Connected Vehicle Environment Core System Concept of Operations (ConOps) Workshop
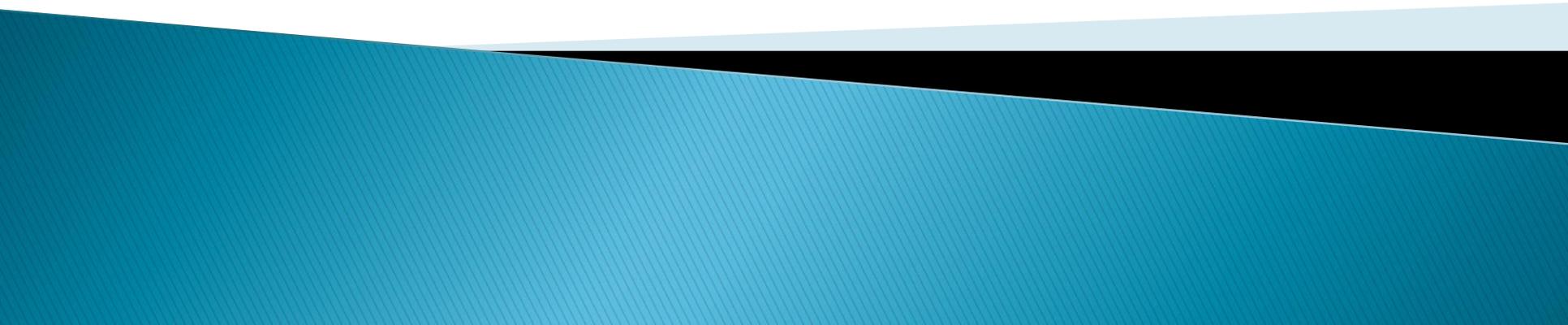
May 17, 2011

Detroit, MI

Agenda

- Opening Comments, Program Overview
- Core System Background, Overview
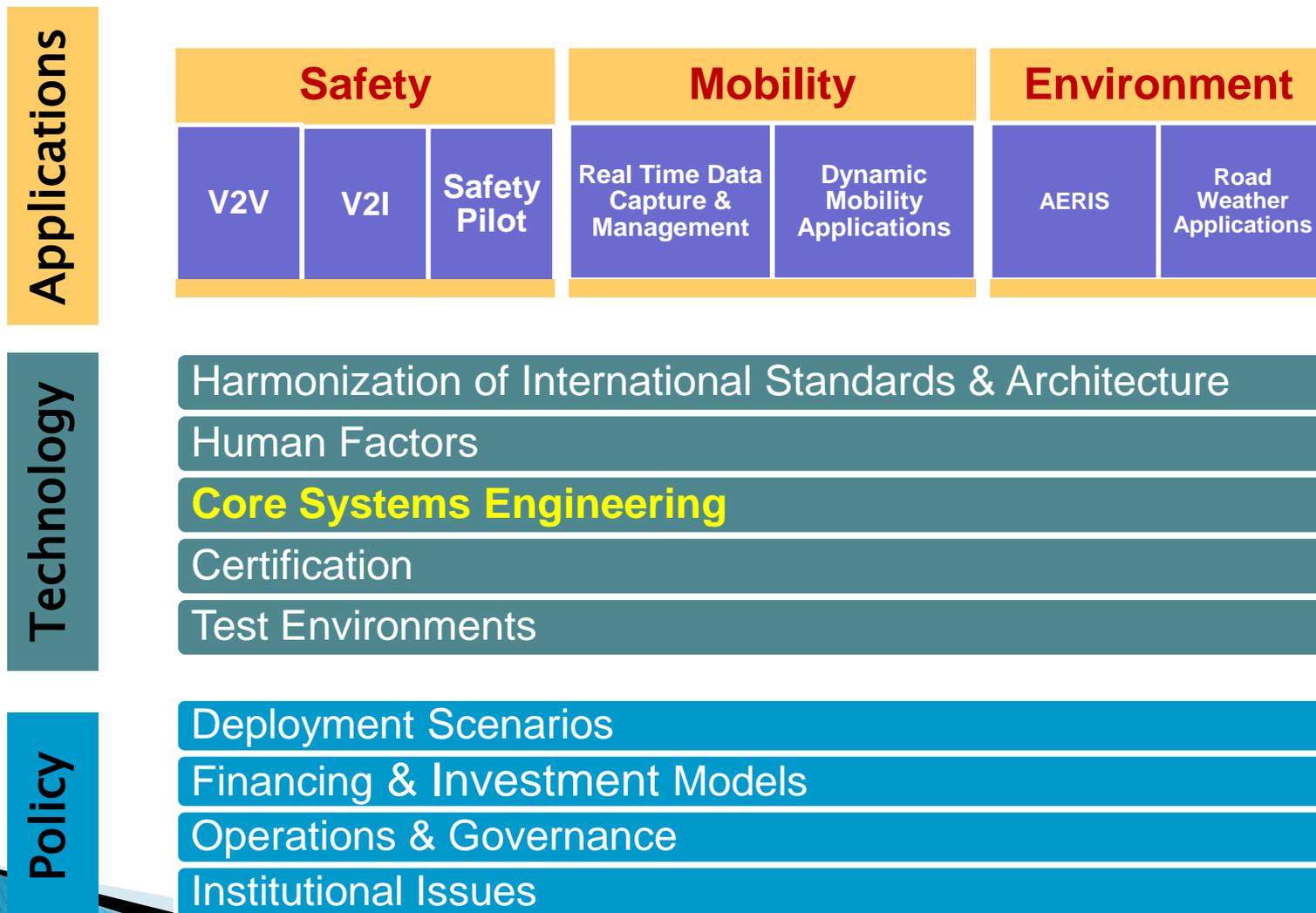- ConOps Discussion
- System Description
- Core System Next Steps
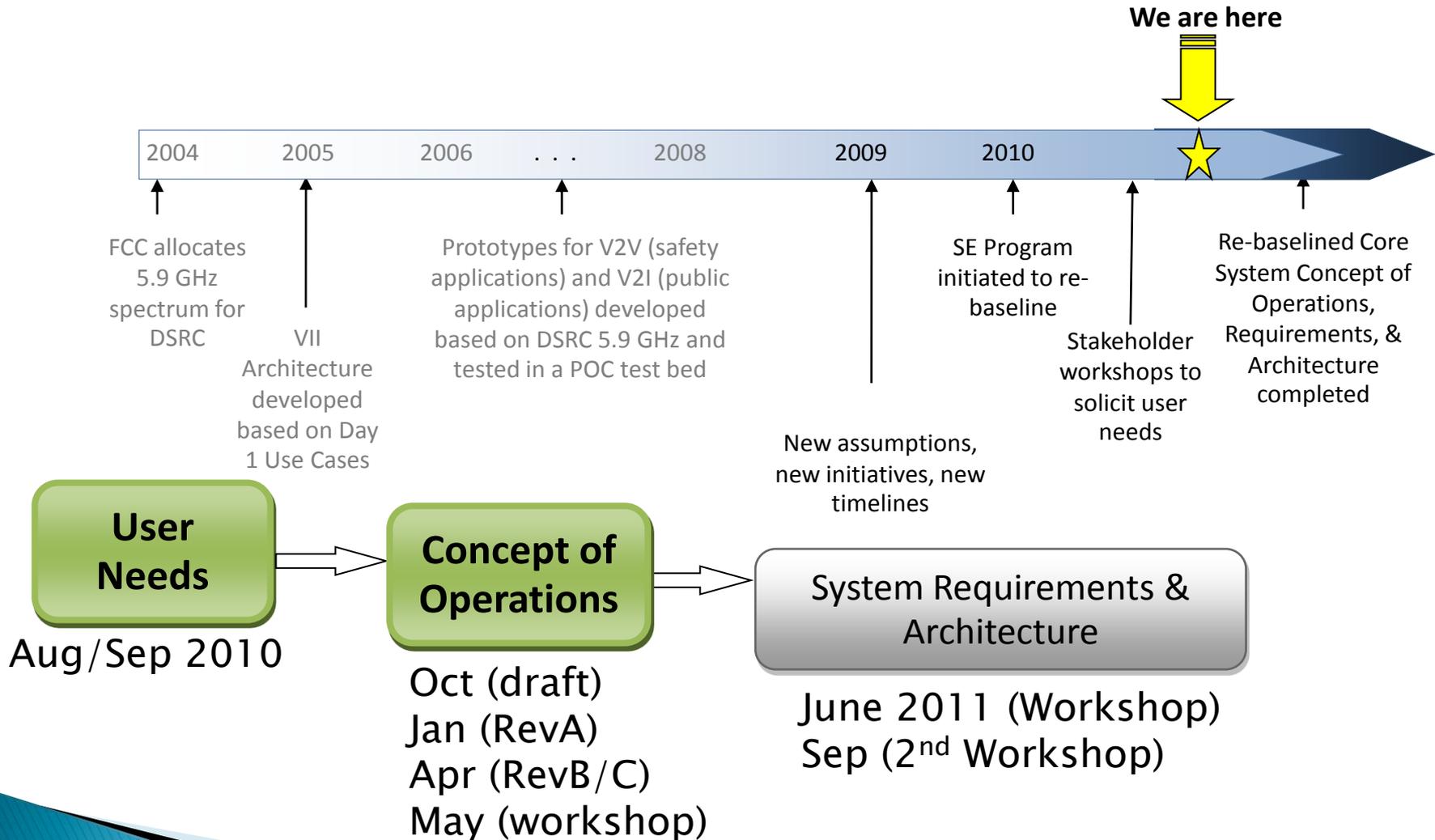
Opening Comments

>> Welcome, Program Overview

Welcome & Introductions

- Who we are, how we got here
- Purpose for today
  - Present the Core System ConOps
  - Open discussion, questions/comments captured
  - Preview architecture development activities
- Breaks: 10:15–10:30, 2:15–2:30
- Lunch: 12:00 – 1:15

ITS JPO Program Structure

Applications

Safety			Mobility		Environment	
V2V	V2I	Safety Pilot	Real Time Data Capture & Management	Dynamic Mobility Applications	AERIS	Road Weather Applications

Technology

- Harmonization of International Standards & Architecture
- Human Factors
- **Core Systems Engineering**
- Certification
- Test Environments

Policy

- Deployment Scenarios
- Financing & Investment Models
- Operations & Governance
- Institutional Issues

Core System Timeline

We are here

| 2004 | 2005 | 2006 | . . . | 2008 | 2009 | 2010 | | |

FCC allocates 5.9 GHz spectrum for DSRC

VII Architecture developed based on Day 1 Use Cases

Prototypes for V2V (safety applications) and V2I (public applications) developed based on DSRC 5.9 GHz and tested in a POC test bed

SE Program initiated to re-baseline

New assumptions, new initiatives, new timelines

Stakeholder workshops to solicit user needs

Re-baselined Core System Concept of Operations, Requirements, & Architecture completed

User Needs

Aug/Sep 2010

Concept of Operations

Oct (draft)
Jan (RevA)
Apr (RevB/C)
May (workshop)

System Requirements & Architecture
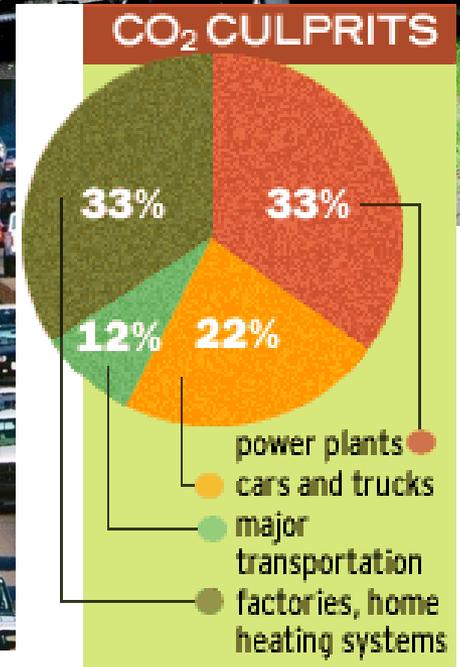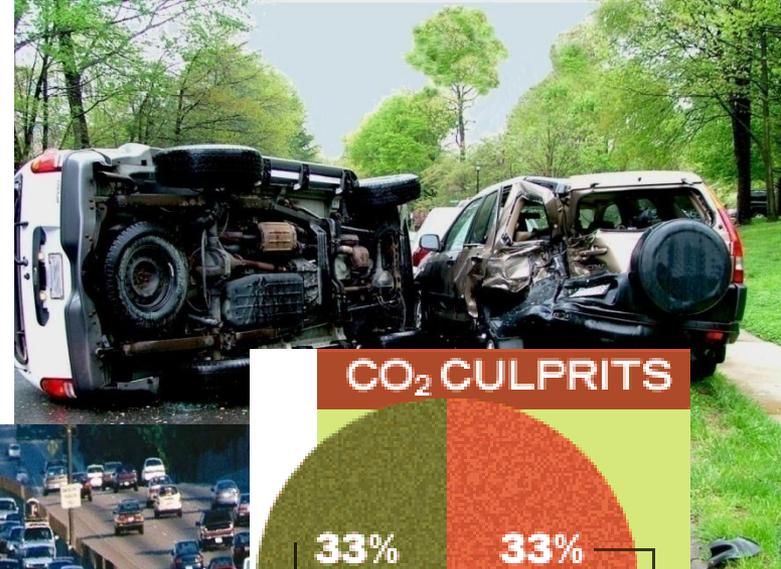
June 2011 (Workshop)
Sep (2nd Workshop)

Core System Background

» Background / Overview of the overall environment / Core System and its components

The Problem

- Safety
  - 33,963 deaths in '09
  - 5,800,000 crashes/year
  - Leading cause of death for ages 4-34
- Mobility
  - 4.2 billion hours of travel delay
  - $78 billion cost of urban congestion
- Environment
  - 2.9 billion gallons of wasted fuel
  - Emissions

