The USA's 5.9 GHz DSRC Prototype Development Program

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Topics

- Prototypes – WHAT?
- Status of activities
- The schedule
- Potential rollout scenario

5.9 GHz DSRC Prototypes

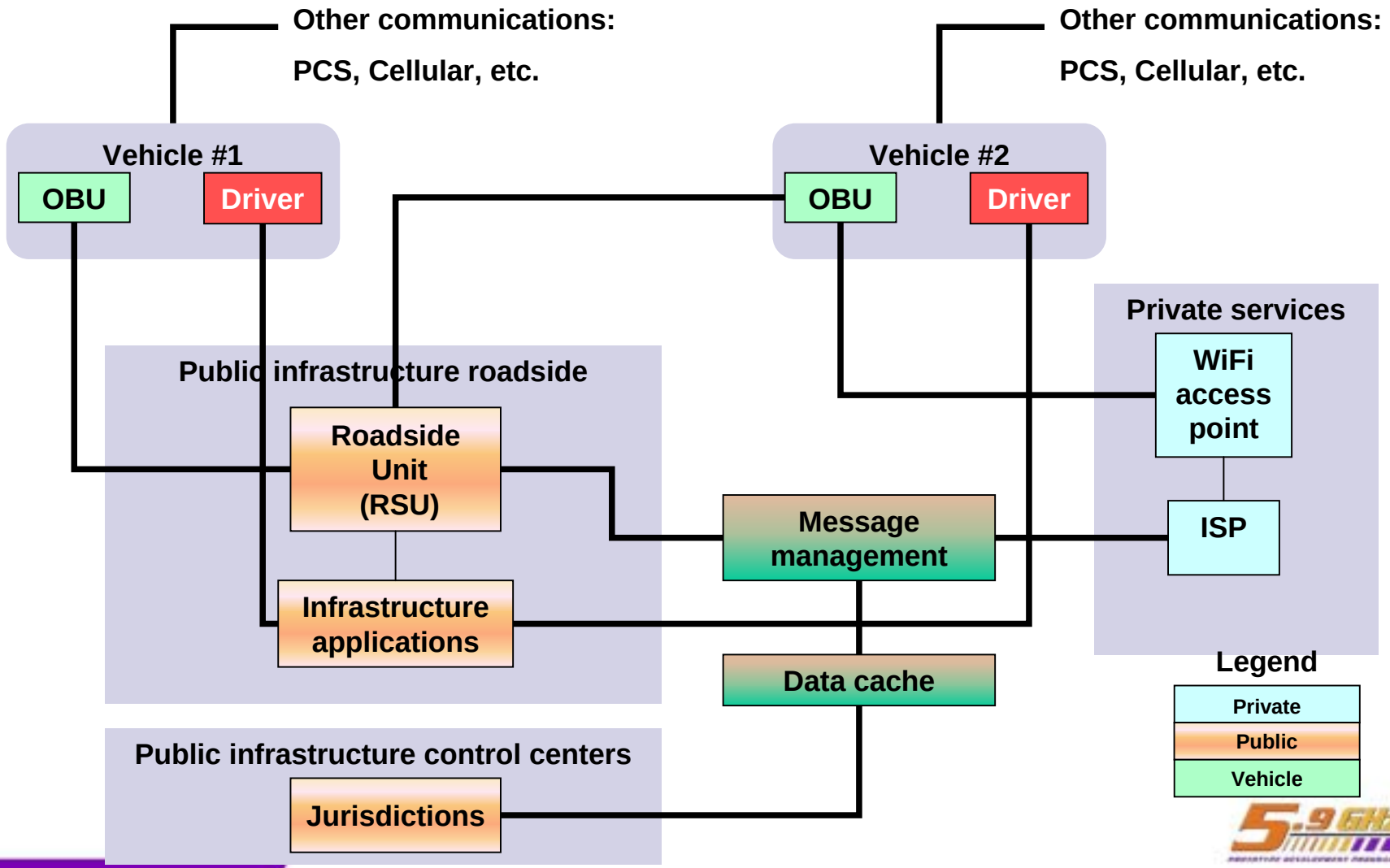
What?

