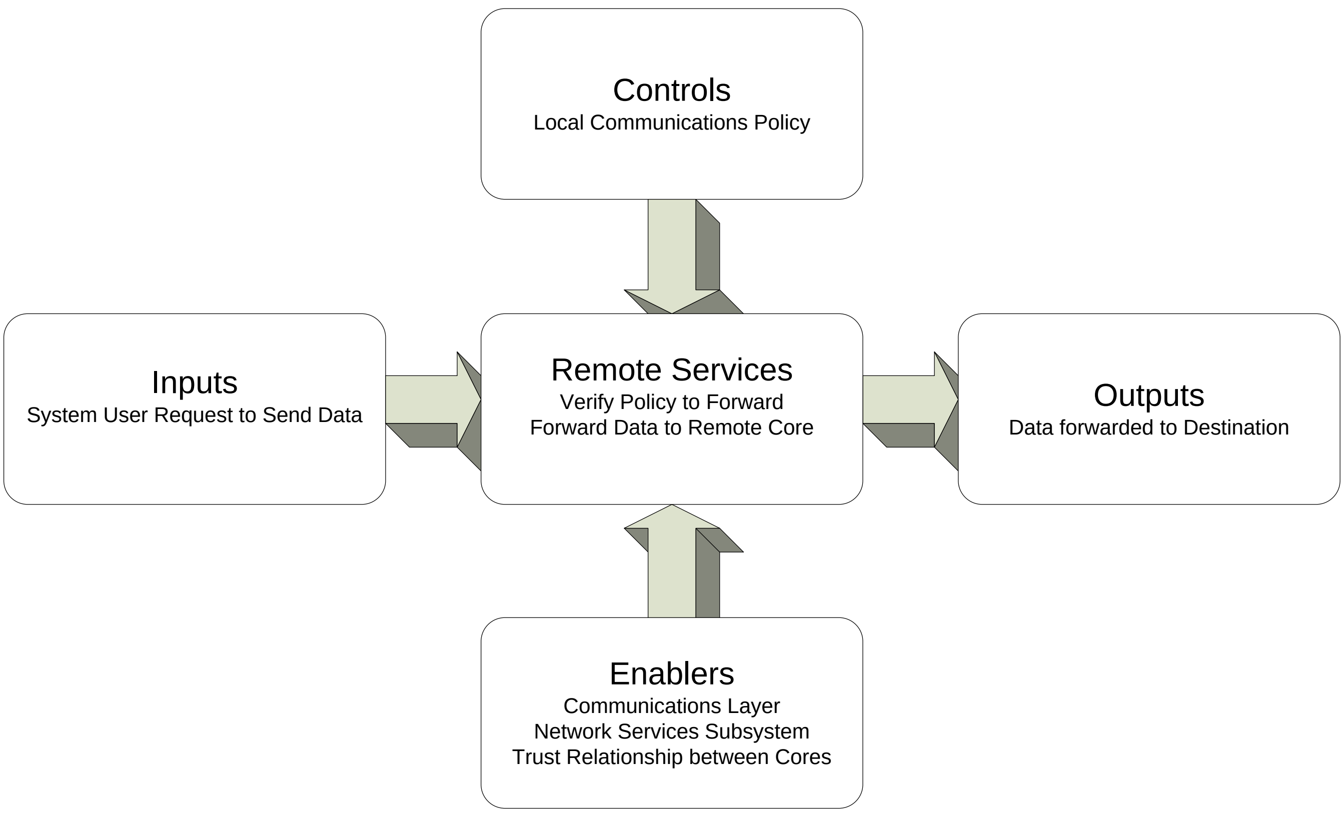


Figure 6-13: Remote Services (Proxy) Context Diagram

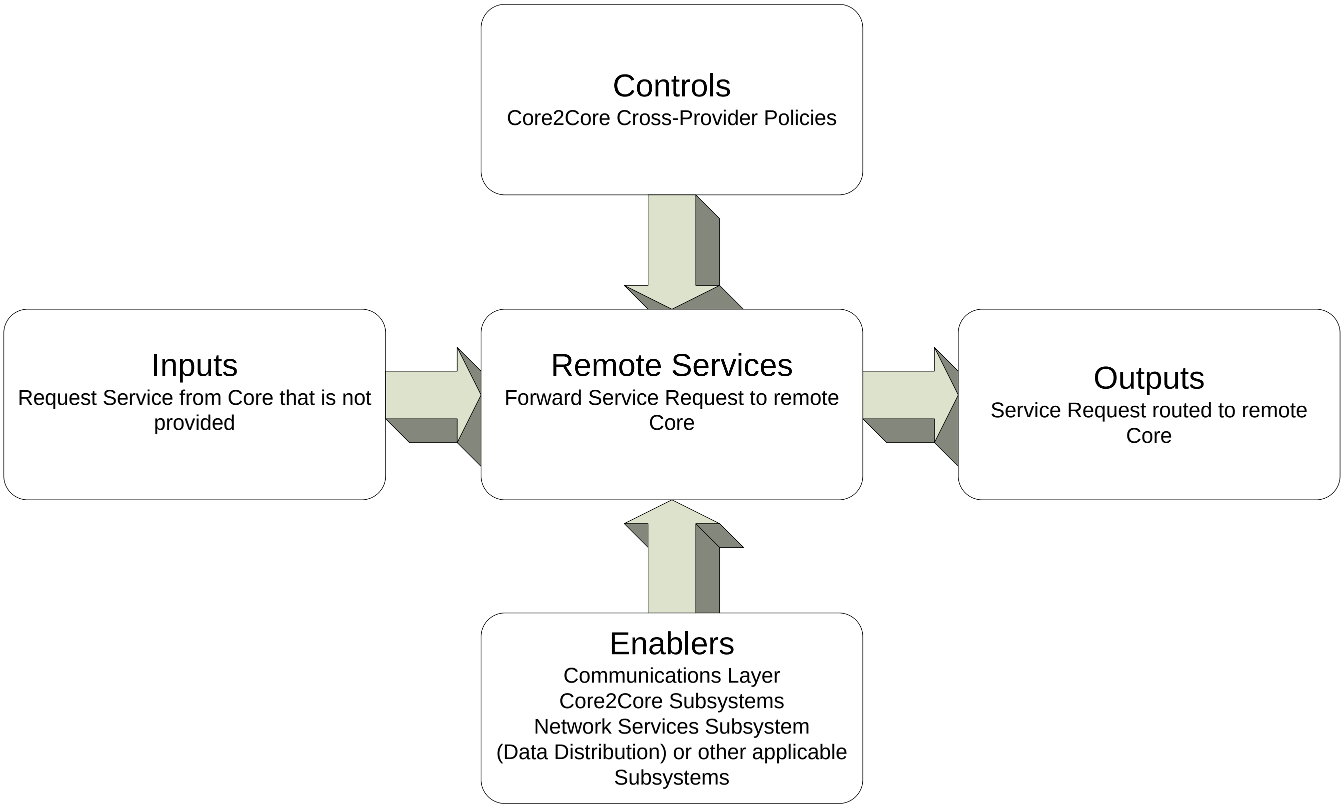


Figure 6-14: Remote Services (Communications) Context Diagram

The Remote Services activity diagram in Figure 6-15 depicts both aspects of this scenario. First, it shows how the appropriate Core System for a service request that cannot be met by the received Core is determined. Once the System User is informed of the Core that provides the service the System User requires, it can send its request to that Core. If the System User cannot communicate directly with the remote Core, then the Core it is in contact with provides a proxy. This proxy could simply be a routing of the request, which would be provided by the Network Services subsystem, but is not shown on the diagram to promote readability.

The type of request the System User makes is not relevant to the activity diagram; all such requests are handled similarly. However, this activity flow only occurs if the Core System does not provide the service the System User is requesting (otherwise the Core would service the request).

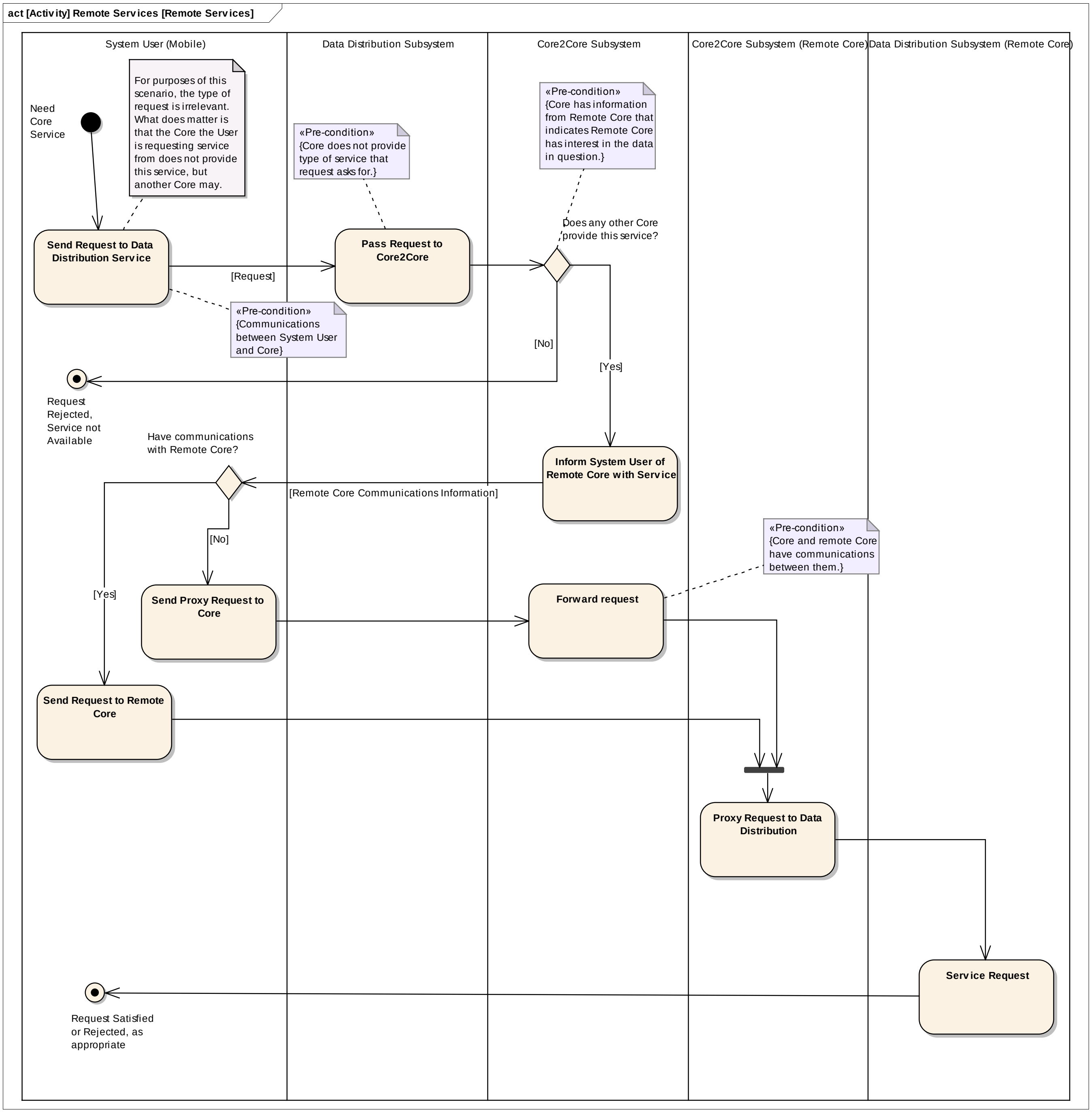


Figure 6-15: Remote Services Activity Diagram

6.7 Core Service Status Distribution

The Core System shares the status of its services with System Users and other Cores. Sharing service status with System Users helps manage System User expectations. Sharing service status with other Cores enables those Cores to understand the status of Cores they have relationships with (and may need to provide service takeover for, see Section 6.12).

Figure 6-16 shows the context for Core Service Status Distribution. This scenario is primarily concerned with the Service Monitor subsystem which monitors the status of all subsystems and reports status information to System Users.

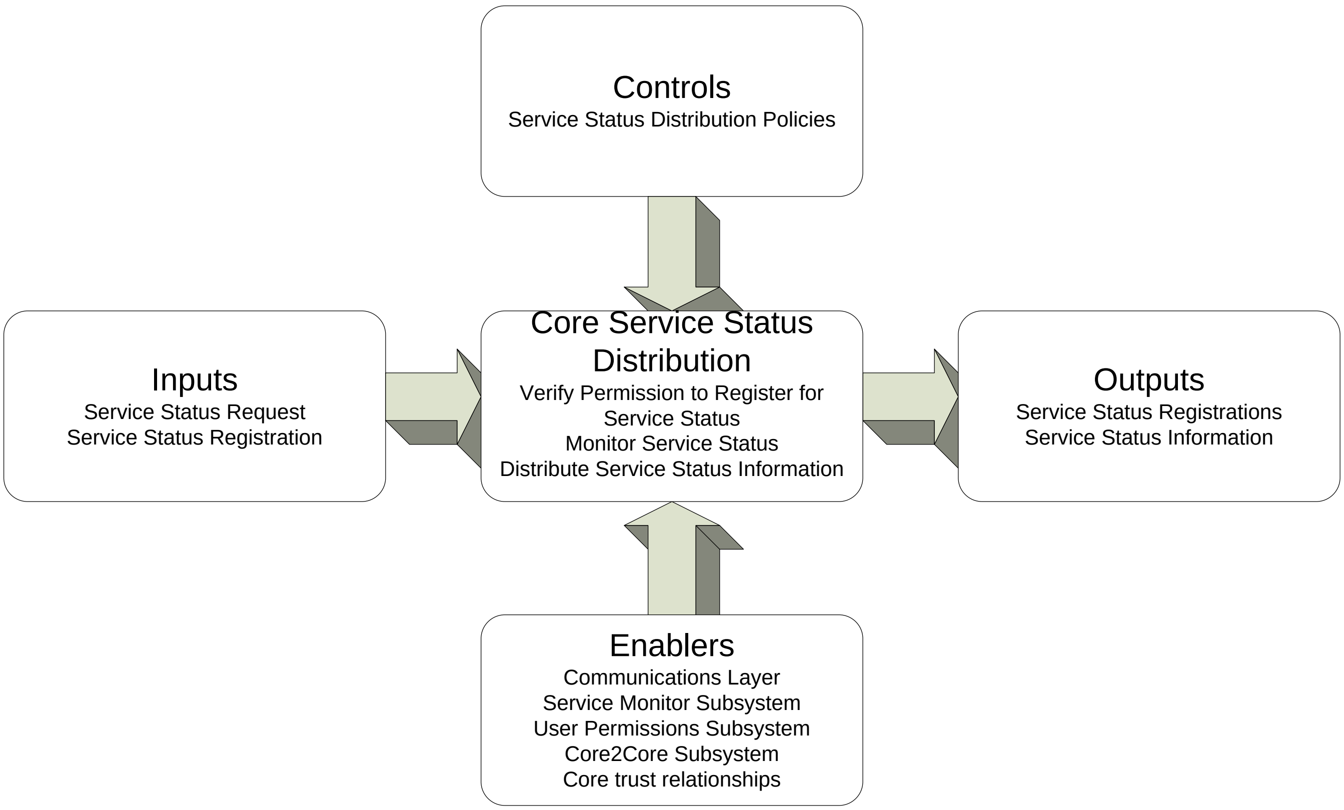


Figure 6-16: Core Service Status Distribution Context Diagram

Figure 6-17 illustrates query-based service status distribution. The Core System constantly monitors the status of its services. When a System User or other Core requests service status information, the Core System provides service status information to them.

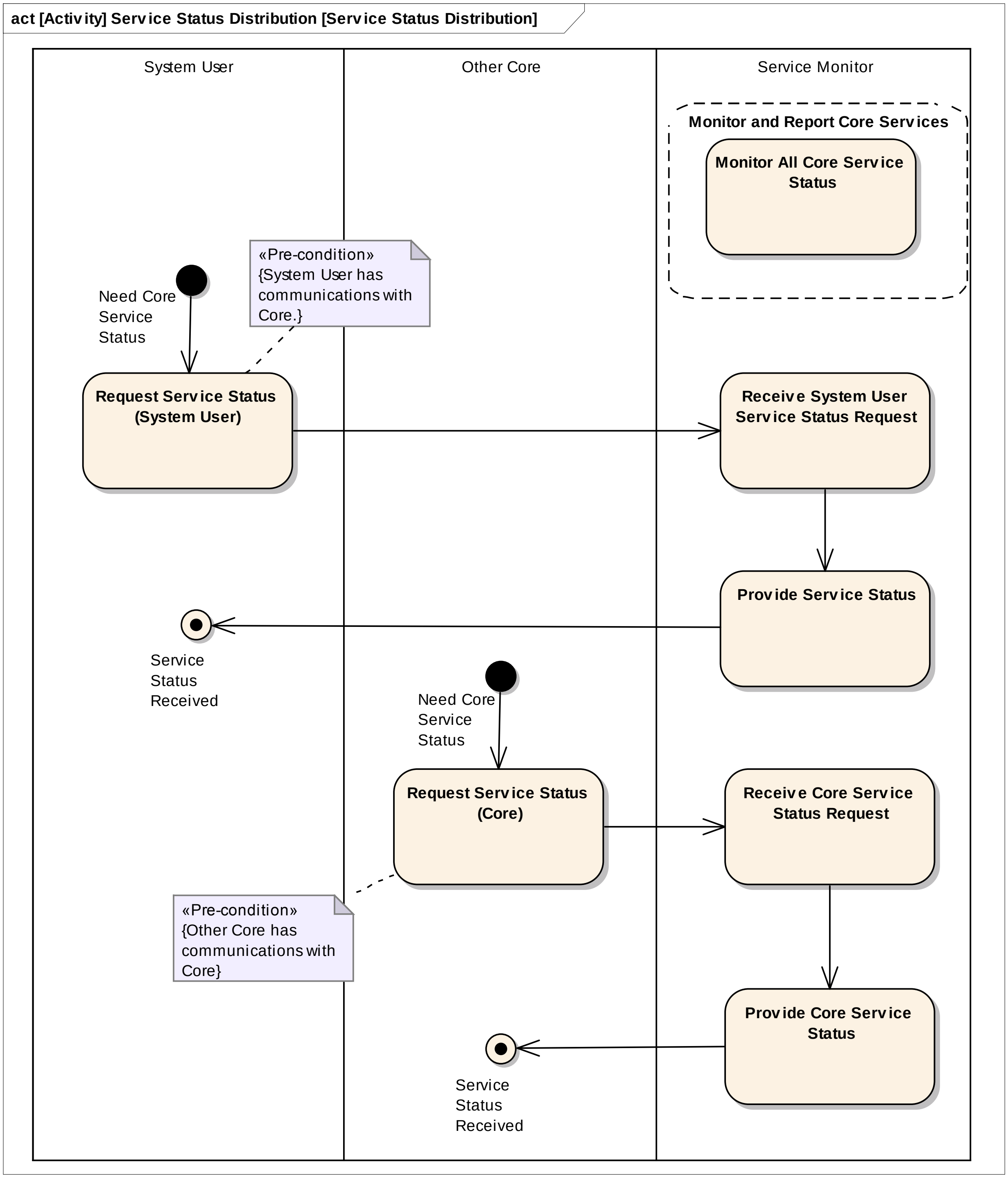


Figure 6-17: Query-based Service Status Distribution Activity Diagram

Figure 6-18 illustrates the periodic service status distribution. The Core System constantly monitors the status of its services, and periodically provides service status information to other Cores and System Users that are registered to receive this information. Cores and System Users register to receive this information by requesting registration. The User Permissions subsystem determines if the requestor is permitted to receive the service status information they request and if so, the System User or Core is added to the list of registrants that to receive service status information.

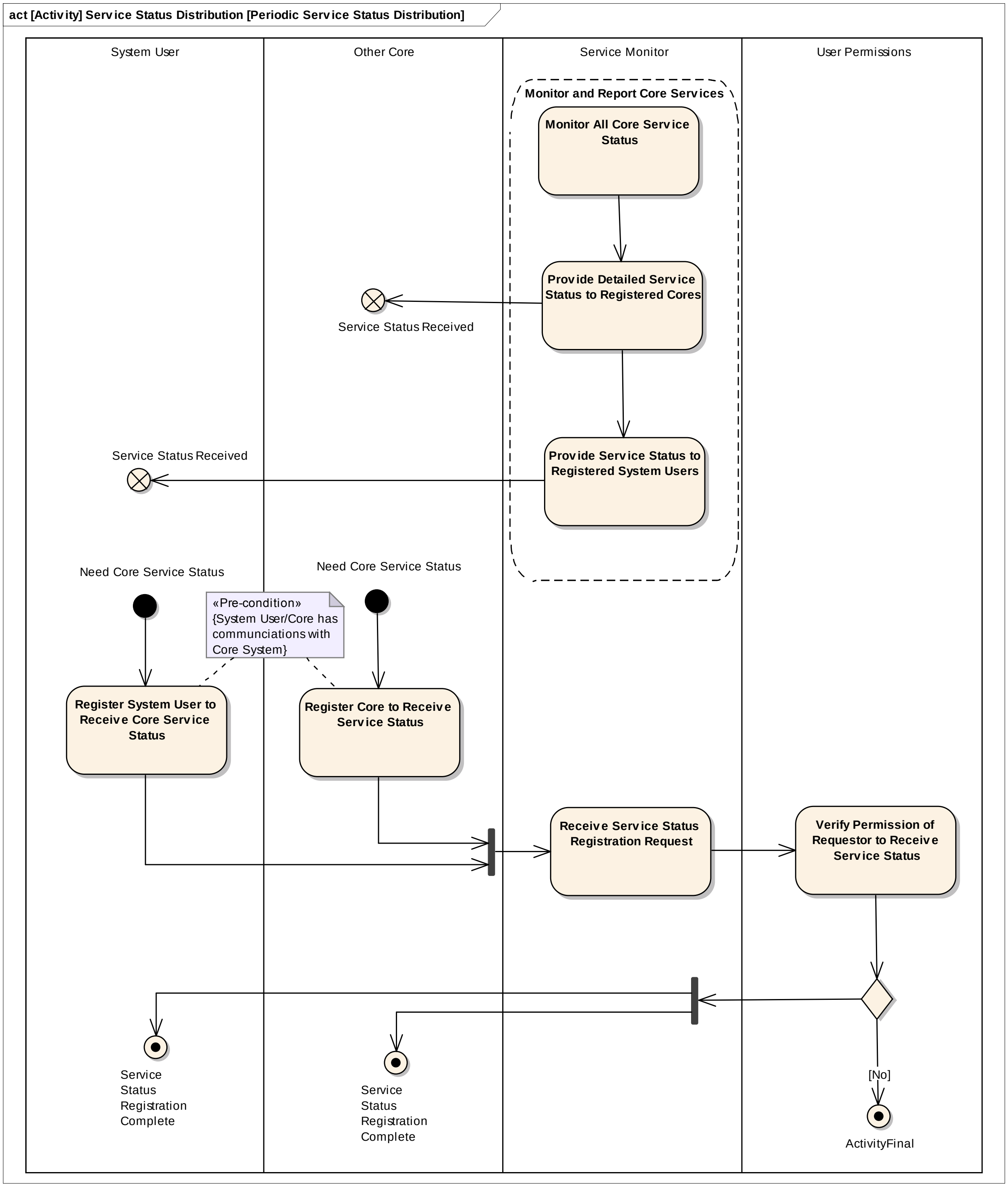


Figure 6-18: Periodic Service Status Distribution Activity Diagram

6.8 Core System Operations

Core System Operations describes the day-to-day "housekeeping" activities that the Core System and Core Personnel are engaged with the aim of monitoring and maintaining operation of Core System services. The efforts involved will vary depending on several factors:

3. As noted in Section 5.0, Core System scope is highly variable. Generally speaking, the larger a Core's deployment footprint, the more operational responsibilities Core System Personnel will have.
4. Cores operating under policies that do not require much (or any) intervention from a human decision maker in order to function will naturally require less Core Personnel than one that does require more human interaction.

The Core System Operations context diagram is shown in Figure 6-19.

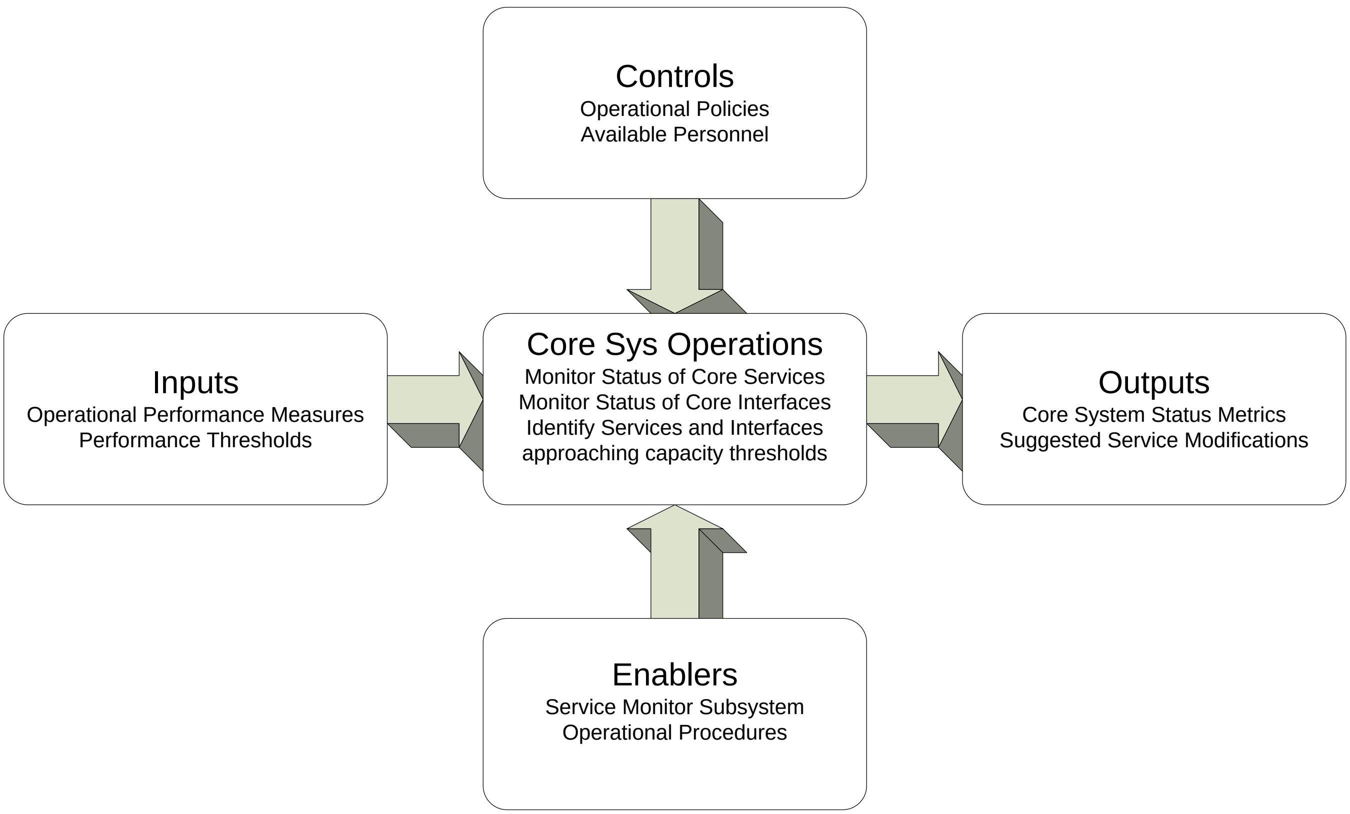


Figure 6-19: Core System Operations Context Diagram

Core System Personnel activities will be governed by a set of operational procedures which should be defined prior to beginning operations. For the purposes of developing an understanding of the scope of these responsibilities, the following activity flows (Figure 6-20) document the types of activities personnel may have to engage in, but not the procedures themselves. These procedures will include diagnosis of subsystem performance, Core and subsystem state and mode, and how to alter states and modes. Procedures should also identify the possible ramifications of such alterations, as they could result in notifications to the Core System Personnel and/or interactions with other Cores (e.g., bringing another Core online to provide services for this Core).