CO₂ CULPRITS

- 33%
- 33%
- 12%
- 22%

power plants
cars and trucks
major transportation
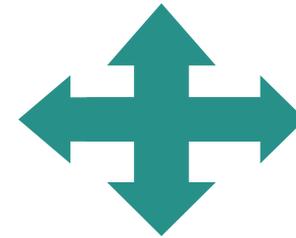factories, home heating systems

In an environment of connected vehicles…

- Drivers, Passengers, System Operators
- Using wireless communications technologies and applications
- Realize
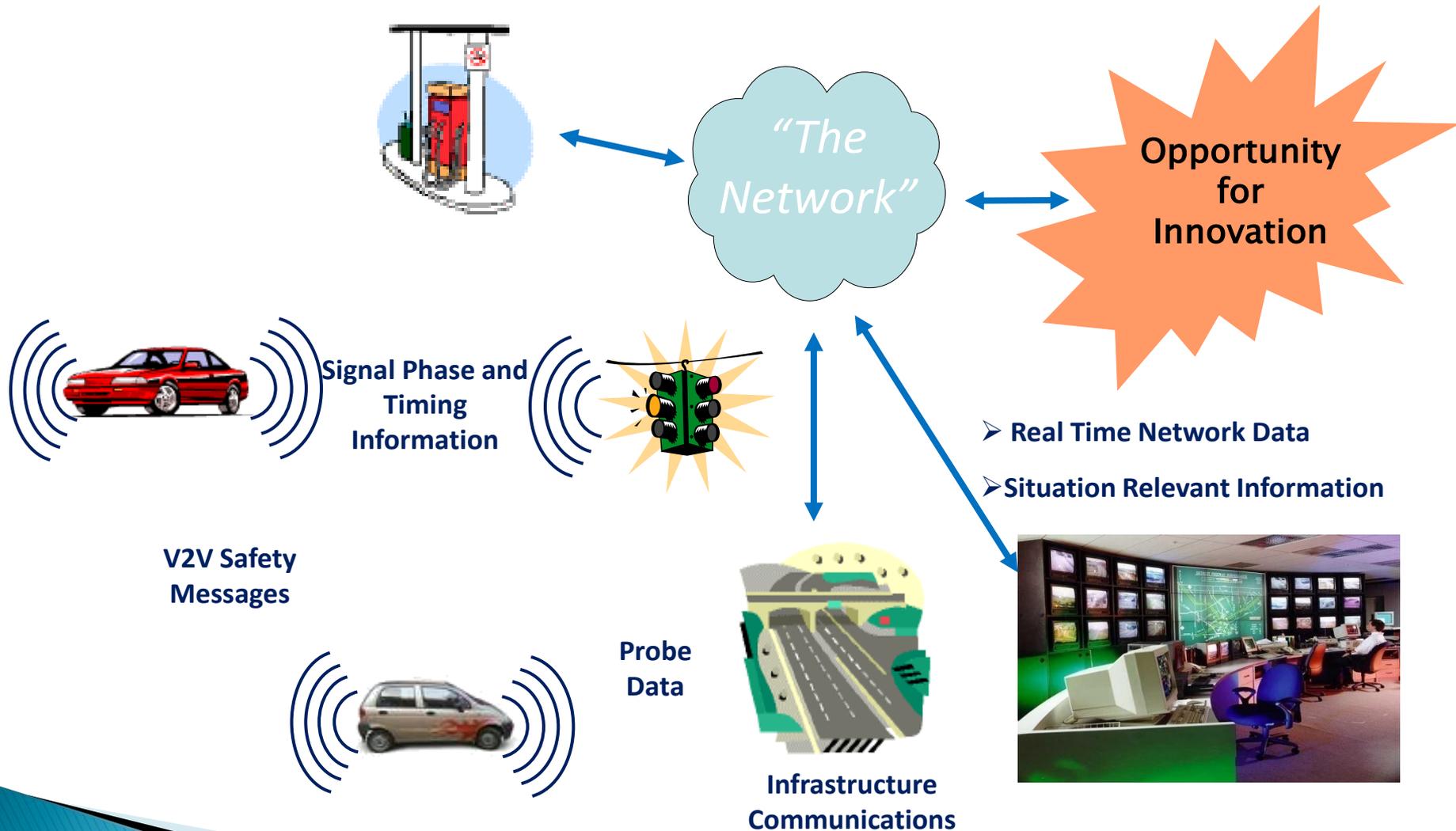 ◦ Safety, Mobility, Environmental benefits

Drivers

Vehicles

Infrastructure

Wireless Devices

Connectivity drives the benefits

"The Network"

Opportunity for Innovation

Signal Phase and Timing Information

V2V Safety Messages

Probe Data

Infrastructure Communications

Real Time Network Data

Situation Relevant Information

Driving Influences

- Since VII, additional communications media available
- Expanding of both mobile platforms (all vehicle types, plus pedestrians and other road users) and potential users of data, providers of data (not just traditional transportation players)
- Applications development, include data capture and usage is decoupled from a single large system

Core System Needed

- Provides common services and interfaces
- Provide trusted environment for the applications and users
- Support diversity
  - applications, communications media, deployment models
- Plan for the future
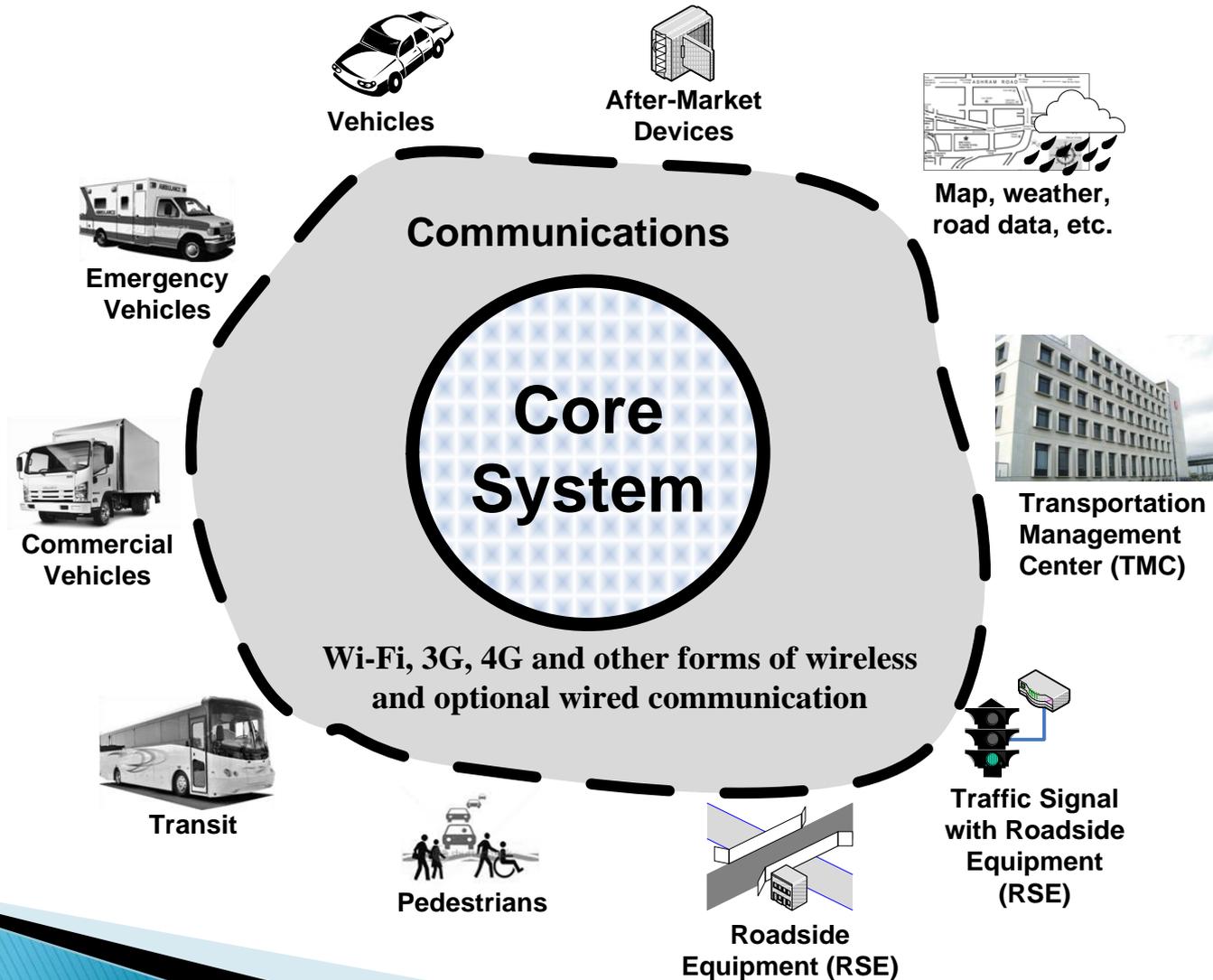 - Future technologies, extensible architecture

Core System – provide services that…

- Enable data transfers between system users
  - Mobile
  - Field
  - Center
- In a secure, trusted environment
  - Enabling trust between parties that have no direct relationship
  - Enabling secure data exchange between parties that have no direct relationship
  - Enabling the exchange of data between parties that have data and parties that want data

Core System Scope

▸ What the Core System Does NOT do…
  ◦ Store data for long periods of time
  ◦ Host applications
  ◦ Sit in a single location
  ◦ Require any particular comm or hardware technologies (other than what will be needed to support the requirements)
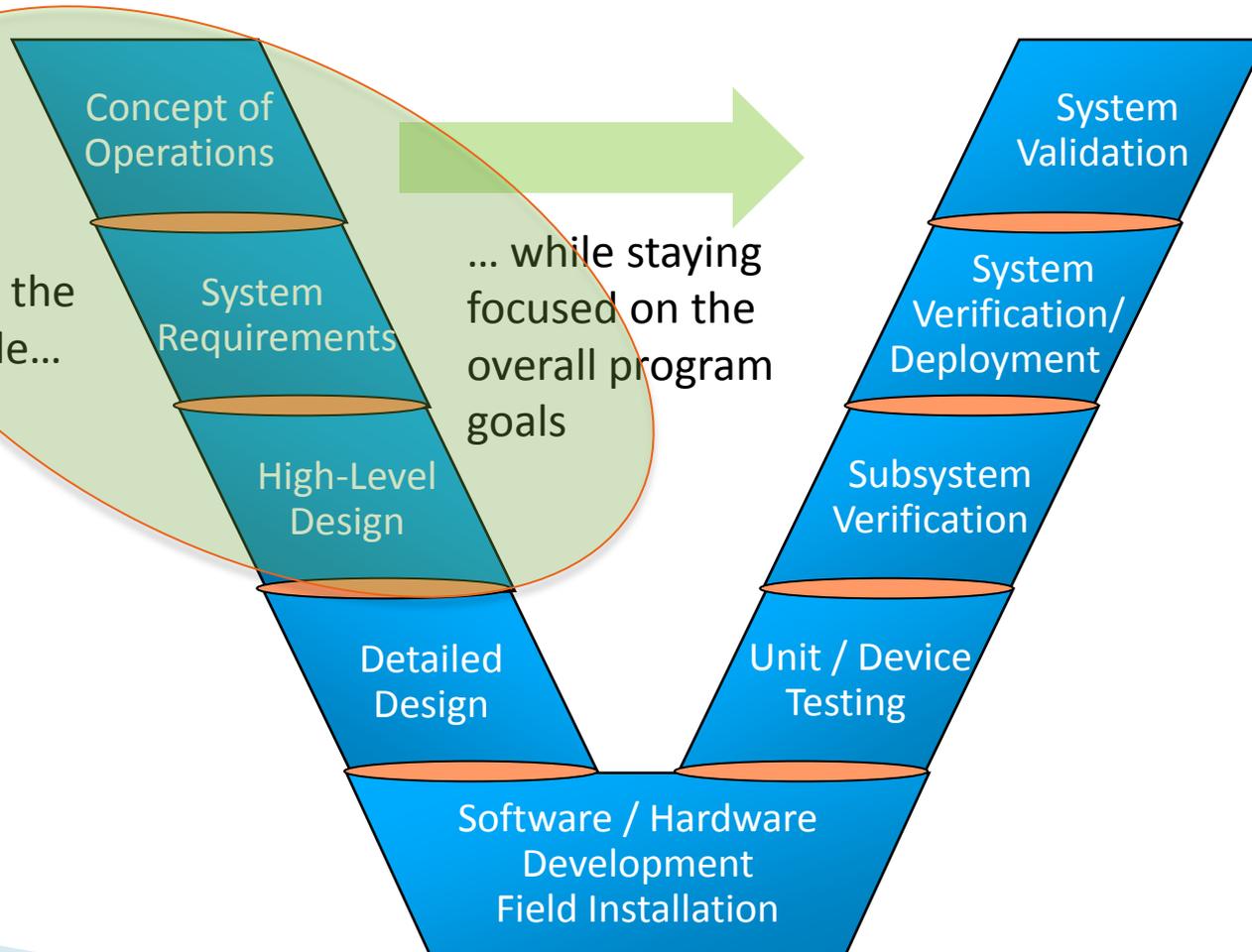
Core System serving larger set of applications

Vehicles

After-Market Devices
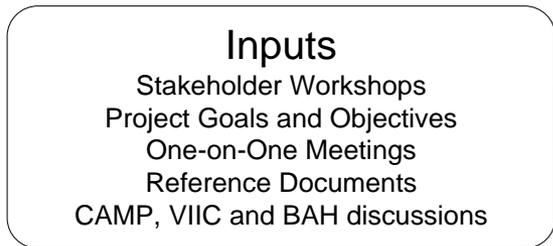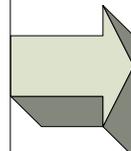
Map, weather, road data, etc.