5.9 GHz DSRC – What Is It ?

The Next Generation of Short-Range Communications

- Transmission Range increases 2 orders of magnitude
  - From 10 meters to 1000 meters
- Transmission Rate increases 2 orders of magnitude
  - From 0.25 Mbps to 25 Mbps
- Tailored to the hi-speed mobile environment
- Near-instant access

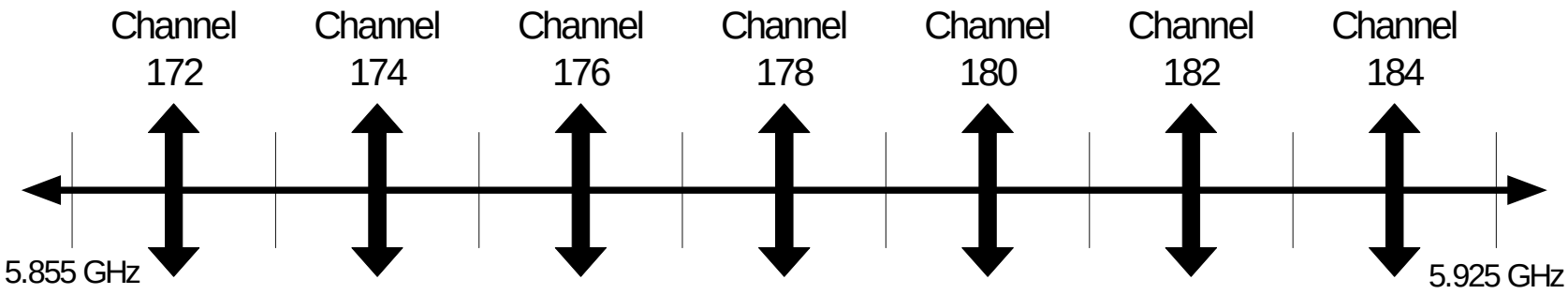
VII Tier 1 Architecture



U.S. DOT wanted….

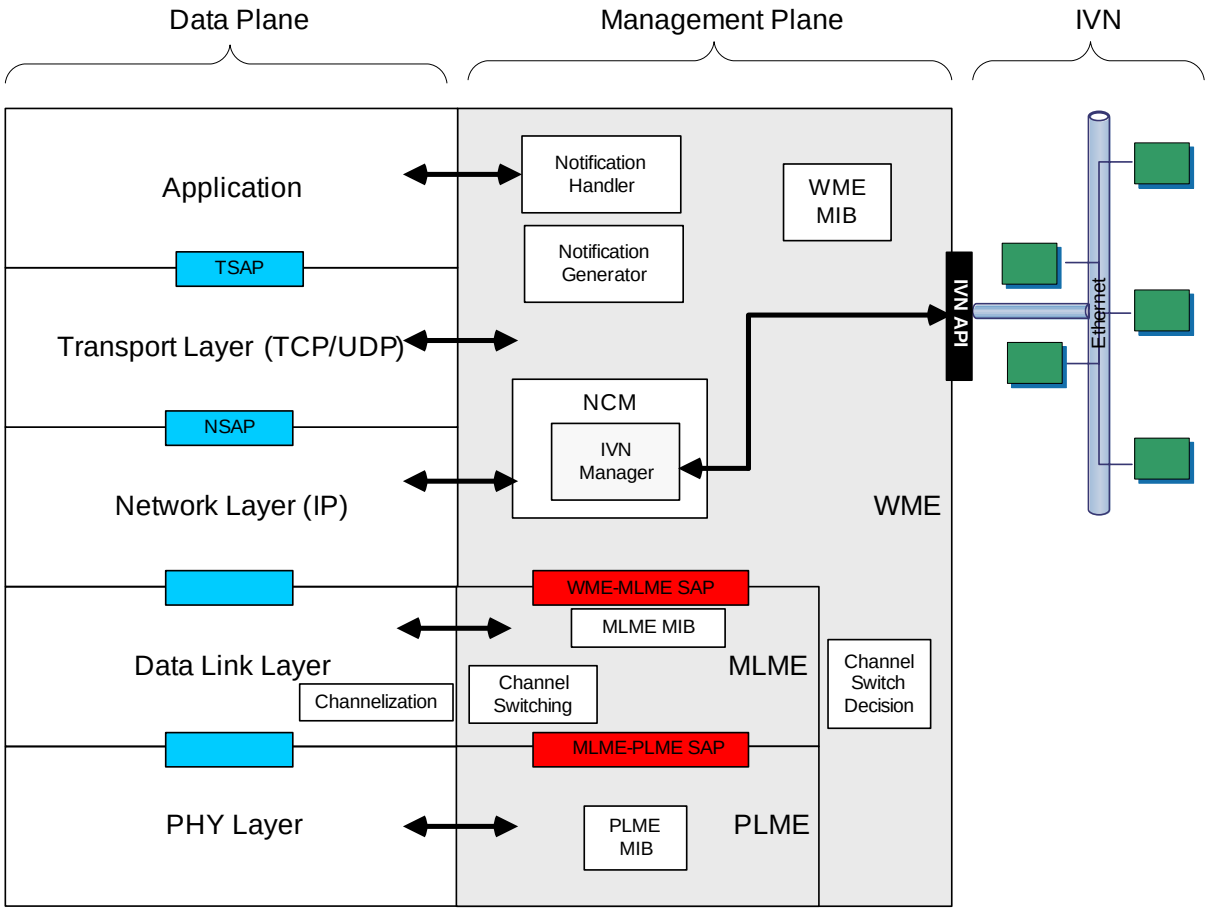
- Fast-paced prototype development program for 5.9 GHz DSRC
  - Industry driven
  - Shared-cost, but heavily funded up front by DOT
- Goals:
  - Prove the standards
  - Provide standard-compliant operational hardware for the vehicle OEMs
  - Perform testing to confirm vitality of the hardware, reasonableness of certain safety applications, and system acceptance by vehicle users
  - Provide a launching pad for DSRC industry