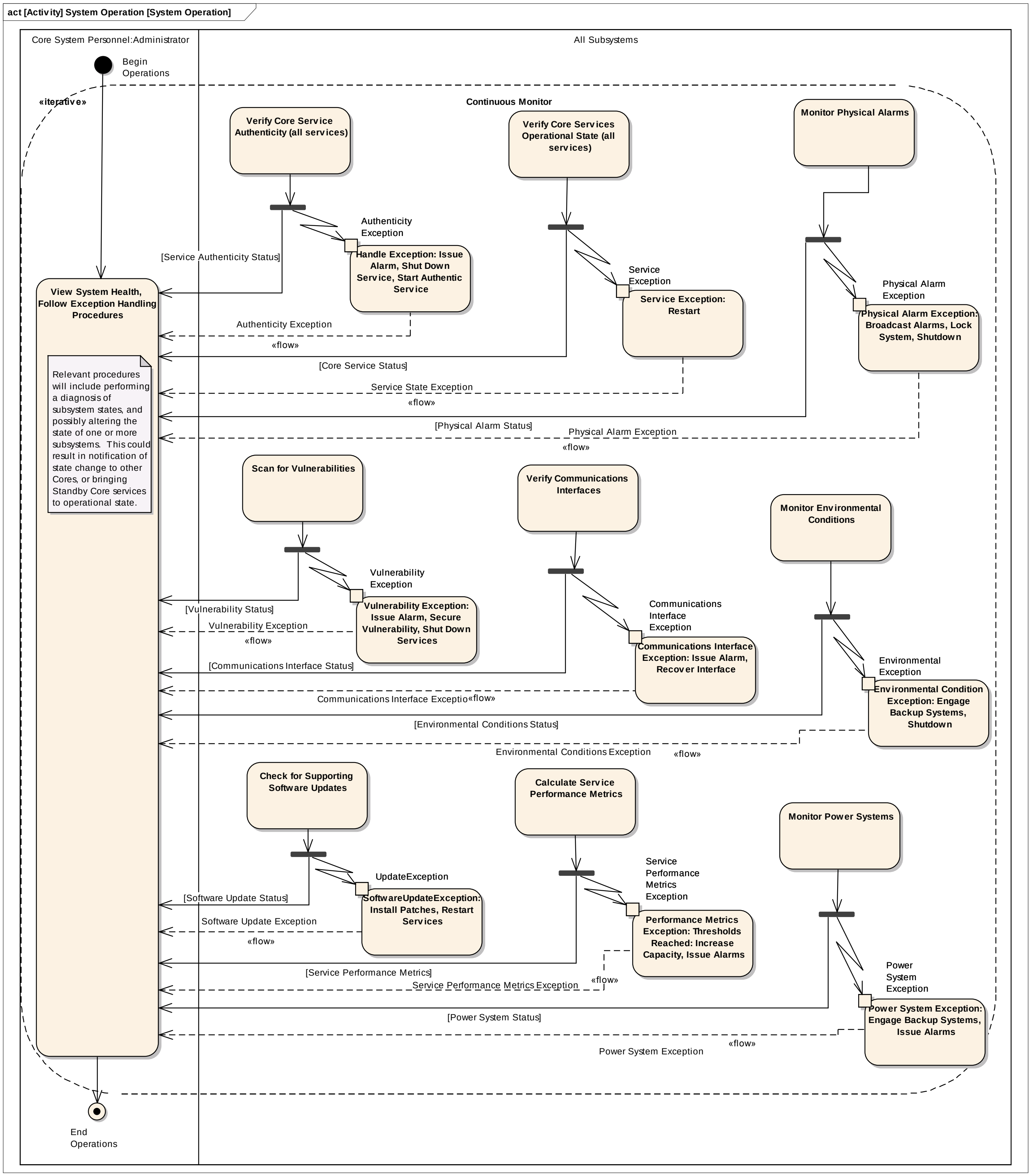


Figure 6-20: Core System Operations Activity Diagram

6.9 System Expansion

System expansion refers to modification of the Core System to increase capacity or add a new capability (i.e., data aggregation). The following context diagram (Figure 6-21) serves for both.

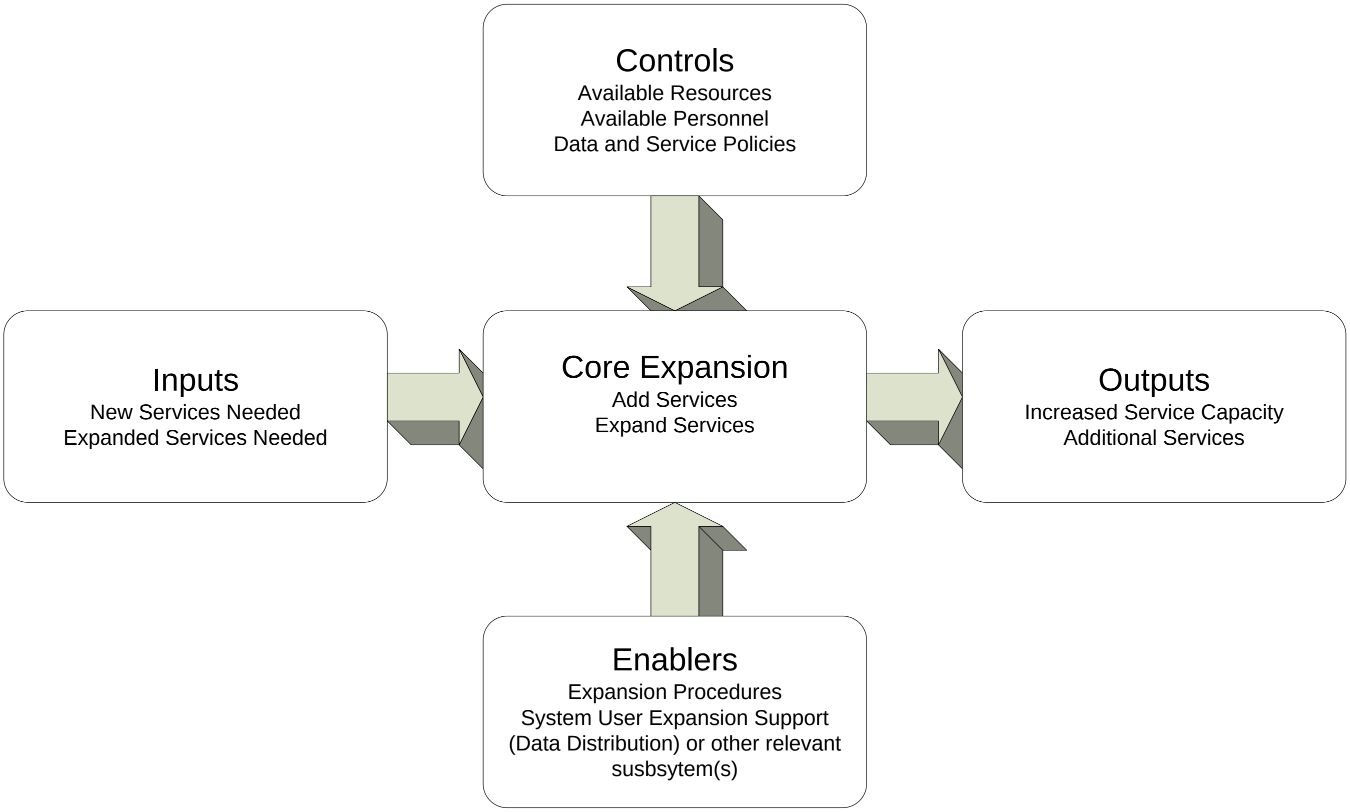


Figure 6-21: System Expansion Context Diagram

This scenario depicted in the activity diagram presented in (Figure 6-22) concerns what happens when a given Core is deployed without a service, in this case Data Distribution's data aggregation capability. Installing new functionality is a task for Core System Personnel. The Data Distribution subsystem's configuration settings must be modified to support the new functionality. Services provided to System Users should not be interrupted. However while existing data subscriptions will continue to operate, they must be modified to leverage the data aggregation functionality.

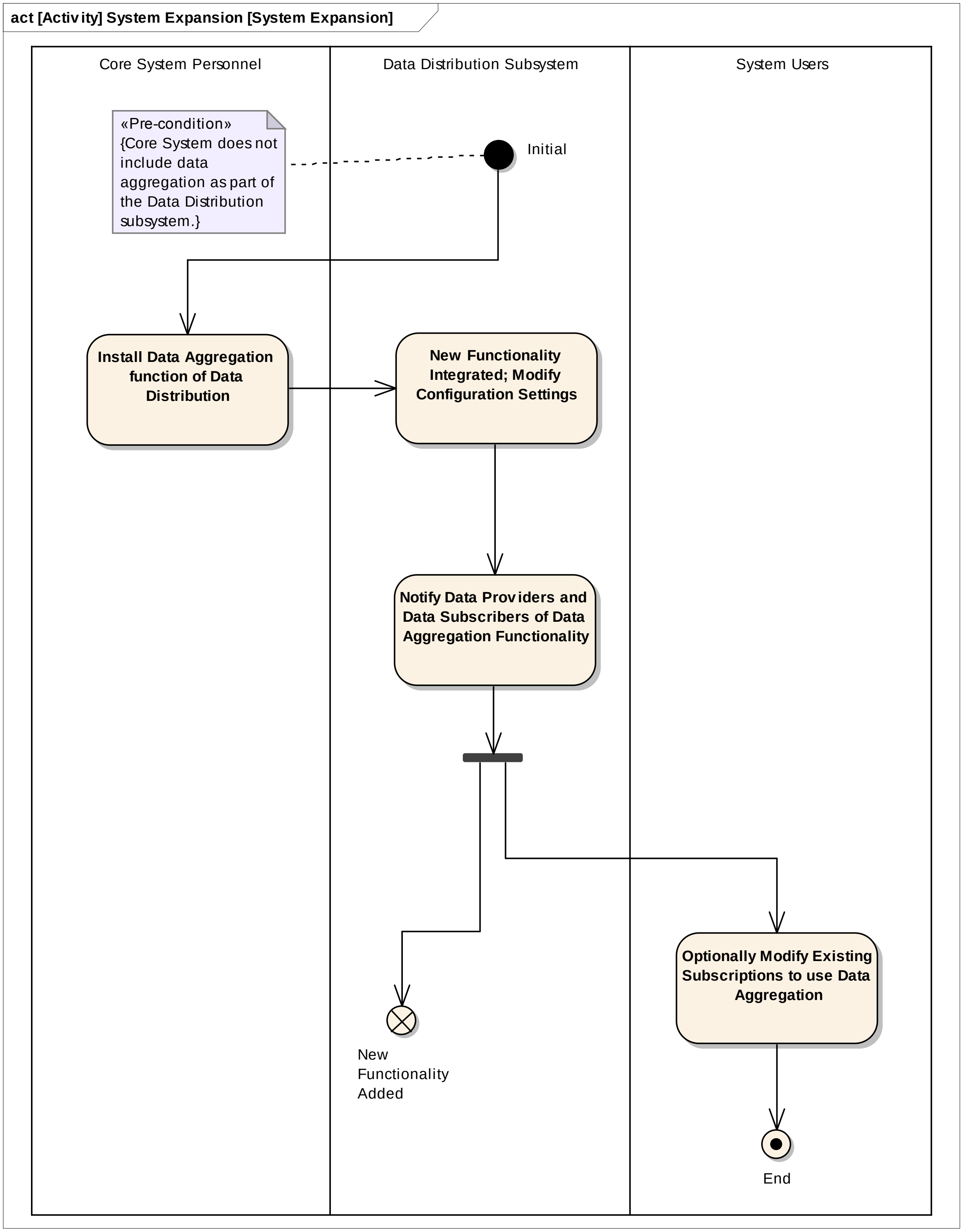


Figure 6-22: System Expansion Activity Diagram

6.10 Core Discovery

This scenario depicts how a System User discovers a Core System and request services. The System User queries the Communications Layer for the address of a Core. The Core address can then be used to query the Core for the status of available services. The context diagram for Core discovery is shown in Figure 6-23.

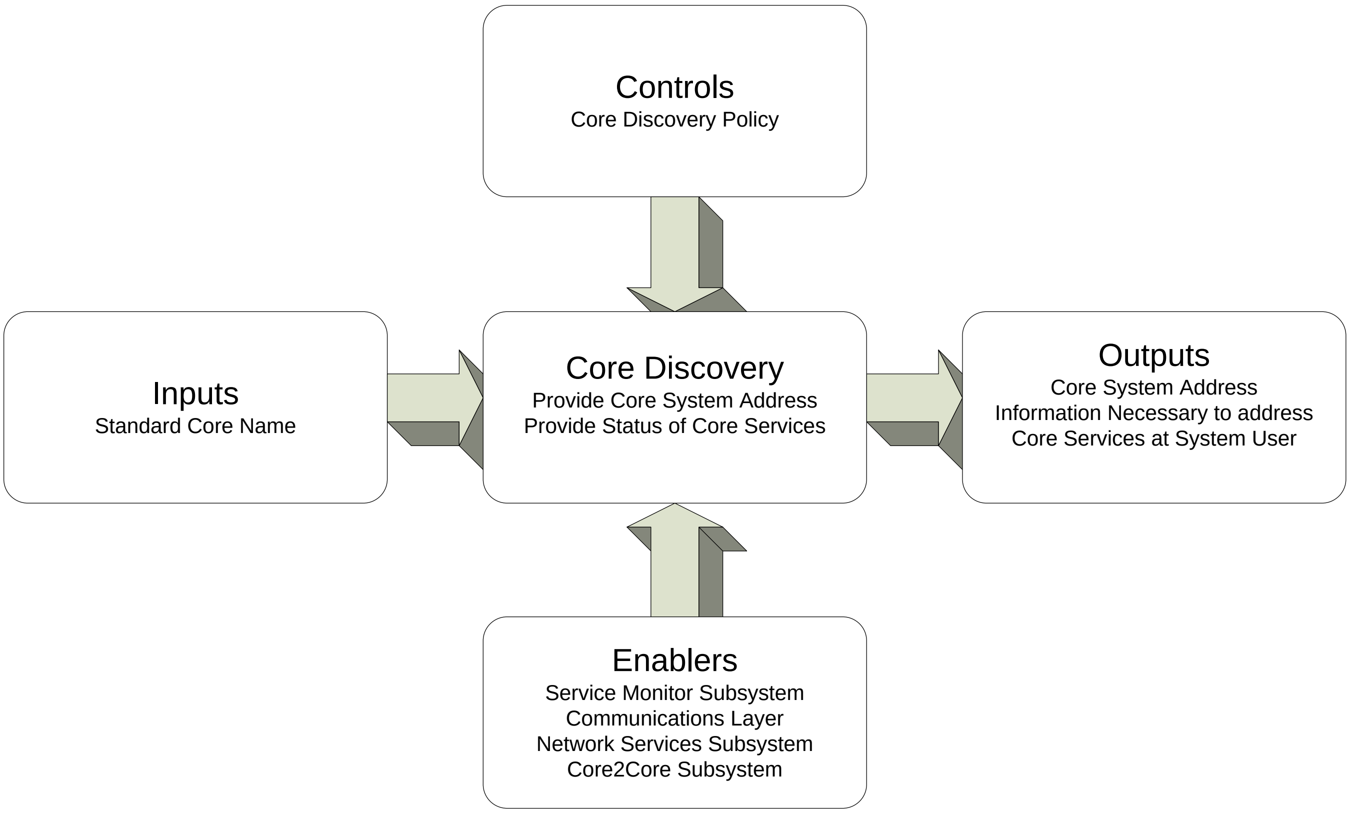
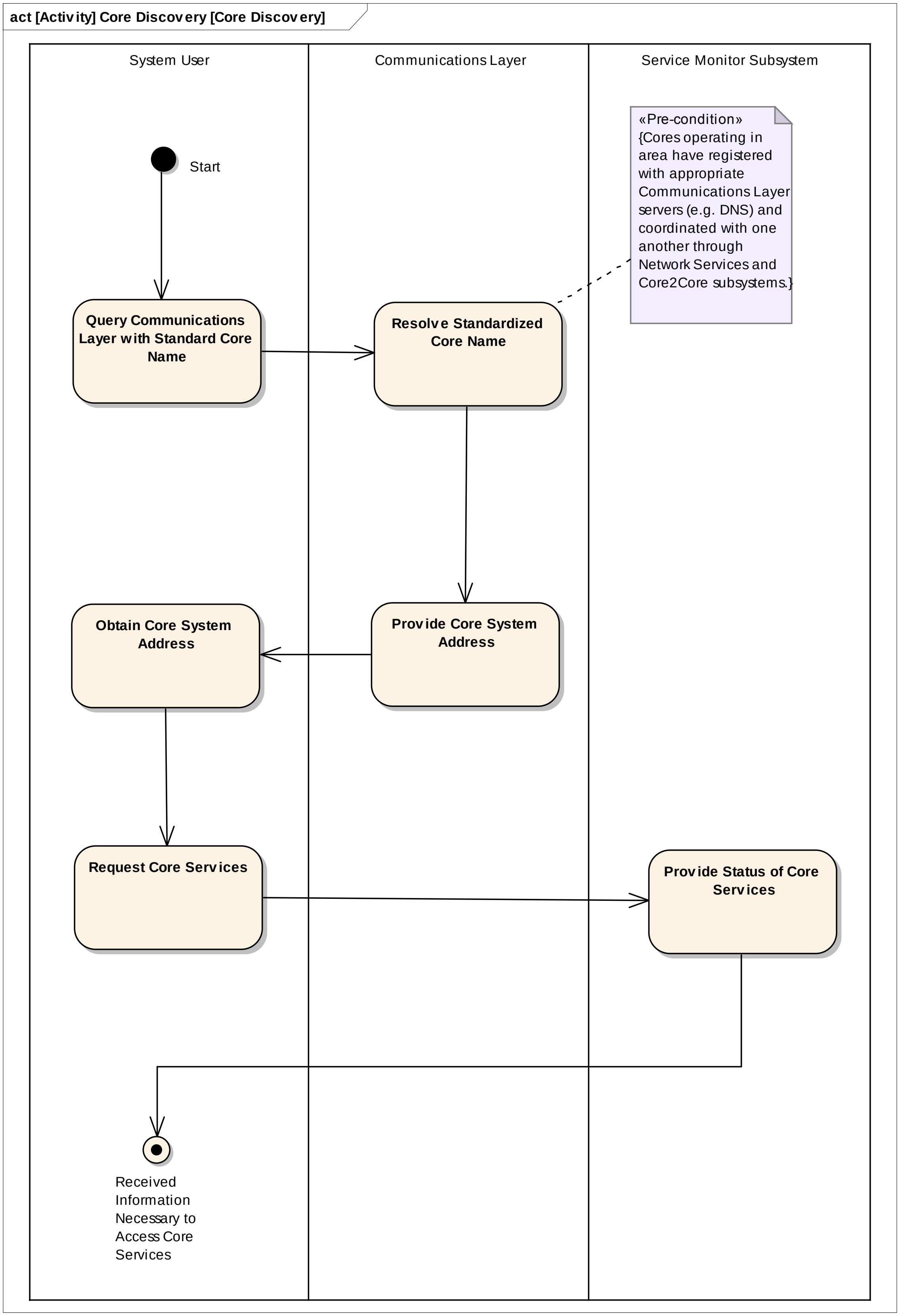


Figure 6-23: Core Discovery Context Diagram

The System User queries the Communications Layer with a standardized Core System domain name. The Communications Layer returns a Core address that has been previously registered with that name for the area the System User is in (this implies some functionality on the part of the Communications Layer which will have to be resolved either by communications providers or included as part of the communications functionality of System User devices). The Core address is used to communicate with that particular Core to determine Core service availability. The System User is provided with information on which services are available and how to access them. The activity diagram for Core discovery is shown in Figure 6-24.



Z

Figure 6-24: Core Discovery Activity Diagram

6.11 Service Data Backup

In order to secure data and provide for service takeover by another Core, a Core System needs to provide its configuration data to that other Core. This includes what services it operates, the configuration of those services, scope, and performance information. For some services this includes System User-specific information. For example, the data distribution subsystem may provide subscription information to a backup Core.

Figure 6-25 shows the context diagram for this scenario. The Privacy Policies Framework is included as a control because some shared information, such as data subscriptions, may include PII. Management of this PII must be compatible with the principles laid out in the Privacy Policies Framework. A Core could have multiple backup agreements and have its configuration data backed up at multiple other Cores.

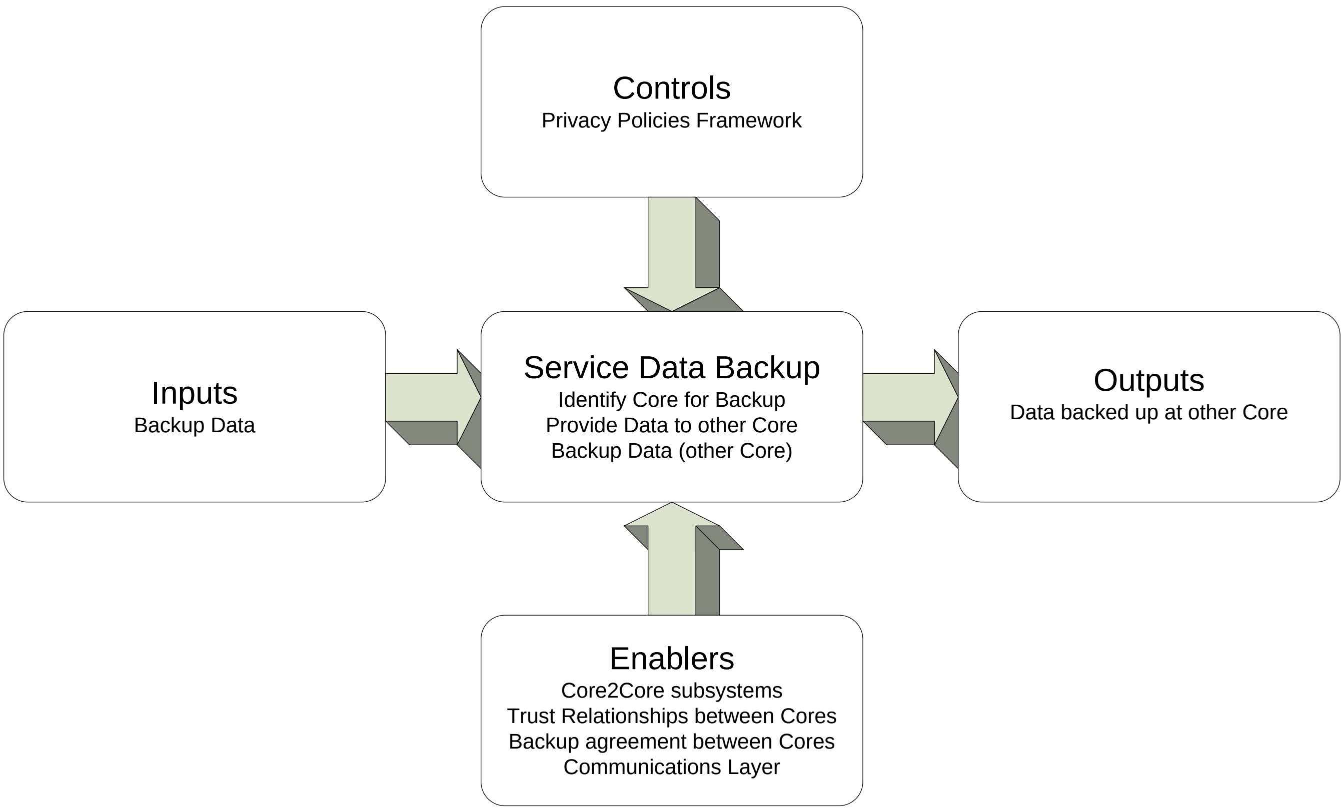


Figure 6-25: Service Data Backup Context Diagram

The activity diagram in Figure 6-26 illustrates the backup process. In the event that the Core needs to restore data from the other Core, a similar process could be used in reverse, restoring data from the other Core and modifying the configuration of the Core to match the restored data. See Section 6.12 for a related example.

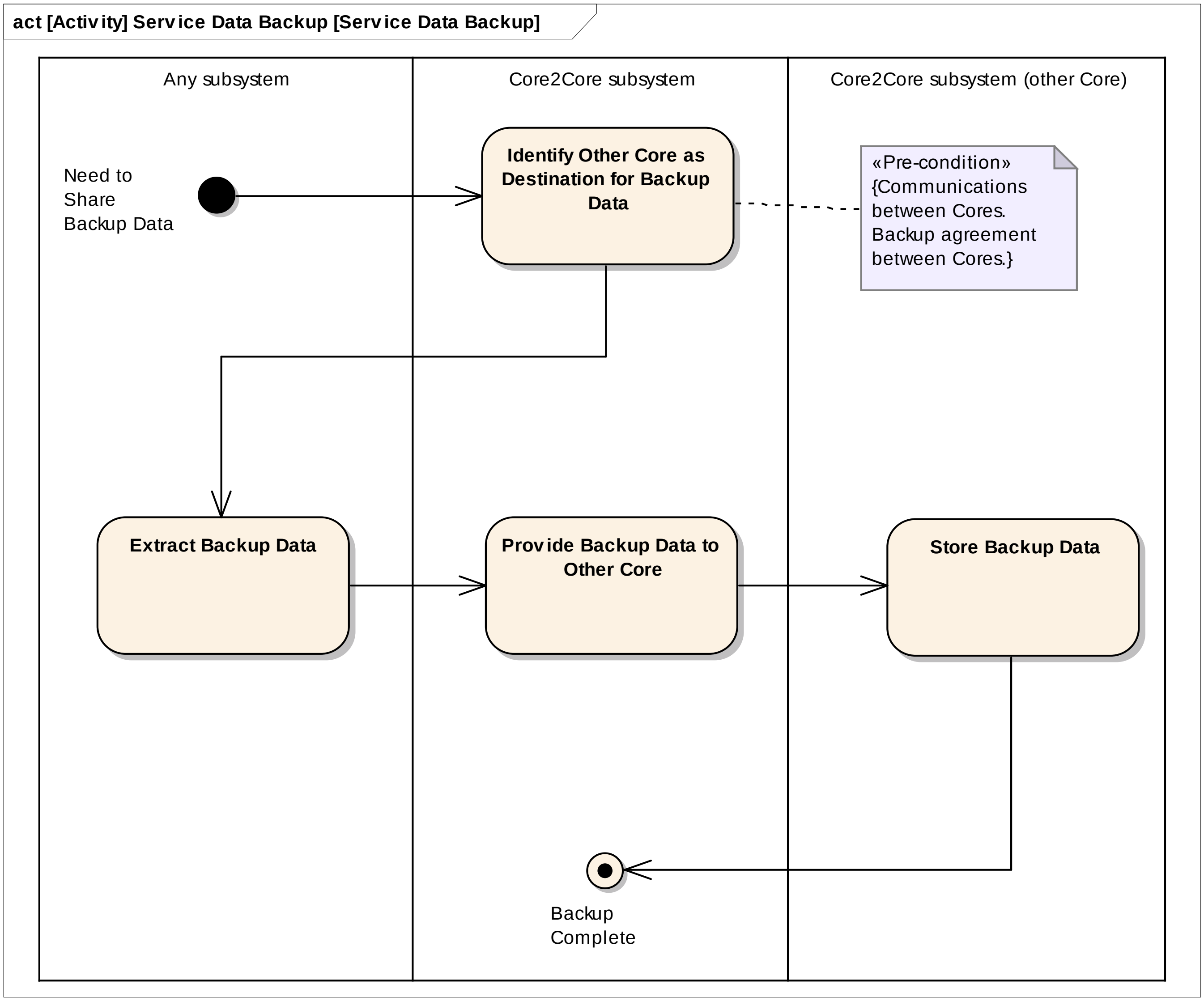


Figure 6-26: Service Data Backup Activity Diagram

6.12 Service Takeover

This scenario depicts how one Core System provides service on behalf of another. The reason for the takeover of service may be anything; likely reasons include maintenance activities or emergency action. The Core2Core subsystems interact with the Core System Personnel of the Cores to establish the takeover.

The context diagram for Service Takeover is shown in Figure 6-27.

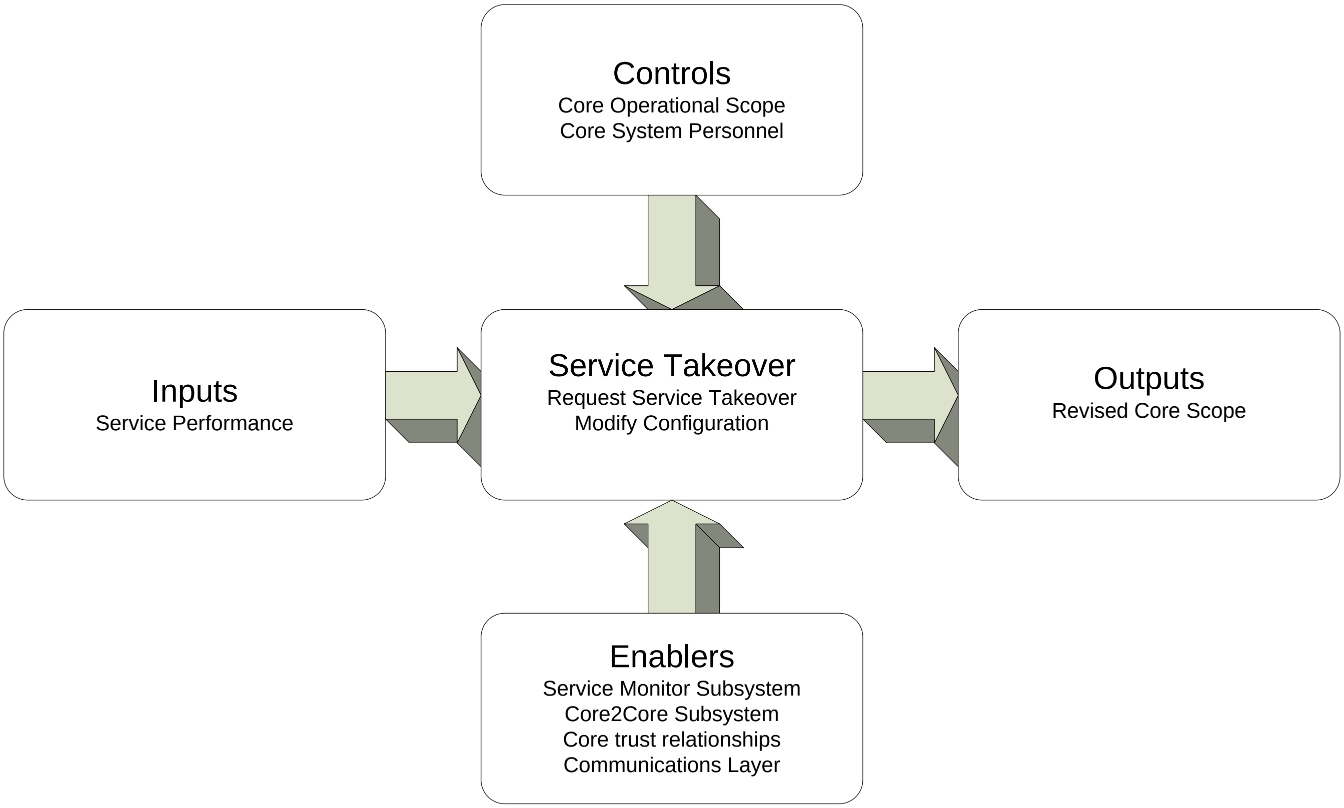


Figure 6-27: Service Takeover Context Diagram

The Service Monitor subsystem provides performance monitoring of all subsystems. Relationships between Cores are implemented by Core2Core, which handles all interactions for service takeover.