Emergency Vehicles

Communications

Core System

Commercial Vehicles

Transportation Management Center (TMC)

Wi-Fi, 3G, 4G and other forms of wireless and optional wired communication

Transit

Pedestrians

Roadside Equipment (RSE)

Traffic Signal with Roadside Equipment (RSE)

The System Engineering Process

Concentrate on the early SE life cycle…

… while staying focused on the overall program goals

Concept of Operations

System Requirements

High-Level Design

Detailed Design

Software / Hardware Development Field Installation

Unit / Device Testing

Subsystem Verification

System Verification/ Deployment

System Validation

Gathering User Needs, What we heard…

- Give me the data – current traffic, all roads, all the time
- Standardize it
- Support multiple modes – include Cyclists, Pedestrians, other vulnerable users
- Set driver's expectations: inform them when safety or mobility services are available
- Support targeted broadcasts to sets of vehicles by location, type, individual
- Support multiple uses of data sets via standardized interfaces, services
- Support roaming for users devices
- Provide authentication, ensuring users that messages are from legitimate sources

Developing a ConOps

Controls
Contract Assumptions
Project Management Plan
Configuration Management Plan
Systems Engineering Management Plan

Inputs
Stakeholder Workshops
Project Goals and Objectives
One-on-One Meetings
Reference Documents
CAMP, VIIC and BAH discussions

Activities
Transform User Inputs into User Needs
Define Operational Vision from User Inputs
Develop Concept of Operations
Develop Operational Scenarios

Outputs
Completion of the Concept of Operations
Basis for Requirements Traceability

Enablers
Stakeholder Involvement
Action Items
Risk Items

Core System ConOps

- Characterize the Current System
- Identify users' Needs
- Define Concepts of the Proposed System
- Operational Scenarios of the Proposed System
- Summary of Impacts, Analysis

Core System ConOps

- Initial Draft delivered October 2010
  - Reviewed by DOT, support staff, VIIC/CAMP, Testbed team
  - Needs from perspective of application users/stakeholders,
  - Determined that Core System ConOps should focus on underlying needs across the board of all system users
- Revision A delivered January 2011
  - Focus on Core System and its System Users and their common needs: security, network services, data distribution, system management
  - Consider Applications and Communications separately from the Core System
- Rev B – April 2011 (Rev C corrected formatting)
  - Incorporated walkthrough comments; confirmed Needs and system elements

Core System ConOps

- Current System Discussion
- Needs – Justification for Changes to Current System
- Concepts of the Proposed System
- Operational Scenarios of the Proposed System
- Summary of Impacts, Analysis
- References

Core System ConOps, Part 1

>> Users and Their Needs

Users of the Core System

- Transportation Users, e.g., private vehicle drivers, public safety 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
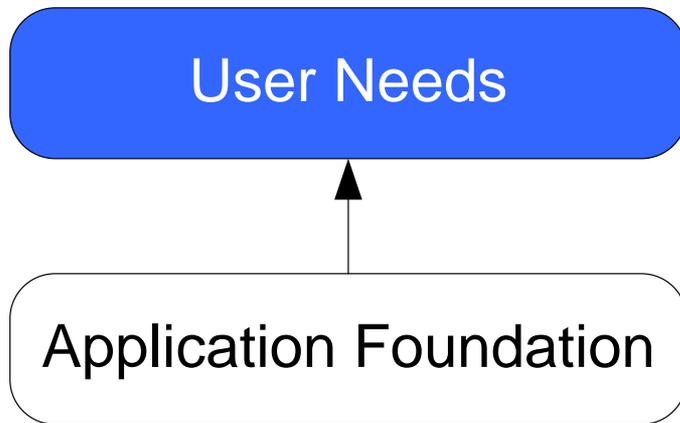
Users of the Core System

- Public Safety, e.g. incident and emergency management, including fire, police and medical support
- Information Service Providers, including traffic, weather and mobility applications
- Environmental Managers, including emissions and air quality monitors
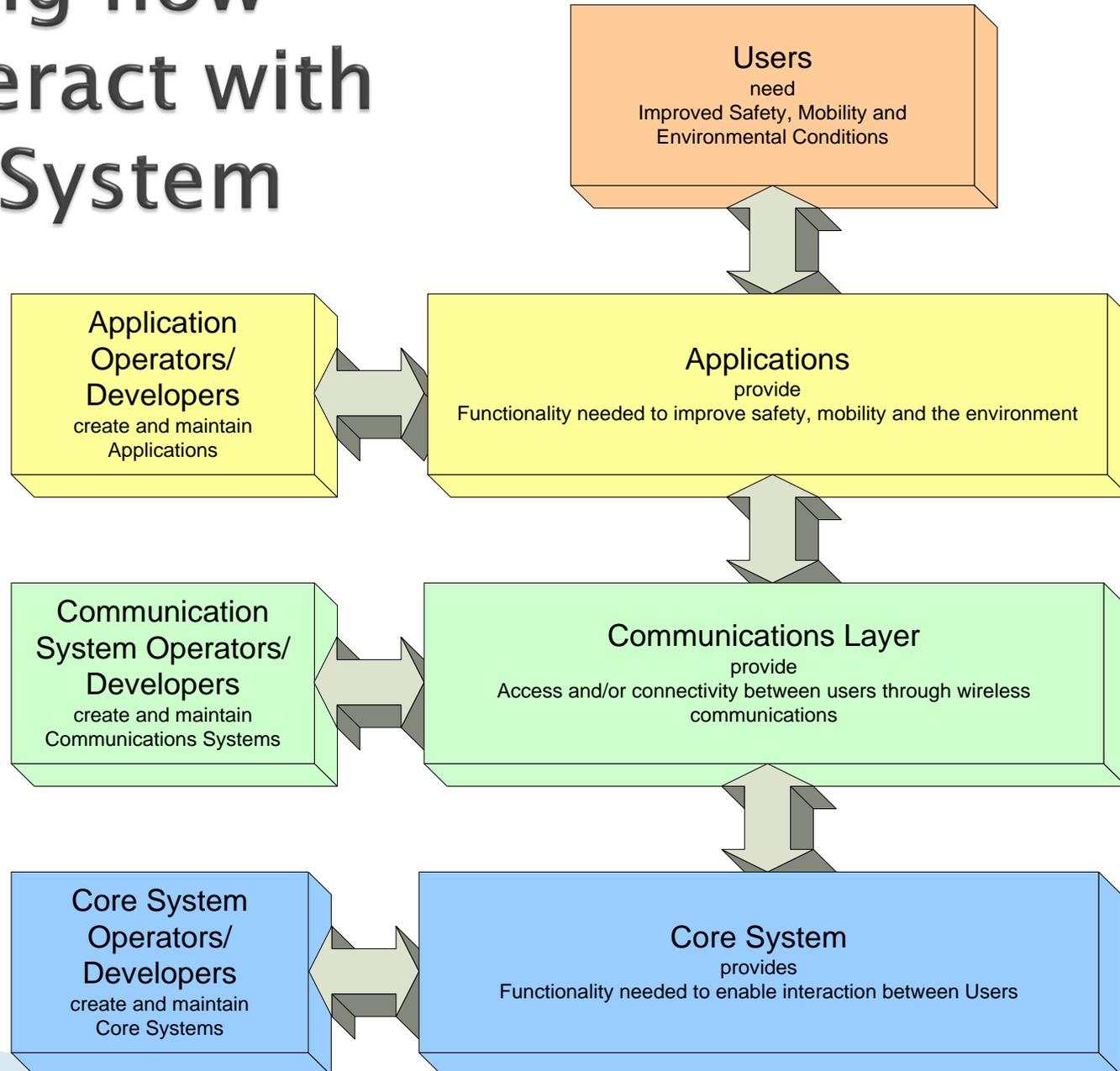
Users of the Core System

- Manufacturers/Developers:
  - Vehicles, onboard devices, field equipment, software
- Communications Providers, including cellular network operators
- Federal regulatory and research agencies

Identifying Needs/Goals for the Core System

User Needs

↑

Application Foundation

System Needs

↑

Operational Goals

Organizing how users interact with the Core System

Users
need
Improved Safety, Mobility and Environmental Conditions

Application Operators/ Developers
create and maintain Applications

Applications
provide
Functionality needed to improve safety, mobility and the environment

Communication System Operators/ Developers
create and maintain Communications Systems

Communications Layer
provide
Access and/or connectivity between users through wireless communications

Core System Operators/ Developers
create and maintain Core Systems

Core System
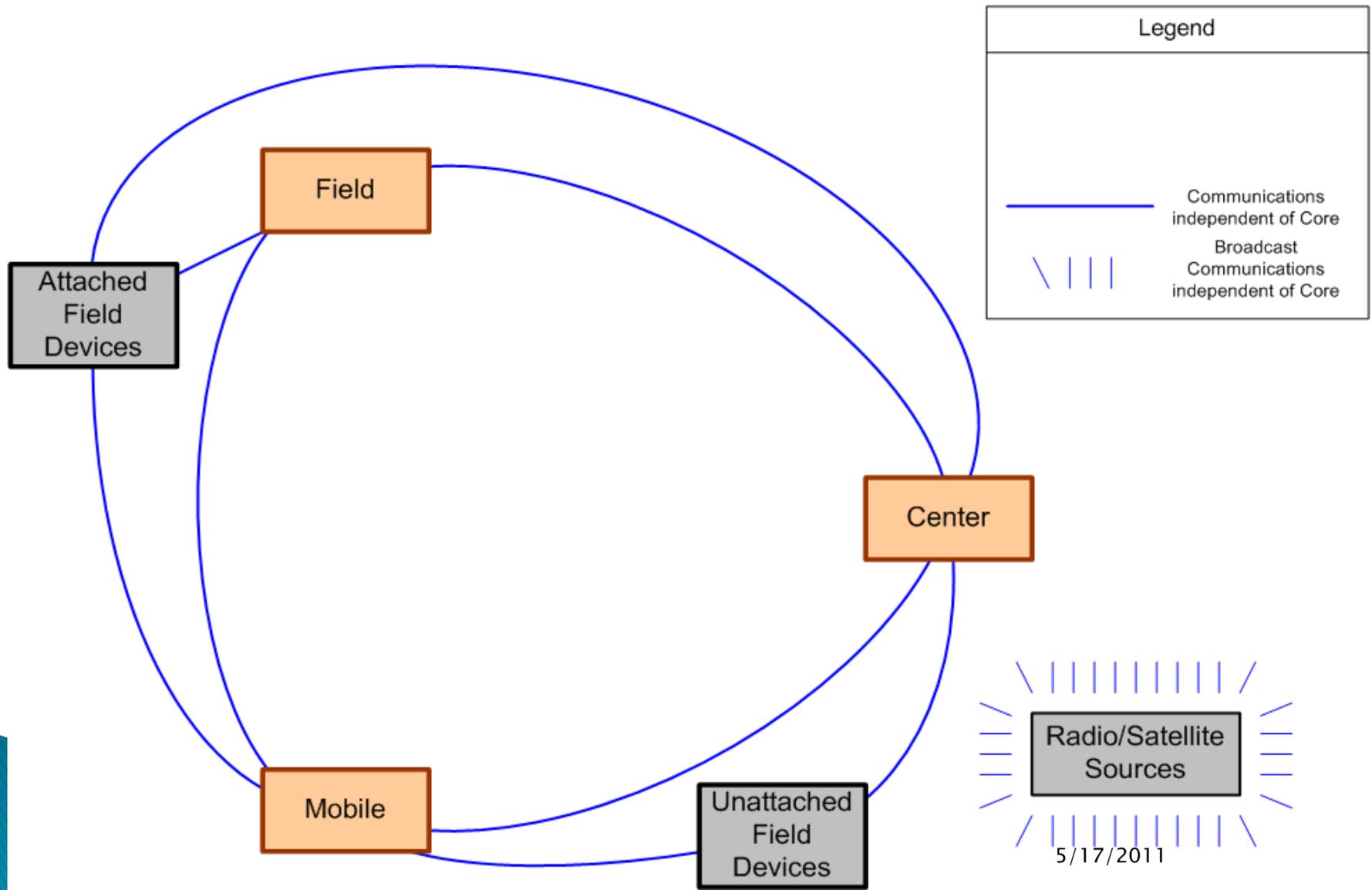provides
Functionality needed to enable interaction between Users

Operational Goals that will characterize the Core System

- Flexibility
- Extensibility
- Scalability
- Maintainability
- Deployability
- Reliability