We Have Spectrum



- Channel 178 used as Control Channel
- All other channels used as Service Channels
- Each channel is 10 MHz

OSI-Based Architecture Overview



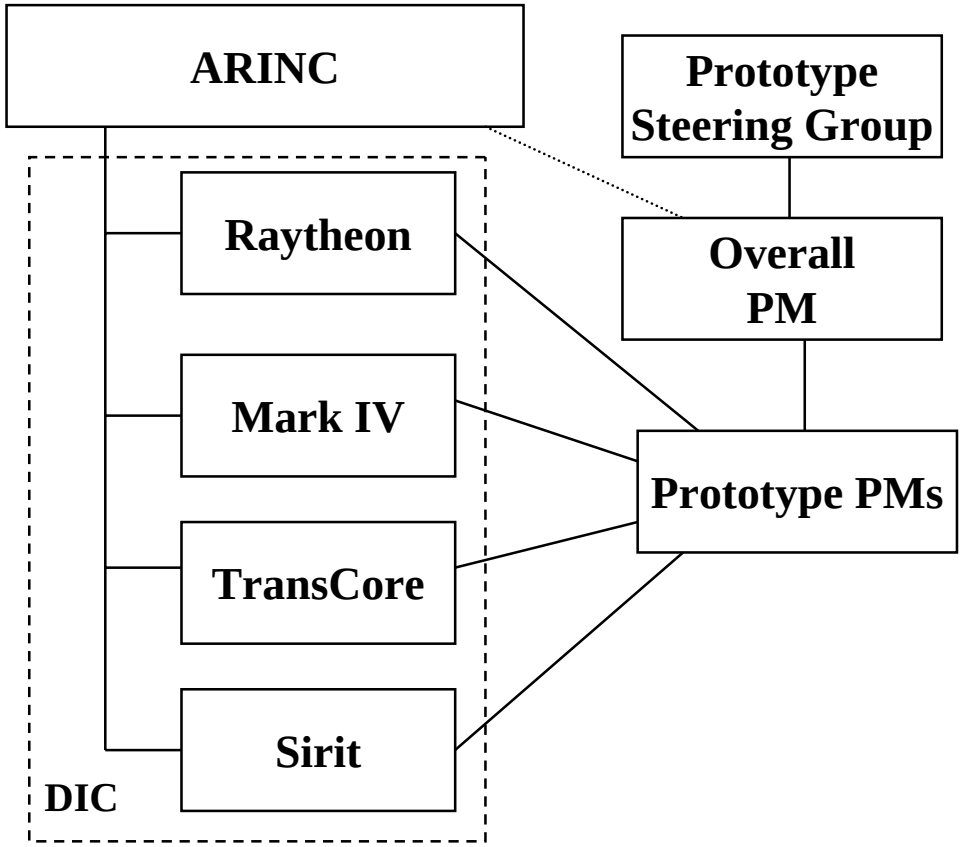
Contract for Prototype Development

- Substantial funding committed
- Contracted to DSRC Industry Consortium (thru ARINC)

- Participating members:
  - TransCore
  - Mark IV
  - Raytheon
  - Sirit

  Four competitors working together ???