The activity diagram in Figure 6-28 illustrates the roles that Core System Personnel and Core2Core subsystems play. Service Monitor subsystems are involved prior to the start of this activity, and may contribute to the starting condition by determining service takeover is required. Also, Cores could implement service takeover in an automated fashion without Core System Personnel involvement; in this case the Service Monitor subsystem would initiate operations as shown here in the Core System Personnel swim lane, while configuration of subsystems at both Cores would have to be managed by the subsystems themselves. Note that the configuration information necessary to establish the service takeover must already have been exchanged. This could be done as part of data backup; see Section 6.11 for details.

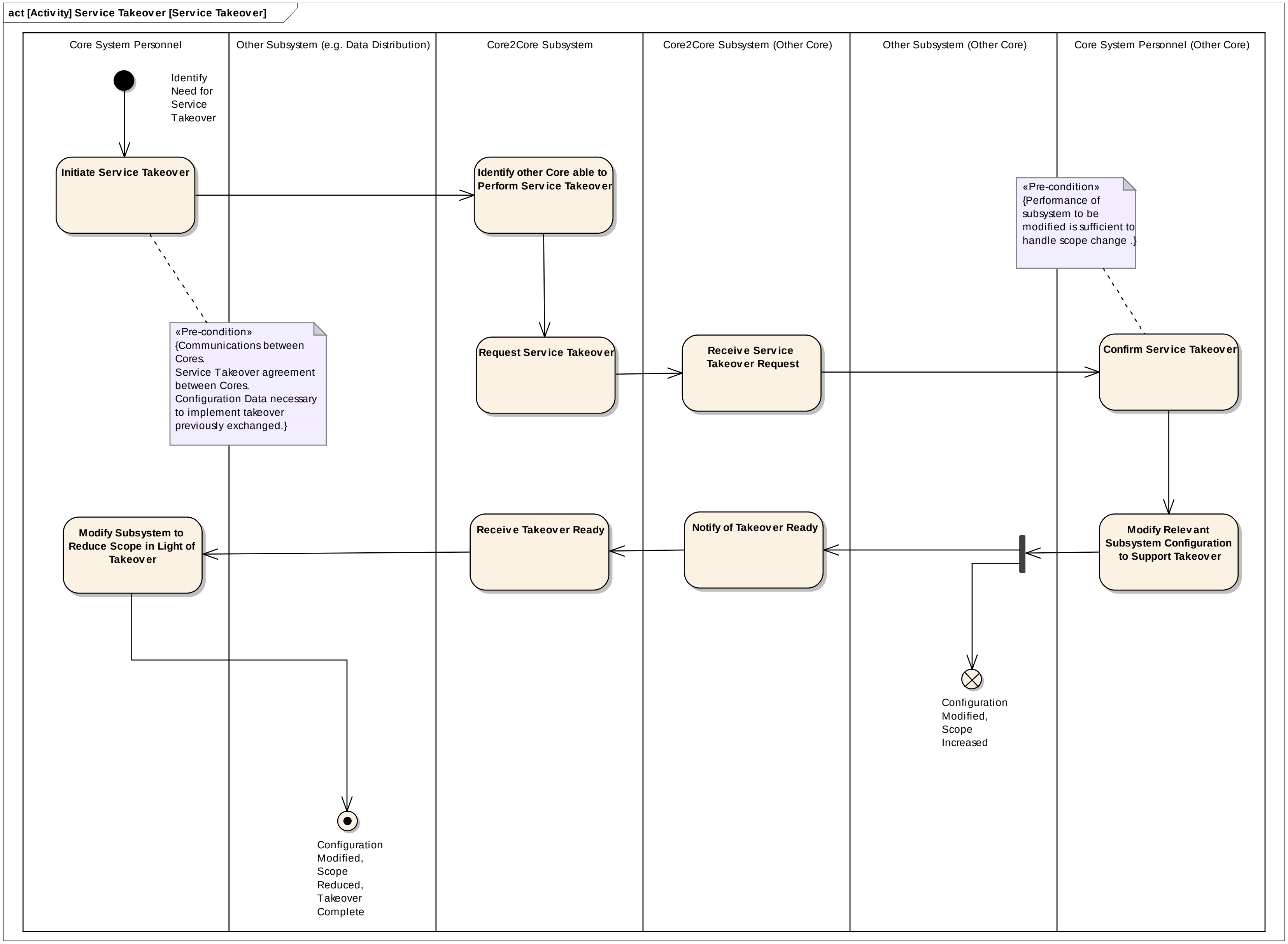


Figure 6-28: Service Takeover Activity Diagram

7.0 SUMMARY OF IMPACTS

Implementation of the Core System will support the vision of enabling transformative change within the transportation environment. The Core System facilitates interactions between Mobile, Field and Center-based entities; this forms the foundation for communication-based applications. The subsections below identify potential operational impacts, organizational impacts, and impacts during development as well as ways of measuring these impacts.

7.1 Operational Impacts

This section describes the impacts that the Core System will have on the entities (public agencies or private firms) that operate the system as well as the users that use the technologies and applications that will be deployed in the *connected vehicle* environment. Operational impacts of the Core System will include capabilities that are beneficial to users, developers, operations and maintenance personnel.

The most significant operational impact of the Core System will be providing the foundation for new applications that provide benefits to travelers and the transportation system to improve safety, traveler's mobility, and reducing transportation's impact on the environment. Expected benefits include:

- Reductions in numbers of accidents, accident severity and a corresponding drop in transportation-related fatalities. Insurance costs should decrease accordingly.
- Reductions in congestion, delay and related time lost commuting; increased use of public transportation and increased multi-modal coordination.
- Reductions in transportation-related greenhouse gas emissions.
- Data collection enabled by the Core System will also enhance existing transportation applications. Two commonly cited examples from the user needs workshops are that traffic mobility applications will benefit from new sources of traffic data and weather applications will benefit from new sources of weather data.

Deployment of the Core System will open up access to applications over different communication access mechanisms such as 3G/4G cellular, thus fusing new communications media with what had previously been closed communications networks. This allows agencies operating transportation infrastructure the opportunity to reduce their reliance on or commitment to maintaining their own communications infrastructure. Today, the traveling public accesses traveler information via the internet, telephone, DMS, or the radio – all of which are limited somewhat by the deploying agency's installation coverage and policies and procedures governing those outlets. Future applications will provide more ways to receive useful, timely information.

Procuring network access at the Core System and by/for System Users will have a long term fiscal impact. Cores that operate publish and subscribe services may have to absorb significant bandwidth costs. System Users relying on cellular communications will have to pay for those links. Centers that pull large amounts of data may also see significant communications costs. Field users may as well, though the variety of access methods, including traditional terrestrial land lines and private networks that may already exist to support other ITS may ameliorate some of these costs.

The primary impacts to operators and maintenance staff of the Core System are the new hardware and software that will be deployed to perform the functions listed in Sections 4.0 and 5.0. The hardware will include workstations, servers, routers, firewalls etc. that will need to be operated and maintained.

The incorporation of network management tools and diagnostic software tools should simplify the day-to-day operations of operations and maintenance personnel. Regardless of how difficult the Core and various communications systems are to manage however, those personnel will still have more responsibilities than they do today, simply by having to operate the Core System.

Operators and maintenance staff will also be impacted by changes to operational procedures. Current operational procedures are primarily focused on roadside device management whereas this program will provide the ability to focus on communications directly to the vehicle. This allows for more dissemination locations, with more flexibility and potentially more content to be communicated to travelers. For example, a DMS currently is at a fixed location so only drivers within sight of the sign will receive the message displayed on the sign. With this program, the ability to send messages similar to what is currently displayed on a DMS to in-vehicle systems will be possible.

The deployment of the Core System will facilitate the collection of new data from new sources, chiefly vehicle-based, that can be used by transportation planners and other staff to improve long range planning. This should improve visibility into traffic patterns, usage of transit facilities, and relationship and trend analysis, such as between traffic and weather conditions. Enhanced data collection should also facilitate new ways of monitoring and managing traffic that help in improving operations. Data retention requirements should also be considered.

Testing and deployment of the Core System will have an impact on the Operations staff that may already be operating a transportation system; the Core System will need to operate in parallel. Integration issues between legacy systems and Cores could hinder Core deployment. For example, a traveler information system may be based on a legacy database. In order to take advantage of data from data providers of this program the operators of that traveler information system may need to develop special interfaces.

Security and privacy requirements will introduce a new set of policy and institutional issues that need to be addressed. For instance, the security requirements of technologies such as 3G/4G cellular need to be evaluated and understood when these communication mechanisms are used. The services of the Core System open the possibility for application developers to take advantage of the centralized security mechanisms of the Core to supplant their current independent approaches to security – they can let the Core take care of security and concentrate on their application needs.

It will be necessary to deploy system and technological refreshes on a continuous basis to keep the Core System up-to-date. It will be necessary to patch software and upgrade hardware on a regular basis. Procedures and mechanisms for these updates will have to be developed and agreed to by Core System operators. The subsystems described in Section 5.0 such as Service Monitor will allow the system to be maintained and kept up-to-date. Over time, deployment and use of *connected vehicle* technologies will supplant existing devices/systems and reduce the maintenance required for those legacy systems.

The Core System support for wireless systems will provide bandwidth for larger data set exchanges than what is possible with DSRC alone. Even travelers that do not interact with the Core or System Users will benefit through improved traffic control, improved transit operational efficiencies, better response time for incidents, etc.

Device manufacturer support for the *connected vehicle* environment will enable a variety of new operational procedures that should improve remote diagnosis of vehicle and device problems. This could result in a closer relationship between manufacturers and vehicle/device owners, particularly if software refresh of OBE is regularly required. At least in the early phases of deployment, as services are rolled out and operations refined, this seems likely.

Additional operational impacts may include the following items:

- Changes in operational risks – integrating with public system networks may increase opportunities for Core Systems to be exposed to hacking or other intrusions. On the other hand, more detailed and geographically comprehensive information about the road conditions are available using this program which will lead to better management of the transportation network.
- Advances in technology – faster processing, different communications mechanisms available, and other aspects like the use of IPv6 may impact how the Core System is deployed and may require additional training for personnel using and maintaining the system.

7.2 Organizational Impacts

This section addresses the impacts the new system will have on deployers and operators of the Core System. Public agencies or private entities that will plan for, manage, operate and maintain a Core will establish roles and responsibilities that are different than what exists at present. New roles may need to be created in certain areas like governing the relationships between Cores, coordinating with public and private network operators, security certificate authorities etc. while responsibilities of some of the existing personnel involved with planning, managing, operating and maintaining will be modified to align with the Core System needs.

A new organization may need to be created to manage the certification of Core Systems, the management of Core boundaries and to foster or at least enable relationships between Cores. This organization should include representatives of Core deployers, but may also include representatives of other stakeholders.

Based on the changes in work load, there may be a requirement to hire or retrain additional personnel subject to budgetary considerations. For example, deployment of the Core System will provide a variety of new data that can be used to improve operations. However, if this results in increased workload, hiring of extra staff may need to be evaluated. Early on, the existing staff will likely be tasked with additional duties to operate and maintain the new system.

The organizational impacts will vary depending on the deployment approach chosen. While no policy decisions have yet been made with regard to how Core Systems may be deployed, there are some impacts that can be identified. A Core deployer may contract out the entire system, some parts of it, or may decide to build and manage the system using their own agency resources. In some cases, the same organizations that manage and operate ITS today will be deploying and managing this next generation system. In other cases, there will be new organizational structures established. The services deployed and the sequence in which these services are deployed may also have organizational impacts (for example, initial deployments might be limited in scope, such as a deployment focused on support for commercial vehicle fleet operations).

Personnel assigned to Core System positions will be required to meet the minimum skill requirements that will be identified. This will vary based on the types of services implemented and applications supported by a Core. For example, some operators will need to be able to monitor and maintain system security credentials. Other operators may need to be able to manage databases and how System Users access system resources. Training needs to be provided to existing personnel to enhance their skill level to meet these minimum skill requirements. For positions where this is not possible, recruitment from outside the organization should be considered.

Training should include classroom training and hands-on training on each of the subsystems as well as operations and maintenance crew training. Classroom training provides the student with the concept of operations, relationships, individual product features, and an introduction to the hardware and software interfaces. Hands-on training allows the student to work with hardware components and software applications to view/change product configurations and practice basic operator and maintainer tasks.

Crew training provides the operators the necessary skills to operate their portion of the system in conjunction with other operators external to the Core System. The goal of crew training is to achieve a required level of proficiency for each Core System position by conducting challenging scripted scenarios that replicate typical operations in the Core.

In addition, personnel should be provided training on courses when it is expected that they need to be certified to operate and maintain certain types of equipment, software, or network services.

Deployment of the Core System subsystems will occur across multiple agencies (both public and private) with interdependent, and in some cases, overlapping areas of responsibilities. These interactions with other agencies, both government and private, will require institutional agreements in order for the Core to work. These institutional agreements will help identify the boundaries for the responsibilities of personnel across Cores, certificate authorities, government organizations, legal authorities, private network operators and public network operators, etc. Arrangements should also be considered for providing contingency operations at one or more sites following an emergency, natural disaster, or other accidents.

Manufacturers of vehicles equipped to participate in the *connected vehicle* environment may also require requisite organizational bodies to implement and manage the applications they use to monitor and maintain vehicles they support.

7.3 Impacts during Development

This section addresses the impacts that the Core System will experience while the system is being developed or expanded. During the development phases, there will likely be a need for continuous analysis, research and planning. Demonstrations and test activities will need to be conducted using facilities such as the Detroit test-bed. New and enhanced capabilities will need to be tested, verified and validated. Performance measurements, both qualitative and quantitative, will need to be collected during the early testing. Continuous analysis, research and planning will be required in the areas of security and scalability etc. The activities may include modeling of these features to better understand the impacts.

Demonstrations and test activities should be conducted whenever development of a significant feature set is complete. Parallel operations will be conducted, wherever possible, with existing systems continuing to operate while the Core System is installed and tested. As the Cores are established and new features are added or technology is refreshed, similar demonstrations and test activities should still be conducted.

Additional impacts may include the following:

- Development of rules and controls needed for operational implementation.
- System documentation updates.
- Involvement in studies, meetings, and discussions prior to design and programming.

- Involvement in reviews and demonstrations, evaluation of revised operating capabilities, development or modification of databases, and required training.
- Impact of new interface design and testing

7.4 Measuring the Impacts

The Core System can provide metrics that are indirectly related to the overall program goals but that provide indicators of the success of the Core System:

- Number and types of applications registered with the Core System
- Number and type of data subscribers
- Number and type of data providers
- Usage of Data Distribution services
- Other Core Service metrics like system availability to indicate overall health of the system

Other measures including adoption of *connected vehicle* applications and their usage (number of application hits) will require evaluating data from sources external to the Core System. Other statistics like new organizations created, jobs created, companies created can also be measured to evaluate the indirect impacts of deploying a Core. Implementation of the Core will cost money for equipment, network communications, and labor. The impact of these costs should also be measured. Additional analysis will be needed to determine the costs associated with operations, organizations and development.

To measure the performance of the system or the impact of the deployment of Core System will require measuring and comparing pre-defined parameters with current values. The necessary baseline measurements will vary by region and by the services being deployed.

Performance measurement should be part of the continuing operation of any automated system like this program. Agencies or companies deploying a Core System will establish the metrics they consider important for their operation and continually or periodically measure the behavior of the system against those metrics. Variations from the baseline metrics will be reviewed for potential problems with deployed systems or identifying changes or upgrades needed over time.

Misbehaving entities will have a negative impact on the adoption and success of this program. Misbehavior detection mechanisms are incorporated into the Core System, but policies for action based on misbehavior are left to the Core operator to determine, based on local policies and agreements with other Cores. Parameters should be identified for certifying and decertifying operating entities associated with Core Systems. These parameters include items related to service like number of user complaints, time taken to service a complaint, number of outages, downtime etc.

Availability of the Core System is paramount for gaining acceptance with users of this program. Impacts of the Core System being unavailable or operating in degraded mode need to be measured and all efforts should be made to ensure that user acceptance is not affected.

8.0 ANALYSIS OF THE PROPOSED SYSTEM

Various improvements, disadvantages and limitations, and alternatives and trade-offs considered are covered in this section.

8.1 Summary of Improvements

The Core System will provide new and enhanced capabilities as described in Section 4.0. These new and enhanced capabilities will offer numerous benefits, some of which are improvements over the current system.

Trusted Short Range Communication: Interactions between entities in the transportation environment, when those entities have a reasonable assurance of trust between them, will provide increased situational awareness for all parties involved. Vehicles, field devices and handhelds can all learn the locations and even current operating measures such as speed and direction of other vehicles and devices in their proximity. This short range situational awareness improvement should provide the foundation for safety and local area mobility applications.

Trusted Long Range Communications: Improved access to entities not in the proximal transportation environment (chiefly backoffice, but possibly remote field devices) will provide greater ease of access to mobility and commercial information for vehicles and other transportation users. It will also provide backoffice users with greater access to data describing the transportation environment, and if anonymous probe data is widely available, greatly expand the potential base from which those applications can be sourced.

Increased Communications Options: Support for a variety of communications options for Mobile users, including DSRC, cellular and Wi-Fi provides flexibility and increased performance over the entire communications layer. Allowing cellular access to Core services frees up DSRC bandwidth to focus more on safety applications; while safety was always prioritized above mobility and other applications, the existence of alternatives could simplify operations for radios that do not have to service non-safety demands. Further, by providing other options there is greater likelihood that non-safety applications will have access to the communications resources they require in order to provide benefits.

Infrastructure-light Deployments: By refocusing the Core System as a provider of services and removing its responsibility for operating and maintaining a communications network, it has become possible to deploy Core services without an extensive network of RSEs. This enables deployments of Cores independent of the time or other resources required to establish significant field infrastructure, allowing some operational benefits in a shorter time. For example, a Core could be deployed to distribute certificates, thereby facilitating trust and enabling V2V safety applications between equipped vehicles. Meanwhile, deployment of RSEs with V2I safety applications at key intersections can proceed at its own pace, without being constrained by the need to provide all services in the *connected vehicle* environment. There is still some question as to how effective non-DSRC communications will be in distributing large numbers of certificates. The certificate management scheme has not yet been architected, but the usefulness of cellular and Wi-Fi communications for the distribution of large numbers of certificates is a topic for further study.

Publish-Subscribe Data Distribution: Publish-subscribe offers deployers an efficient way to distribute data that could not be easily done otherwise. Including this functionality in the Core ensures that it is constrained by the relevant privacy policies, and may provide users more faith that their data are being handled in a way they are comfortable with. Further, broadening publish-subscribe beyond probe data offers application developers more options with regard to reaching their end users.

Open Standards: Open standards offer the promise of high reliability with a technology refresh advantage. This also provides an open market place for application development and integration, which should yield a rich, broad suite of applications from a variety of providers.

Scalable, Deployable Certificate Management: Certificate management is the basis for establishing and maintaining trust and enabling encrypted data exchange. Viewing the Core System as a set of services that can be implemented independent of a specific box of hardware provides the foundation for a scalable system design. Architectural design will have to pass the scalability test, particularly in regard to the structure of the ESS that supports IEEE 1609.2 certificate management, but by considering scalability and certificate distribution issues now the foundation has been laid for a deployable, scalable certificate management system.

Physical Environment Mitigation: The ability to maintain systems, delivering high-availability services is crucial to the user's perception of system utility. If a system is not available when a user needs it, from his perspective it doesn't work. The Core System includes availability monitoring, interface status and performance monitoring and mechanisms for users to determine which services are available and where. While the POC implementation of VII included some of this from the operator's perspective, these concepts were not clearly described in the NSR, and in no case did they include the type of user feedback envisioned here.

System Deployment Options: The Core System is conceived such that it can be deployed independently within a single jurisdiction, or widely on a large scale, depending on the needs and desires of the entity deploying the system. This allows each entity and jurisdiction to make their own decisions about when, where and how extensively to offer Core services. It keeps the Core small enough that it could be implemented by a wide variety of capable enterprises, not dependent on large scale organizations. This concept is also consistent with traditional transportation funding and operations policies. While the Core may not be deployed by a transportation entity, they are one likely candidate for doing so and by allowing the scope and services of the Core to vary, that option is preserved.

8.2 Disadvantages and Limitations

Research programs are ongoing to mitigate risks of the underlying technologies of this program which should also help identify any limitations in the Core System and the sum of Core Systems; i.e., how Cores interact and provide services. The concept of a federated system of systems which allows deployers and operators flexibility could potentially result in multiple, disjointed systems that are difficult to link together. The interoperability and interdependence needs incorporated in this document attempt to address this, but it is still possible that the collective task of managing these many systems could become difficult.

The deployment of this program will likely be regional and evolutionary. This is more practical than one large deployment when considering capital and other resources required, but will result in slower realization of benefits than if one large system were quickly deployed. As more and more mobile devices become enabled, and as field devices and centers become integrated into the system, more benefits will be realized.

Deploying the Core System across the entire country is by no means a turnkey operation. This is because the Core System is not a one-size fits all localities kind of system. The Core System will have to be refined for each locality to meet the specific needs of that locality. Also, it will be necessary to address what to do with existing, legacy systems. It will take a long time for Core deployments to integrate with or even supplant traditional ITS. The challenge will be to integrate these different Cores to work together within the context of standards, policy, budget, and institutional constraints.

Design, development and deployment of the Core System will involve additional cost to procure the hardware and software, train personnel etc. This program will have to compete for funding with other projects like traditional road construction or bridge repairs and upkeep.

The Core System will need to be flexible to accommodate what may seem to be opposing policy issues such as maintaining user privacy while ensuring security of the system.

Applications should be designed in such a way so they are not dependent on continuous communications with the Core System. While the Core System concept leverages existing communications to provide large coverage areas from the moment a Core is deployed, the availability and performance characteristics of these communications technologies vary, and are all outside the direct control of the Core.

The Core System will need to monitor the performance of the communications networks. For example, if DSRC channels become congested during a disaster or other emergency situation, System Users using DSRC should be informed and suggested to reroute communications. Alternatively, the Core could switch to a restricted mode in an emergency condition. This would reduce its communications needs without breaking system services. Without direct access to the DSRC medium however, it is difficult for the Core to monitor that part of the *connected vehicle* environment. The Core must rely on information provided by System Users that use DSRC.

System Users that connect to the Core System through cellular technologies will pay for that access in the form of a monthly fee or contract, while DSRC users may not. If the System User sees a benefit to paying for a particular type of media access, they will use that service. In areas with significant DSRC deployments, this may lead to abandonment of cellular technology access, or lead to incentives from cellular providers to use their services.

Personnel will have to be trained on the Core System and new policies and procedures will need to be developed.

Management of PII is more complex in the current vision of the *connected vehicle* environment than it was when VII was developed. The scope of the Core System is significantly different from that of VII: the Core includes facilitating services but no applications, and communicates through intermediaries to Mobile Users. The *connected vehicle* environment as a whole is larger than the VII environment due to the inclusion of other forms of wireless communication to support the Mobile User.

Table 8-1 summarizes the responsibilities of Core System and other entities when accounting for privacy principles of the VII Privacy Principles document. Privacy principles are quoted directly from the text of the document, which include references to VII. For purposes of evaluating the principles and applying them to the Core or other systems within the *connected vehicle* environment, the following methodology was used:

- The term “National VII Program” was interpreted as “*connected vehicle* environment”
- The term “VII-derived personal information” was interpreted as “personal information derived from data provided by a user of the *connected vehicle* environment”
- The term “VII System” was interpreted as “Core System”

The privacy policy responsibilities of the Core System can be enforced by a governance model that certifies Core Systems. Cores should be certified prior to operations and periodically monitored for adherence to the privacy principles. If a Core does not comply with the privacy principles it should not be certified and its digital certificate should be revoked.

The privacy policy responsibilities of non-Core participants in the *connected vehicle* environment can be enforced through the certification process. If an application or device does not adhere to a principle, then the application or device should not be granted certification. Without certification, Core Systems will refuse to pass data provided by that entity and/or revoke its certificate, and other certified devices and applications could refuse to communicate with uncertified devices and applications.

Table 8-1: Privacy Principles and the *connected vehicle* Environment

Privacy Principle	Privacy Principle Text	Core System Responsibility	Other System Responsibility
Respect of Privacy and Personal Information	Commitment to respect for individual privacy in a National VII Program means that VII-derived personal information should be acquired, retained, disclosed, and used only in ways that protect the privacy of individuals. Personal information users should collect, retain and use only anonymous information whenever possible. Users of VII-derived personal information and VII System administrators are expected to be accountable with regard to the personal information they collect and/or use in a National VII Program.	The only personal information expected to be used by the Core System is that used to generate digital certificates and manage the accounts of Core System Personnel. Such information is protected by the first need of the system, Data Protection.	Other *connected vehicle* applications may acquire and retain personal information to generate digital certificates or provide application functions. Disclosure of this information should be governed by an agreement between the user and the ESS or application provider.
Information Purposes	A personal information user should acquire, use, disclose and retain personal information only for valid purposes, consistent with the goals of a National VII Program, as described in the VII Privacy Limits, below. A personal information user should: • inform a personal information subject about the purposes for which personal information will be collected, used or disclosed before collecting personal information from that subject so that the personal information subject can decide whether or not to agree to use of their personal information for those purposes; • use and/or disclose personal information to third parties, only for valid purposes about which the information subject has been informed; and • retain personal information for only as long as the information serves a valid purpose; • limit the storage of personal information to a specified duration that should reflect the period of time necessary to fulfill the purpose for which personal information was collected. (See Information Protection and Retention Principle, below.)	PII may be required for User Trust Management and User Permissions functions. When establishing user accounts and granting certificates, the Core will have to provide a license agreement describing its management of PII to the affected user. The typical Mobile User will have no need to interact with these functions, and thus there is no privacy concern for the End Mobile User.	PII may be required for by applications or ESS. Application Certification entities should take this principle into account when certifying applications. An ESS that provides certificate distribution functions may need to collect and store personal information, and should do so for the period over which the certificates it issues could be used.

Privacy Principle	**Privacy Principle Text**	**Core System Responsibility**	**Other System Responsibility**
Acquisition	In acquiring personal information, a personal information user should: • assess the potential impact on the privacy of personal information subjects; • collect only personal information that is reasonably expected to support current or planned activities; and • collect personal information consistently with valid purposes for information collection (See Information Purposes Principle, above) and the notices that the personal information user has provided to personal information subjects. (See Notice Principle below.)	See Information Purposes principle	See Information Purposes principle
Notice	Before a personal information user collects personal information, the information user should provide effective advance notice to each information subject about: • what personal information is collected; • why the personal information is collected; • how the personal information will be used; • what steps will be taken to protect the confidentiality, integrity, and quality of the personal information; • any opportunities to remain anonymous; • the consequences of providing or withholding personal information; • how long the personal information will be retained, and; • rights of recourse and redress. (See Accountability Principle, below.)	The Notice principle should be applied when the Core System requests PII for any reason. However the typical Mobile User does not need to supply PII to the Core, so there should be no privacy concern.	The Notice principle should be applied to all ESS and applications that require PII. For applications, this should be part of the license agreement between the provider of the application and the user of the application.
Fair Information Use	A personal information user should use personal information about an information subject only in ways that are compatible both with the notice provided by the information user (See Notice Principle above) and with the information subject's reasonable expectations regarding how the personal information will be used.	The Fair Information Use principle should be applied to any PII the Core System has. The Core uses PII only to manage user accounts and digital certificates (which are the products of interactions between a user and the Core	For applications, this should be part of the license agreement between the provider of the application and the user of the application.

Privacy Principle	Privacy Principle Text	Core System Responsibility	Other System Responsibility
		where the core can provide notice and set the user's expectations).	
Information Protection and Retention	Within a National VII Program, the VII System's technical architecture and structure should be designed to implement advanced security and other technologies to protect personal information against improper collection, disclosure or misuse in ways that may affect the privacy interests of personal information subjects.. Personal information users and information administrators should apply administrative, physical and technical controls appropriate to the protection of personal information derived from or obtained through the VII System. Particular attention should be given to: • maintaining the security of personal information; • protecting confidentiality of personal information against improper access; and • assuring the quality and integrity of personal information collected or maintained. Personal information users and information administrators should only retain personal information that is relevant to a valid purpose and only for as long as, and to the extent that, the information is protected against improper access, disclosure or use. Personal information users and information administrators should have data storage procedures that assure appropriate, secure disposal of personal information: • when there is no longer a valid purpose for retaining the personal information, or • when a stated or required time limit on data retention has been reached, or • when data transmission has been completed within the VII System. Identifiers, such as data addresses (potentially identifying a data source) captured during transmission or transport of data	Most of this principle is addressed by the Data Protection and System Integrity needs. These needs trace to requirements in the SyRS and various objects in the SAD that provide secure storage and maintain the integrity of the Core System. The SAD specifically addresses the removal of source header information that could be used to identify a data provider.	Applications making use of PII should be required to follow this principle in order to obtain certification. Applications that do not use PII should not have to follow this principle.