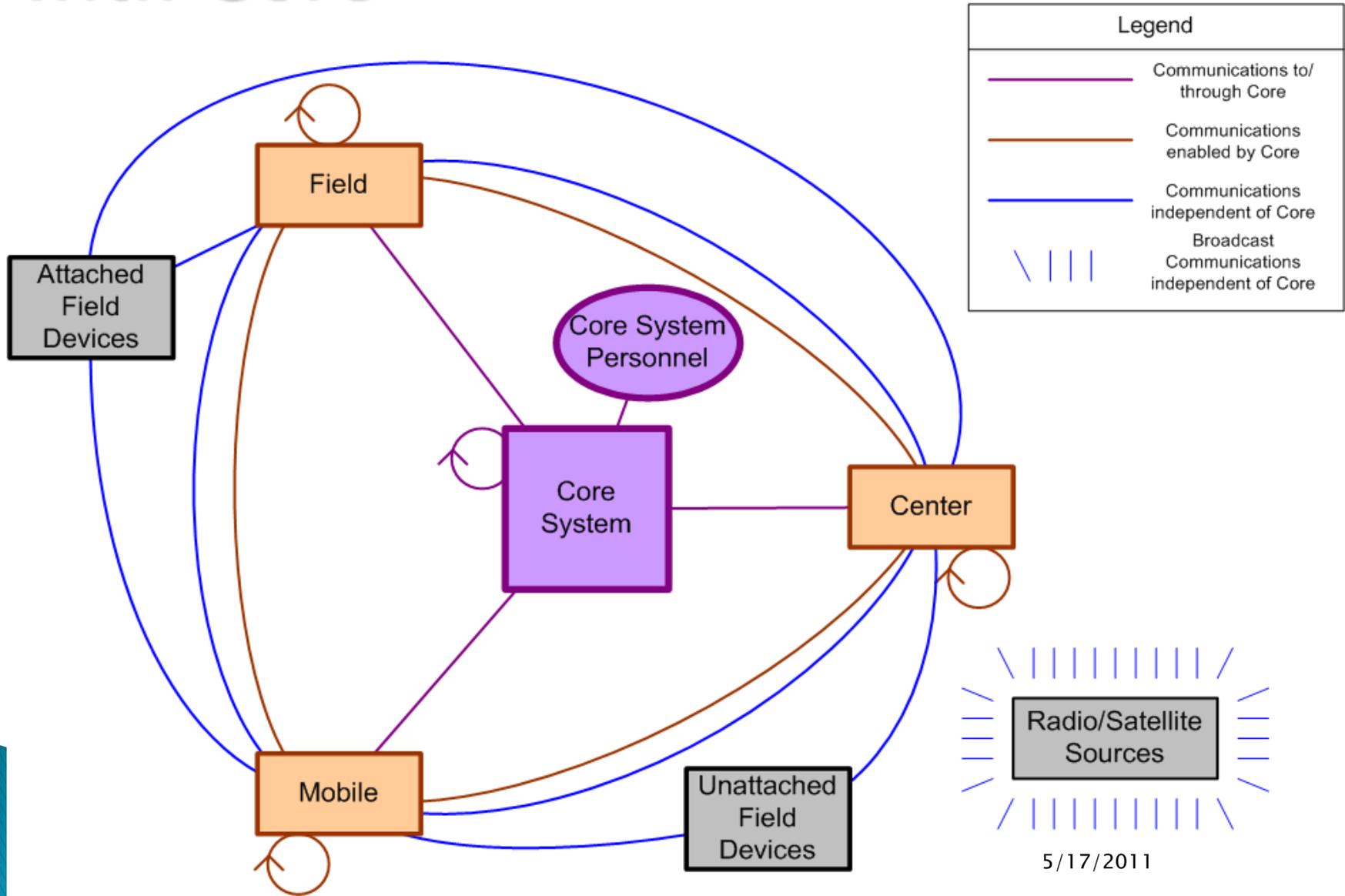# Core System Context

Core System Context: Current Environment

Legend

Communications independent of Core

Broadcast Communications independent of Core

Field

Attached Field Devices

Center

Mobile

Unattached Field Devices

Radio/Satellite Sources

Connected vehicle environment with Core

Legend
- Communications to/through Core
- Communications enabled by Core
- Communications independent of Core
- Broadcast Communications independent of Core

Connected vehicle environment with Core and External Support
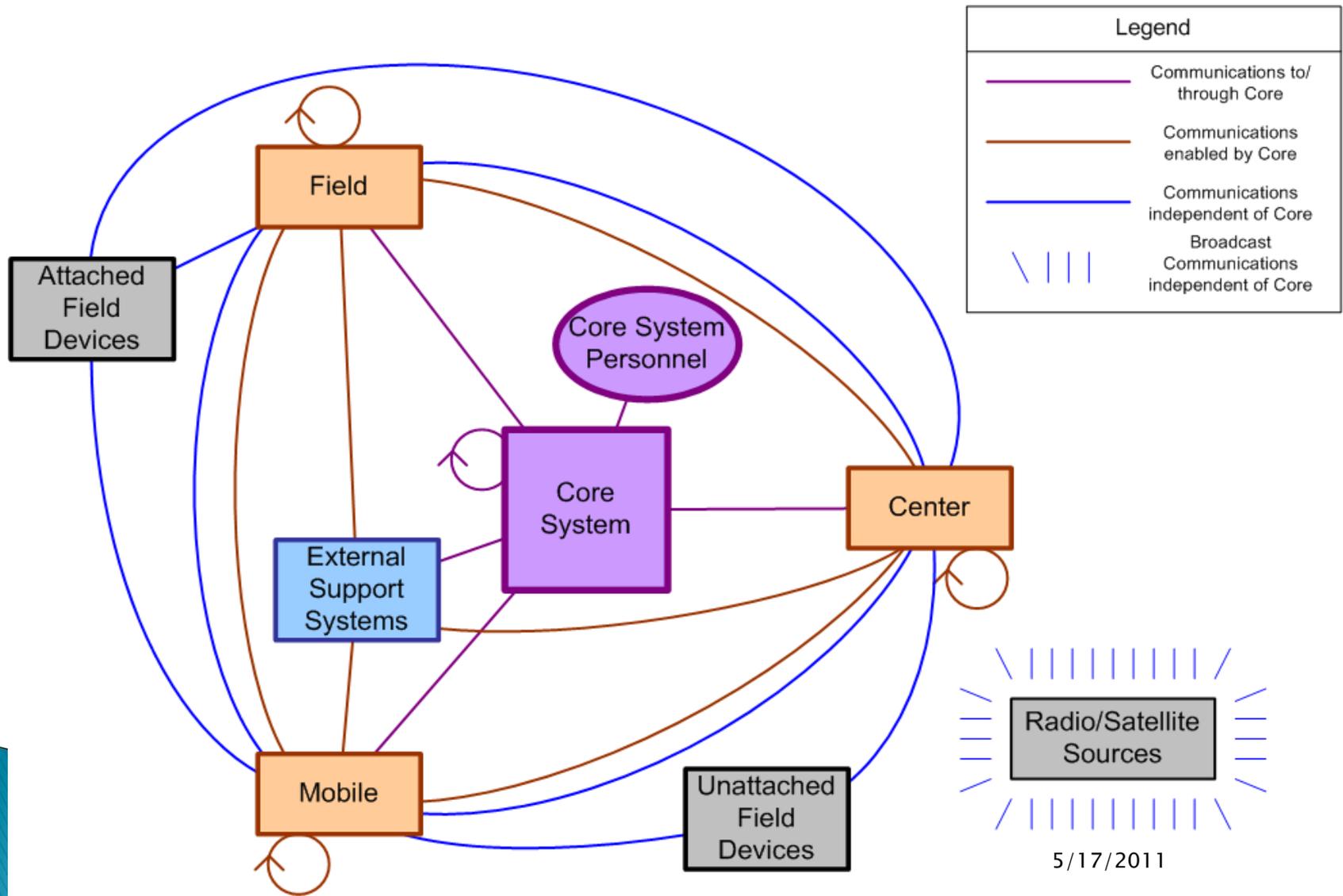
Core System Needs

>>

Core System Needs

- 2 Types of Needs Addressed:
  - User needs – capability required for that user to accomplish their goal
  - System needs – capability required in order to meet the operational goals
- In a nutshell:
  - Provide trust/security
  - Enable data exchanges
  - Take care of itself
  - Work with other cores

Things the Core System Needs to Do

▸ Data protection
  ◦ Facilitate secure exchange of data
▸ Facilitate trust
  ◦ With and between System Users
  ◦ Revoke trust credentials when necessary
▸ Authorization
  ◦ Manage who can do what
  ◦ Verify
  ◦ Identify misbehavior and allow System Users to provide misbehavior input

Things the Core System Needs to Do

▸ Time
  ◦ Components of Core System use standard basis for time, synchronization
  ◦ GROUP DISCUSSION
    • Should Core provide that Time information/sync data to its System Users?

Things the Core System Needs to Do, continued

▸ Facilitate the provision of data
  ◦ Match data providers with data consumers
  ◦ Data redistribution (publish-subscribe, aggregation, anonymization, etc.)
  ◦ Facilitate situational-relevant distribution
    • Geography or Time
  ◦ GROUP DISCUSSION
    • Should Core *advertise* applications available to its System Users?

Things the Core System Needs to Do, continued

- Network Services
  - support users accessing Core System over variety of communications mechanisms
- Take care of itself
  - Service Status
  - Integrity Protection
  - System Availability
  - Performance Monitoring

Things the Core System Needs to Do, continued

- Coordinate activities with other Core Systems
  - Support multiple, independent deployments
  - While providing Interoperable services across Cores
  - And coordinating activities together to deliver information consistently

Constraints / Assumptions

- VII Privacy Policies Framework still applies
- IEEE 1609.x family used for DSRC
- X.509 based certificates except for DSRC-specific apps
- SAE J2735 basis for mobile user messages
- Other open standards may be needed for Core System interfaces
- Comm based on IP v6

Constraints / Assumptions

- Comm will be provided by System Users
- Data (probe, basic safety) provided anonymously by mobile users
- Some vehicle based safety applications may be mandatory (beyond scope of this effort)
- Other mobility applications will be opt-in
- Deployment of Cores may be evolutionary, regional
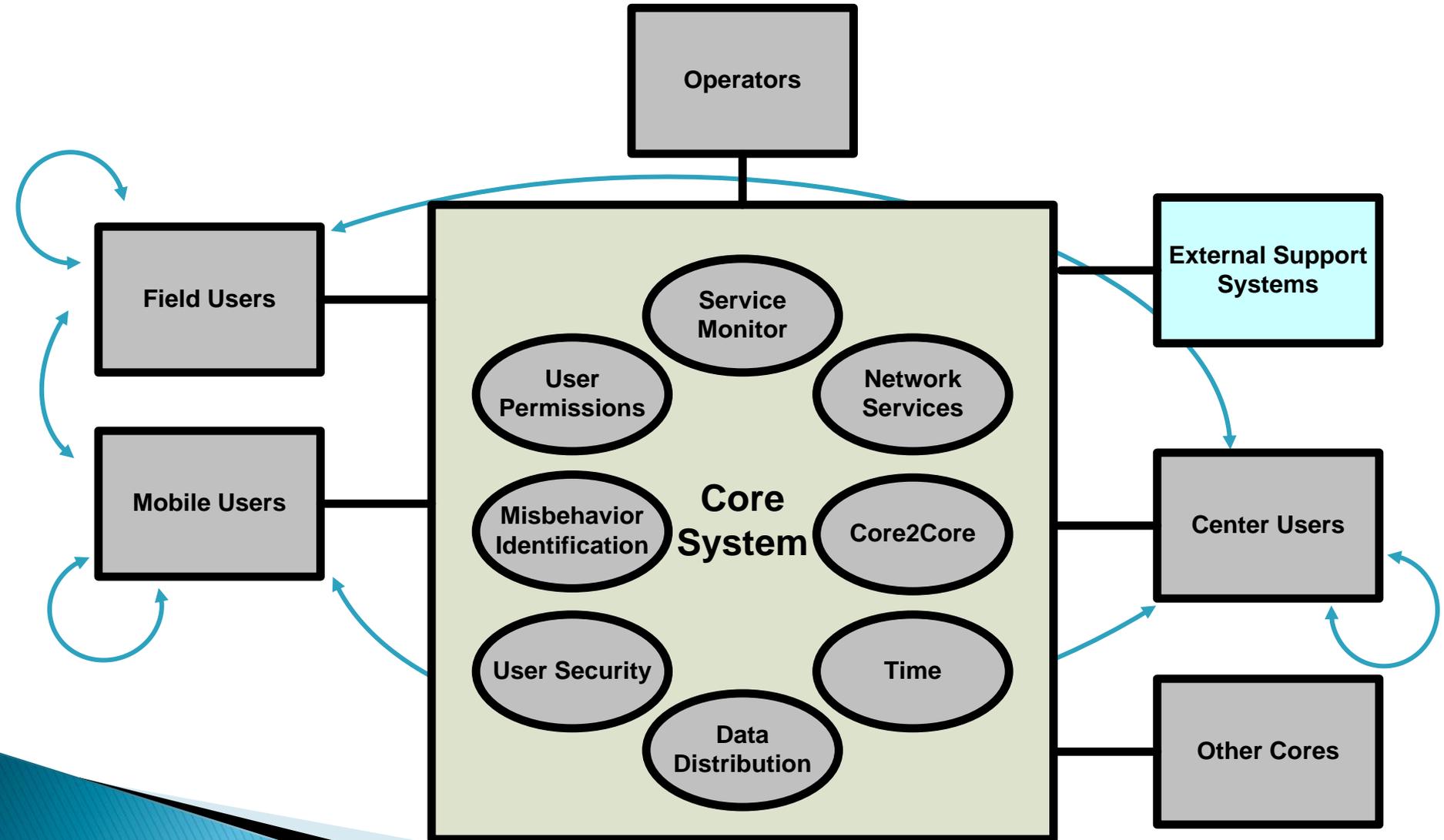
Core System ConOps, Part 2

>> The System – its subsystems and its interfaces

Core System FAQs

- What is it?
  - Set of services, enabling higher-level applications
- Just what can I do with this thing?
- Who Am I?
  - System Users
    - Mobile
    - Center
    - Field
  - Core System Personnel
    - Administrators, Operators, Maintainers, Developers, Deployers