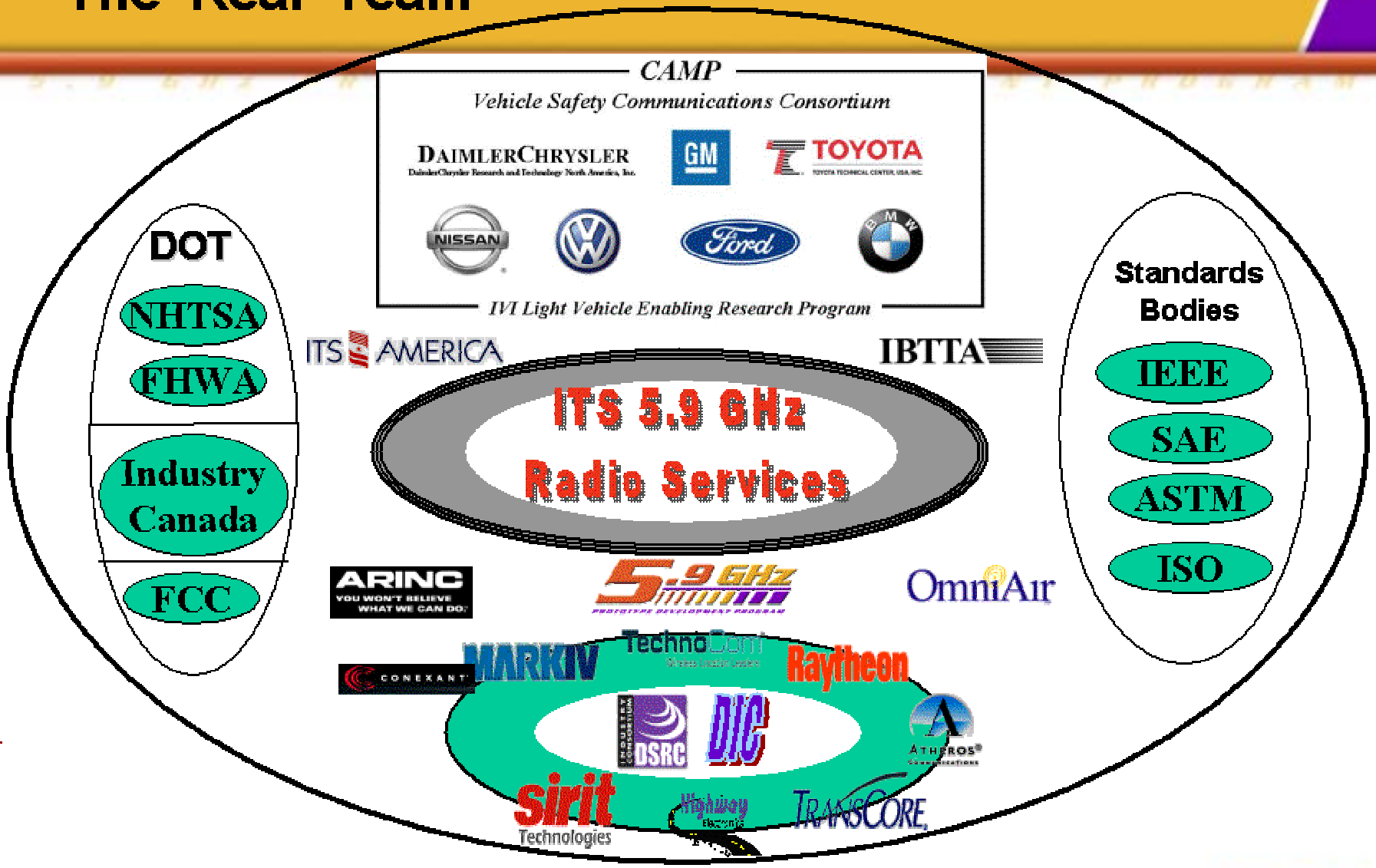
Prototype Project Organization



Roger O'Connor
Highway Electronics

Mark IV - - Roger Tong
Raytheon - - Doug Kavner
Sirit - - Randy Roebuck
TransCore - - Filip Weytjens

The 'Real' Team



Status

- Standards
- Design
- Hardware Development
- Software Development
- Test Planning