Privacy Principle	Privacy Principle Text	Core System Responsibility	Other System Responsibility
	within the VII System should not be retained longer than is necessary to accomplish the data transport or transmission.		
Openness	Personal information users and information administrators: • should be informed about privacy issues and the best ways to protect personal information derived from the National VII Program; • should inform prospective personal information subjects about personal information the personal information user collects through the National VII Program; and • should explain to personal information subjects protections for personal information derived from National VII Program, and the length of time personal information will be retained by the personal information user. Personal information subjects should be able to rely on personal information users for adequate information about: • the nature and extent of personal information collected from them; • the purposes for which such personal information is collected; • the uses of personal information made by personal information users; • the opportunity not to provide personal information; • the protections for confidentiality, integrity, and quality of personal information; • the consequences of providing or withholding personal information; • opportunities to remain anonymous; and• rights of recourse and redress for misuse of personal information. (See Accountability Principle, below.)	This implies a requirement to educate Core System Personnel. Policies about information protection and use. The principle can be partially accommodated by providing use information as part of any license or notice issued as part of a PII request. However the managers of Core Systems will need to train their operators on the policies and practices pertaining to privacy issues and the use of PII; this could impact the overall cost of operating a Core System.	This places requirements on the education of personnel that distribute applications. Policies about information protection and use can be accommodated by providing use information as part of any license or notice issued as part of a PII request. The requirement to educate personnel in privacy issues and the use of personal data does impact the cost of an application, which may be passed on to the user.
Participation	In addition to receiving information regarding how personal information is collected and used in a National VII Program, each personal information subject should be expected to protect his or her own privacy. Personal information users	The Core System interacts with applications operating on devices. The devices should be responsible for	This principle implies that devices that interact with the Core System need to be able to secure PII they contain. This

Privacy Principle	**Privacy Principle Text**	**Core System Responsibility**	**Other System Responsibility**
	should provide each personal information subject opportunities to: • access personal information about himself or herself; • correct any inaccurate personal information about the personal information subject; • object to improper or unfair personal information use; and • choose to remain anonymous, and not provide personal information.	securing any PII attached to them or provided to them by an end user. The requirement to allow users to correct their personal information may affect the User Permissions subsystem, and is reflected in the SAD and SyRS.	includes any signature or artifact of their construction that could be used to determine the identity of the end user. For example, some devices may include information about their manufacture as part of a message. This information should be able to be turned off by the end user.
Accountability	A personal information user should respond to inquiries and complaints about interference with privacy interests or misuse of personal information, including use of personal information in ways that are incompatible with notice provided to information subjects (see Notice Principle, above). If an information subject has a complaint that he or she has been harmed by improper collection, retention, disclosure or use of his or her personal information by a personal information user, the information subject should have appropriate means to raise and resolve the complaint.	This principle applies to the manager and operator of the Core System. It implies that they need to provide a feedback mechanism to handle complaints about the Core's use of PII. An Enterprise relationship between the user and the operator and manager of the Core is included in the SAD.	This principle could apply to the manager and operator of the ESS and applications. Application developers may be required to maintain such mechanisms in order to obtain certification. ESS could be required to maintain such mechanisms in order to provide certificate distribution services to the *connected vehicle* environment.

8.3 Alternatives and Trade-offs Considered

Throughout the development of the ConOps, a number of alternatives and trade-offs have been considered that will affect the definition of the Core System. These include:

- Storage of collected transportation related (probe) data within the Core System
- Placement of RSEs with respect to the Core System boundary
- Scope of services included in the Core System vs. those moved to end user applications
- No external support systems
- Communications options for deployers
- Deployment options
- International architectures

Data Storage: Alternatives for data storage within the Core System were considered. It was decided that the Core itself did not require probe data storage in order for the system to function. Probe data is not needed within the system. The data is needed for other applications and the Core will provide the services to ensure that the data can be made available to requesting systems.

RSEs: The Roadside Equipment that includes the radio communications to mobile devices has been placed outside the Core System boundary and included as part of the Field element. RSEs are the 'first point of contact' between DSRC-enabled mobile devices and the transportation communications network. If it was included in the Core System any other first points of contact would also have to be included, such as cell towers, and the system would have to define the interface with end users. This allows the Core System to maintain the interface at the application boundary, allowing the applications maximum flexibility in their user interface design. This also allows for more flexibility in the definition of the field equipment. Field equipment can be developed to include the DSRC radio along with sensors or controllers or storage as the developers see fit. For example, medium term storage could be a need for rural settings where data is aggregated at the RSE over low bandwidth connections. Drawing the RSEs outside the Core System boundary also eases the transition to allowing for third party or private ownership of RSEs.

Scope of Services: The set of functionality included in the Core System has been limited to just those that are necessary to enable the *connected vehicle* environment – ensuring the integrity of the system, establishing and maintain trust between System Users, distributing data and monitoring Core performance. Applications such as collection of data or support for regional standardized clearing houses for data may be useful considerations for certain types of data or for certain regions.

No ESS: The Core System could be conceived without allowing for External Support Systems. This would force all capabilities to be included in the Core, and reduce the flexibility of implementation. This is especially apparent with regard to the distribution of digital certificates. The architecture for IEEE 1609.2 certificate distribution infrastructure is still not clear, but will likely be more complex to implement if the number of CAs is more than a handful. In fact it may be preferable to have only one. If the CA were forced to be included in the Core, this would require a single very large Core or at most a small number of large Cores (i.e., less than 20) for the entire United States, whose main responsibility was certificate distribution. While these large Cores could be built, they would require a new administrative structure since they are not tied to localities or even states. Allowing ESS to fill particular niche roles in the *connected vehicle* environment does not eliminate the organizational problem entirely (someone still has to manage the ESS), but does distinguish it from the management of Cores.

Communications Options: With the current definition of the Core System, once the data providers are registered with a Core and the data consumer's sets up a subscription for the data, the data can pass between directly between providers and consumers without involving the Core. This decoupling of the Core services from the actual communications provides increased access to the data and flexibility to the deployers of the system. Additionally, the communications networks to support this program could be set up in various configurations including having their own RSE network, establishing their own WiMAX capability, or they could use existing Municipal Wi-Fi or other available networks.

Deployment Options: With any system development stakeholders should consider what their alternatives are before making any major investments. There are several basic high-level options from which to choose:

- Do Nothing
- Develop the system as defined in the ConOps
- Let the private sector manage development and deployment
- Choose other alternatives

For this program, the Do Nothing option will be selected by those users that decide, for whatever reason, to continue managing traffic, providing traveler information, managing incidents, providing any transportation service the way they do it today. 'Do Nothing' doesn't mean that the world will be stuck in its old, as-of-today way of doing things. Instead, there are a number of new technologies that are available and which are being adopted by automobile vendors, application developers etc. without going down the route offered by this program. To a large extent, mobility-related aspects could be addressed with the wide adoption of Smartphones with their plethora of applications

Developing the system as defined in the ConOps (and as to be further defined in the requirements and architecture definitions) could take place any number of ways, but is generally bound by the answers to two questions:

1. Who will fund the deployment of the Core System?
2. Who will provide governance over certain parts of the system, such as certificate management or data access (assuming shared archival data environments)?

Since the answers to these questions are still unclear, the engineering process will continue to include as much flexibility in the development of the Core System as possible. This will undoubtedly be reflected in the architecture, as it will have to accommodate deployments that are built and operated by entities of widely varying sizes and capabilities.

It is possible that a commercial entity may develop and operate the Core System. Elements of the Core System could be deployed using web-based services which may make it easier for deployment in a larger number of markets.

A Private Sector development and deployment with a large corporation taking over the design of this program with no government involvement at all might be possible. A large private Internet or Communications firm may see the commercial or business advantages of designing their own Core System. However, open interfaces would still be required in order for individual devices and applications to be interoperable.

Other options include cases where stakeholders deploy their own communications and applications outside of those proposed by this program. The ConOps development process has attempted to include as wide a group of stakeholders as possible in order to develop a system that is acceptable to as many as possible. However, if stakeholders choose alternative means of deploying services that is outside the scope of the Core System, their utility may be limited.

Another alternative for consideration is to rely on autonomous safety systems coupled with whatever the commercial sector develops in terms of *connected vehicle* systems. While this program clearly brings additional benefits, it is likely that it may take a longer time for this program to be deployed when compared to the alternatives considered here.

International Architectures: The Framework Architecture Made for Europe (FRAME) has recently been updated to include Cooperative ITS systems. ITS services (traffic safety, traffic efficiency, freight and fleet applications, and value-added services) are all accounted for in the User Needs discussed in this ConOps. It should be noted however, that the FRAME ITS Service User Needs will continue to inform the system engineering effort associated with this program, as much of the material included in the Cooperative ITS systems update is written at a level akin to what will be the Core System Requirements.

In addition, the Communications, Air-interface, Long and Medium range (CALM) set of standards defines a set of system interactions for the wireless vehicular environment. These too are covered by the User Needs captured in this ConOps.

9.0 NOTES

This section contains an alphabetical listing of abbreviations and acronyms used in this document.

Table 9-1: Abbreviation and Acronym List

Abbreviation/ Acronym	Definition
AMS	Analysis, Modeling, and Simulation
AASHTO	American Association of State Highway and Transportation Officials
AMDS	Advisory Message Distribution Service
APTA	American Public Transportation Association
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
BAH	Booz Allen Hamilton
CA	Certificate Authority
CALM	Communications Access for Land Mobile Standards
CAMP	Crash Avoidance Metrics Partnership
CCH	Control Channel (interval)
CCTV	Closed Circuit Television
CICAS	Cooperative Intersection Collision Avoidance Systems
cmp	Components
COM eSafety	Communications for eSafety
ConOps	Concept of Operations
COOPERS	Cooperative Systems for Intelligent Road Safety
COTS	Commercial off-the-shelf
CRL	Certification Revocation Lists
CVIS	Cooperative Vehicle Infrastructure System
CVO	Commercial Vehicles Operation
DCM	Data Capture Management
DGPS	Differential GPS
DMA	Dynamic Mobility Applications
DMS	Dynamic Message Signs
DSRC	Dedicated Short Range Communication
EC	European Commission
EEBL	Emergency Electronic Break Light
ENOC	Enterprise Network Operations Center
ETSI	European Telecommunications Standards Institute
INCOSE	International Council on Systems Engineering
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FRAME	Framework Architecture Made for Europe

Abbreviation/ Acronym	Definition
FTA	Federal Transit Administration
GADS	Green Action Decider System
GHz	Gigahertz
GIS	Geographical Information Systems
GPS	Global Positioning System
HOV	High Occupancy Vehicle
HRI	Highway Rail Intersection
ICM	Integrated Corridor Management
IEEE	Institute for Electrical and Electronics Engineers
INCOSE	International Council of Systems Engineers
ISO	International Standards Office
ISP	Internet Service Provider or Information Service Provider
IT	Information Technology
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
ITU	International Telecommunications Union
IVBSS	Integrated Vehicle-Based Safety Systems
JPO	Joint Program Office
LTE	Long Term Evolution
NAVTEQ	Navigational Technology and Data Used to Develop Maps
NCAR	National Center for Atmospheric Research
NEMA	National Electrical Manufacturer’s Association
NSR	National System Requirements
NTCIP	National Transportation Communication for ITS Protocol
OBE	Onboard Equipment
OBU	On Board Unit
OEM	Original Equipment Manufacturer
OSI	Open System Interconnection
PDS	Probe Data Service
PII	Personally Identifiable Information
POC	Proof of Concept
PMP	Project Management Plan
PMU	Private Mobile User
PSMU	Public Service Mobile User
QC	Quality Control
RITA	Research and Innovative Technology Administration's
RSE	Roadside Equipment

Abbreviation/ Acronym	Definition
RSU	Roadside Unit
SAE	Society of Automobile Engineers
SCH	Service Channel (interval)
SDN	Service Delivery Node
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SPAT	Signal Phase and Timing
SRS	Software Requirements Specification
stm	State Machine
SUV	Sport Utility Vehicle
SysML	Systems Modeling Language
SysRS	System Requirements Specification
TC	Technical Committee
TMC	Transportation Management Center
TRSP	Traffic Responsive (Signal Control)
UML	Unified Modeling Language
USDOT	US Department of Transportation
VDT	Vehicle Data Translator
VII	Vehicle Infrastructure Integration
VIIC	Vehicle Infrastructure Integration Consortium
VMS	Variable Message Signal
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WAVE	Wireless Access in Vehicular Environments
WiMAX	Worldwide Interoperability for Microwave Access

10.0 APPENDICES

10.1 Workshops

10.2 Vancouver, BC Workshop (10 & 11 August, 2010)

Subject: Vancouver, BC User Needs Findings
Location: Vancouver Convention Center, Room West 113
Date: Tues (8/10/10) and Weds (8/11/10)

SE project Support:
Dawn Hardesty Noblis
Jeris White Noblis

SE project Team:
Kevin Hunter LM
Jeff Brummond Iteris
Tom Lusco Iteris
Alan Clelland Iteris (on phone)
Roger Koehler Iteris (on phone)

Participants:

Last Name	First Name	Agency	Tues Session (8/10/10)	Wed Session (8/11/10)
Barbaresso	Jim	HNTB	x	x
Beaubien	Dick	Hubbell, Roth and Clark	x	x
Boaz	Ralph	Pillar Consulting	x	x
Briggs	Valerie	USDOT/RITA/ITS JPO	x	x
Bush	Mark	AASHTO	x	x
Butin	Robert	USDOT / RITA	x	
Cunard	Richard	TRB		x
Deneau	Danielle	Road Community for Oakland County	(on phone)	(on phone)
Duncan	Gary	CTO / Econonlite	x	x
Engelmann	Martin	Deputy Executive Director / CCTA	x	
Garretson	Dan	Pinyon Labs	(on phone)	(on phone)
Hayer	Jatinder	Sr Mgr Epcor Technologies	x	
Hill	Chris	Mixon / Hill	x	
Jacobson	Les	PB World	x	
Kance	Peter	City of Portland Division Mgr	x	
Leslie	Andrew	Hewlett Packard	(on phone)	
McCourt	Ranoy	DKS Associates	x	
McKeever	Ben	USDOT / FHWA	x	
Miller	Dave	Siemens	x	x

Last Name	First Name	Agency	Tues Session (8/10/10)	Wed Session (8/11/10)
Narla	Siva	ITE		
Piotrowicz	Gary	Road Community for Oakland County	x	x
Poe	Chris	TTI	x	
Rausch	Bob	VP / TRANSCORE	x	x
Rossman	Dave	YCA	x	x
Rupert	Bob	FHWA / Team Leader	x	
Saleem	Faisel	Maricopa County DOT	x	x
Schopp	Bruce	NEMA	x	x
Seymour	Ed	Associate Director TTI	x	x
Sloan	Suzanne	Volpe	x	
Tipaldo	John	VP / TRANSCORE	x	
Urbanik	Tom	Kittenban & Associates	x	
Wolanin	Emil	Montgomery County DOT	x	x
Wright	Jim	AASHTO	x	x

10.3 Detroit, MI Workshop (25 & 26 August, 2010)

Subject: Detroit, MI User Needs Workshop - Findings
Location: Doubletree Dearborn
Date: Wednesday (8/25/10) and Thursday (8/26/10)

USDOT RITA:
Walt Fehr

SE project Support:

Dawn Hardesty	Noblis
Jeris White	Noblis
Jean Borgella	Citizant

SE project Team:

Dave Binkley	LM
Kathy Bonaffini	LM
Larry Virgallito	LM
Kevin Hunter	LM
Murty Neti	LM
Jeff Brummond	Iteris
Tom Lusco	Iteris

There were 2 sets of breakout sessions. On day 1 users could decide between 3 rooms to focus on Devices, Road Weather/Traffic Management, or Back Office systems. On day 2 each group covered the same subject matter and are only shown here by the room they were in.

Participants:

Last Name	First Name	Agency	1a Devices	1b Road Weather/ TrafMgmt	1c Back Office	2a Erie/Ontario	2b Allen Park	2c Dearborn
Al-Holou	Nizar	Univ of Detroit, Mery	x					
Armstrong	April	SAIC	x					
Barbaresso	Jim	HNTB		x				
Bierlein	Dawn	Road Commission for Oakland County		x			x	
Brugeman	Valerie	Center for Automotive Research	x					
Burrows	Bob	G4 Apps Inc	x					x
Byk	Peter	SAE International	x				x	
Cadagin	Ed	Ford Motor Company – Automotive Safety Office		x		x		
Carter	R.T.	SAIC		x				
Carter	Mark	SAIC			x			
Coduti	Kurt	Michigan Department of		x				x

Last Name	First Name	Agency	1a Devices	1b Road Weather/ TrafMgmt	1c Back Office	2a Erie/Ontario	2b Allen Park	2c Dearborn
		Transportation						
Cook	Steve	Michigan Department of Transportation		x				
Crawford	Mark	Somat Engineering			x	x		
Deneau	Danielle	Road Commission for Oakland County		x				
DiMambro	Tom	GM	x				x	
Dion	Francis	UMTRI		x				
Domin	Chris	Ricardo Inc	x					
Duan	David	Kostal North America	x					x
Fahie	Michael	Booz Allen Hamilton	x				x	
Fecker	Anthony	SAIC	x					
Free	Jake	Free Enterprises		x				x
Garretson	Dan	Pinyon			x			
Gonzalez	Alan	Drive NonStop	x					
Goudy	Roy	Nissan Technical Center North America	x			x		
Handman	Art	Independent Consultant		x				x
Hedges	Chris	Delphi	x				x	
Hoevel	Morrie	FHWA – Michigan Division Office						
Junak	Matthew	HNTB		x				x
Kelly	Kevin	MIS						x
Krause	Joe	TK Holdings	x				x	
Krechner	Dan	Cambridge Systems	x					
Kurihara	Thomas	TKstds Management			x	x		
Lahue	Craig	IBM			x			
LeBlanc	Dave	UMTRI	x					
Lotoczky	Rick	Vector Cantech, Inc					x	
McCormick	Scott	Connected Vehicle Trade Association				x		
McNamara	Dave	MTS LLC						
Mixon	Lee	Mixon Hill			x			
Naboulsi	Mouhamad	iQ-Telematics	x				x	
Noblett	Mike	IBM	x			x		
Patel	Arpan	Somat Engineering, Inc.		x				
Pemble	Bill	State of Michigan			x		x	
Piotrowicz	Gary	Road Commission for						

Last Name	First Name	Agency	1a Devices	1b Road Weather/ TrafMgmt	1c Back Office	2a Erie/Ontario	2b Allen Park	2c Dearborn
		Oakland County						
Rakouth	Heri	Delphi			x			x
Rausch	Robert	TransCore	x				x	
Robinson	Ralph	University of Michigan			x	x		
Roebuck	Randy	Sirit			x			x
Schaffnit	Tom	Honda R & D Americas, Inc, VIIC			x			
Shultz	Scott	Automotive Insight	x					x
Shuman	Valerie	SCG, LLC	x	x			x	
Shoemaker	Peter	Pinyon	x		x			x
Shogan	Scott	Parsons Brinckerhoff					x	
Smith	Matt	Michigan Department of Transportation						
Sugarman	Jim	HP		x				x
Suzuki	Megumi	Toyota Motor North America, Inc.	x					
Tang	Zwick	Eaton Corporation	x			x		
Thomas	Mike	Automotive Insight						
Underwood	Steve	Univ of Michigan, Dearborn			x	x		
Wallace	Richard	Center for Automotive Research		x				x
Zhang	Hongwei	Wayne State University	x					x

10.4 San Jose, CA Workshop (1 & 2 September, 2010)

Subject: San Jose, CA User Needs Workshop - Findings
Location: Doubletree San Jose
Date: Wednesday (9/1/10) and Thursday (9/2/10)

USDOT RITA:
Walt Fehr

SE project Support:

Dawn Hardesty	Noblis
Jeris White	Noblis
Jean Borgella	Citizant

SE project Team:

Dave Binkley	LM
Kathy Bonaffini	LM
Larry Virgallito	LM
Kevin Hunter	LM
Azra Ghassemi	Iteris
Tom Lusco	Iteris

There were 2 sets of breakout sessions. On day 1 users could decide between 3 rooms to focus on Devices, Road Weather/Traffic Management, or Back Office systems. On day 2 each group covered the same subject matter and are only shown here by the room they were in.

Participants:

Last Name	First Name	Agency	1a Devices	1b Road Weather/ TrafMgmt	1c Back Office	2a Carmel	2b Santa Clara
Andrews	Scott	Cogenia Partners, LLC	x				
Armstrong	April	SAIC		x			
Asuncion	Robert	Republic ITS					
Banner	Janet	Metropolitan Transportation Commission			x		x
Blair	Kathy	Alcatel-Lucent					x
Bonomi	Flavio	Cisco					
Brandt	Pete	Daimler Trucks North America	x			x	
Brown	Mike	SwRI				x	
Brown	Graham	Mercedes Benz Research	x				
Burkhard	Brian	HNTB Corporation		x			
Campbell	John	Battelle				x	

Last Name	First Name	Agency	1a Devices	1b Road Weather/ TrafMgmt	1c Back Office	2a Carmel	2b Santa Clara
Cechini	Frank	FHWA-CADIV		x		x	
Chan	Ching-Yao	California PATH, UC Berkeley	x		x		x
Crothers	Tim	FHWA		x			
Day	John	IBM Research					
Einsig	Barry	Harris Corporation	x		x	x	x
Fok	Edward	FHWA		x		x	
Francis	Chris	VDOT		x			
Free	Jake	Free Enterprises/ Go-Light	x			x	
Garretson	Dan	Pinyon Partners					
Gerges	Ramez	California DOT	x		x		
Glancy	Dorothy	Santa Clara University			x		x
Gledhill	Jeff	Verizon Business					
Gwynne	Gloria	Caltrans	x			x	
Hansra	Pete	Caltrans		x			
Huynh	David	City of Fremont, CA		x			
Khijniak	Dmitri	Kapsch TrafficCom Inc.	x				
Koeberlein	Bob	Idaho Transportation Department		x			x
Komoda	Norio	Sakura Assoc				x	
Koslowski	Thilo	Gartner					
Krueger	Greg	U.S. Department of Transportation					
Kruke	Kevin	HELP Inc./PrePass	x				
Leader	Shel	Telvent	x		x	x	x
Manasseh	Christian	Mobius Logic					x
Martinez	Ellen	Republic ITS					
McDonough	Richard	New York State DOT	x			x	
McPharlin	Tom	Transdyn, Inc.		x			
McRae	Jeff	Caltrans				x	
Misener	Jim	University of California PATH Program		x			
Moghe	Ashok	Cisco Systems					x
Mortensen	Steve	Federal Transit Administration	x			x	
Mujumdar	Sunil	SQL Stream			x		x
Naschke	Douglas	IBM					

Last Name	First Name	Agency	1a Devices	1b Road Weather/ TrafMgmt	1c Back Office	2a Carmel	2b Santa Clara
Novosad	Steve	PBS&J		x	x		
Nozzari	Sean	Caltrans		x			
Paulraj	Dominic	Arada Systems					
Peredo	Gordon	Mercedes-Benz R&D North America	x				
Peterman	Josh	Fehr & Peers		x			
Puvvala	Ravi	Savari Networks LLC	x				x
Redd	Jordan	Cogenia Partners, LLC.					
Roy	Richard	SRA	x				
Saletta	Rick	SQL Stream				x	
Saret	Jacob	Stanford University	x				
Schmiedeberg	Anne	Car Buddy	x				
Shinn	Rich	DKS Associates					x
Shladover	Steven	University of California PATH Program	x				
Shoemaker	Peter	Pinyon Partners					
Spencer	Jeff	Federal Transit Administration	x		x		
Tirey	Kyla	Mercedes Benz Research	x				
Torng	Gwo-Wei	Noblis	x				
Verma	Harsh	RSYSTEMS	x			x	x
Webster	Nathan	n/a		x		x	
Wilson	Chris	TomTom	x				
Winckler	Andreas	BMW Group Technology Office Palo Alto	x				
Zhang	Wei-Bin	California PATH Program	x				
Zografos	Taso	SAIC	x		x		

10.5 Washington DC Workshop (29 & 30 September, 2010)

Subject: Washington, DC User Needs Workshop - Findings
Location: The University of California Washington Center
Date: Wednesday (9/29/10) and Thursday (9/30/10)

USDOT RITA:
Walt Fehr

SE project Support:

Dawn Hardesty	Noblis
Jeris White	Noblis
Paul Gonzalez	Noblis (Day 1)
Jean Borgella	Citizant

SE project Team:

Dave Binkley	LM
Kathy Bonaffini	LM
Larry Virgallito	LM
Kevin Hunter	LM
Murty Neti	LM
Cliff Heise	Iteris
Tom Lusco	Iteris

There were 2 sets of breakout sessions. On day 1 users could decide between 3 rooms to focus on Fleet Operations, Transportation Operations, or Back Office systems. On day 2 each group covered the same subject matter and are only shown here by the room they were in.

Participants:

Last Name	First Name	Agency	1a Fleet Ops	1b Transp Ops	1c Back Office	Rm 317	Rm 318
Abdelmename	Hedhli	DC LCPC			x	x	
Armstrong	Lee	Armstrong Consulting	x				x
Athreya	Prahlad	AVIS BUDGET GROUP	x				x
Bayless	Steven	ITS America			x		
Body	Chris	Mark IV		x			
Bolduc	Pierre	Transport Canada	x				x
Bowman	Darrell	Virginia Tech Transportation Institute	x				
Bowman	Darrell	Virginia Tech Transportation Institute				x	
Bruemmer	David	5D Robotics			x		
Buckley	Dan	Harris Corp			x		

Last Name	First Name	Agency	1a Fleet Ops	1b Transp Ops	1c Back Office	Rm 317	Rm 318
Bykins	Tony	LGS Innovations			x	x	
Caldwell	Stan	Carnegie Mellon University		x			
Catlin	Barbara	Trans Core		x			
Chan	Patrick	ConSysTec		x		x	
Coventry	Antony	Vaisala Inc.		x			x
Cronin	Brian	ITS JPO Program Lead			x		x
Curtis	Deborah	USDOT/ FHWA		x			
Edelstein	Bev	AmeriTrak Fleet Solutions	x				x
Edelstein	Jeff	AmeriTrak Fleet Solutions	x				x
Fawkes	Larry	Oracle			x		
Feast	Laura	SAIC		x			x
Free	Jake	Free Enterprises/ Go-Light			x		x
Gillis	Joe	Booz Allen Hamilton		x			x
Griffin	Gene	Upper Great Plains Transportation Institute					
Guevara	Gabe	FHWA		x		x	
Hartley	Scott	5D Robotics	x			x	
Hatipoglu	Cem	Federal Motor Carrier Safety Administration	x				
Herring	Alex	Vaisala			x	x	
Knapp	Geoff	IBI Group		x		x	
Kurihara	Thomas M.	TK Standards Management, IEEE 1609 WG		x		x	
Lisogorsky	Leonardo	New Flyer Industries	x			x	
MacKenzie	Rod	ITS America	x				
Messa	Tyler	Consultant ISO; Telecommunications Industry Association			x		
Mueller	Jonathan	Federal Motor Carrier Safety Administration	x				
Murtha	Suzanne	Kapsch	x				
Park	Hyungjun	Univ of VA Center for Transportation Studies				x	
Parkany	Emily	Booz Allen Hamilton			x		x
Peters	Joe	FHWA				x	x
Pincus	Marcia	ITSJPO		x			x
Roberts	David	Temple, Inc		x		x	
Rowe	Regan	5D Robotics	x				

Last Name	First Name	Agency	1a Fleet Ops	1b Transp Ops	1c Back Office	Rm 317	Rm 318
Schnacke	Dick	TransCore	x				
Slizofski	Allie	Drive Engineering; URS Corp		x			
Spencer	Jeff	FTA				x	
Spencer	Matthew	Student				x	
Toscano	Mario	Drive Engineering		x			
Turato	John	AVIS BUDGET GROUP	x			x	
Wagley	Raj	FTA/USDOT			x		x
Webb	George	Palm Beach County		x		x	
Wilder	Charlene	FTA	x				
Wilkins	PJ	E-ZPass Group		x			x
Williams	Keith D.	FHWA, Office of Safety Integration		x			
Witherspoon	James	VDOT		x			
Young	Steve	PrePass					x
Yousuf	Mohammed	PHWA			x		x

10.6 San Antonio, TX Workshop (5 October, 2010)

Subject: San Antonio, TX User Needs Workshop – Findings
American Public Transportation Association (APTA) Conference.
Location: Hyatt San Antonio Hotel in San Antonio, TX, Room Presidio B
Date: Tuesday (10/05/10)

SE project Support:
Gwo-Wei Torng Noblis

SE project Team:
Dave Binkley LM
Kevin Hunter LM

Participants:

Last Name	First Name	Agency	Transit Session
Allen	Todd	Route Math Software	X
Bata	Andrew	NYC Transit	X
Dow	Kevin	APTA	X
Gangol	Sharon	San Antonio VIA Auditor III	X
Hemily	Brendon	ITS America	X
Hiller	Bill	Trapeze ITS	X
Hough	Jill	SURTC/UGPTI	X
Jackson	Dave	BAH	X
Marraro	Tony	HNTB	X
Reavey	Patrick	DIGI, Government Sales Rep	X
Wetula	Leo	Volpe Center	X
Wilson	Michael	Accenture	X

10.7 One-on-One Meetings

10.7.1 AERIS

Location: USDOT
Date: 9 July 2010

Participants:

USDOT RITA	Walt Fehr
USDOT AERIS	Marcia Pincus
USDOT AERIS	Bob Ferlis
Noblis	Dawn Hardesty
Noblis	Jeris White
Noblis	Paul Gonzalez
Noblis	Jim Fisher
Citizant	Jean Borgella
LM SE Team	David Binkley
LM SE Team	Kevin Hunter

The objective of the Applications for the Environment: Real-Time Information Synthesis (AERIS) Program is to generate, acquire, and process environmentally-relevant real-time transportation data to create actionable information that supports "green" transportation choices. There is a need to monitor auto exhaust at all times, but particularly on Code Red days. The AERIS Program would like to leverage like data already collected by the CVO and Transit programs.