Core System Subsystem Context

Operators

Field Users

Mobile Users

External Support Systems

Center Users

Other Cores

Core System

Service Monitor

User Permissions

Network Services

Misbehavior Identification

Core2Core

User Security

Time

Data Distribution
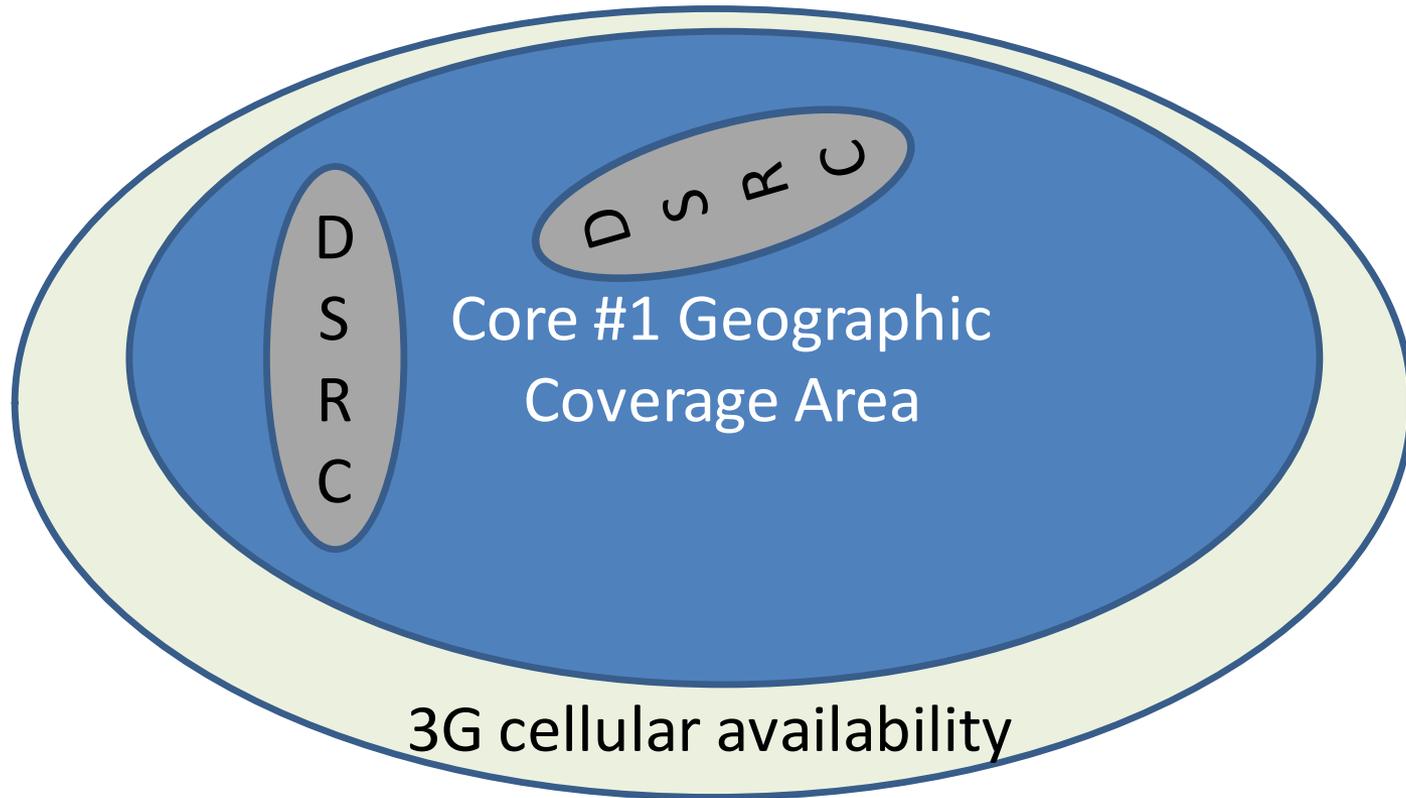
Operational Environment

- Heterogeneous community of systems, agencies, locations
- (Don't think control center) – not a physical plant, it's a collection of services
- Different Deployment Considerations
  - Standalone
  - Collocated
  - Distributed

Single Core Deployment

DSRC

D S R C

Core #1 Geographic Coverage Area

3G cellular availability

Multiple Overlapping Core Deployments

Core #1 Geographic Coverage Area

Core #2Geographic Coverage Area

DSRC

DSRC

3G cellular available
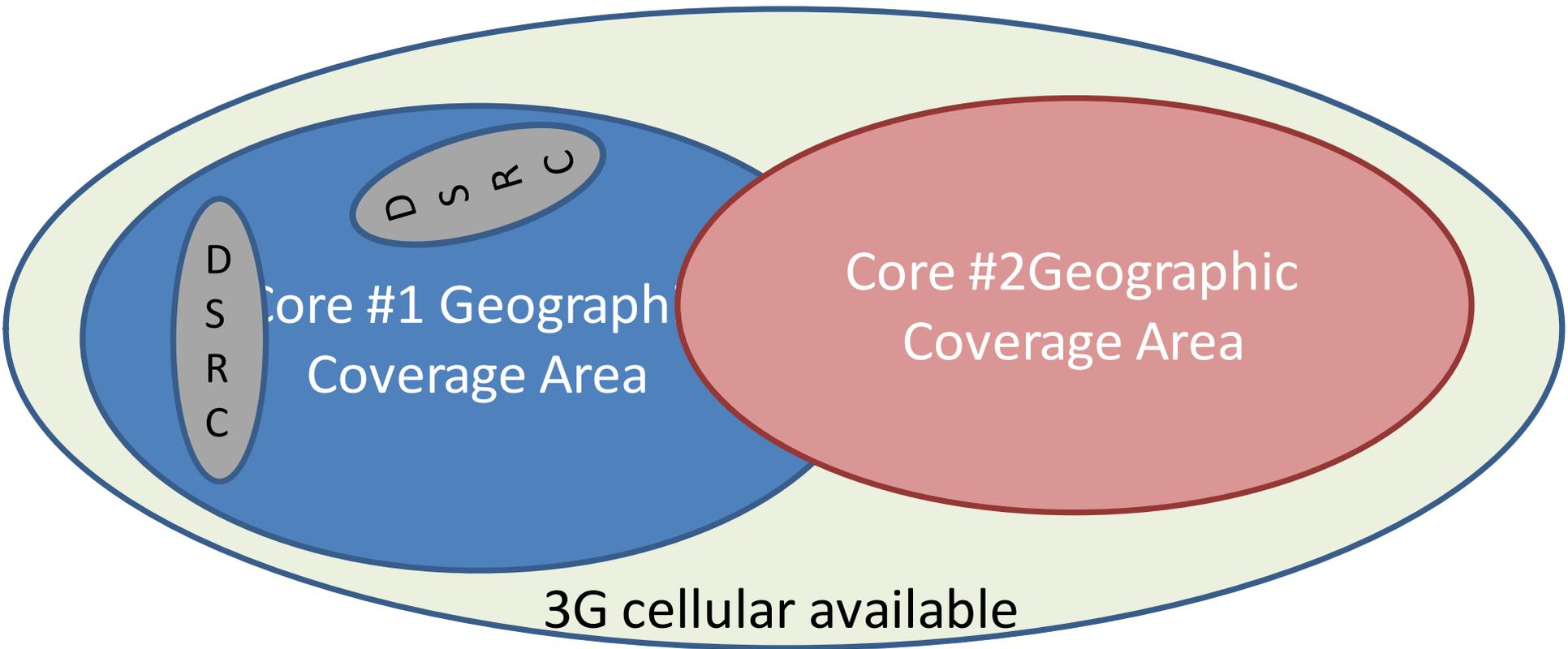
Multiple Overlapping Core Deployments w/Shared Services

Core #1 Geograph Coverage Area

Shared

Core #2Geographic Coverage Area

DSRC

3G cellular available
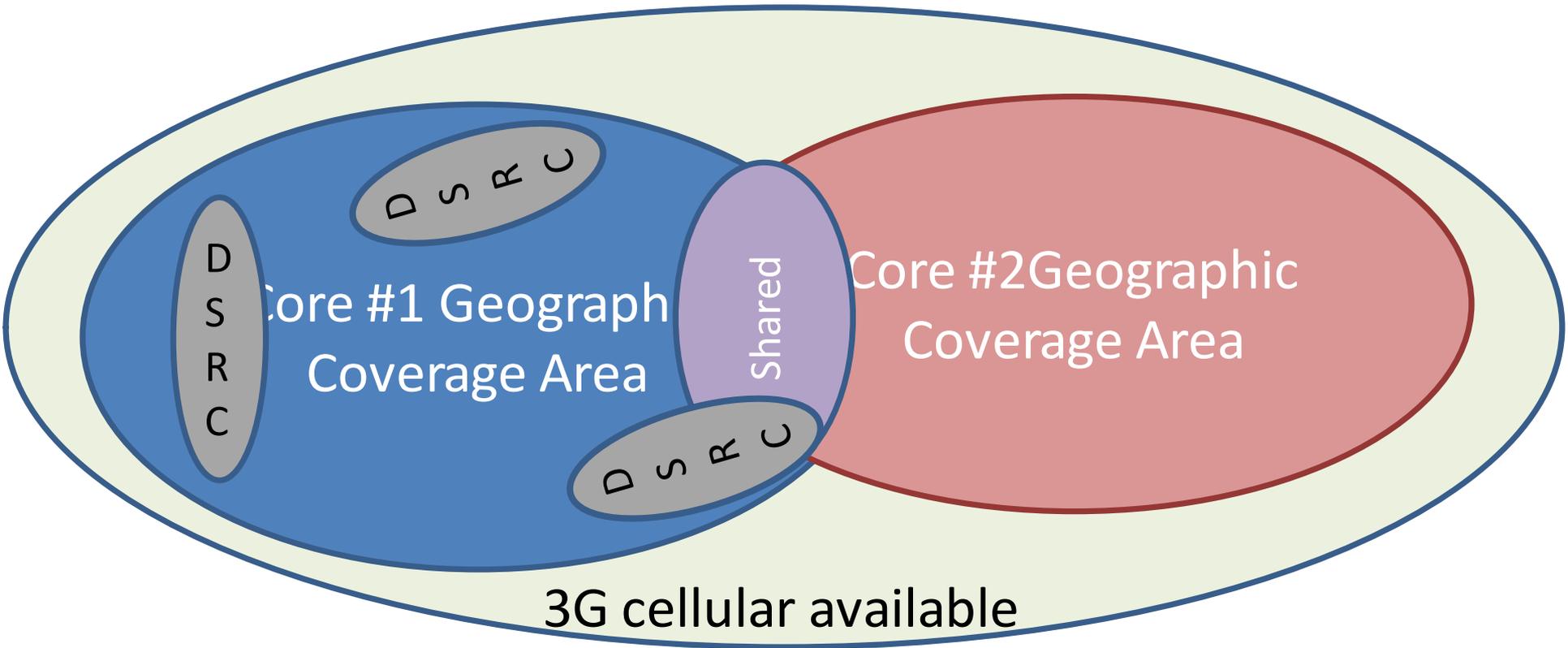
System Users: Differences

- Differentiated by location
  - Center users are at fixed-point, back-office or operational centers
  - Field users are located in proximity to the transportation environment; i.e., on the roadside
  - Mobile users are in the transportation environment, and mobile (duh!)
- All use the Core System in the same basic ways
- Experience may be limited by the communications they have

From a System User's Perspective

- What do they need to do with the Core System?
  - Get certificates
  - Receive certificate revocation lists
  - Why?
    - To enable other people to trust you
    - To know whether to trust others
    - To send and receive encrypted messages
    - To be able to run applications
      - Everything – safety, mobility, environmental
      - Especially: V2V safety

From a System User's Perspective

- What data can the System User get from the Core System?
  - Whatever other System Users are providing
    - Focused on Mobile ←→ Center
- How does it work?
  - Data consumers subscribe to receive data, specifying types that they want
  - Data providers register to provide data, specifying types that they can provide
  - Core provides forwarding, aggregation and anonymity
  - Core may enable direct provider-to-consumer linkage

From a System User's Perspective

- Does it do anything else?
  - Network services
    - Provides support services necessary to enable communications for users of DSRC networks.
    - Provides situational-relevant dist
  - User Permissions: allows a user to query whether a given message was sent by a user allowed to send that message.

From a System User's Perspective

- But wait, there's more!
  - Service Monitor:
    - Tells you what Core services are available (data distribution, network services etc.)
    - Tells you what applications are registered in the area, and where they operate.
  - Misbehavior Identification
    - Allows you to tell the Core who you think is misbehaving
    - Analyzes data sent by users, identifies bad actors, revokes their permissions and certificates if appropriate

The Core System is comprised of Subsystems

- Subsystems to address the needs, provide the Core Services
  - Core2Core
  - Data Distribution
  - Misbehavior Identification
  - Network Services
  - Service Monitor
  - User Permissions
  - User Security
  - Time

Basic Questions

- If a Core provides a service, must it provide that service regardless of end-user communications capabilities?
  - Yes:
    - Makes it simple to determine which Core is responsible for each services,
    - But increases the complexity Core-side for providing services over varied communications media with varied performance characteristics.
  - May want to allow for Cores that could be dedicated to certain types of media (i.e., the 4G Core, the DSRC Core, etc.)

Another Basic Question

▸ Could multiple Cores share provision of the same service in a given area, even over the same communications media type?

◦ Yes.

- There would have to be one default provider for overlap areas, but there could be multiple providers.

- As long as Mobile/Center/Field users could change their Core service provider, this could work.

- Also, there could be multiple DSRC infrastructure providers in the same area.