Standards

The initial standards task

- Content
  - Support standardization activity
  - Oversee communication security
  - Test the resulting standards

Specifically does not say ‘Develop the Standards’

A small problem -

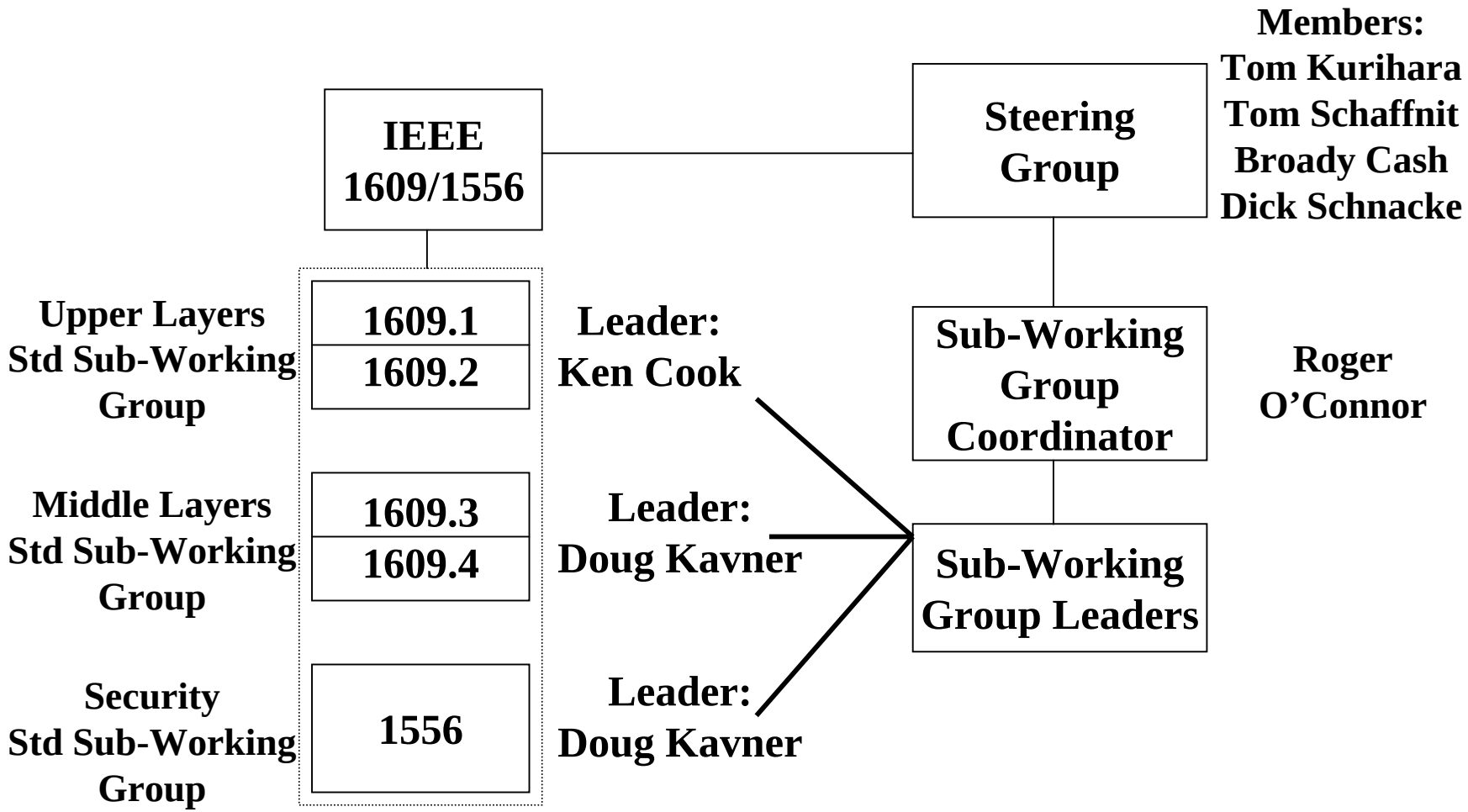
- Development of standards had been in work for 4+ years
- Moving forward slowly

Program to develop ‘standard-compliant prototypes’ soon caught up and passed the standards process

- The solution:

US DOT issued a contract amendment to fund DSRC Industry Consortium to expedite completion of standards

IEEE Sub-Working Groups



Current status

- All standards except Security will be delivered to IEEE Working Group by 17 December 2004
- Security standard will be delivered in January 2005