10.7.2 Commercial Vehicles Operation (CVO)

Location: USDOT
Date: 31 July 2010

Participants:

USDOT RITA	Walt Fehr
ITS JPO Program Lead	Kate Hartman
USDOT	Mike Onder
FHWA	Bob Rupert
USDOT	Randy Butler
USDOT FMCSA	Jonathan Mueller
Noblis	Dawn Hardesty
Noblis	Jeris White
Citizant	Jean Borgella
LM SE Team	David Binkley
LM SE Team - Iteris	Tom Lusco

The main focus of this meeting was to discuss how Commercial Vehicle Operations (CVO) efforts would interact with this program.

10.7.3 Real-Time Data Capture and Management

Location: USDOT
Date: 9 July 2010

Participants:

USDOT RITA	Walt Fehr
ITS JPO Program Lead	Brian Cronin
FHWA R&D	Gene McHale
FHWA Office of Operations	Walter During
Noblis	Dawn Hardesty
Noblis	Jeris White
Noblis	Paul Gonzalez
Noblis	Karl Wunderlich
Noblis	Meenakshy Vasudevean
Citizant	Jean Borgella
LM SE Team	David Binkley
LM SE Team	Kevin Hunter

The main focus of this meeting was to discuss what data needed to be captured to accommodate any logging capability. This led into a discussion of how does that data need to be sent, how is it collected, and how would it be aggregated? Brian Cronin stated that the data needed to be real-time to be used for applications and that all data needed to be captured (no definition on what is meant by all data).

10.7.4 Dynamic Mobility Applications

Location: USDOT
Date: 7 Oct 2010

Participants:

ITS JPO Program Lead	Kate Hartman
FHWA Turner Fairbanks	Ben McKeever
USDOT RITA	Walt Fehr
FHWA Operations	Gabe Guevara
FHWA Office of Freight Management	Randy Butler
FTA	Steve Mortensen
FHWA Office of Freight Management	Mike Onder
JPO	Greg Krueger (on the phone)
LM SE Team	David Binkley

The discussion was mostly about programmatics - they are collecting ideas for ways to use data on this program once it's collected. So far they have received 60 responses to their RFI and intend to hold a workshop to present them and then issue an Request for Proposal (RFP) next year to see who wants to do some of the more interesting apps.

Randy Butler promoted the idea of web services, as they implemented with their Electronic Freight Management project. DMA is twinned in some ways to the Data Capture Management (DCM) project that is looking at creating the structure for the data collection environments that then get turned into useful apps by DMA.

10.7.5 Policy

Location: USDOT
Date: 12 July 2010

Participants:

USDOT RITA	Walt Fehr
USDOT ITS JPO Policy	Valerie Briggs
Volpe	Suzanne Sloan
Noblis	Dawn Hardesty
Noblis	Jeris White
Citizant	Jean Borgella
LM SE Team	David Binkley
LM SE Team	Kathy Bonaffini

Valerie Briggs was interested in understanding the SE tasks and deliverables in the hope using the SE ConOps input to help develop policy. The SE Team concern is that Policy is likely to apply constraints to the SE tasks/architecture. The policy schedule as of July 2010 follows:

- Governance Information Technology (IT) experts will meet in Dec 2010
- Identify decision making body in Jan/Feb 2011
- Policy Research will continue through 2013
- NHTSA will follow for another 5 years after that for rulemaking
- May be 10 years before rulemaking is finalized

There was a discussion on what the need for security is and what management and oversight would be required if needed. Also, what is the right level of privacy?

10.7.6 FHWA Road Weather Management

Location: Noblis
Date: 28 July 2010

Participants:

FHWA Road Weather Management Team	Paul Pisano
USDOT RITA	Walt Fehr
Noblis	Chaz Harris
Noblis	Dawn Hardesty
Noblis	Jeris White
LM SE Team	David Binkley
LM SE Team - Iteris	Jeff Brummond

Notes:

- Public sector , private sector, transportation, weather providers
- MDSS – safety and mobility
- Vehicle data translator – dynamic segmentation, temp, pressure
- Yaw, tire related, pavement surface condition
- Translator, 2nd version, data coming straight from the vehicle
- Need safety V2V notification of pavement conditions
- Vehicle as a data source, looking at CAN bus, states putting IR sensors other sensors
- New project for National Center for Atmospheric Research (NCAR) 3rd round of VDT, work with state DOTs, calibrated IR sensor – use directly
- Going to NCAR and Clarus
- SAE 2735 – weather elements, weather data frame, weather report weather frame
- CAN bus standards light and heavy duty OBD2 interface standard common for all vehicles, emissions – Dave Acton working on a physical interface in right place and a standardized message set SAE committee
- 3rd phase NCAR project, point data to models, in conjunction with states, working for overall decision support
- SWR, MODSS, multi-state control strategy tool, multi-state traveler info
- Next phase may tie tools to maintenance and construction decision support system
- Weather responsive traffic management strategies, signal timing, ramp metering, DMS with Battelle, gap timing, longer yellow phase – not possible in current technology
- Weather data into signal controllers
- Path – EAR- fully adaptive traffic control
- Need to know why traffic flow is slowing
- Snow removal
- Aurora Pooled Fund Study, State DOT
- State DOT movement of data to/from vehicle – applications

10.7.7 Standards

Location: USDOT
Date: 13 July 2010

Participants:

USDOT RITA	Walt Fehr
USDOT JPO	Steve Sill
Noblis	Ann Diephaus
Noblis	Dawn Hardesty
Noblis	Jeris White
LM SE Team	David Binkley
LM SE Team – Iteris	Tom Lusco

This program may be able to leverage some of the existing standards, but these standards may need to be modified to accommodate data. Walt asked which interfaces need to be used as control points and the answer was look at the National ITS Architecture for guidance and the CALM architecture could be looked at for additional standards mapping guidance.

10.7.8 Transit

Location: USDOT
Date: 12 July 2010

Participants:

USDOT RITA	Walt Fehr
USDOT ITS JPO Transit	Yehuda Gross
USDOT FTA	Jeff Spencer
Noblis	Gwo-Wei Torng
Noblis	Dawn Hardesty
Noblis	Jeris White
Citizant	Jean Borgella
LM SE Team	David Binkley
LM SE Team	Kathy Bonaffini

Currently ITS devices are not integrated on transit vehicles (multiple antennas, radios) so this program offers the potential to provide a more integrated system with greater bandwidth and real time information. Safety information needs to be secure to protect transit agencies from litigation.

10.7.9 Cooperative Safety

Location: USDOT
Date: 26 July 2010

Participants:

USDOT RITA	Walt Fehr
USDOT ITS JPO	Mike Schagrin
Noblis	Dawn Hardesty
Noblis	Jeris White
Citizant	Jean Borgella
LM SE Team	Kathy Bonaffini
LM SE Team – Iteris	Tom Lusco

This meeting mainly identified the key individuals the SE team should contact.

10.8 Consolidated User Input

This table represents the various user input from the workshops, one-on-ones, other venues, and documents.

Table 10-1: Consolidated User Input

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
1	1, 2, 3, 5, 6, 22, 23	Workshop	Vancouver	Limited roadway performance data is available.	Provide the data to enable more sophisticated methods of traffic control (e.g. adaptive signals).	With more spatially comprehensive real-time data, we can operate signals better, increasing mobility through intersections constrained by signals.
2	4	Workshop	Vancouver	Enforcement of HOT/HOV, prioritization of multi-passenger vehicles is difficult and manpower intensive.	Provide the occupancy status of each individual vehicle to the operators of roadways where such information is relevant.	Optimizing road network performance includes prioritization by number of vehicle occupants. Moving two people helps the network more than moving one.
3	7	Workshop	Vancouver	We can't store and access all the roadway performance data that we want.	Provide a way for us to access historical and real-time roadway performance data for every time of day, day of year, special event condition.	Better historical data will allow more effective signal timing.
4	8,9	Workshop	Vancouver	Detection of roadway incidents requires manual authentication.	Provide data or information sufficient to determine the existence and location of a roadway incident.	Automated incident detection will decrease response time of safety agents and decrease manpower requirement for traffic management.
5	10	Workshop	Vancouver	Failure of roadside infrastructure is not automatically detected		
6	11	Workshop	Vancouver	Limited road weather information is available.	Provide road weather information, particularly in areas near traffic signals.	Better road weather information, particularly in areas near traffic signals, would enable more effective traffic management, signal timing in particular.
7	12	Workshop	Vancouver	Signalized intersections often have no understanding of the pedestrian situation.	Provide a mechanism for detecting and distributing numbers and locations of pedestrians.	Better understanding of the real time pedestrian situation will improve traffic management; historical information will allow better informed signal timings.
8	13	Workshop	Vancouver	Signalized intersections do not detect cyclists.	Provide a mechanism for detecting and distributing numbers and locations of cyclists.	Detecting cyclists will allow signalized intersections to accommodate them in timing.
9	14	Workshop	Vancouver	Signalized intersections do not detect trains far enough in advance to accommodate the extensive red time due to train passage.	Provide a means for identifying the speeds and locations of trains well in advance of roadway crossings.	Better knowledge of when trains will affect traffic will allow management of traffic to compensate for the long red time that occurs when the train passes.
10	16	Workshop	Vancouver	Signalized intersections do not detect transit vehicles as anything other than a vehicle and so cannot manage them with higher priority.	Provide a means for locating transit vehicles far enough in advance of traffic signals to allow modification of timing.	Prioritization of transit vehicles provides better net throughput.
11	17	Workshop	Vancouver	Even when we know a transit vehicle is coming, we don't know the passenger count.	Provide the passenger count for transit vehicles to the signal controller at signalized intersections the vehicle approaches.	Prioritize vehicles with passengers.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
12	18	Workshop	Vancouver	Signalized intersections do not detect emergency vehicles as anything other than a vehicle and so cannot manage them with higher priority.	Provide a means for locating emergency vehicles far enough in advance of traffic signals to allow modification of timing.	Prioritization of emergency vehicles enables them to reach their destination faster, and also should minimize the disruption their passage has on the roadway network.
13	20, 23	Workshop	Vancouver	Traffic managers have limited capability for communicating with drivers.	Provide a mechanism for traffic managers to communicate road conditions, warnings and emergency information to drivers.	More geographically customized, directed information may be given; reduction in the cost of acquisition, operations and maintenance of driver communications devices (HAR, DMS).
14	21	Workshop	Vancouver	There are too many crashes at intersections.	Provide capabilities that reduce crashes at intersections.	Safety
15	24, 25	Workshop	Vancouver	Advanced traffic control strategies are impractical for many agencies due to technical or cost reasons.	Provide data sufficient to enable advanced traffic control in a simple, standard and open format.	More advanced traffic control will yield higher mobility.
16	26	Workshop	Vancouver	This program may raise drivers' expectations.	Provide a feedback mechanism to drivers indicating when this program is active, and what services it is offering.	Managing drivers' expectations so that they operate vehicles with proper knowledge of their environment.
17	27	Workshop	Vancouver	The infrastructure turnover rate is so slow that much of the deployed infrastructure is never or infrequently replaced.	This program should provide some services without requiring infrastructure replacement.	Infrastructure replacement is expensive in money and manpower.
18	1	Workshop	Detroit	Too much information is being presented to the driver.	Provide Service Quality Indicators and support for degraded operations	To help with the acceptance of the program
19	2	Workshop	Detroit	Highly accurate positioning data is not available on vehicles	Highly accurate positioning data on vehicles.	Applications requiring position information may not be developed or used without reliable high-accuracy positioning services.
20	3	Workshop	Detroit	High speed wireless communications are not always available to vehicles.	High speed low latency communications must be available.	To support safety applications.
21	4	Workshop	Detroit	Network and data schema are not available, and the existing material (National ITS Architecture) does not go far enough.	Published Network Architecture and data standards to sufficient detail to enable development.	Without well specified network and data schema, developers may not invest because they do not know what is required.
22	5	Workshop	Detroit	Data available on the vehicle bus is not well documented; it is not clear what will be documented.	Provide standard APIs to Aftermarket manufacturers.	Well documented interfaces providing known data will enable application development.
23	6	Workshop	Detroit	Unauthorized access to DSRC network from other networks disrupt the transportation system by sending messages with malicious intent.	Limit access to the DSRC radio.	Maintain safe operation of the vehicle.
24	7	Workshop	Detroit	Unauthorized transmissions can disrupt "the system."	Provide security mechanisms to prevent bad actors from accessing the system.	Maintain safety and operations of the system.
25	8	Workshop	Detroit	Security mechanisms may introduce excessive latency, compromising the timeliness of data, resulting in application disuse and lower safety.	Communications latency must be matched with the timeliness requirements of data.	Vehicle safety should not be compromised by security mechanisms.
26	9	Workshop	Detroit	Uncertainty about device and application certification requirements discourages developers from investing.	Define required certifications and eliminate multi-layered (national and state) certifications.	Well defined certification requirements will enable business to understand their business cases, expediting application development.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
27	10	Workshop	Detroit	Vehicles may end up with many different devices to support different applications.	Provide an integrating structure that enables multiple applications on a single device.	The fewer devices required, the more applications individuals may feel are available to them.
28	11	Workshop	Detroit	Current message set definition does not provide a sufficient level of detail to enable all of the envisioned applications.	Define a new message that includes additional information.	More data will allow faster development of basic applications and provide opportunities for more advanced applications.
29	12	Workshop	Detroit	Transportation system infrastructure may be limited in availability in some geographic areas.	Use V2V propagation to enable some safety applications.	To reduce the reliance of safety applications on potentially unavailable infrastructure.
30	13	Workshop	Detroit	This program's deployment strategy lacks clarity, creating uncertainty with stakeholders.	Define the deployment strategy.	Reducing or removing uncertainty for stakeholders will remove one barrier to investment.
31	14	Workshop	Detroit	Research data is difficult to acquire.	Provide a centralized means for making research data available.	To provide increased confidence in deployment.
32	1	Workshop	Detroit	We don't have traffic data beyond instrumented freeways, limiting our understanding of traffic conditions.	Comprehensive road network traffic data, including vehicle speed, vehicle count, origin and destination.	With comprehensive road network traffic data, we could better manage traffic, and save money by not having to install new infrastructure-based sensors.
33	1	Workshop	Detroit	Planning needs require long-term storage of traffic condition information.	A repository to hold the comprehensive traffic data, including vehicle speed, vehicle count, origin and destination.	A repository will enable the planning and asset management processes to provide better outputs in the future.
34	2	Workshop	Detroit	Traffic data needs to be analyzed/synthesized in order to be useful.	A standardized method for accessing and processing data in order to produce useful information for traffic management, possibly an open data warehouse.	In order to be useful, data has to be analyzed and turned into information. This program could produce a lot of data, and turning it into information could be a significant task.
35	3	Workshop	Detroit	A high fuel consumption rate is harmful to the environment.	Increase mobility by providing means to enable signal optimization and flow coordination, allowing vehicles to minimize start/stop.	Start/stop causes large fuel consumption, increasing emissions; decreasing start stop will benefit the environment.
36	4	Workshop	Detroit	Driver expectations are based on typical conditions, and do not account for anomalies such as incidents or bad weather.	Monitor traffic flow to see if there are any road closings or other related information.	….because it can
37	4	Workshop	Detroit	Driver expectations are based on typical conditions, and do not account for anomalies such as incidents or bad weather.	Push advisory of weather information to a selective set of drivers within an affected area.	….because it can
38	4	Workshop	Detroit	Driver expectations are based on typical conditions, and do not account for anomalies such as incidents or bad weather.	Provide accurate and timely geographical weather and road surface condition data.	….because it can
39	5	Workshop	Detroit	Incidents in rural environments are common but response delay is higher than in urban areas.	Provide vehicle information when needed, emergency information including mayday, to an emergency responder contact.	Providing an On-Star-like May Day service for all drivers would save lives.
40	6	Workshop	Detroit	Evacuating vehicles is uncoordinated with no dynamic route guidance.	Provide situational awareness of the mobility environment for evacuations.	This program offers the potential for improving situational awareness to a greater degree than any other available solution.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
41	7	Workshop	Detroit	Road weather and surface condition information is not comprehensive, being known only at select RWIS sites.	Provide more comprehensive weather and surface condition data sourced from vehicles, including temperature, wiper usage, traction control and ABS events.	Additional data would enable and strengthen many possible applications, but at minimum improve weather forecasting and observing.
42	7	Workshop	Detroit	Road weather and surface condition information is not comprehensive, being known only at select RWIS sites.	Provide calibrated sensor information from specialized vehicles like snow plows.	Additional data would enable and strengthen many possible applications, but at minimum improve weather forecasting and observing.
43	7	Workshop	Detroit	Road weather and surface condition information is not comprehensive, being known only at select RWIS sites.	Provide different levels of weather and surface condition information for various types of vehicles, particularly fleet vehicles.	Additional data would enable and strengthen many possible applications, but at minimum improve weather forecasting and observing.
44	8	Workshop	Detroit	There are too many weather-related accidents.	Provide higher resolution of weather and surface conditions to the traveler.	Providing more granular weather and surface condition information would help improve the maintenance and operations of the road network during adverse weather conditions.
45	8	Workshop	Detroit	There are too many weather-related accidents.	Provide higher resolution of weather and surface conditions to traffic control system devices.	Providing more granular weather and surface condition information would help improve the maintenance and operations of the road network during adverse weather conditions.
46	8	Workshop	Detroit	There are too many weather-related accidents.	Provide higher resolution of weather and surface conditions to vehicle fleets.	Providing more granular weather and surface condition information would help improve the maintenance and operations of the road network during adverse weather conditions.
47	1	Workshop	Detroit	I don't have access to my potential customers wherever I would like.	Provide ubiquitous wireless coverage between ISPs and vehicles throughout the country.	With ubiquitous coverage, ISPs can provide meaningful information and services in a dynamic environment; anywhere, anytime.
48	2	Workshop	Detroit	I don't have complete situational awareness of other vehicles in the immediate area around my vehicle.	Provide locations, speeds and other data about vehicles in the local environment to vehicles.	By providing information about the local vehicle situation, vehicle safety applications will be enabled.
49	3	Workshop	Detroit	I don't have complete awareness of traffic and weather conditions of the roads on my route.	Provide the locations and impact of traffic and weather condition information that may impact driver trips to drivers.	This will increase mobility by empowering drivers to make more informed decisions.
50	4	Workshop	Detroit	Companies that provide services come and go; technology advances, resulting in established systems that are difficult to extend and/or maintain.	Ensure interoperability over a period of time by defining standardized, open, extensible interfaces.	By mandating or facilitating the creation of open, standardized interfaces this program can facilitate interoperability and thus ensure a long life cycle of enabled devices and applications.
51	5	Workshop	Detroit	Distracted driving, which leads to tickets, fines and accidents.	This program should provide information in such a way as to avoid distractions.	Fewer distractions = fewer accidents = more safety.
52	6	Workshop	Detroit	Responding to subpoenas and legal investigations requiring access to data costs me money and resources.	Minimize the requirements for data collectors to respond to legal investigations and subpoenas.	In addition to the cost savings for ISPs and public agencies, attributable data may be a barrier to implementation because if people perceive a data privacy issue, they will not opt in.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
53	7	Workshop	Detroit	Systems are not architected to allow changes in privacy requirements.	The system architecture needs to be flexible enough to adjust to social use/policy choices as they evolve.	What is unacceptable today may not be acceptable today, and in order for this program to be worthwhile, it must adapt.
54	8	Workshop	Detroit	Interoperability between devices.	All interfaces should be publicly defined and open; mandatory standards should be defined for every interface.	Standardization will avoid issues associated with being locked into proprietary systems.
55	8	Workshop	Detroit	Interoperability between devices.	All interfaces should be publicly defined and open; mandatory standards should be defined for every interface.	Standardization will avoid issues associated with being locked into proprietary systems.
56	9	Workshop	Detroit	Road congestion due to accidents and construction is not reported in such a way that drivers know their optimal routes.	Provide traveler information to travelers more efficiently, telling them accident locations, alternate routes, recommended routes and alternate mode information.	More efficient dissemination of traveler information will increase mobility; existing services such as MapQuest are limited, particularly in multi-modal choices.
57	10	Workshop	Detroit	We don't have a way to authenticate safety messages.	Provide a mechanism for the authentication of safety messages.	Safety applications must trust their inputs.
58	11	Workshop	Detroit	We don't have a way to ensure anonymity/privacy of safety messages.	Safety messages must be anonymized.	If we don't ensure anonymity, it will be difficult to protect privacy.
59	12	Workshop	Detroit	We don't have a way to ensure delivery of safety messages in real time.	Need to ensure the delivery of safety messages in real-time.	Safety messages must be delivered in time for them to be acted upon, which is often quite quickly.
60	13	Workshop	Detroit	Certain services may monopolize the stream of information the driver/traveler, preventing other services from gaining access.	Provide a means for balancing the flow of information between various services.	Flood of information from various services is not fair to other services.
61	14	Workshop	Detroit	Vehicles often do not know their absolute position or relative position with sufficient accuracy to enable applications.	Provide lane-level accuracy to vehicles.	Knowing where you are is critical to many applications, particularly safety applications.
62	15	Workshop	Detroit	Safety applications require the most recent map data, including 3D map data.	This program should provide up-to-date 3D digital maps to vehicles.	Maps must be kept up to date with construction and maintenance changes, and experience has shown that customers with navigation units do not generally do this on their own.
63	16	Workshop	Detroit	Driver may not know whether or not his installed safety applications are supported in a given area.	Provide a means for informing the driver when various active safety applications depending on local wireless communications (DSRC, including 5.9) is functioning or not functioning.	Managing the drivers' expectations is critical to him being able to safely operate the vehicle.
64	17	Workshop	Detroit	Road condition information is often received too late for the driver to properly react to it.	Need to provide drivers with advance warning of road conditions that may impact their safety in time for them to act on it.	Safety is compromised by late information delivery.
65	18	Workshop	Detroit	I don't have any way of preventing data that I transmit wirelessly from being accessed by others.	Need to provide a means for encrypting data that is transferred.	Without encryption, personal transaction data may be received by the wrong people.
66	19	Workshop	Detroit	Privacy safeguard design difficulties are slowing down deployment.	(Possibly all) applications, but certainly some should be Opt-in.	Allows the system to be deployed by bypassing privacy concerns; customers that are concerned about privacy will not install compromising applications.
67	20	Workshop	Detroit	My applications require raw data.	Need standardized output of data to facilitate collection and processing.	To provide a level playing field for service providers to provide value added services as information processors.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
68		Workshop	Detroit	Provide sufficient functionality to eliminate lane markings	Provide information normally presented by lane markings to the vehicle.	
69		Workshop	Detroit	Provide sufficient functionality to eliminate signalized intersections	Provide arbitration for intersection access.	
70		Workshop	Detroit		Provide the ability to plan and manage the flow of traffic through a large area by delivering real-time accurate travel time data, link by link.	
71		Workshop	Detroit		Provide sufficient information to enable adaptive traffic control.	
72		Workshop	Detroit	Improve CVO fleet safety status monitoring through increased data transmission	Provide CV safety status information in real time to center.	
73		Workshop	Detroit	Commercial vehicles broadcast HAZMAT transport information.	Provide means for CV to broadcast HAZMAT containing information and other vehicles and roadside to receive.	
74		Workshop	Detroit	Commercial vehicles transmit warnings to avoid roads that have too many commercial vehicles on them	Provide means for CV to broadcast presence as CV.	
75		Workshop	Detroit	Optimal route determination based on commercial vehicle traffic data.	Provide means to deliver route guidance information to specific vehicles based traffic data from CV.	
76		Workshop	Detroit	Notification to the blind of approaching vehicles	Provide vehicle approaching alerts to blind pedestrians.	
77		Workshop	Detroit		Provide sufficient information to enable better picture of environmental information (air quality, weather data for example)	
78		Workshop	Detroit	Broadcast of various mayday-type messages	Provide mayday message broadcast.	
79		Workshop	Detroit	Adaptive cruise control requires information that most vehicles do not have.	Provide the vehicle with the information necessary to enable adaptive cruise control, including following distance.	
80		Workshop	Detroit	Left turns require the driver to make a quick judgment.	Provide the vehicle with the information necessary to provide advice on when NOT to take a left turn, based on approaching vehicles.	Provide sufficient functionality to enable left turn assist (don't turn, there's a vehicle coming)
81		Workshop	Detroit	Provide sufficient functionality to eliminate signalized intersections	Provide arbitration for intersection access.	Provide sufficient functionality to enable removing traffic lights
82		Workshop	Detroit	Provide sufficient functionality to enable in-vehicle signage	Provide the information contained on static and dynamic road signs to the vehicle.	
83		Workshop	Detroit			Sell traffic signal priority to the highest bidder.
84		Workshop	Detroit	Maintaining HOT lane performance in a dynamic environment, managing critical density points.	Provide "request to enter HOT lane" to arbiter of HOT lane entry.	
85		Workshop	Detroit	State DOTs and ISP are starved for road weather information.	Provide road weather information to state DOTs and ISPs	
86		Workshop	Detroit	Provide vehicle event change information (ABS, wipers etc.)	Provide vehicle-based event-driven vehicle performance snapshots to interested parties.	
87		Workshop	Detroit	Road maintenance personnel don't have an automatic method for determining the condition of their roadways.	Provide vehicle-based road roughness, including pothole information, to interested parties.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
88		Workshop	Detroit	Determining safe speed for curves depends vehicle characteristics that are vehicle-type specific.	Provide road characteristics information to the vehicle.	
89		Workshop	Detroit	Determining vehicle-specific dynamic speed limits requires knowledge of vehicle performance characteristics by the speed limit authority.	Provide vehicle performance characteristics to the speed-limit establishing authority.	
90		Workshop	Detroit	Establish various roles and levels of security for different types of users	Provide role-based security.	Enables various levels of permission for different types of users.
91		Workshop	Detroit	Deployment	Provide an architecture that allows small deployments in limited geographic areas to accomplish specific goals.	Investors may be willing to put infrastructure out there based on certain geographies; e.g., border wait times.
92		Workshop	Detroit	Pedestrians slow down traffic flow.	Provide locations of pedestrian crossings with pedestrian traffic to vehicles in real-time.	By identifying active pedestrian crossings, this information could be passed to vehicles that could choose to avoid those locations, thus improving mobility for all parties.
93		Workshop	Detroit		Provide automatic pedestrian crossing signalization, without having to wait for pedestrians to trigger by pressing a button.	If there were some higher level understanding of pedestrian flow (beyond just at a single intersection), pedestrian platoons could be managed, increasing mobility.
94		Workshop	Detroit			Provide turning movement counts at intersections.
95		Workshop	Detroit	Maintenance and construction workers are endangered by passing traffic.	Provide maintenance and construction worker location information to nearby vehicles.	
96		Workshop	Detroit	Pedestrians are endangered by passing traffic.	Provide pedestrian location information to nearby vehicles.	
97		Workshop	Detroit			In-vehicle PDAs should function as vehicles, once exiting a vehicle, change mode back to pedestrian
98		Workshop	Detroit		Provide personal origin-destination information	Even better than vehicle O-D, since you get a personal start and end.
99		Workshop	Detroit		Provide walk request for pedestrian crossings through PDA.	
100		Workshop	Detroit	Visually impaired pedestrians don't know where vehicles are, and thus don't know when they are at risk.	Provide the locations of surrounding vehicles to PDAs.	For the blind, detect other broadcasters around you, to act as a "seeing eye handset"
101		Workshop	Detroit	Provide transit operators with understanding of how many people are queued at a stop.	Provide information from transit stops to transit operators.	
102		Workshop	Detroit	Slugs don't have a standardized, authenticated mechanism of finding riders/rides.	Enable secure, person-to-person slug O/D information exchange.	
103		Workshop	Detroit	Locally relevant safety information is difficult to obtain.	Provide safety messages from a vehicle to application (roadside or center).	Provide safety messages with localized, specific content.
104		Workshop	Detroit	Locally relevant safety information is difficult to obtain.	Provide safety messages from a vehicle to application (roadside or center).	Provide advisory messages with localized, specific content.
105		Workshop	Detroit	Maintenance and construction workers are endangered by passing traffic.	Provide maintenance and construction worker location information to nearby vehicles.	Provide work zone warning information when workers are present and working and traffic is approaching.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
106		Workshop	Detroit	Businesses can't attract as many customers as they would like.	Provide generalized indication of potential customer locations to businesses, based on PDA locations.	Use localized broadcast to offer commercial services to attract customers (e.g., $.50 off coupon at Starbucks)
107		Workshop	Detroit	Businesses can't attract as many customers as they would like.	Provide generalized indication of potential customer locations to businesses, based on PDA locations.	Use commercial needs about customer locations and demands to create a market such than aggregator would collect customer location and time data and resell
108		Workshop	Detroit	Public safety deployments usually done based on non-real time statistics, depend on dispatch response.	Provide safety messages from a vehicle to application (roadside or center).	By spotting trouble spots, which is done with statistical analysis post-real-time today, police could get more timely information and respond far more quickly.
109		Workshop	Detroit	Identify the locations of stops, schools and curves	Provide road and road context (stops, schools, etc.) information to vehicles.	
110		Workshop	Detroit			Provide direction-based speed warnings
111		Workshop	Detroit	Avalanche and other local natural disaster-like warnings	Provide natural disaster information relevant to the vehicle's future route to vehicles.	
112		Workshop	Detroit	Distribute surface condition information to vehicles	Provide surface condition information relevant to the vehicle's future route to vehicles.	
113		Workshop	Detroit	Distribute GPS differential corrections	Provide information from external non-ITS sources e.g., differential GPS corrections, timing) to vehicles.	
114		Workshop	Detroit	Provide advance warning of congestion	Provide congestion information relevant to the vehicle's future route to vehicles.	
115		Workshop	Detroit	Provide railroad crossing information (when it will be blocked and on what roadways)	Provide railroad crossing and blockage information to vehicles for the vehicle's future route.	
116		Workshop	Detroit		Provide alert to vehicle when a train is coming along the route the vehicle is traveling.	
117		Workshop	Detroit			Provide roadside information even for vehicles many hours away
118		Workshop	Detroit	Warning of bad drivers around you	Provide safety messages from a vehicle to application (roadside or center) in real-time.	
119		Workshop	Detroit	Warning of bad drivers around you	Provide information describing location and characteristics of "bad driving" vehicles to vehicles in real-time.	
120		Workshop	Detroit		Provide variable lane control information to vehicles during high volume conditions, for vehicles on or approaching variable lane-enabled roadways.	
121		Workshop	Detroit	Forecasting during high-volume conditions, for example where to park for large events	Provide near-real time parking information to vehicles en-route.	
122		Workshop	Detroit	Warn of maintenance work or lane closures	Provide lane closure information to vehicles on or near closed lanes.	
123		Workshop	Detroit	Warn other vehicles of snowplow locations	Provide locations of snow plows to vehicles in area.	
124		Workshop	Detroit	Broadcast safety-related information, particularly for incident management; consider using emergency vehicles as broadcasters.	Provide incident-related information to vehicles that may be impacted by the incident	
125		Workshop	Detroit	Warnings to trucks of where to get off because of bridge constraints	Provide bridge/tunnel constraint information to vehicles upstream of restrictive entry.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
126		Workshop	Detroit	Warn of maintenance work or lane closures	Provide construction information, including lane closure information to vehicles on or near closed lanes.	Updated construction information, including lane closures
127		Workshop	Detroit	Curve data activate if relevant to the vehicle and route	Provide curve characteristics data to vehicles upstream of curve.	
128		Workshop	Detroit	SPAT, so that vehicles can be programmed ahead of time to adjust speed accordingly	Provide real-time information (SPAT) from roadside devices to vehicles.	
129		Workshop	Detroit		VMS content, in-vehicle signage of DMS	Note: language customization
130		Workshop	Detroit	Alert people of open parking spaces to encourage alternate mode use	Provide parking space information near alternate modes to vehicles in the area.	
131		Workshop	Detroit	Provide messages to cyclists indicating best locations to cross the road.	Provide local safety routing and road crossing information to cyclists.	
132		Workshop	Detroit			HAZMAT information
133		Workshop	Detroit	Blind spots could provide information to pedestrians and bicyclists.	Provide local safety routing and road crossing information to pedestrians and cyclists.	
134		Workshop	Detroit			For roundabouts with 3 lanes, rebroadcast vehicle location to pedestrians.
135		Workshop	Detroit		Provide SPAT and personal location information to the blind	To assist the blind in crossing intersections
136		Workshop	Detroit	Broadcast when next bus is available.	Provide real-time transit information to mobile users.	
137		Workshop	Detroit			Distribute the CRL
138		Workshop	Detroit		Provide vehicle locations to vehicles in immediate area.	To assist when there are several vehicles approaching an intersection and one of them may not have visibility into all other vehicles.
139		Workshop	Detroit		Global standardization is needed for software (interfaces and certain services).	Standardization will avoid issues associated with being locked into proprietary systems.
140		Workshop	Detroit		Certification is needed	
141		Workshop	Detroit			Traffic information
142		Workshop	Detroit		Provide ADT and OD information to centers.	Saves putting out counters, long term money savings
143		Workshop	Detroit		Provide secure financial transaction between vehicle and toll authority for dynamic pricing	Road pricing, charge based on time of day, congestion, lane used, priority access, rural or urban road, #occupants
144		Workshop	Detroit	Automated parking	Provide secure financial transaction between vehicle and parking authority for automated parking assignment/charging	
145		Workshop	Detroit	Request for identification of parking space, availability of certain types of parking spaces (handicapped, visitor); guide vehicle to parking spot	Provide parking space characteristic information from roadside or center to vehicle, including routing information.	
146		Workshop	Detroit	Electronic screening, weigh-in-motion	Provide secure transactions to enable the exchange of CV information sufficient to conduct weigh-in-motion/electronic screening	
147		Workshop	Detroit	Permitting	Provide secure transactions to enable CVs to apply for and receive permits electronically.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
148		Workshop	Detroit	Vehicle condition monitoring	Provide the exchange of vehicle condition information from vehicles to centers.	
149		Workshop	Detroit		Provide WIM information to public safety vehicles.	Send WIM information to public safety vehicle to have them intercept vehicle
150		Workshop	Detroit		Provide secure exchanges to enable limited remote control of HAZMAT vehicles	HAZMAT monitoring, tracking, remote disabling
151		Workshop	Detroit	Transit connection protection: vehicle to vehicle connections	Enable the exchange of transit vehicle messages to ensure protection: occupancy, arrival times.	
152		Workshop	Detroit	Visibility into location of buses and schedule adherence	Provide the locations of buses and schedule adherence to centers.	
153		Workshop	Detroit	Device location at bus stop, next bus at, passenger awaiting	Provide notification to transit vehicles of status of stops, location of potential passengers.	
154		Workshop	Detroit	Dynamic ride matching (slugging)	Secure exchange of ride-sharing information, including personal authentication.	
155		Workshop	Detroit	OnStar-like crash notification and emergency dispatch	Provide notification of an accident directly from vehicle to emergency responders.	
156		Workshop	Detroit	Transmit diagnostics from crashed vehicle.	Provide exchange of diagnostic information between crashed vehicle, emergency responders.	
157		Workshop	Detroit	Police car send messages directly to vehicle it is pursuing.	Enable secure exchange between police and pursued vehicle.	
158		Workshop	Detroit	Commercial vehicle overnight parking request and sale.	Provide location, routing and payment for CV parking.	Improve use of existing parking infrastructure, meet need of CVO community at the same time.
159		Workshop	Detroit	Monitor and report if CV drivers are getting sufficient rest	Provide exchange of in-cab sensory data between CV and center	
160		Workshop	Detroit		Provide locations of all freight between CV and center.	Monitor freight locations; in the case of a natural disaster, prioritize removal of freight by location and type. Improve disaster response, saving money in lost goods.
161		Workshop	Detroit			Weigh-in-motion, truck/driver log, cross-border clearance.
162		Workshop	Detroit		Provide enforcement-related vehicle operating characteristics to enforcement agency	Electronic enforcement
163		Workshop	Detroit	Management of truck routing when trucks operate in hazardous environments, e.g. ice road truckers	Provide routing information to CV in hazardous environments.	
164		Workshop	Detroit	Paratransit support where vehicle communicates location to dispatcher and vice-versa	Exchange paratransit location information with center.	
165		Workshop	Detroit	Weather-related warnings to specifically affected parties, guaranteed delivery	Provide weather-related warnings directly to those likely to be affected.	
166		Workshop	Detroit	Identify vehicles on approach to signal, schedule vehicle to hold green longer for increased weight vehicles.	Provide vehicle weight, acceleration and other performance characteristics to signal.	Modify timing to account for performance of HVs.
167		Workshop	Detroit	Ferry ticketing	Exchange payment information between boarder and ferry operator.	
168		Workshop	Detroit	Provide longer pedestrian crossing times for disabled/aged pedestrians	Communicate disabled/aged pedestrian location and destination to signal.	
169		Workshop	Detroit	Bike-to-bike collision avoidance		