More Basic Questions

- Can a user make use of the same service from multiple Cores?
  - Yes
- What services need to be coordinated between Cores?
  - Data distribution
  - Misbehavior Identification
  - Network Services
  - User Permissions
  - User Security

Interfaces with the Core

» How System Users will interact with the Core

The Core System Interfaces within the connected vehicle environment
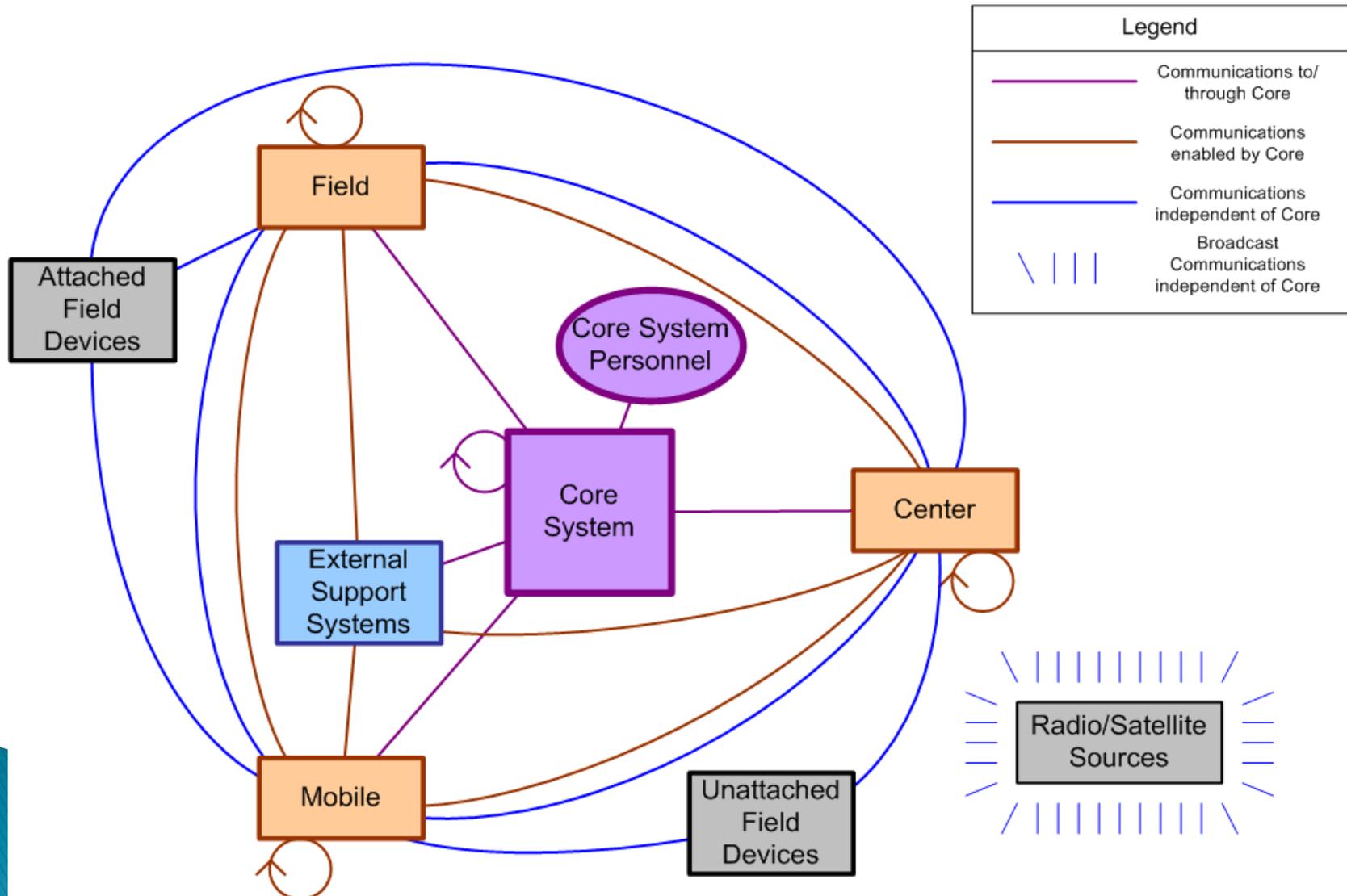
Mobile System Users Interact with Portions of the Core System
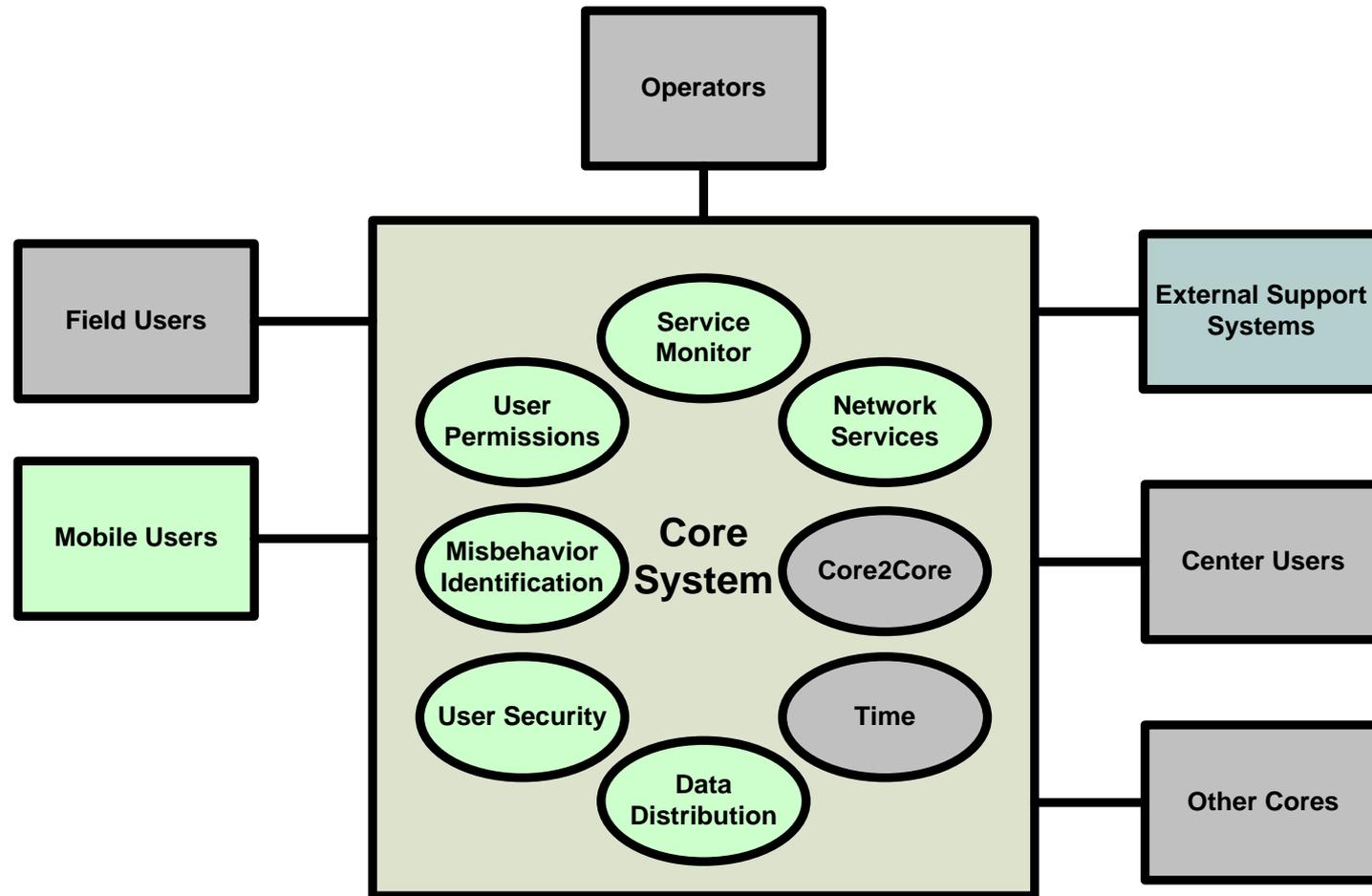
Field System Users Interact with Portions of the Core System
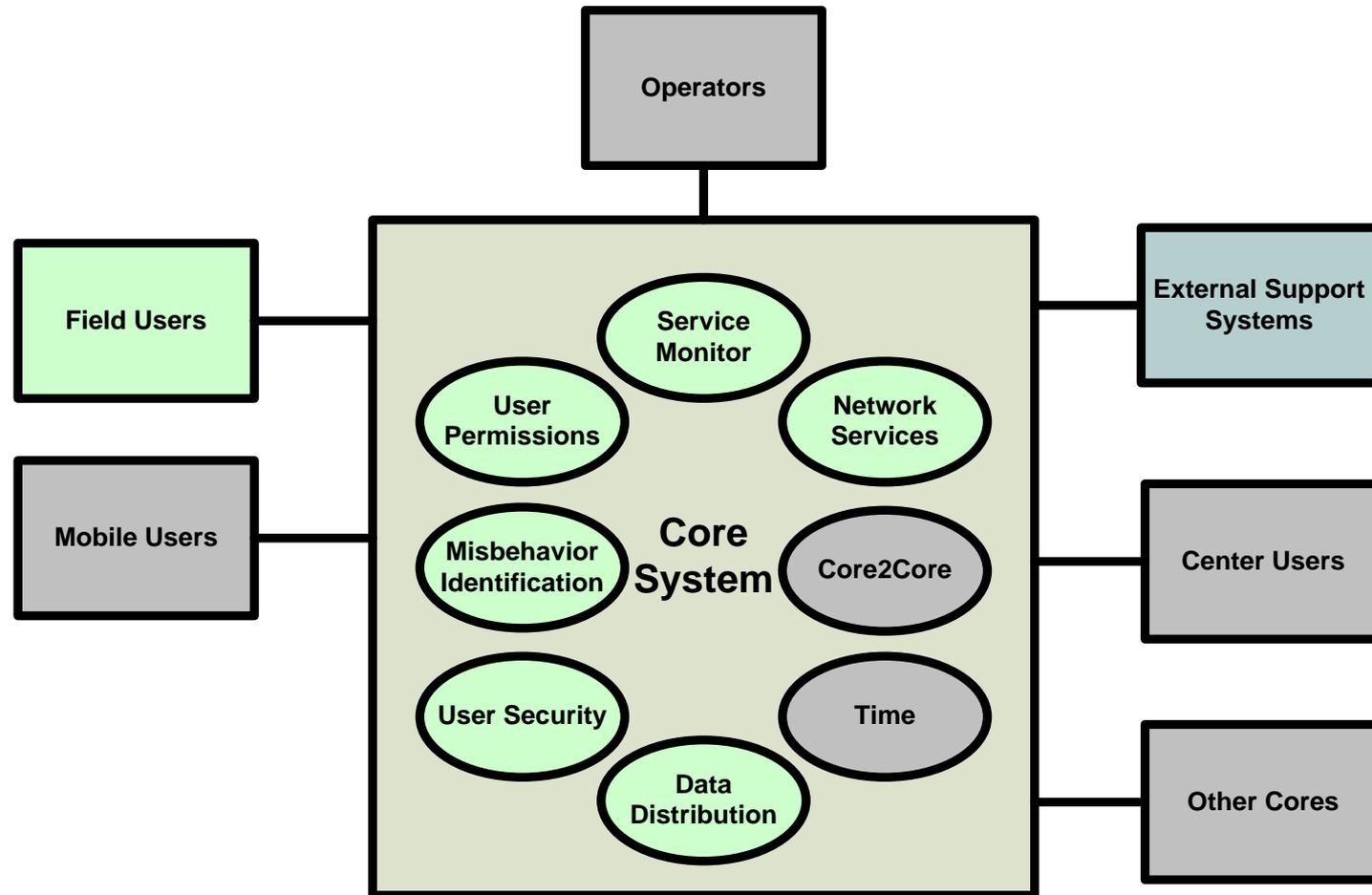
Center System Users Interact with Portions of the Core System