- Meanwhile, the Radio standard is nearing completion and has been designated by IEEE as 802.11p

  (yes, we're going to be a mobile wireless LAN)

Design

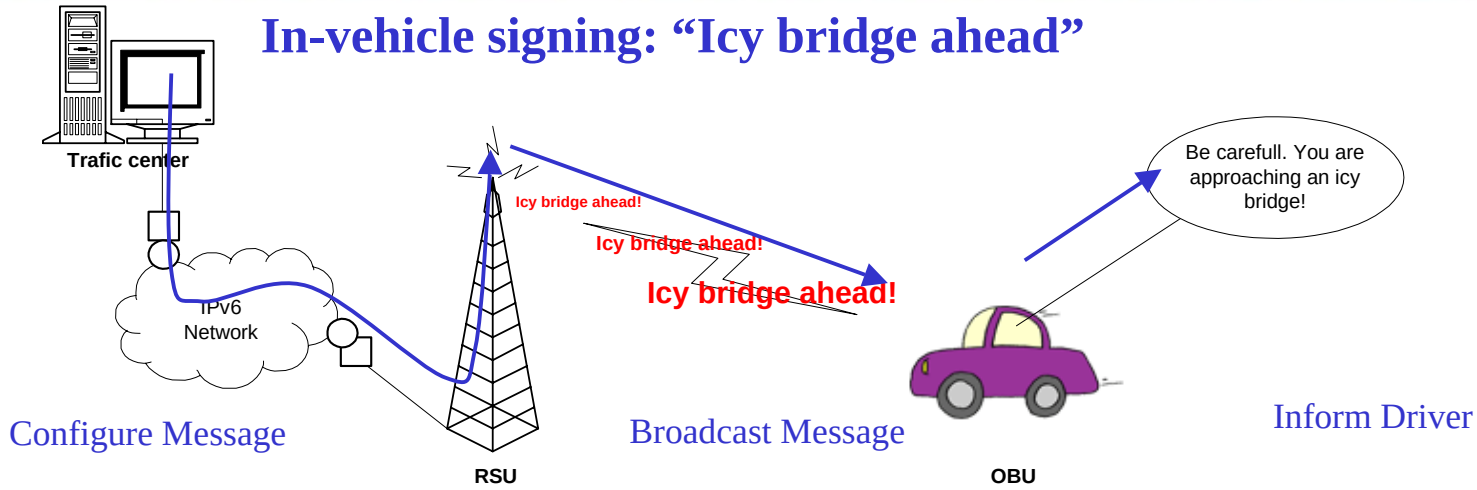
The system design task

- Content
  - Selection of applications
  - Requirements (Functional, Performance, Testing)
  - Architecture and network topology
  - Prototype development plan

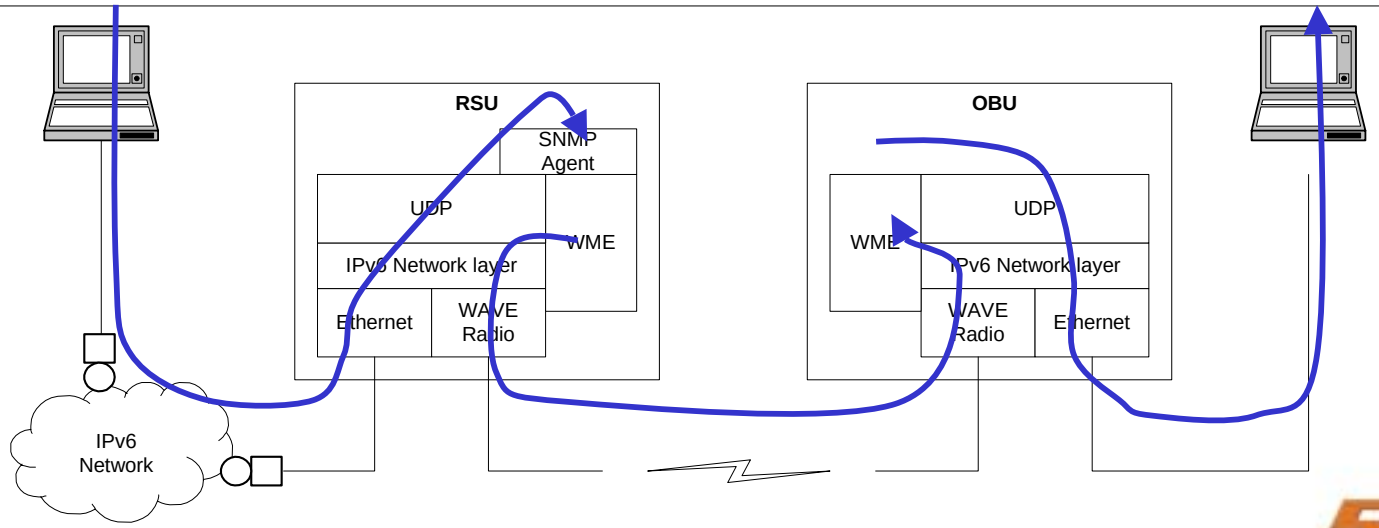
Development of scenarios & functionality