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170		Workshop	Detroit	Other reservation-like activities: doctor appointments, ferry reservations, rest, etc.	Provide for exchange of 3rd party reservation information.	
		Workshop	Detroit	Cyclists don't trigger signals.	Provide bike-to-signalized intersection data exchange.	
171		Workshop	Detroit	Cyclists can't always find a bike with a bike rack	Provide for exchange of information between cyclist and transit: I want a bus with a bike rack; bus responds with status, and if not available with the nearest bus that does have space and a rack.	
172		Workshop	Detroit		Provide border wait times to travelers that are remote	
173		Workshop	Detroit	Cyclist or disabled pedestrian request green signal from traffic light.	Communicate cyclist or disabled/aged pedestrian location and destination to signal.	
174	1	Workshop	San Jose	Safety applications are constrained by the limited range of DSRC, which is itself constrained by antenna placement.	The DOT needs to sponsor additional research into the optimal placement and number of DSRC radios and antennas for large vehicle types.	Antenna placement becomes a serious constraint on large vehicles, where the vehicle itself can occlude transmissions.
175	2	Workshop	San Jose	Vehicles sizes are not uniform.	On-board safety systems need to be able to identify vehicle envelope.	Collision avoidance applications will care about the edges of the vehicle, not the middle.
176	3	Workshop	San Jose	Many commercial and transit vehicles have too many stand-alone devices on board already.	This program needs to establish standards and interface designs to enable developers to create integrated platforms.	Having integrated systems will increase acceptance, reduce driver workload and thereby increase safety.
177	4	Workshop	San Jose	Vehicles may change their size envelope over the course of a trip (adding a trailer, extending cargo beyond the length of the bed, etc.)	Devices with on-board vehicle characteristics systems need to be able to adapt to changes in the vehicle envelope automatically without requiring operator intervention.	Without correct information on the vehicle envelope, on-board systems may send incorrect safety messages.
178	5	Workshop	San Jose	Evolutionary rollouts imply that multiple versions of onboard and roadside equipment will exist, raising incompatibility challenges.	The system needs to ensure backwards compatibility to accommodate devices that are deployed over different timeframes.	Safety systems deployed over time need to be aware of older systems so they can work together.
179	6	Workshop	San Jose	Train location transmissions are not included in any current system specification.	This system needs to provide a mechanism for the reception of rail location transmissions.	We need train positioning information to enable rail collision avoidance.
180	7	Workshop	San Jose	Devices may become outdated as standards and requirements change.	This program needs to establish standards and policy to ensure that devices are built to open standards that can be upgraded as technology changes.	Ensures overall safety on the roadway between vehicles and mobility services continue to be made available.
181	8	Workshop	San Jose	There are multiple data sources, but today's systems are all standalone, making sharing difficult.	This program should ensure that standards are established and available to accommodate inputs from multiple sensors.	Increases overall effectiveness.
182	9	Workshop	San Jose	Management systems as well as vehicle-based systems need more data to support management of the network and vehicle operations.	This system needs to collect information about vehicles on the road and about the road from vehicles or other sensors.	Increasing situational awareness will help the driver make better decisions.
183	10	Workshop	San Jose	The safety of pedestrians and bicycles is at risk if drivers are not aware of their presence.	This system needs to provide information that will increase the awareness of vehicle operators toward cyclists.	Overall improvement in safety.
184	11	Workshop	San Jose	There is no collision warning for pedestrians or bicyclists.	Need a way to alert pedestrians and bicyclists about the presence of vehicles and potential for crashes.	Cyclists and pedestrians are at risk of significant injury in the case of collision.
185	12	Workshop	San Jose	Device context is relevant to data generation and information presentation to the operator.	Devices need to be context aware to be able to adapt the amount and frequency of the data transmitted and information presented.	Consistent behavior can be established through use of standards.

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186	13	Workshop	San Jose	Geometry and roadway obstacles pose significant collision risk.	Devices on board need highly localized, dynamic map data that reflects the vehicle's current surroundings.	Without up-to data situational information, accidents may still occur due to transient changes in roadway geometry.
187	14	Workshop	San Jose	Transit systems do not have good visibility into the demand on their system.	Need this system to provide interfaces to collect information about potential transit passengers that can be used by the transit system.	Automated interfaces can supplement current manual collection means to support better management of the system.
188	15	Workshop	San Jose	Many buses in urban areas are equipped with bike racks but in high demand areas these can be full when potential passengers need them, resulting in disgruntled passengers that don't use the transit system.	Need expanded data about the arrival of the next bus to be provided to individual travelers, including time, capacity, bike rack capacity, handicap facilities available and the availability of alternatives.	Better information will allow travelers to make more informed decisions.
189	16	Workshop	San Jose	Current fare payment methods are slow and restrict the speed of boarding buses.	Need automated fare collection that can operate as fast as it takes a rider to walk onto the bus.	This program can provide alternative communications paths as well as standardized mechanisms that can be integrated with other payment systems.
190	16	Workshop	San Jose		Need automated fare collection that can respond to dynamic pricing models.	This program can provide alternative communications paths as well as standardized mechanisms that can be integrated with other payment systems.
191	17	Workshop	San Jose	Some passenger counting systems cannot provide real-time information to management systems because of communications limitations.	Need expanded data on bus information (passengers, vehicle, and security) to be supported through the network as an alternative to other transit networks.	Improve the reliability of the transit system and increase overall ridership and usage.
192	18	Workshop	San Jose	The biggest cost in transit is liability and the cost of collisions	Need expanded information about the situation around transit vehicles as a means to avoid collisions, including the locations of pedestrians and other vehicles.	Reducing the number of bus collisions will have a positive effect on the transit agency's bottom line.
193	19	Workshop	San Jose	Malicious actors can disrupt the performance of the system and/or steal personal information.	This system needs to provide mechanisms to prevent unauthorized access to system data and services.	This program can set policy and ensure its enforcement to increase confidence in the use of the system.
194	20	Workshop	San Jose	Roadway pricing models vary by lane and time of day and number of occupants.	This program needs to provide accurate positioning data and vehicle occupancy information.	This information will enable road pricing applications.
195	1	Workshop	San Jose	Motorists are not kept informed [of traveler information] in a timely manner.	More efficient way to collect 511 data.	Automated data collection will improve data quality.
196	2	Workshop	San Jose	Trip times are not reliable.	Trip travel times to get there early (or JIT); latency of information should be less than travel time.	
197	3	Workshop	San Jose	Travelers do not understand intermodal dependencies and their impact, and therefore do not sufficient understand travel data to make an information modal change decision; they don't shift modes.	Provide predictive and real-time travel times for multimodal options.	
198	4	Workshop	San Jose	Travelers miss the connection when going from one mode to another, and when shifting modes from a vehicle because parking availability information is inaccurate.	Parking information needs to be made accurate at the time the driver queries it.	
199	5	Workshop	San Jose	Mode utilization is not maximized.	Real time and predictive multimodal and parking availability data.	
200	6	Workshop	San Jose	Transient travelers (tourists) do not shift modes.	Provide cost, travel time, quality of ride benefit to encourage shift.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
201	6	Workshop	San Jose	Transient travelers (tourists) do not shift modes.	Provide the basis for implementing user fees by monitoring VMT.	User fees may encourage mode shifting
202	7	Workshop	San Jose	We have difficulty providing accurate travel times everywhere.	Reliable, consistent data from vehicles throughout the whole region.	
203	8	Workshop	San Jose	Reckless driving, specifically the driver that tries to beat the light and that drives erratically.	Collect data about driver behavior.	Provide the foundation for incentivizing safe driver behavior.
204	9	Workshop	San Jose	Incident response is often delayed or inappropriate due to a lack of information.	More timely detection and data about the nature of crashes, HAZMAT if any, severity of injuries and precise location.	
205	10	Workshop	San Jose	Rapid detection and appropriate response is required for HAZMAT incidents.	Information about HAZMAT carrying commercial vehicles while traveling.	
206	11	Workshop	San Jose	The number of animal/vehicle collisions is increasing.	Establish zones for animal crossing and a detection system; this system could broadcast the location of the zone with an alert.	
207	11	Workshop	San Jose	The number of animal/vehicle collisions is increasing.	Equip animals with transmitters so they might be detected. IntelliMoose.	
208	12	Workshop	San Jose	Pedestrian/vehicle collisions in uncontrolled crosswalks.	Broadcast the location of the pedestrian with an alert.	
209	13	Workshop	San Jose	Accidents due to fog and icy roads.	Real time road weather conditions.	
210	14	Workshop	San Jose	Difficult to acquire and disseminate tourist related information.	Provide tourist information and payment support (lodging, vehicle repair) for small towns.	To help attract tourists and increase local revenues.
211	15	Workshop	San Jose	Drivers are not alert in work zones, compromising the safety of workers.	Provide work zone alerts for drivers.	
212	16	Workshop	San Jose	Drivers and pedestrians ignore railroad crossing signs, vehicles stop on tracks or don't notice fixed route transit vehicles.	Provide credible, convincing warnings to vehicles, cyclists and pedestrians to change their behavior at railroad crossings.	
213	17	Workshop	San Jose	Difficult to obtain real time traffic data for the money I have budgeted.	Cost efficient means to obtain traffic data, specifically speed, queue, volume, turning movements, platoon arrival, vector, acceleration, lat/long to 1/2 length.	The current approach is too expensive; this system can provide a single point of data collection.
214	18	Workshop	San Jose	Drivers are not aware of cyclists and misjudge cyclists speed.	Location of cyclists to drivers.	
215	19	Workshop	San Jose	Traffic signal sensors cannot detect cyclists.	Better detection of cyclists.	
216	20	Workshop	San Jose	Motorcycles are difficult to spot.	Provide alerts from motorcyclists to vehicles.	
217	20	Workshop	San Jose	Motorcycles are difficult to spot.	Provide remote assisted brake to motorcycle to slow it down	
218	20	Workshop	San Jose	Motorcycles are difficult to spot.	Provide vehicle approaching alerts to motorcycles.	
219	21	Workshop	San Jose	Road surface condition information is not granular enough to be useful for motorcycles and cyclists.	Collect and provide more granular information to 2-wheeled vehicles.	
220	22	Workshop	San Jose	Multiple Emergency vehicles all requesting signal priority at the same time cause conflicts.	Inform conflicting emergency vehicles of competing priorities.	
221	23	Workshop	San Jose	Public safety vehicles and/or personnel are struck by vehicles while working.	Provide an alert to passing vehicles to indicate a vehicle is stopped on the shoulder.	
222	24	Workshop	San Jose	Oversized and over-width vehicles impact tunnels and bridges causing accidents.	Provide alerts in advance to CVs for weight and size restrictions.	
223	24	Workshop	San Jose	Oversized and over-width vehicles impact tunnels and bridges causing accidents.	Issue public safety alerts to police to track vehicles that proceed into bridges/tunnels they cannot pass.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
224	1	Workshop	San Jose	Current quality of VMT information used in the planning process is poor in quality.	Provide VMT data to the planning process.	Because it can…
225	2	Workshop	San Jose	We don't have a way to attribute road usage to individual vehicles and/or drivers.	This system needs to record the number of miles traveled by each vehicle to enable revenue collection methods such as MBUF.	Because it can…
226	3	Workshop	San Jose	Traffic condition information is expensive, not ubiquitous and inaccurate.	This system needs to provide comprehensive, accurate and ubiquitous traffic condition and incident information so that travelers can make informed decisions and so that they can be satisfied that their decisions were correct (peace of mind).	
227	4	Workshop	San Jose	Cannot invest in this program without well defined interfaces.	Well defined open interfaces.	Open interfaces will encourage small business.
228	6	Workshop	San Jose	We do not have real time dynamic maps that capture incidents, congestion, road work etc.	Real time incident and flow data.	This system can potentially deliver ubiquitous data.
229	7	Workshop	San Jose	Navigation maps don't reflect the current state of roads while the vehicle is en-route.	A way to communicate route suggestions to specific vehicles.	Application viability, supporting business stability.
230	8	Workshop	San Jose	Exchanging information with other service providers is difficult.	This system should provide a standardized mechanism to facilitate the exchange of information between service providers (brokerage, data and QS advertisement).	To facilitate the growth of the service provider business side, particularly for small business.
231	9	Workshop	San Jose	Acquiring Road Operating Permit requires personal presence.	Need to be able to transmit authenticated permit application so the granting agency without requiring personal presence.	Saves time and money.
232	10	Workshop	San Jose	The permit process is not being followed.	Need authenticated information to be transmitted to the agency, and permits to come back to the operator.	Reduces the number of scofflaws.
233	11	Workshop	San Jose	Lack of availability of vehicle location and performance data.	This system should provide a rich set of vehicle data.	Business application providers will develop business models when they see what is available.
234	14	Workshop	San Jose	Transit agencies do not have accurate aggregations of traveler movements, particularly in real time, so they cannot properly measure and respond to demand.	Real time accurate traveler movement information.	
235	15	Workshop	San Jose	Toll transponders are not interoperable.	Provide toll payment services.	So I can get rid of all these different transponders!
236	16	Workshop	San Jose	Managing the logistics of toll transponders is expensive and time consuming.	Provide a way of doing toll collection without transponders.	Relieves agencies of the need to manage transponders, saving time and resources.
237	17	Workshop	San Jose	Toll account management is expensive and time consuming.	Provide a means for third party payment mechanisms.	Relieves agencies of the need to manage accounts, saving time and resources.
238	18	Workshop	San Jose	Toll roads see decreased usage when there are viable alternate routes.	Provide a mechanism for the tolling agency to provide information to a specific vehicle operator.	This program could leverage the tolling mechanism to charge for increased services, creating new business models.
239	19	Workshop	San Jose	Service subscribers may pay for services that are granted by local or regional ISPs, but want to get the same services when they leave the covered area.	A capability to obtain information regardless of location with only one subscription (e.g., as in cell phone roaming)	This program should work as a proxy for service providers to help them do business.
240	20	Workshop	San Jose	Toll operators are unable to detect violators of HOV lanes.	Need to provide a mechanism to count vehicle occupants.	

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241		Workshop	San Jose	Lane departure warning	Provide the CV with an indication of when it departs a lane without a turn signal.	
242		Workshop	San Jose	CVs have large blind spots that other drivers are not always aware of.	CV broadcast its "sight envelope".	
243		Workshop	San Jose	Broadcast weight, height to be used at bridge environments.	CVs need to broadcast their physical characteristics.	
244		Workshop	San Jose	Weight, acceleration broadcast for safety at intersections and bridges.	CVs need to broadcast their physical characteristics.	
245		Workshop	San Jose	Prioritize dynamic routing to favor CVs broadcasting heavy weight (full).	Provide locations of CVs to centers performing dynamic routing.	
246		Workshop	San Jose	Provide traffic maps, particularly rural.	Collect CV traffic data to generate rural traffic maps.	
247		Workshop	San Jose	OD of commercial vehicles for long term routing modeling.	Collect OD of commercial vehicles.	
248		Workshop	San Jose	Enforcing lane restrictions is manpower intensive.	Provide automatic notification of trucks being in the wrong lane; trucks need lane level absolute positioning accuracy.	
249		Workshop	San Jose	Roads deteriorate faster due to CV traffic.	Monitor truck-miles on roadway segments.	By monitoring truck mileage on roads, we can predict when maintenance must be done on a per-lane basis.
250		Workshop	San Jose	Vehicle situational awareness of surroundings is compromised by line-of-sight and unpredictable or unsafe actions of other vehicles.	Provide the vehicle with a situational picture of other vehicles in its vicinity.	
251		Workshop	San Jose	Merging is complicated by line-of-sight, congestion and unpredictable or unsafe actions of other vehicles.	Provide a means for a merging vehicle to request merge permission from vehicles on the mainline.	
252		Workshop	San Jose	Left turns require the driver to make a quick judgment.	Provide the vehicle with the information necessary to provide advice on when NOT to take a left turn, based on approaching vehicles.	Provide sufficient functionality to enable left turn assist (don't turn, there's a vehicle coming)
253		Workshop	San Jose		Provide means for tracking vehicles that are violating the law.	
254		Workshop	San Jose		Provide means to enforce speed limits automatically.	Free up police to pursue other higher priority activities.
255		Workshop	San Jose	Drivers don't always realize when they are violating the speed limit.	Provide means to alert a driver when her vehicle is violating the speed limit.	
256		Workshop	San Jose	Detecting unsafe conditions across all roads is difficult.	Provide vehicle performance and sensory data to a long term archive.	Analysis of historical vehicle data can yield understanding of unsafe roads.
257		Workshop	San Jose	Determining road network performance requires access to data that is not typically captured today.	Provide road network performance data to a long term archive.	Analysis of historical road network performance data will improve understanding of road network performance
258		Workshop	San Jose	Determining the real-time "state of the road" requires the collection of data beyond the scope of today's sensory infrastructure in most areas.	Collect information from vehicles that can be used to produce traveler information.	
259		Workshop	San Jose	Determining optimal pricing for HOT lanes requires accurate real time traffic data.	Provide speed and road lane location information to aid in determining optimal pricing for HOT lanes.	
260		Workshop	San Jose	Use queue lengths as key input to allocating resources to manage traffic.	Monitor queue lengths.	
261		Workshop	San Jose	Safety and mobility.	Use information to predict local trajectories.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
262		Workshop	San Jose	To assist with traffic and incident management.	Detect incidents.	
263		Workshop	San Jose	To enable HOT, better traffic management, incident detection and incident management.	Must provide lane level positioning accuracy.	
264		Workshop	San Jose	Identifying locations, severity of potholes in time consuming and riddled with errors from inaccurate citizen reports.	Provide vehicle accelerometer data to maintenance centers.	Analysis of accelerometer data will lead to automated detection of potholes which will increase maintenance efficiency.
265		Workshop	San Jose	Planning bus routes requires knowing where and when people need transit.	Provide means to collect PDA travel route ("breadcrumb") data and archive it for future analysis.	
266		Workshop	San Jose	Pedestrian crossings impact signal timings; understanding pedestrian movements is difficult without much data capture and analysis.	Provide means to collect PDA travel route ("breadcrumb") data and archive it for future analysis.	
267		Workshop	San Jose	Cyclists don't trigger signals.	Provide means for cyclists and pedestrians to automatically trigger (relevant) crossings.	
268		Workshop	San Jose	Slow-moving pedestrians cannot always clear intersections in time.	Re-broadcast position of pedestrians (especially disabled) crossing streets.	This could be heard by relevant vehicles to avoid potential collisions.
269		Workshop	San Jose	Collisions involving HAZMAT require special handling; responders do not always know the contents of involved vehicles.	Provide means to collect and distribute cargo information to first responders.	In the case of an incident, provide information so that responders can react appropriately for potentially dangerous, HAZMAT cargos.
270		Workshop	San Jose	Roadway throughput is negatively affected by lots of "stop and start" actions by vehicles.	Provide signal timing state information to vehicles.	To support better route guidance, optimal speeds along corridors.
271		Workshop	San Jose	Potentially hazardous road characteristics lead to accidents.	Provide nearby roadway characteristics information to vehicles.	To inform vehicles and thereby decrease the chances of an accident.
272		Workshop	San Jose	Potentially hazardous road conditions lead to accidents.	Provide nearby road condition information from vehicles to other vehicles.	To inform vehicles and thereby decrease the chances of an accident.
273		Workshop	San Jose		Provide a means to provide dynamic local information such as parking zone, enforcement hours, speed zones, intersection layouts etc. to vehicles.	Provide intersection layout, parking zone, enforcement hours, speed zones
274		Workshop	San Jose		Transit vehicle priority	
275		Workshop	San Jose		Emergency vehicle preemption	
276		Workshop	San Jose		Provide road weather conditions to vehicles	
277		Workshop	San Jose		Provide information from external non-ITS sources e.g., differential GPS corrections, timing) to vehicles.	Distribute GPS differential corrections
278		Workshop	San Jose	Determining optimal pricing for HOT lanes requires accurate real time traffic data.	Provide speed and road lane location information to aid in determining optimal pricing for HOT lanes.	Condition pricing
279		Workshop	San Jose	Collisions between vehicles and infrastructure.	Provide warning to vehicle that it is in danger of colliding with infrastructure.	
280		Workshop	San Jose	Collisions in congested conditions trigger other collisions.	Provide warnings to surrounding vehicles of a collision imminent in their area.	
281		Workshop	San Jose		Provide "train approaching" advisory at RR grade crossings.	
282		Workshop	San Jose	Collisions in congested conditions trigger other collisions.	Provide warnings to surrounding vehicles of an incident or collision imminent in their area.	Provide "high speed vehicle potential collision alert"
283		Workshop	San Jose	A disabled vehicle may be in an area where it is outside of communications range to infrastructure.	Provide vehicle-to-vehicle communications relay.	To enable to the relay of critical disabled vehicle information.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
284		Workshop	San Jose		Guide high speed vehicle chase targets.	Funnel vehicle to a location to minimize impact.
285		Workshop	San Jose		Provide traffic signal state to vehicles.	Enable red-light violation pre-warning.
286		Workshop	San Jose	Red lights increase emissions.	Provide traffic signal state to vehicles.	To enable engine management to reduce emissions if the signal is red for an extended period.
287		Workshop	San Jose		Collect time and location of intersection violations and provide to archive for later analysis.	Use data on intersection violations to support cost benefit analysis of adding equipment to that intersection.
288		Workshop	San Jose		Provide physical restriction information (height, weight, HAZMAT, etc.) to vehicles prior to final decision point.	Identify weight, height and width restrictions on tunnels and bridges.
289		Workshop	San Jose		Provide parking space availability and location to vehicles in advance of their arrival.	Safety and mobility improvements as drivers avoid frustration; also incentivize mode shifting.
290		Workshop	San Jose		Broadcast the number of seats available on transit vehicles to vehicles approaching a mode shift decision point.	Incentivize mode shifts
291		Workshop	San Jose		Various commercial broadcasts	Advertising
292		Workshop	San Jose		Traveler information broadcasts - travel time for various modes.	To enable informed decision making.
293		Workshop	San Jose		Provide means to communicate back to pedestrians.	To notify of walkway closures, escalators and the like.
294		Workshop	San Jose		Provide an advertising mechanism	
295		Workshop	San Jose	There is insufficient vehicle usage information to help vehicle manufacturers profile and target their vehicle users.	Provide a means for vehicle manufacturers to gain information on how the vehicle is being used.	Vehicle manufacturers: Aggregate driver behavior information, profile users and target marketing.
296		Workshop	San Jose	There is insufficient vehicle usage information to help insurance companies to profile and target their vehicle users.	Provide a means for insurance companies to gain information on how the vehicle is being used.	Insurance companies: Aggregate driver behavior information for insurance purposes
297		Workshop	San Jose	There is currently no means to determine the number of occupants in a vehicle	Provide a means to detect the number of vehicle occupants	In support of roadway planning
298		Workshop	San Jose	There is no way to monitor safe transit vehicle operator behavior	Provide monitoring information regarding unsafe transit vehicle operators behavior	Record and monitor transit vehicle operator behavior
299		Workshop	San Jose	There is no way to monitor transit vehicle operator behavior for training purposes	Provide monitoring information regarding transit vehicle operators behavior for training purposes	Training assistance for transit operators in training
300		Workshop	San Jose	Remote physical monitoring of transit vehicles requires motion video transmission, requiring bandwidth not available with current transit systems.	Provide means for getting video from transit/fleet vehicles back to operations center.	Upon detection of a dangerous situation, activate camera.
301		Workshop	San Jose	There currently is no way to monitor and transmit transit parking information	Provide a means to determine transit vehicle parking availability	Monitor transit capacity
302		Workshop	San Jose	There currently is no way to monitor and transmit transit vehicle health	Provide a means to monitor and transmit transit vehicle health	Monitor transit vehicle health
303		Workshop	San Jose	There could be a more comprehensive way to perform wireless roadside inspections and WIM	Provide a means to collect wireless comprehensive roadside inspection information including WIM	Wireless roadside inspection/WIM
304		Workshop	San Jose	There could be a more comprehensive way to perform commercial vehicle driver credential screening	Provide a means to collect wireless comprehensive commercial vehicle driver credential information	Driver Credential screening