Operators

Field Users

Mobile Users

Core System

Service Monitor

User Permissions

Network Services

Misbehavior Identification

Core2Core

User Security

Time

Data Distribution

External Support Systems

Center Users

Other Cores
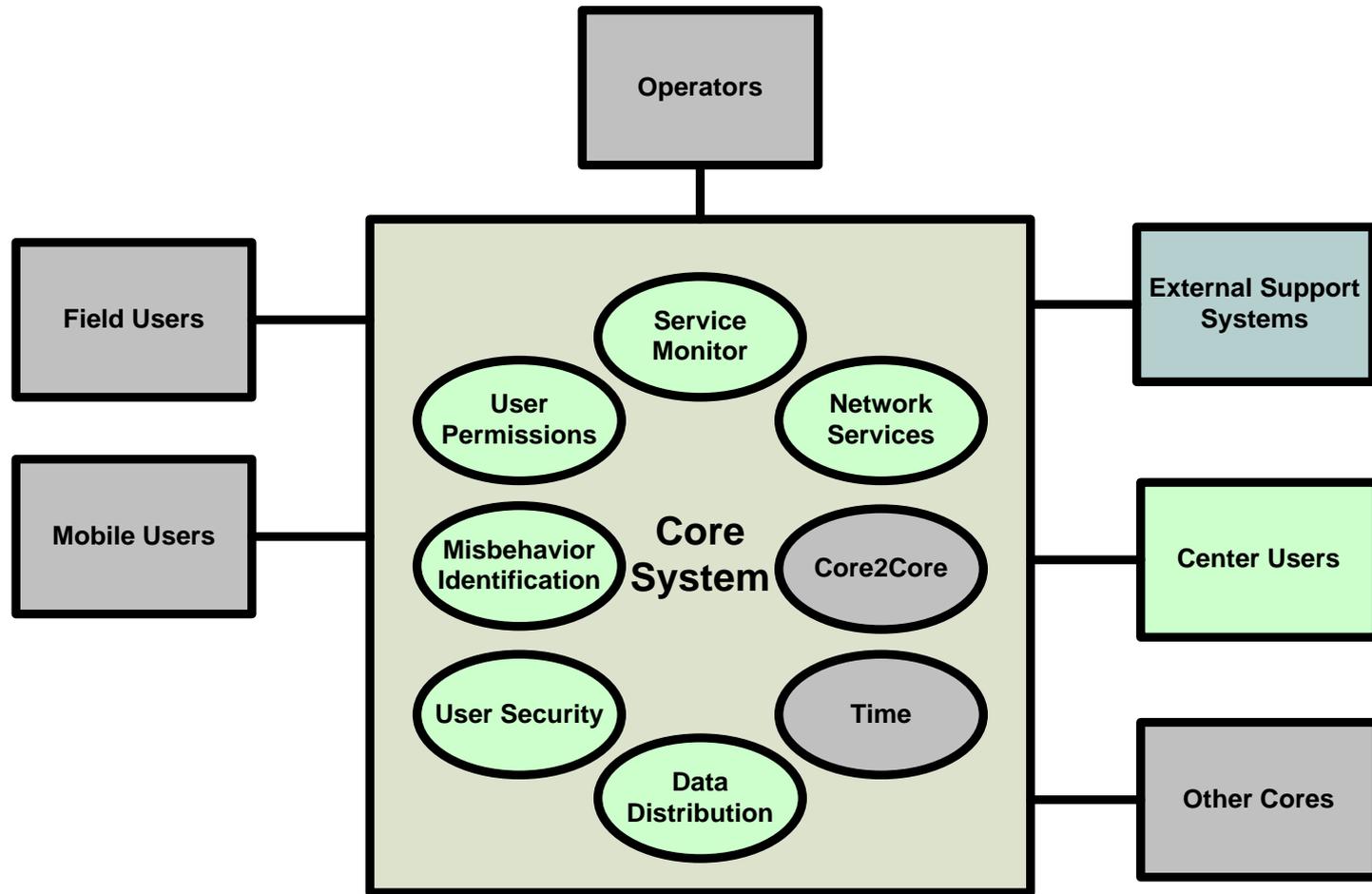
Core System Personnel (operators) interact with all subsystems
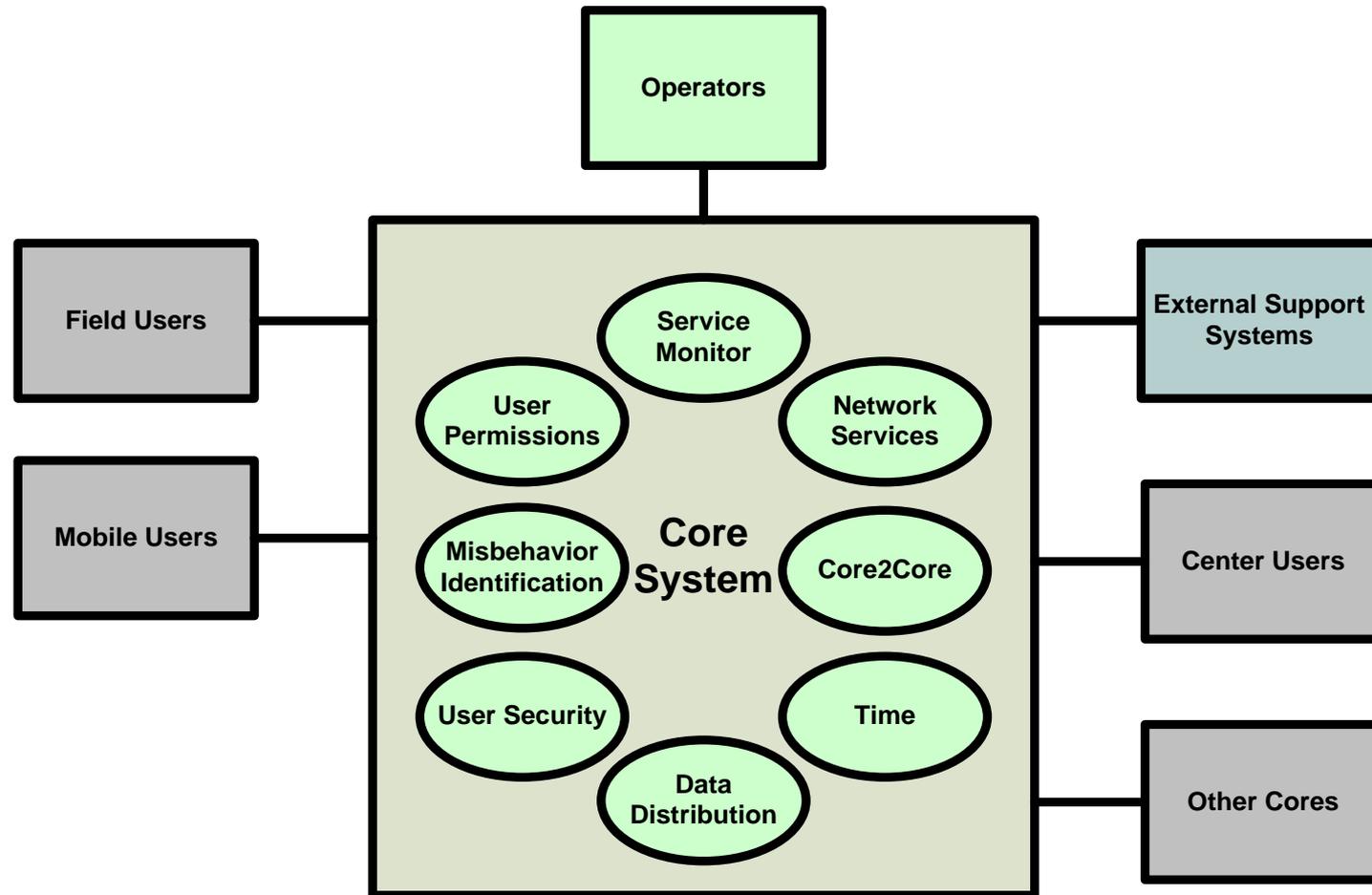
Core to Core Interactions
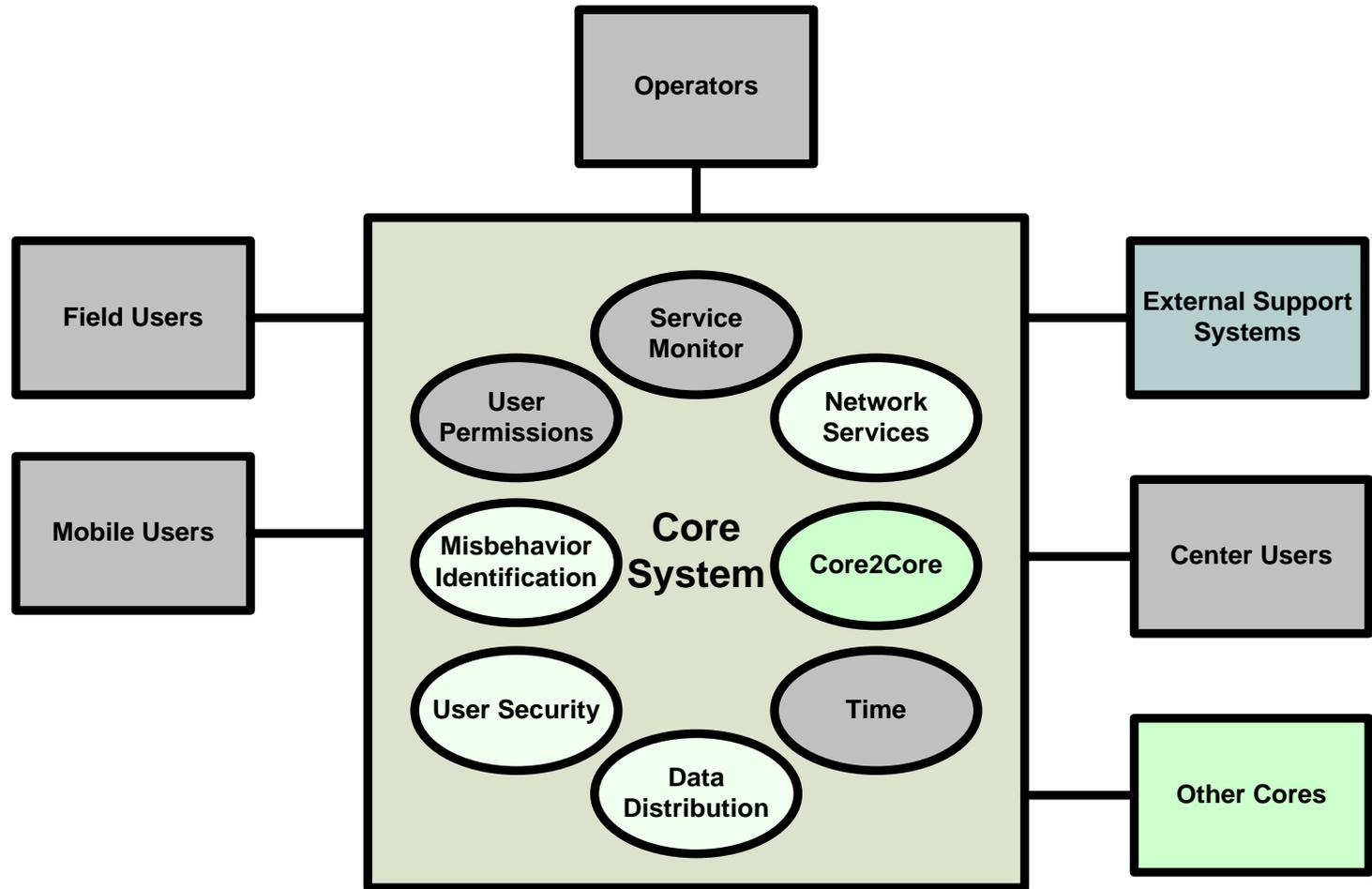
Core System Communications

>>

A Few Words on Communications

- The provision of communications between two devices is not inside the Core.
  - RSE are outside the Core
  - As are Blutooth, WiFi, Cell towers, etc.

Why separate Communications from Core Services?

- **Deployment and maintenance**: this makes the Core System a set of software, that can be deployed anywhere and operate over any area, independent of the deployment of communications.

- **Flexibility**: by decoupling communications architecture from core services, intra-core policies are separated from access mechanisms. This enables a variety of Core2Core relationships, and offers users more flexibility.

Supporting Direct Connections with the Core

Direct Comm Layer

Core System

Field, Center, & other direct connect devices
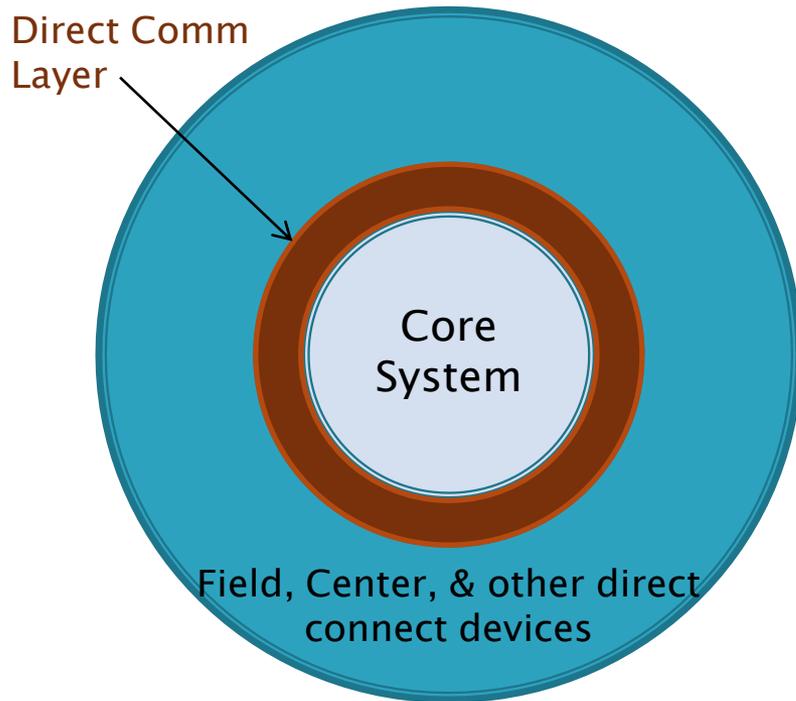
▸ **Direct Connect:** device is capable of directly addressing the Core System. May include RSE & other field devices, centers, and mobile devices connecting through wide–area wireless.

Supporting Indirect Connections with the Core

Core System

Indirect Comm Layer

Vehicles, Mobiles, other indirect connect devices
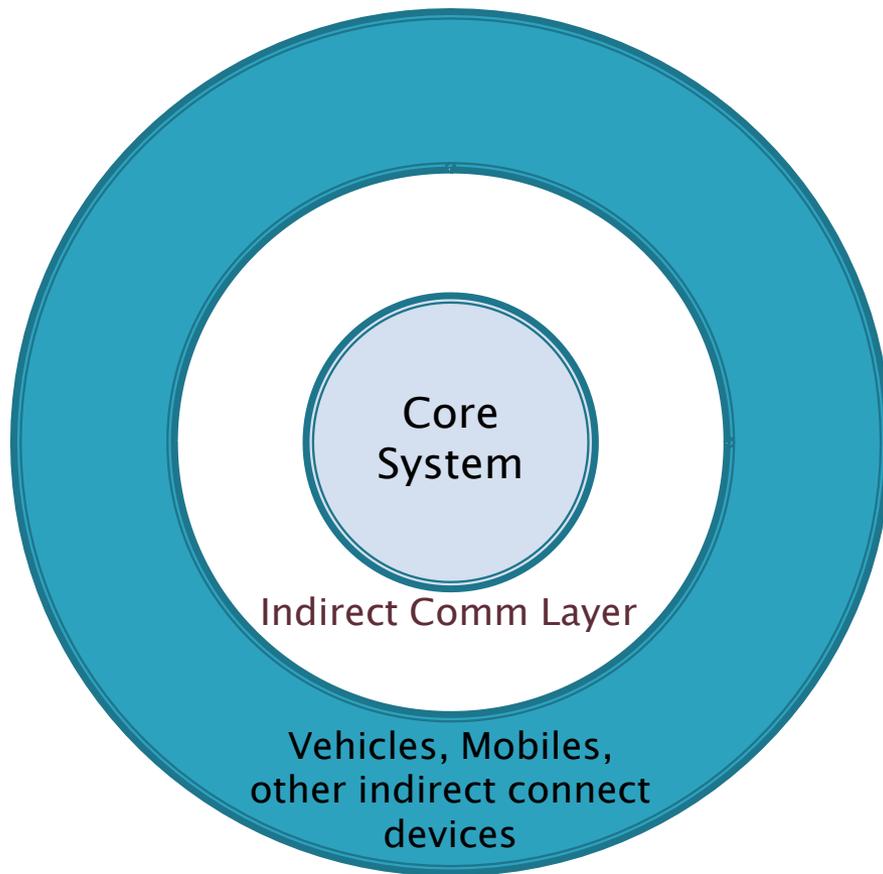
▸ Indirect Connect: device requires an intermediary in order to exchange data with the Core. Indirect connect includes mobile devices connecting through DSRC, and may include RSE and other field equipment and any other mechanisms.