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
305		Workshop	San Jose			Mobile inspection
306		Workshop	San Jose	There could be a more comprehensive way to perform commercial vehicle carrier screening	Provide a means to collect wireless comprehensive commercial vehicle carrier information	Provide carrier/drive info about their vehicles
307		Workshop	San Jose	Driver distraction is a leading cause of accidents.	Provide some means for detecting distracted drivers.	Detect and avoid driver distraction
308		Workshop	San Jose	Commercial vehicles are unfamiliar with route restrictions and choices	Provide tailored route guidance to commercial vehicles for safe and efficient travel	Provide guidance to ensure that commercial vehicle operators do not take their vehicles into places they shouldn't
309		Workshop	San Jose	Specific containers are difficult to locate and determining their secure status	Provide a means to collect container location and status information	Secure monitoring of containers
310		Workshop	San Jose	Commercial vehicles need better fuel and lodging options	Provide commercial vehicle fuel and lodging location information	Location-based fuel and lodging
311		Workshop	San Jose	Commercial vehicles cannot easily determine parking options when their shift is about over	Provide commercial vehicle parking location and availability options	Parking monitoring
312		Workshop	San Jose	Commercial vehicles cannot easily make parking reservations	Provide a means to communicate commercial vehicle parking reservations	Parking reservations
313		Workshop	San Jose	Heavy vehicles cannot be easily identified by type of vehicle in order to determine unique sensor data characteristics	Provide a means to communicate heavy vehicle type and characteristics	Track types of data customized to type of HV
314		Workshop	San Jose	Commercial vehicles need more efficient border crossings	Provide a means to exchange commercial vehicle information for border clearance	Commercial vehicle border crossing information
315		Workshop	San Jose	Some road usage pricing systems cannot distinguish vehicle classes and charges the same for all	Provide a means to collect and transmit vehicle type including number of axles	Support fairer road impact pricing by collecting vehicle type and #axles
316		Workshop	San Jose	Some road usage pricing systems cannot determine vehicle route	Provide a means to collect and transmit vehicle route information	Universal tolling, VMT bill, shorter trip fee
317		Workshop	San Jose		Provide a means to communicate secure payment transactions	E-payment
318		Workshop	San Jose	Some road usage pricing systems cannot distinguish vehicle type and vehicle occupancy in order to determine charge	Provide a means to collect and transmit vehicle type and occupancy and provide payment transaction	HOT/HOV pay for ridership
319		Workshop	San Jose	Transit vehicles could improve their routes if more information was available	Provide a means to collect store transit vehicle route information to determine optimum routing	Improved vehicle routing
320		Workshop	San Jose	Lack of transit vehicles passenger count data	Provide a means to collect store transit vehicle passenger count data	Passenger count
321		Workshop	San Jose	Remote physical monitoring of transit vehicles requires motion video transmission, requiring bandwidth not available with current transit systems.	Provide sufficient capacity to provide full motion video.	Remote monitoring of physical state of vehicle
322		Workshop	San Jose			Bus operations and maintenance monitoring
323		Workshop	San Jose			Driver performance monitoring
324		Workshop	San Jose		Provide a secure exchange mechanism to exchange tasking information between transit, rail vehicles and transit management centers.	Multi-modal tasking
325		Workshop	San Jose	Fixed bus schedules are regimented an inflexible, making them inefficient.	Provide for the exchange of pickup requests and transit stop occupancy between riders, transit stops and buses.	To enable flexible fixed routing, increasing bus efficiency and lowering emissions.
326		Workshop	San Jose	Scheduling a trip that requires mode shifts is difficult.	Provide secure information exchange between potential travelers and multimodal trip planners.	Full itinerary preparation and payment

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
327		Workshop	San Jose		Provide a secure information mechanism to exchange maintenance, operational data between transit vehicles and transit management centers.	Assorted transit vehicle data download
328		Workshop	San Jose		Provide secure information exchange between PDAs and transit vehicles, transit management.	Bus or paratransit vehicle requests or reservation from potential passengers.
329		Workshop	San Jose	Paying for transit fair slows bus loading.	Provide means to facilitate payments for transit vehicle riders.	Reducing payment time will decrease loading time which will increase net passenger throughput.
330		Workshop	San Jose	The services we want to provide require constant connectivity.	Ubiquitous communications coverage	
331		Workshop	San Jose		Provide for a secure exchange of information between a CV and freight management.	For reload requests, to reduce deadheading.
332		Workshop	San Jose			Parking reservations
333		Workshop	San Jose	HV mechanical failures can take a long time to properly respond to.	Communications (not necessarily high speed) over all CV routes.	Knowing details about a vehicle failure will enable more efficient dispatch of repair vehicles.
334		Workshop	San Jose	Permit process takes trucks out of service and puts them in line.		Permit granting and revocation
335		Workshop	San Jose	Vehicles don't yield to pedestrians in crosswalks.	Provide a means for identifying offending vehicles.	This information could be used in [punitive or informative] ways to improve pedestrian safety.
336		Workshop	San Jose	Pedestrians and vehicles interact often, and inattentive pedestrians or vehicle operators may collide.	Provide collision alerts to pedestrians of vehicles that may hit them.	
337		Workshop	San Jose	Bike-specific features such as stands, parking areas and blockages are not monitored by traditional traffic monitoring.	Provide a means for cyclists to provide bike path information to service providers.	Allowing cyclists to identify bike stands, parking areas, blockages.
338		Workshop	San Jose	Bike paths are "captive" routes, and an incident blocking the path may cause a severe disruption for cyclists.	Provide for the exchange of bike path incident information between service providers and cyclists.	Incident notification on bike paths
339		Workshop	San Jose	Mode shifting and slugging require coordination between traveler and 3rd parties that is not well facilitated today.	Provide for the exchange of ride sharing and mode shift information between travelers and ISPs, transit centers.	multi-modal and mode shifting assistance (slugging)
340		Workshop	San Jose	Internet services are required to access some services.	Provide access to Internet services.	Surf the web, read e-mail etc.
341		Workshop	San Jose	Ride sharing absent trust between participants would benefit from independent assessment of the character of participating individuals.	Provide secure transactional links between prospective ride-sharers and 3rd party verification providers.	
342		Workshop	San Jose	Bike parking locations are not well marked, resulting in cyclists searching for places to securely store their vehicle.	Provide information exchange between data stores that identify bike storage locations and risk and cyclists.	Bike rack location and risk
343		Workshop	San Jose	Bike-route selection should take into account different factors than vehicle route selection.	Provide information exchange between route providers and cyclists.	Bike-specific navigation
344		Workshop	San Jose	Cyclists are affected by signals to a more significant degree than vehicles, being unable to trigger actuation and still having to abide by rules, and being more incentivized to maintain a constant speed.	Provide the real-time status of signal timings to cyclists in the area.	Signal timing status to help cyclists choose routes

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
345		Workshop	San Jose	Large groups of cyclists have different performance characteristics than similar groups of vehicles, but have to follow the same signalization rules.	Provide signal preemption, priority and dynamic retiming support for signals seeing a high concentration of cyclists	
346		Workshop	San Jose		Remote request for ped signals	
347		Workshop	San Jose	Signals operate on static or actuated patterns that do not respond well to dynamic conditions, increasing congestion.	Provide more advanced (upstream) traffic condition information to signals to enable dynamic signal control.	
348		Workshop	San Jose	Transportation charges are small fees often paid by cash or change, which require physical exchange, slowing down traffic.	Facilitate the exchange of information to support micropayments.	
349		Workshop	San Jose	Different systems may use different communications media for the same application.	Coordinate the exchange of information between various communications mechanisms (3G, DSRC etc.)	
350		Document	Final Report: VII POC Tech Desc - Veh		Provide for infrastructure initiated safety applications	VII Viability Criteria
351		Document	Final Report: VII POC Tech Desc - Veh		Support vehicle initiated safety applications	VII Viability Criteria
352		Document	Final Report: VII POC Tech Desc - Veh		Provide for collection of various mobility data from vehicles	VII Viability Criteria
353		Document	Final Report: VII POC Tech Desc - Veh		Provide for use of collected mobility data by state and local authorities	VII Viability Criteria
354		Document	Final Report: VII POC Tech Desc - Veh		Exhibit sufficient benefit in terms of road and traffic management and transportation efficiency	VII Viability Criteria
355		Document	Final Report: VII POC Tech Desc - Veh		Vehicles can access private services through the system	VII Viability Criteria
356		Document	Final Report: VII POC Tech Desc - Veh		Private services can access vehicles through the system	VII Viability Criteria
357		Document	Final Report: VII POC Tech Desc - Veh		Co-existence of private services with safety and mobility services is economically viable	VII Viability Criteria

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
358		Document	Final Report: VII POC Tech Desc - Veh		Private services can be implemented in a manner that does not interfere with safety and mobility applications	VII Viability Criteria
359		Document	Final Report: VII POC Tech Desc - Veh		System is resistant to denial of service, replay and intrusion attacks	VII Viability Criteria
360		Document	Final Report: VII POC Tech Desc - Veh		Security compromises can be identified and mitigated	VII Viability Criteria
361		Document	Final Report: VII POC Tech Desc - Veh		Security credentials can be properly distributed and managed at all levels of deployment	VII Viability Criteria
362		Document	Final Report: VII POC Tech Desc - Veh		Roadside Equipment software can be remotely managed through the network	VII Viability Criteria
363		Document	Final Report: VII POC Tech Desc - Veh		VII-related vehicle software can be securely maintained over the vehicle life cycle	VII Viability Criteria
364		Document	Final Report: VII POC Tech Desc - Veh		Cannot track and individual vehicle over any road segment longer than 2 km	VII Viability Criteria
365		Document	Final Report: VII POC Tech Desc - Veh		Cannot identify any individual vehicle as violating a traffic law through publicly collected data	VII Viability Criteria
366		Document	Final Report: VII POC Tech Desc - Veh		Cannot identify a vehicle or vehicle occupant or owner from messages sent to, or through, the infrastructure	VII Viability Criteria
367		1-on-1	Owosso Tour		Data should not be used for law enforcement.	Hearsay: "Owosso citizens"
368		1-on-1	Owosso Tour		Anonymity is preserved	
369		1-on-1	Owosso Tour		Younger citizens do not care about anonymity	
370		1-on-1	Owosso Tour		Need to pre-empt traffic signals to enable better traffic flow	
371		1-on-1	Owosso Tour		Need to provide a mechanism to record vehicle miles in support of mileage-based user fees	
372		1-on-1	Owosso Tour		This system should be built by people local to its deployment.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
373		1-on-1	Owosso Tour		This system should provide benefit to safety and mobility at intersections without requiring new signal controllers	
374		1-on-1	Owosso Tour		Mobility improvements must be sufficient that users are willing to pay for them.	
375		1-on-1	VIIC		The Vehicle must not be inside the System	
376		1-on-1	VII Testbed		The maintenance concept should not require taking infrastructure out of service for extensive periods.	
377		1-on-1	VII Testbed, BAH meeting, Noblis Security Briefing		Security must be integral to the system concept	
378		1-on-1	VII Testbed		The maintenance concept should not require more personnel than …. WHAT?	
379		Document	VII ConOps V1.2		Need to improve vehicle safety margins.	
380		Document	VII ConOps V1.2		Support V2V safety applications	
381		Document	VII ConOps V1.2		Provide communications from DHS (FEMA) to drivers in case of natural disasters and security incidents.	
382		Document	VII ConOps V1.2		Provide comprehensive traffic flow information to TMCs to enable global optimization of traffic flow.	
383		Document	VII ConOps V1.2		Provide comprehensive weather information to TMCs to enable global optimization of traffic flow.	
384		Document	VII ConOps V1.2		Provide communications from vehicle to infrastructure necessary to process toll payments, enabling over-the-road tolling, congestion pricing, high-occupancy tolling	
385		Document	VII ConOps V1.2		Provide information and communications necessary to support localized safety improvements	
386		Document	VII ConOps V1.2		Provide means for pre-empting signals for qualified vehicles.	
387		Document	VII ConOps V1.2		Provide means for prioritizing different vehicles at traffic signals.	
388		Document	VII ConOps V1.2		Provide means for monitoring physical state of roadways.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
389		Document	VII ConOps V1.2		Provide increased traffic information to support the planning process.	
390		Document	VII ConOps V1.2		Provide tracking of transit vehicles.	
391		Document	VII ConOps V1.2		Provide mechanism for monitoring maintenance health of transit vehicles.	
392		Document	VII ConOps V1.2		Provide mechanism to improve safety and security of transit customers.	
393		Document	VII ConOps V1.2		Monitor transit vehicles and provide timely arrival information.	
394		Document	VII ConOps V1.2		Monitor transit usage patterns to enable better service planning.	
395		Document	VII ConOps V1.2		Provide emergency information to PSAPs in case of emergency to enable more timely emergency response.	
396		Document	VII ConOps V1.2		Provide information to support air quality analysis, chiefly to MPOs.	
397		Document	VII ConOps V1.2		Provide traffic data to support highway performance monitoring by MPOs.	
398		Document	VII ConOps V1.2		Provide crash data to enable crash data analysis by MPOs.	
399		Document	VII ConOps V1.2		Provide traffic pattern data to enable modeling and transportation planning by MPOs.	
400		Document	VII ConOps V1.2		Provide real-time vehicle data to OEMs to help them improve service and reduce warranty costs.	
401		Document	VII ConOps V1.2		Provide mechanisms for OEMs to interact directly with customer to improve customer relationships.	
402		Document	VII ConOps V1.2		Provide mechanism to track fleet vehicles	
403		Document	VII ConOps V1.2		Provide mechanisms to monitor maintenance status of vehicles in real time.	
404		Document	VII ConOps V1.2		Provide traffic and weather data.	To improve fleet dispatch

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
405		Document	VII ConOps V1.2		Reduce inspection requirements on commercial vehicles, presumably through electronic clearance.	
406		Document	VII ConOps V1.2		Provide new communications mechanisms enabling tolling agencies to dispense with toll tags.	Reduce toll operating costs, improve toll-related driver convenience
407		Document	VII ConOps V1.2		Provide mechanisms to enable open-road tolling, congestion pricing and HOT lanes	Reduce toll operating costs, improve toll-related driver convenience
408		Document	VII ConOps V1.2		Reduce toll operating costs	
409		Document	VII ConOps V1.2		Improve toll-related driver convenience.	
410		Document	VII ConOps V1.2		Need to increase throughput at fueling stations.	
411		Document	VII ConOps V1.2		Need to provide increased driver convenience at fueling stations.	
412		Document	VII ConOps V1.2		Need to reduce fueling station operations costs.	
413		Document	VII ConOps V1.2		Need to provide increased throughput at parking facilities	
414		Document	VII ConOps V1.2		Need to provide increased driver convenience at parking facilities	
415		Document	VII ConOps V1.2		Need to reduce parking facility operations costs	
416		Document	VII ConOps V1.2		Need to promote awareness of surrounding retail locations.	
417		Document	VII ConOps V1.2		Need to minimize the amount of time transit vehicles are slowed or stopped by traffic signals.	
418		Document	VII ConOps V1.2		Need to provide more comprehensive traffic data	
419		Document	VII ConOps V1.2		Need to provide more comprehensive weather information	
420		Document	Principles for this DOT Program		Must not compromise safety	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
421		Document	Principles for this DOT Program		Must not compromise security	
422		Document	Principles for this DOT Program		Must protect privacy	
423		Document	VII Day 1 Use Cases		Need to provide traveler information customized to the real-time performance of a traveler's journey.	
424		Document	VII Day 1 Use Cases		Need to enable the dynamic modification of ramp metering rates in response to traffic conditions.	
425		Document	VII Day 1 Use Cases		Need to improve throughput of signalized intersections.	
426		Document	VII Day 1 Use Cases		Need to improve the accuracy of, and reduce the information gathering costs of the planning process.	
427		Document	VII Day 1 Use Cases		Need to improve the distribution of vehicles among parallel routes.	
428		Document	VII Day 1 Use Cases		Need to improve detection of weather-impacted road conditions.	
429		Document	VII Day 1 Use Cases		Need to improve resolution and characterization of treatments on roadways.	
430		Document	VII Day 1 Use Cases		Need to improve detection of physical conditions of roadways (potholes, cracked pavement, etc.).	
431		Document	VII Day 1 Use Cases		Need to provide relevant road weather condition information to travelers.	
432		Document	VII Day 1 Use Cases		Need to improve granularity, precision and accuracy of road weather conditions.	
433		Document	VII Day 1 Use Cases		Need to support fixed fee tolls.	
434		Document	VII Day 1 Use Cases		Need to support variable fee tolls based on distance traveled.	
435		Document	VII Day 1 Use Cases		Need to support service-based tolls such as HOT lanes	
436		Document	Final Report - VII POC Vol 2b - Infra		Need to provide broadcast messages from back office facilities to automobiles in specific geographic areas.	
437		Document	Final Report - VII POC Vol 2b - Infra		Need to provide broadcast messages from roadside infrastructure to automobiles.	
438		Document	Final Report - VII POC Vol 2b - Infra		Need to provide broadcast messages between automobiles.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
439		Document	Final Report - VII POC Vol 2b - Infra		Need to distribute topical information from automobiles to back office users.	
440		Document	Final Report - VII POC Vol 2b - Infra		Need to assure anonymity of users when those users use services not requiring individual identification	
441		Document	Final Report - VII POC Vol 2b - Infra		Need to provide opaque transmission of sensitive data through the system, such that transmitter and end receiver can read information, but no place in between can.	
442		Document	Final Report - VII POC Vol 2b - Infra		Need to ensure the authenticity of transmitted messages.	
443		Document	Final Report - VII POC Vol 2b - Infra		Need to be resistant to denial-of-service attacks	Doesn't call out DoS here, but it is mentioned elsewhere
444		Document	Final Report - VII POC Vol 2b - Infra		Need to be able to identify and terminate a severe attack on the system.	
445		Document	VII POC Apps ConOps V1.4		Need to provide road and traffic condition information (including travel times, incidents, road closures, work zones) that may affect trips to travelers.	
446		Document	VII POC Apps ConOps V1.4		Need to provide mechanisms enabling vehicles to present locally relevant signage and legal information to vehicle drivers and occupants.	
447		Document	VII POC Apps ConOps V1.4		Need to provide routing directions to vehicle operators, with routes distributing traffic to provide best use of the roadway network.	
448		Document	VII POC Apps ConOps V1.4		Need to provide mechanisms for paying for parking depending on vehicle location and vehicle type.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
449		Document	VII POC Apps ConOps V1.4		Need to provide mechanism to pay for gasoline depending on vehicle location and fuel type.	
450		Document	VII POC Apps ConOps V1.4		Need to provide mechanisms to pay roadway tolls depending on vehicle location (by lane) and vehicle type.	
451		Document	VII POC Apps ConOps V1.4		Need to measure the effectiveness of signal systems (possibly by measuring queue length, stop locations, stop delay, cycle failures, time and position trajectories, queue overflows, arterial travel time).	
452		Document	VII POC Apps ConOps V1.4		Need to collect the data necessary to improve signal performance (possibly including volumes by lane, turning movements, stops and stop locations, stop delay)	
453		Document	VII POC Apps ConOps V1.4		Need to provide the measures necessary to determine the effectiveness of ramp metering systems (possibly including:	link travel times on adjoining freeways, mainline speed by lane, ramp queue length, delay on ramps and mainline, queue spillback, stops and stop locations on ramps and mainline, stop delay on ramps and mainline, time in queue)
454		Document	VII POC Apps ConOps V1.4		Need to help generate new ramp meter rates (possibly by providing the following measures:	link travel times on adjoining freeways, mainline speed by lane, ramp queue length, queue spillback, stops and stop locations on ramps and mainline, stop delay on ramps and mainline, time in queue)
455		Document	VII POC Apps ConOps V1.4		Need to efficiently determine the location and severity of potholes	
456		Document	VII POC Apps ConOps V1.4		Need to determine ground-level atmospheric conditions	
457		Document	VII POC Apps ConOps V1.4		Need to determine pavement surface conditions, including slickness and moisture covering.	
458		Document	VII POC Apps ConOps V1.4		Need to provide locally relevant weather advisories to vehicle drivers and occupants	
459		Document	VII POC Apps ConOps V1.4		Need to provide the measures necessary to evaluate road network performance (possibly including travel times, volumes, trip paths).	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
460		Document	VII POC Apps ConOps V1.4		Need to help balance the traffic load amongst corridor assets (possibly by providing the following measures:	travel times by link on freeways and arterials, speed profiles by lane on freeways and arterials, volumes on freeways and arterials, stop locations on freeways and arterials, stop delay on freeways and arterials, lane closures on freeways and arterials.
461		Document	VII POC Apps ConOps V1.4		Need to send high-priority messages from one vehicle to another vehicle in a timely fashion (for example, "I'm slamming on the brakes now!" to vehicles in the immediate rear of the speaking vehicle)	
462		Document	VII POC Apps ConOps V1.4		Need to warn vehicle operators of an impending violation of a traffic signal.	
463		Document	VII POC Apps ConOps V1.4		Need to warn vehicle operators of an impending violation of an unsignalized intersection.	
464		Document	VII POC Apps ConOps V1.4		Need to warn vehicle operators of a potential safety event (lane departure, rollover) due to a combination of vehicle speed and roadway geometry.	
465		Document	Final Report - VII POC Vol 3b		Need to protect against malicious intrusion	
466		Document	Final Report - VII POC Vol 3b		Need to ensure the anonymity of users	
467		Document	Final Report - VII POC Vol 3b		Need to maintain the privacy of users	
468		Document	Final Report - VII POC Vol 3b		Need to provide anonymous probe data from vehicles to data consumers	
469		Document	Final Report - VII POC Vol 3b		Need to provide TOC advisory messages to vehicles in targeted geographic locations	
470		Document	Final Report - VII POC Vol 3b		Need to provide communications between vehicles and remote network servers (TOCs)	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
471		Document	Final Report - VII POC Vol 3b		Need to provide communications between signal controllers and vehicles	
472		Document	Final Report - VII POC Vol 3b		Need to provide communications between signal controllers and remote network servers (TOCs)	
473		Document	Final Report - VII POC Vol 3b		Need to provide authentication of messages exchanged between vehicles and signal controllers	
474		Document	Final Report - VII POC Vol 3b		Need to provide authentication of messages exchanged between vehicles and remote network servers	
475		Document	Final Report - VII POC Vol 3b		Need to provide authentication of messages exchanged between vehicles	
476		Document	Final Report - VII POC Vol 3b		Need to provide heartbeat messages to enable safety applications by improving situational awareness between vehicles	
477		Document	Final Report - VII POC Vol 3b		Need to generate and distribute localized micro maps containing detailed roadway geometries for intersections and roadway segments.	
478		Document	Final Report - VII POC Vol 3b		Need to provide position correction data to vehicles	
479		Document	Final Report - VII POC Vol 3b		Need to remotely provision and manage roadside equipment from a central platform	
480		1-on-1	AERIS		Monitor auto exhaust at all times, particularly on Code Red Days	
481		1-on-1	CVO		Heavy vehicle needs to share its characteristics with the roadside.	
482		1-on-1	CVO		Roadside needs to share heavy vehicle characteristics with centers.	
483		1-on-1	CVO		Trucks need to be interoperable with other vehicles	
484		1-on-1	Policy		Privacy framework needs to be preserved	2 OEMs will walk away if it isn't
485		1-on-1	Standards		V2V needs to supplement infrastructure.	Provide increased range in areas of low deployment
486		1-on-1	Transit		Transit vehicles need more communications bandwidth than they have today.	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
487		1-on-1	Transit		Transit vehicles need reduced communications latency versus what they have today.	
488		1-on-1	Transit		Transit vehicles need operator-initiated video transmission from bus to center.	To support safety and protect against litigation.
489		1-on-1	Transit		Needs the ability to know how many passengers are on each bus, both at the bus and the center.	
490		1-on-1	Transit		Real-time bus fare transactions.	
491		1-on-1	Transit		Need the ability to provide bus operational characteristics (health, emissions) to the center.	
492		1-on-1	Transit		Provide transit information, such as available services, bike rack and disabled equipment status, to travelers in real time	
493		1-on-1	Transit		Provide a means to tell cyclists when a bus is nearby.	
494		1-on-1	Transit		Provide a means to tell pedestrians when a bus is nearby.	
495		1-on-1	Transit		Paratransit needs to be able to have guaranteed real-time communication of route and person to pick up.	In case of emergency evocation for people with special needs.
496		1-on-1	Weather		Centers need to obtain road surface conditions that affect vehicle safety.	
497		1-on-1	Weather		Provide the facilities to enable weather-responsive traffic management strategies	
498		1-on-1	Weather		Get weather data into traffic signal controllers	
499		Workshop	DC	How to get municipalities on board? Municipalities own equipment and right of way over deployed equipment. Mayor controls when lights turn red/green. How will this system work with them? Too many controllers who do not have capacity to manage the systems. Understaffed. Neighboring municipalities may not work in a consistent manner. Incompatibilities. How will this program address this issue? Standards and governance model.	Standards for Interfaces, Accommodate variations Governance Structure	Accommodate variations while maintaining common interfaces will increase deployability and support cross jurisdictional services.
500		Workshop	DC	How to get municipalities on board? Municipalities own equipment and right of way over deployed equipment. Mayor controls when lights turn red/green. How will this system work with them? Too many controllers who do not have capacity to manage the systems. Understaffed. Neighboring municipalities may not work in a consistent manner. Incompatibilities. How will this program address this issue? Standards and governance model.	Governance Structure	Well defined governance structure will support cross jurisdictional services.
501		Workshop	DC	Incompatible time references create problems with coordinating signal timing	Need to reference common time stamp/source - common reference point - known reference point	To be able to accurately locate where vehicle is to safely operate systems