What this means…

- The deployment and maintenance of field infrastructure is separated from the provision of enabling services.
- The deployment and maintenance of communications networks is separated from the provision of enabling services.
- Communications to support *the larger connected vehicle environment* can be customized for each deployment;
- Based on the needs of the deploying stakeholders

Core System Next Steps

>> Collecting Feedback, Proceeding

The System Engineering Process

Concentrate on the early SE life cycle…

… while staying focused on the overall program goals

Concept of Operations

System Requirements

High-Level Design

Detailed Design

Software / Hardware Development Field Installation

Unit / Device Testing

Subsystem Verification

System Verification/ Deployment

System Validation
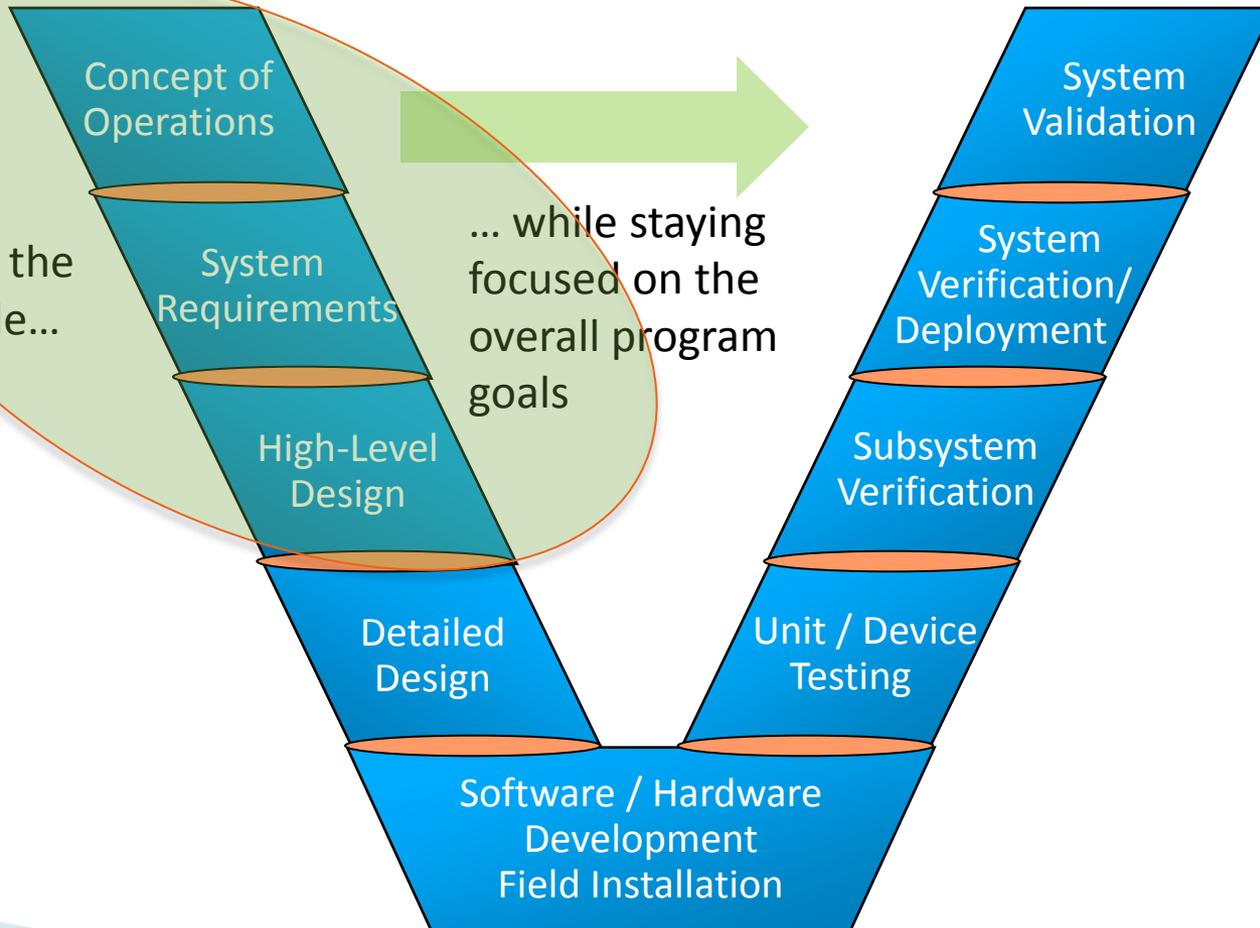
What to Expect from SE Steps

Concept of Operations Document

- User Needs, Expectations, Constraints
- High Level System Description
- Operational Scenarios

System Requirements Document

- *What* – functional requirements, interface definitions
- *How Well* – performance
- *Under What Conditions* – environmental, non-functional

System Architecture Document

- *See next slides*

System Architecture Definitions

▶ Architecture: The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution. (IEEE 1471)

▶ Viewpoint: a framework of rules for developing architecture views based on a related set of concerns

▶ View: a representation of the system from the perspective of a set of concerns

System Architecture Relationships

System —has an— Architecture

System —has 1.*— Stakeholder

Architecture —described by 1— Architectural Description

Stakeholder —identifies 1.*— Architectural Description

Stakeholder —is important to 1.*— Concern

Stakeholder —is addressed to 1.*— Viewpoint

Architectural Description —selects 1.*— Viewpoint

Architectural Description —is organized by 1.*— View

Concern —has 1.*— Stakeholder

Concern —is used to cover 1.*— Viewpoint

Viewpoint —conforms to— View

What makes the Architecture?

- Stakeholders and their Concerns
- Viewpoint Specifications
- Views defined in accordance with those Viewpoints, each of which addresses specific stakeholder concerns

Core System Architecture Viewpoints & Views

Enterprise View point	Functional Viewpoint	Connectivity Viewpoint	Communications Viewpoint	Information View point

Architecture Viewpoints and Views

Enterprise Viewpoint
Relationships between Organizations

Enterprise View 1	Enterprise View 2	Enterprise View 3

Functional Viewpoint
Logical interactions between Functional Objects: Hardware, Software or People (OSI 7)

Functional View 1	Functional View 2

Connectivity Viewpoint
Connections between Nodes (hardware), Links (interfaces) and Applications (software) (OSI 7)

Connectivity View 1	Connectivity View 2	Connectivity View 2

Communications Viewpoint
Layered communications protocols (OSI 1 -5) between Nodes (hardware)

Comm View 1	Comm View 2

Information Viewpoint
Data Object structure, relationships, metadata and constraints (OSI 6)

Information View 1	Information View 2	Information View 3

Core System Viewpoints

- **Enterprise**:
  - ◦ Organizational entities and their relationships. Focuses on scope and policy.
- **Functional**:
  - ◦ System as a collection of abstract objects that interact at interfaces.
- **Connectivity**:
  - ◦ System as a set of components that interact across links.
- **Communications**:
  - ◦ Mechanisms required to communicate between system components.
- **Information**:
  - ◦ Kinds of information handled by the system.

Example Enterprise View

Enterprise View

Scenario: Distribution of DSRC Certificates
Variation: External CA, External RA
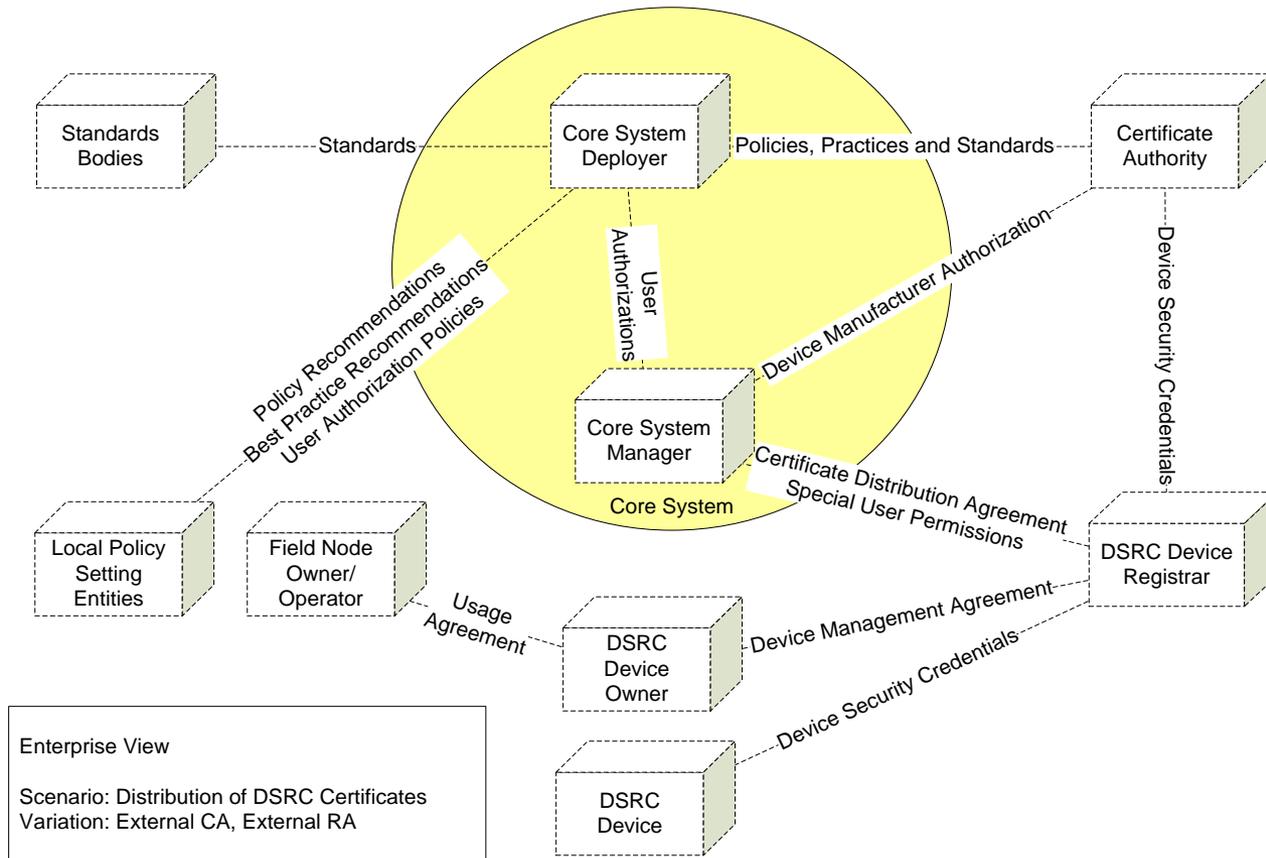
View Example: Communications
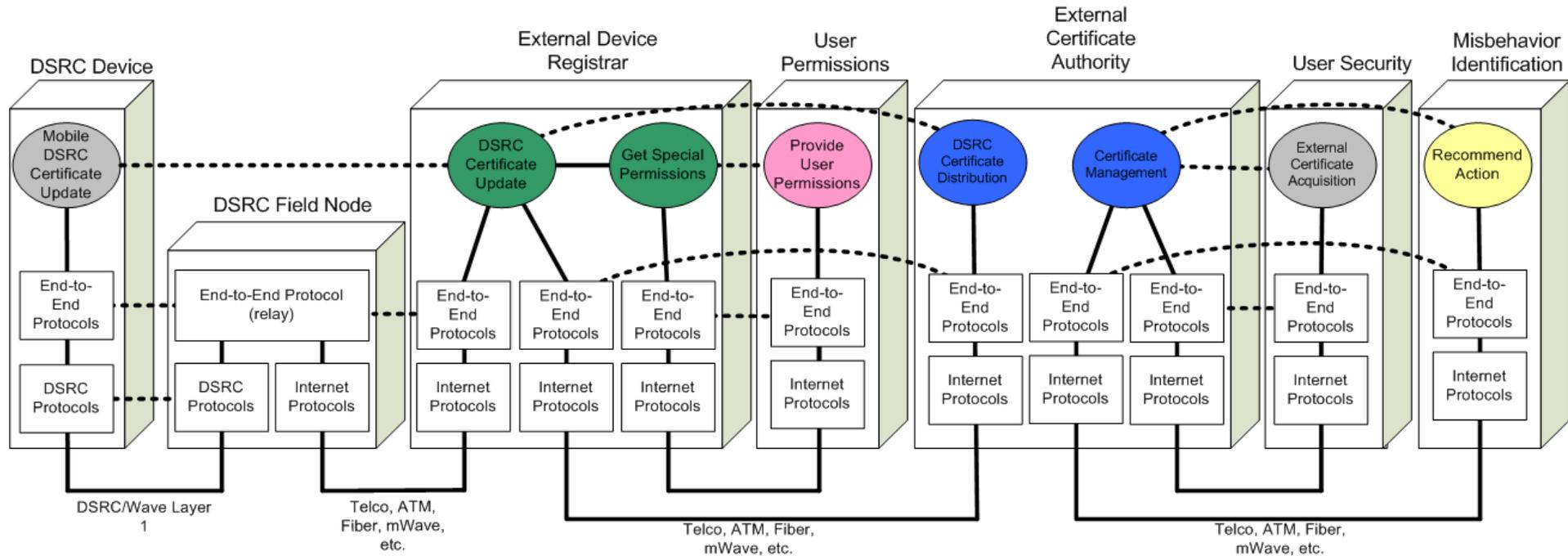
Communications View

Scenario: Distribution of DSRC Certificates
Variation: External CA, External RA

Core System Architecture

- Provides mechanism to explore alternative views
- Includes traceability between views (across viewpoints)
- As well as traceability to Requirements

Core System Development Next Steps

- Feedback from today – please provide to DOT
- System Requirements Specification and draft System Architecture Document
  ◦ Will include alternative architectures to be reviewed and discussed
- Next public workshop: June 28-30, 2011 in Washington, DC

Core System Timeline

We are here

| 2004 | 2005 | 2006 | . . . | 2008 | 2009 | 2010 | ★ |

FCC allocates 5.9 GHz spectrum for DSRC

VII Architecture developed based on Day 1 Use Cases

Prototypes for V2V (safety applications) and V2I (public applications) developed based on DSRC 5.9 GHz and tested in a POC test bed

New assumptions, new initiatives, new timelines

SE Program initiated to re-baseline

Stakeholder workshops to solicit user needs

Re-baselined Core System Concept of Operations, Requirements, & Architecture completed

User Needs

Aug/Sep 2010

Concept of Operations

Oct (draft)
Jan (RevA)
Apr (RevB/C)
May (workshop)

System Requirements & Architecture

June 28-30 2011 (DC Workshop)
Sep 20-22 (San Jose Workshop)