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
502		Workshop	DC	The privacy issue may be a barrier to deployment	Need to ensure Privacy unless they "opt-in" for services & ability to opt-out. If a device like cell phone is docked what happens to privacy - Do Carry-in devices have same anonymity requirements	Separating services by opting-in, and keeping mobility and safety distinct may help eliminate barriers to deployment
503		Workshop	DC	BRT does not have accurate position data on its fleet, which may result in bunching; reduces bus ridership.	Accurate position data on BRT fleet	To maintain headway/spacing or avoiding bunching. Attractiveness of use if reliable, on time. 40% increase in bus ridership. Shared lines with traffic need signaling priority
504		Workshop	DC	Transit data available is not open, preventing transit data use.	Make transit data available open	Enable other applications being built around this data
505		Workshop	DC	Metro station parking lot availability is not known in time to make a decision.	Need to disseminate parking lot availability at metro stations in time to make a decision	Enable saving time and money
506		Workshop	DC	Distraction to drivers causing safety issues	Eliminate/Minimize distraction to driver	keep users safe (human factor/ research) Opportunities for Apps - know destination - redirect info flow
507		Workshop	DC	Data starvation since Fixed RWIS/ESS are spaced every 30 miles	Maintenance Decision Support Systems needs to know current road weather condition as it passes through roadway net - Thermal Maps of roads to identify which roads need to be treated - direct temp - indirect traction control	reduce cost, chemicals & labor reduce environmental Impact create safer roads variable speed based on conditions prioritize by needs
508		Workshop	DC	Data not available that can assist with maintenance work	Need data from vehicles like vibrations, traction for other maintenance apps (bridges, potholes) consider sending data only when certain criteria met	Identify maintenance issues before it turns out to be a problem chip sealing needs to be performed at specific temperatures similarly, stripe painting
509		Workshop	DC		Transit, para, van pools need std. data from vehicle, trip, mile; passenger types	Support federal reporting rqmts. Reimbursement by passenger Tap into vehicle info comm capability Build stds. Messages Improve accuracy, reporting Reduce admin cost
510		Workshop	DC	CVs require multiple tags Prevents people from using electronic payment Cost of collection goes up Less environment friendly	Need national interoperability stds.	So customers (especially CVs) don't have to have multiple tags increase # of people using electronic payment reduce cost to collect greener - # of people
511		Workshop	DC	Need to be able to inform the traveler of alternate routes. But most passengers are not willing to take alternate routes	Real time road condition data	Access to real time data Information stds. Reduce cost vs. DMS Generate faith in people who are then willing to take alternate route. Saves time etc.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
512		Workshop	DC	Code Red Air Quality Day	facilitate making green choices Encourage mode shifts	Use its real-time data, Comms. Need ID to support mitigation response plan - Traffic signal timing - Transit Priority - Bus Rapid Transit - Vary speed limits; inform drivers - Measure effectiveness (Integrate with other sources)
513		Workshop	DC	Congestion at the border crossing to perform inspection (example was given for US/Canada prescreening)	I need to expedite the process of border crossing to avoid congestion. To do this, I need to know the border wait times (forecast + current wait time information) to make a decision on which border crossing to choose (least congestion); need to send credential/ manifest info to border prior to arrival at the chosen border crossing	If this program could provide interoperability regarding truck tags, information could more readily be transferred at the border to match with credentials and load
514		Workshop	DC	We don't have a way to track the truck stops, pickups, waits, etc. prior to border crossing to present to border inspection agent	Border inspection agent needs information about all truck stops, pickups, waits prior to arriving at the border for clearance approval	This program would provide information about truck activities (truck stops, pickups, waits) prior to border crossing for assessment by border inspection
515		Workshop	DC	I don't have a good way of sharing information collected about a commercial vehicle driver's hours of service with Enforcement Agencies	I want to have an efficient, secure means of providing driver hours of service, distance traveled, and vehicle type to Enforcement agency , eventually at highway speeds.	This program could provide standard communication of driver information to the Enforcement community; bridge information exchange void between fleet operators and enforcement officer; exchange latency dependent on application but the system can support low or high latency requirements.
516		Workshop	DC	Commercial vehicle driver service time affects how a fleet manager can make load assignments, and we don't have an effective means of determining the service time.	I need driver hours of service, vehicle type, location; secure linkage required	This system would enable vehicle to center communications for any carrier including real-time location and service hours for load scheduling
517		Workshop	DC	Emergency vehicles trying to get to incident being blocked by vehicles that are not aware of their operation; lack of driver situational awareness	We need to make vehicles aware of emergency vehicle (EV) location/route and incident location; we need to minimize EV conflict with other vehicles	This system would provide EM vehicle location, route, incident location to vehicles along route to aid drivers in making decisions about clearing route for EM vehicle; alert all drivers in area of conditions to avoid area and provide alternate routes; provide signal timing alternatives to offload area congestion; communicate same information to other mobile users (peds, bicycle, motorcyclists)
518		Workshop	DC	Vehicle drivers are not aware of cyclists	I need to make vehicle drivers aware of bicycle	This system would provide bicycle location to vehicles in their immediate area to make them aware of their presence
519		Workshop	DC	There is so much information that we have a problem with presenting the information to the driver in real time in a useful manner	We need to provide incoming information hierarchy; contextual labeling of information; need to reconcile conflicting priorities (speed, location, instructions, etc.)	Standards should include data priorities on interface data at application and communications stack; more priority detail may be needed in SAE 2735; this is likely an application issue

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
520		Workshop	DC	Commercial vehicles, transit vehicles, and tailored vehicles (vehicle towing a camper) vary in size and characteristics (articulation angles) and that information is not known (combination vehicles - multiple trailers)	I want vehicle configuration information to properly support safety applications vehicle length, height, width, articulation (multiple trailers/ components)	Standards should provide standards that guide accurate location information with respect to vehicle configuration
521		Workshop	DC	Our vehicle fleet is inefficiently distributed at the end of the week (Avis moves 1000s of vehicles a day); I need to find the most efficient way to align supply of vehicles (taking into consideration the maintenance needs of the vehicle) with demand.	I need efficient routes to redistribute my vehicles, vehicle locations, traffic conditions/tolls; vehicle demand locations; vehicle tracking; vehicle performance /maintenance status/vitals at origin/destination/enroute (mileage, maintenance requirements, failures); Driver behavior (hard braking, acceleration)	There should be a communications mechanism between vehicle fleet and fleet operations for traffic information, tolls, vehicle locations, traffic conditions; vehicle demand locations; vehicle tracking; vehicle performance/maintenance status/vitals (mileage, maintenance requirements, failures) as input to tune route determination algorithm
522		Workshop	DC	Our rental car drivers are unfamiliar with environment (new city)	We need to be able to provide our rental car drivers with traveler information; real time traffic data including congestion, routing, weather, and aggregation of this information from various sources	There should communications standards supporting ubiquitous coverage of traveler information, including aggregation of that information
523		Workshop	DC	I need a secure way to exchange information with my fleet within my organization (in addition to inter-organization exchanges)	Fleet managers need a direct means to communicate with their vehicles.	There should be standards that support secure, intra-organization information exchange
524		Workshop	DC	There is too much stopping and starting which leads to turbulent flow of traffic	I need signal timing information (when is the light going to change), cooperative signal information	There should be standards that support the provision of signal timing information
525		Workshop	DC	Signal priority is afforded inefficiently	I need to know the real-time passenger occupancy of the transit vehicle, transit vehicle schedule adherence, and signal phase signal status so that I can grant signal priority only to transit vehicles with a minimum number of passengers to offset the impact on traffic signal timing changes	The system should accommodate passenger and schedule adherence information from transit in a standard format as well as real-time traffic conditions to support an informed, real-time signal priority decision
526		Workshop	DC	Without a video feed from a transit vehicle, it is difficult for a management center to manage an on-vehicle transit security incident	I need to transmit on-board video "on-demand" to a management center for proper response; this should occur at stops and while in-transit	The system can provide communications mechanisms for high bandwidth video data on a high priority basis (at stops and in-transit)
527		Workshop	DC	It is difficult to respond to a large scale incident without integration of data/video from various organizations e.g., emergency management, government (defense)	During large scale incidents, I need a way to communicate with various agencies using common data and imagery formats	The program should provide data exchange standards that support interagency communications for response to large scale incidents
528		Workshop	DC	The emergency management (EM) community has difficulty establishing networks at an incident scene to properly coordinate their efforts	I need the ability to set up networks with a limited set of agencies, on an ad hoc basis	The program should provide the capability to accommodate private data exchanges for EM response on networks established on an ad hoc basis
529		Workshop	DC	I do not know the length of the queue line at a traffic signal. Data is not available real-time, thus bottlenecks may occur.	Need relevant queue information.	The system can provide queue data and traffic signal management.
530		Workshop	DC	I currently receive multiple sources of data for traffic management, but have no effective way to analyze it.	Need to capture/extract meaningful and relevant data.	The system can provide data.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
531		Workshop	DC	As population grows in certain areas, I don't have travel pattern data to effectively plan and build roads. I need driveway to driveway type data.	Need O/D data, congestion accident information. Need meaningful data to build sidewalks, roads, traffic signals, additional lanes, etc	Right now, I can only use volunteers to count cars or equip cars with GPS data and track that.
532		Workshop	DC	I do not have access to aggregate transportation data to choose the most effective way to travel (roads, metro, etc). I cannot determine whether the Metro Red Line is on schedule or that Wisconsin Ave is backed up.	Would like a standard data format for all commute mode information.	Data could be aggregated to provide the best decision for travelers. Should this system store this aggregated data? If this system/Gov't does not store that data, then security, standardization and privatization could be an issue. But there are companies that store data effectively (Google, IBM, etc). Is this data associated with "safety of life" issues? If so, then maybe Gov't should take it over.
533		Workshop	DC	The exchange of information is difficult without standard interfaces.	Define the standards for all data stores.	This program includes standards
534		Workshop	DC	I need ubiquitous service for traffic data.	Needs ubiquitous service everywhere.	This system is a single access point to users.
535		Workshop	DC	There is a lack of data for accessibility issues (for mobility, ramps, etc). Includes those with impaired sight and hearing; and age related.	Standardization of data format is needed for transit, walkways, elevators, etc.	No one else will. Constraint with the American Disability Act. This is an issue that this program has to address.
536		Workshop	DC	Dissemination of information all users regardless of cost.	Need to get custom data to users regardless of cost, at some basic level.	It is the Gov't responsibility to provide this data.
537		Workshop	DC	Driver is overwhelmed by information. Driver distraction issue (e.g., sounds, sights).	Need relevant real-time information (adjacent car distances, weather changes, Elk/Deer, etc).	This system can provide relevant data.
538		Workshop	DC	Minor fender benders remain unreported.	Provide information on ALL traffic accidents directly from vehicles to management centers	Current system does not/cannot track minor fender benders.
539		Workshop	DC	It is difficult for drivers to provide input to planners and road managers.	Provide means to securely provide OD information from every vehicle to planning archives.	Increase the breadth of planning data.
540		Workshop	DC	Data is uncharacterized from various sources.	Data from reliable sources are more valued and should be weighted more.	This system COULD provide value to reliable sources versus bad actors.
541		Document	CAMP Security Final Report	There is a possibility that the system will experience malicious attacks or technical defects.	Need to detect misbehavior and remove bad actors as well as malicious and revoked vehicles from the system	
542		Document	CAMP Security Final Report	Entities will not use this program if they cannot trust it and the other entities connected through it	Need to provide proof of identification of entities so they can be authenticated	
543		Document	CAMP Security Final Report	Communication messages can be tampered with	Need to have confidence that the messages have not been tampered with in transit.	
544		Document	CAMP Security Final Report	A trusted or certified vehicle could still start sending spurious (invalid) messages.	Need to have non-repudiation or traceability of the sender for an authority to have proof of wrongful or faulty messages content	

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
545		Document	CAMP Security Final Report	Using a single security authentication record over a large time-span would allow tracking of a vehicle	Each vehicle needs to be loaded with a set of security authentication records that are regularly changed	
546		Document	CAMP Security Final Report	Non-safety applications could interfere with safety applications	Need to ensure that non-safety applications do not interfere with safety applications	
547		Document	CAMP Security Final Report	Various threats will exist against the system	There is a need to provide countermeasures to the threats	
548		Document	CAMP Security Final Report	Entities want to retain their privacy to various levels	Need to provide participating entities with a certain level of privacy	
549		Document	CAMP Security Final Report	Security scheme denies the behaving vehicle of access to transportation services	The security scheme needs to support behaving vehicle mobility.	
550	1	Workshop	San Antonio	There is currently no efficient and accurate way to determine the number of riders on a bus.	Information on the number of riders on a bus would determine the bus route options (dynamic routing) and behavior (signal priority usage or not). Historical data on ridership counts may also be used to help determine what the riders pay for that route.	This system could help determine the ridership counts on buses. It can provide data to analyze and to provide options.
551	2	Workshop	San Antonio	In some Transit Parking lots, there is no way to determine the number of available parking spaces for transit riders or where the available parking spaces are located.	Information on where the available parking spaces are located or if there are no spaces available at all.	Parking lots and ramps can provide data to the vehicle for availability or parking spaces and where they are located.
552	3	Workshop	San Antonio	There is no way to publicize information to others for planning purposes. There needs to be a way to collect lots of transit and mode information.	A means to collect and publicize data.	This system should help to collect this data. This system may or may not store it, but it should be a central focal point to collect it.
553	4	Workshop	San Antonio	Mobility data is typically unavailable because of the current transit "close systems". There is a need for standards, including standard interfaces and open system approach for sharing data.	There is a need for standard interfaces and an open system design for sharing data.	This system should help since it will be based on an open system design with standard interfaces. In addition, this system will likely be the central focal point for collecting data.
554	5	Workshop	San Antonio	If there are no standards, then vehicle manufacturers will do their own thing. Your model/design cannot vary or discriminate from each other.	You would need the OEMs to standardize their HMI designs.	Can this program help here? OEMs will likely work on their own internal HMI designs, but still abide by interface and msg standards.
555	6	Workshop	San Antonio	Different manufacturers will likely produce different type radios, and messages may not be compatible.	Each manufacturer may produce their own radio type, but as a standard, messages and interfaces will be compatible.	This program supports both msg standards and interface standards. As long as the Embedded or After-Market manufacturers abide by those standards, those radios will be interoperable.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
556	7	Workshop	San Antonio	Senior citizens are waiting too long for a bus at a Senior Center.	Utilize the "call and ride" system to divert a bus route to pick up those Senior citizens that are waiting. Provide updated schedule information to the Senior Center of the buses route.	This system can provide optimized dynamic routing for diverted buses. To also provide updated bus schedule information to the Senior Center.
557	8	Workshop	San Antonio	Trains do not provide schedule updates or changes for commuters to be aware of.	Trains need to provide schedule changes and updates.	This system may assist with notifying commuters of train schedule changes.
558	9	Workshop	San Antonio	There are too many pedestrian crosswalk lights that take longer than needed, which affects the traffic signal switching, which impacts traffic flow through that intersection.	Some "fair way" to provide crossing for pedestrians without traffic waiting too long to flow again.	This system could monitor pedestrian crossing and dynamically change the traffic signal when there are no more pedestrians to cross.
559	10	Workshop	San Antonio	Buses are idling way too much and at times are being "queued up" (bunching) behind each other.	Provide vehicle information to inform buses and provide options to avoid queue and idling time.	By providing other vehicle and bus information (e.g., position, time) and signalization, you can avoid bunching and idling. You may not need a command center, the buses would be provided this information and make their own adjustments.
560	11	Workshop	San Antonio	Draw bridges, train crosses, convoys may block traffic flow too frequently and unnecessarily.	Traffic information to provide mobility options.	This is an opportunity to integrate traffic information with other data to optimize traffic flow.
561	12	Workshop	San Antonio	There is not enough information to determine the best route to take.	Traffic and vehicular information	This system should be able to provide this information.
562	13	Workshop	San Antonio	There is currently no way of informing drivers when traffic signals are out (e.g., due to power failure), until they are at that intersection.	Inform drivers of traffic system failures, so that they can choose their routes better.	This system should be able to provide this information to drivers.
563	14	Workshop	San Antonio	There is no way to get enough information of a route for me to choose.	Inform drivers to as much traffic information as possible, so that they can choose their routes better.	This system should be able to provide this information to drivers.
564	15	Workshop	San Antonio	Vehicles are congested, they brake too much, accelerate too fast, which increases pollution.	Provide carbon footprint information to the driver, so they could adjust their driving behavior and speed (assuming they are a good citizen). Maybe an "I smell you" message?	This system could provide this carbon footprint information.
565	16	Workshop	San Antonio	Road usage fee is not fair.	Need usage pricing with a better idea. Pay as you drive pricing is the fairest.	This system could provide this information to local/state entities.
566	17	Workshop	San Antonio	What is my best route?	Multi-modal approach. Need information for options to get to work, How much it costs, how long is it and how much pollution did I make.	This system should be able to provide this information to drivers.
567	18	Workshop	San Antonio	One day a week, I am allowed to telecommute. There is not enough information to determine whether today is my day to telecommute or not.	Traffic, vehicular and mobility information	This system should be able to provide this information to drivers.
568		Workshop	DC	These systems will likely compete with well-established proprietary Transit closed systems.	The Core System architecture should be more open source, open system designed with standards and established secure protocols; and with additional interface capabilities than previous proprietary systems.	Proprietary systems that do not have open interfaces which limit their capability to provide information to all and are likely less secure than standard protocols.
569		Workshop	DC	Wireless devices do not currently have a way to downloaded certificates to provide secure comm interfaces.	There is a need for a Certification Authority (CA) that is centrally managed and controlled.	A centrally managed and controlled CA system would be more efficient and secure.

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
570		Workshop	DC	There are no well-managed evacuation routes and procedures for drivers and pedestrians for hurricanes, flooding and earthquakes.	This program would provide evacuation routes and procedural information to targeting drivers and pedestrian.	For emergency situations, this program provides a means for implementing evacuations for local, state and Federal Gov'ts.
571		Workshop	DC	Transit information is not available to most riders and pedestrians (pedestrians might become riders knowing transit information).	Need to provide Bus ID, GPS, vehicle status, speed, pass counts and pre-payment info.	If Transit data were made available, it would help riders and would provide pedestrians with more information to ride or not.
572		Workshop	DC	Maintenance Decision Support Systems (MDSS) needs additional data for maintenance actions.	MDSS needs to determine best courses of action for snow removal, painting and other maintenance decisions.	MDSS receives partial or inaccurate maintenance information or (in the case of snow removal) data is not real-time. Possible information path: Vehicles and RWIS->NCAR (Vehicle Data Translator - VDT)->Clarus (storage)->State DOT, MDSS
573		Workshop	DC	On Code Red Days, there is no way to provide information to divers to reduce or control emissions.	A need to control the "carbon footprint" for each driver and/or to provide more information to decide on driver options.	This program can enable emissions mitigation response plans to provide a more “green” solution (carbon footprint). This includes speed limits, less braking, slower acceleration and suggestions for better performance. For fleets, in particular, this is a cost savings.
574		Workshop	DC	There is little that can be done to control vehicle emissions.	Federal funding is a way to mandate emissions control, which would force the state and local Gov'ts to take procedures for controlling emissions output.	Cities need to control their pollution levels and this program can help the state and local Gov'ts control emission levels.
575		Workshop	DC	There is insufficient data for travelers with accessibility issues (blind, disabled, seniors, pedestrians) to support their travel experience.	Need to collect data and make it available for travelers with accessibility issues (blind, disabled, seniors, pedestrians).	The disabled user community requires specialized data with which to develop applications to serve their travelers with accessibility needs.
576		Workshop	DC	Real time data that is collected may not be available long enough for users to obtain it.	Need to make collected data available for a short period of time (persistent for enough time for user to obtain it, or for it to be replaced by the next piece of data)	Without a persistence model to some degree, there will be loss of data granularity, and the data will be less valuable to users.
577		Workshop	DC	Data that is processed may not be in the form most useful to the user	Data in raw form needs to be available to all users <with permission to receive it>	Raw data could be cleansed and processed by users who provide specific value to their subscribers
578		Workshop	DC	Data could be transmitted by bad actors and received by unauthorized sources.	Authentication information for credentialing needs to be stored.	Must ensure data exchanges are secure and users authenticated to encourage use of this program.
579		Workshop	DC	Difficult obtaining real time information	Needs to support low latency data exchange	Real time data is needed for many applications.
580		Workshop	DC	User privacy issues	Needs to support secure data/information exchange.	Protect user data and respect privacy issues.
581		Workshop	DC	Quality of the data collected could be varied.	There needs to be quality checking of the collected data	We need to impose a standard that says the data is accurate (data from the 3rd party)

#	Trip Rpt ID	Source Type	Source	Problem	Need	Rationale
582		Workshop	DC	A single repository of all data would be expensive and difficult to manage.	Needs to support a broker function (e.g., Object Request Broker, "network of networks), allowing multiple distributed, independent systems to obtain the data they need to create applications for subscribers	Broker could optimize user requests and route requested data back to user (or user could obtain data directly from collecting source)
583		Workshop	DC	Disparate system/database interfaces with varying data formats will drive up the cost of deployment.	Standards are needed to address the interfaces (data formats) to each repository (similar to a building code)	Standardized interfaces will facilitate gradual deployment and wider use.
584		Workshop	DC	There is so much data collected that the user systems do not have a good way of knowing the breadth of data available	There needs to be a means for the user to know what data is available (i.e., a catalog of the data that has been collected and is available for users)	To encourage development of applications, user systems must know the data exists
585		Workshop	DC	Vehicle doesn't know the range of services available in a given service area	Vehicle needs to know what applications are available in a given service area	Set driver's expectations
586		Workshop	DC	Without certifying devices, there is no control over which devices will be able to connect to the system, and this could be detrimental to the system/band	Need to ensure that unauthorized devices cannot access the Core System, including the allotted frequency band (in the case of 5.9 GHz)	Allowing only devices with certification (across nation or regionally?) will help reduce the potential issue of disrupting message exchange
587		Workshop	DC	There may be a data ownership issue if data that is collected by these devices do not belong to everyone	Need to make sure all data collected by a device deployed as part of this program belongs to everyone….	
588		Workshop	DC	There will be times when information is needed when there are no vehicles on the roads to send the data back (e.g., Icy roads)	This program needs to coexist with current fixed-site sensor technologies	Multiple technologies will likely be used together.
589		Workshop	DC	There isn't a good way to download large amounts of data in real-time.	This program needs to support large data set transfers for routing info and software updates between vehicles and infrastructure	Depending upon the application, real-time updates may be more critical
590		Workshop	DC	Without "guarantee" of message delivery, applications requiring real-time coordination -- such as safety applications - cannot be supported	Need to provide mechanism that ensures data is delivered to support safety applications	Safety applications that require coordination will need a "guarantee" of delivery
591		Workshop	DC	It is unclear how multiple wireless integrated transportation system technologies will coexist.	This program needs to support all technologies (3G, 4G, plus 5.9 for safety), the selection of which depends on determination of which technology is best for which services and security rules for each	Multiple technologies will be available to support transportation applications, so there is a desire for them to converge.
592		Workshop	DC	For many applications, particularly safety applications, data must be accurate	Need accurate data exchange	Support safety applications; utility of data for data users/applications developers who depend upon the quality of data.
593		Workshop	DC	Difficult obtaining real time information	Need all data publishers to be dynamic	Real-time information is required.

11.0 GLOSSARY

Table 11-1: Glossary

Term	**Definition**
Access Control	Refers to mechanisms and policies that restrict access to computer resources. An access control list (ACL), for example, specifies what operations different users can perform on specific files and directories.
Analysis	The process of studying a system by partitioning the system into parts (functions, components, or objects) and determining how the parts relate to each other.
Anonymity	Lacking individuality, distinction, and recognizability within message exchanges.
Application	A computer software program with an interface, enabling people to use the computer as a tool to accomplish a specific task.
Authentication	The process of determining the identity of a user that is attempting to access a network.
Authorization	The process of determining what types of activities or access are permitted on a network. Usually used in the context of authentication: once you have authenticated a user, they may be authorized to have access to a specific service.
Assumption	A judgment about unknown factors and the future which is made in analyzing alternative courses of action.
Back Office	See Center
Bad Actor	A role played by a user or another system that provides false or misleading data, operates in such a fashion as to impede other users, operates outside of its authorized scope.
Center	An entity that provides application, management, administrative, and support functions from a fixed location not in proximity to the road network. The terms “back office” and “center” are used interchangeably. Center is a traditionally a transportation-focused term, evoking management centers to support transportation needs, while back office generally refers to commercial applications. From the perspective of the Core System ConOps these are considered the same.
Class of Service (CoS)	Class of Service (CoS) is a way of managing traffic in a network by grouping similar types of traffic (for example, e-mail, streaming video, voice, large document file transfer) together and treating each type as a class with its own level of service priority.
Commercial Application	An application provided by a private entity, usually in exchange for payment.
Concept of Operations (ConOps)	A user-oriented document that describes a system’s operational characteristics from the end user’s viewpoint.

Term	Definition
Constraint	An externally imposed limitation on system requirements, design, or implementation or on the process used to develop or modify a system. A constraint is a factor that lies outside – but has a direct impact on – a system design effort. Constraints may relate to laws and regulations or technological, socio-political, financial, or operational factors.
Contract	In project management, a legally binding document agreed upon by the customer and the hardware or software developer or supplier; includes the technical, organizational, cost, and/or scheduling requirements of a project.
Data Provider	A System User that supplies data to the Core System for publication to other System Users.
Data Subscriber	A System User that receives data from the Core System that was provided to the Core by another System User.
Deployability	Able to be deployed in existing roadway environments, without requiring replacement of existing systems in order to provide measurable improvements.
Desirable features	Features that should be provided by the Core System.
Digital Certificates	A digital certificate is an electronic "identification card" that establishes your credentials when doing business or other transactions on the Web. It is issued by a certification authority. It contains your name, a serial number, expiration dates, a copy of the certificate holder's public key (used for encrypting messages and digital signatures), and the digital signature of the certificate-issuing authority so that a recipient can verify that the certificate is real. Note: From the SysAdmin, Audit, Network, Security Institute - www.sans.org website.
DNS (Domain Name System)	The internet protocol for mapping host names, domain names and aliases to IP addresses.
Encryption	Scrambling data in such a way that it can only be unscrambled through the application of the correct cryptographic key.
End User	The ultimate human user of a product or service.
Entity	A physical or abstract thing of interest.
Environment	The circumstances, objects, and conditions that surround a system to be built; includes technical, political, commercial, cultural, organizational, and physical influences as well as standards and policies that govern what a system must do or how it will do it.
Essential features	Features that shall be provided by the Core System.
Extensibility	The ability to add or modify functionality or features with little or no design changes.
Flexibility	The ability to adjust or adapt to external changes with little or no design changes.
Functionality	The capabilities of the various computational, user interface, input, output, data management, and other features provided by a product.

Term	**Definition**
Geo-cast	The delivery of a message to a group of network destinations identified by their geographical locations.
Hardware	Hardware refers to the physical parts of a computer and related devices. Internal hardware devices include motherboards, hard drives, and memory. External hardware devices include monitors, keyboards, mice, printers, and scanners.
Jurisdictional Scope	The power, right, or authority to interpret and apply the law within the limits or territory which authority may be exercised.
Maintainability	To keep in an existing operational state preserved from failure or decline of services (with minimum repair, efficiency, or validity).
Optional features	Features that might be provided by the Core System.
On-Board Equipment (OBE)	Computer modules, display and a DSRC radio, that is installed and embedded into vehicles which provide an interface to vehicular sensors, as well as a wireless communication interface to the roadside and back office environment.
Point of Service	The Core System which provides a "gatekeeping arrangement" to connected System Users with functions and capabilities.
Priority	A rank order of status, activities, or tasks. Priority is particularly important when resources are limited.
Privacy	From the VII Privacy Policies Framework: the respect for individual choices about, and control over an individual's personal information.
Problem domain	A set of similar problems that occur in an environment and lend themselves to common solutions.
Reliability	Providing consistent and dependable system output or results.
Request for Quotation (RFQ)	A request for services, research, or a product prepared by a customer and delivered to a contractor with the expectation that the contractor will respond with their proposed cost, schedule, and development approach.
Scalability	The capable of being easily grown, expanded or upgraded upon demand without requiring a redesign.
Scenario	A step-by-step description of a series of events that may occur concurrently or sequentially.
Service	A set of related functionalities accessed using a prescribed interface.
Software	Software is a general term that describes computer programs. Terms such as software programs, applications, scripts, and instruction sets all fall under the category of computer software.
Special Permissions	Authorization granted to perform actions specific to 3rd party applications, using IEEE 1609.2 certificates as the permission grant mechanism. Also called certificate-managed application permissions.
States or Modes	A distinct system setting in which the same input will produce different results than it would in other settings.

Term	Definition
System	(A) A collection of interacting components organized to accomplish a specified function or set of functions within a specified environment. (B) A group of people, objects, and procedures constituted to achieve defined objectives of some operational role by performing specified functions. A complete system includes all of the associated equipment, facilities, material, computer programs, firmware, technical documentation, services, and personnel required for operations and support to the degree necessary for self-sufficient use in its intended environment.
System Need	A capability that is identified and supported within the Core System to accomplish a specific goal or solve a problem.
Traceability	The identification and documentation of derivation paths (upward) and allocation or flow down paths (downward) of work products in the work product hierarchy. Important kinds of traceability include: to or from external sources to or from system requirements; to or from system requirements to or from lowest level requirements; to or from requirements to or from design; to or from design to or from implementation; to or from implementation to test; and to or from requirements to test.
Trust Credentials	A user's authentication information which determines permissions and/or allowed actions with a system and other users.
Uni-cast	The sending of a message to a single network destination identified by a unique address.
User	An entity that uses a computer, program, network, and related services of a hardware and/or software system. In the case of the Core System this includes System Users that refers to the combination of Mobile, Field, and Center based devices and applications. The term End User refers to the human user of the System User device. End Users do not interact directly with the Core System, but are referred to as the ultimate beneficiaries or participants in the *connected vehicle* environment.
User Need	A capability that is identified to accomplish a specific goal or solve a problem that is to be supported by the system. A user requirement for a system that a user believes would solve a problem experienced by the user.
User Classes	A category of user, typically with different user profiles and access rights to the system.