Scenario

In-vehicle signing: “Icy bridge ahead”

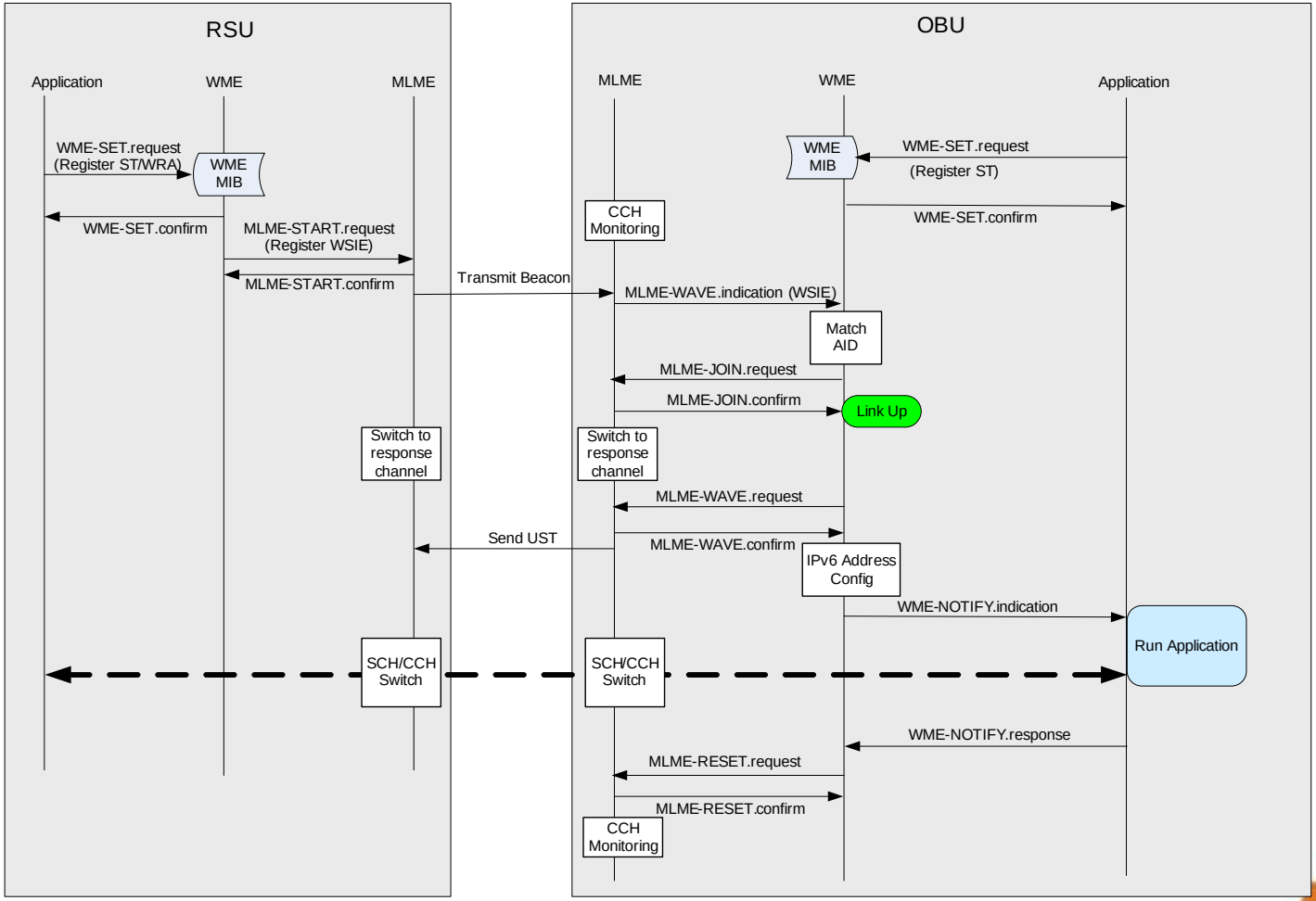


Prototype Implementation



Functional Dissection of Each Application

RSU/OBU Service Channel Transaction

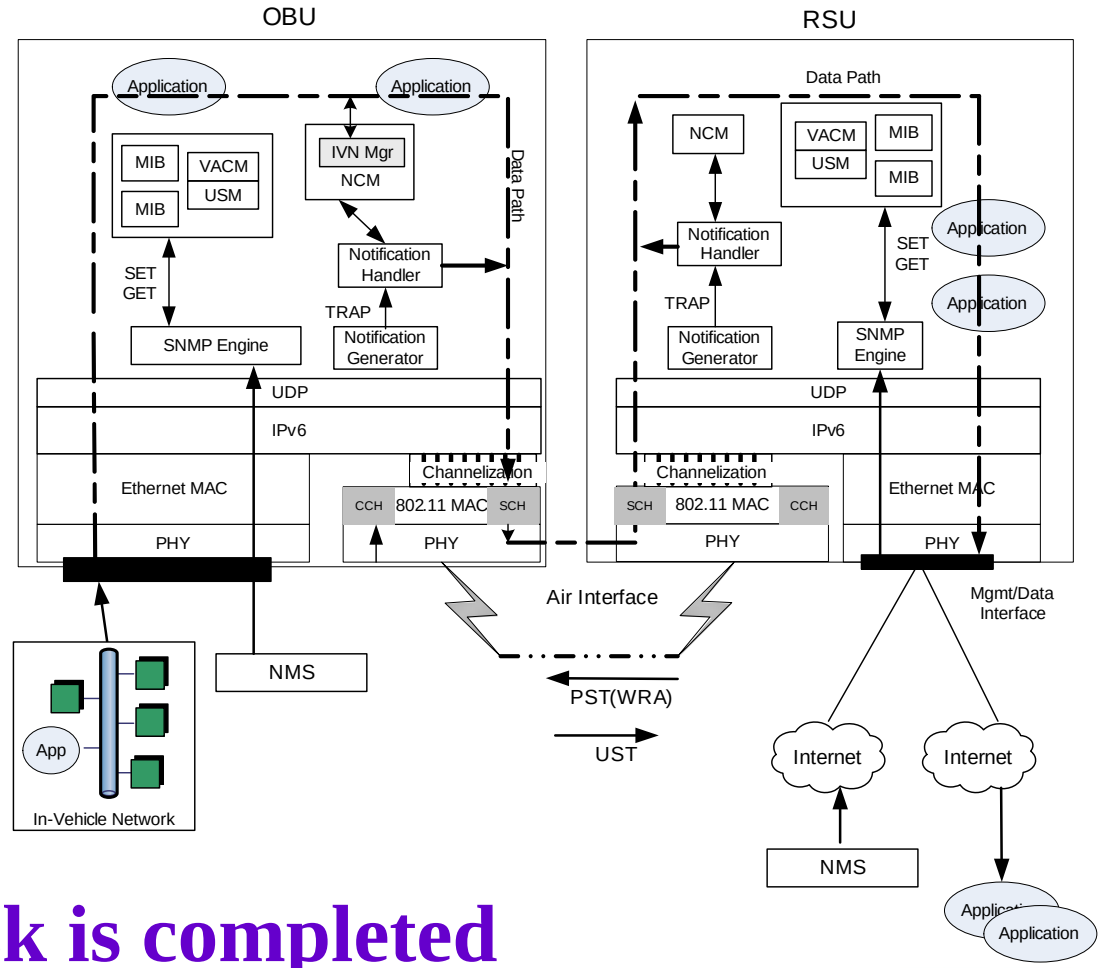


What Makes the Solution Complex?

- Unlike conventional 802.11, communication points are moving about at high speeds
- Must operate as master/slave when communicating to roadside but as peer-to-peer when vehicles talk directly
- Must acquire in milliseconds
- Must change channels in microseconds
- Must control power dynamically to decrease interferences
- Must always get the most important message through first
- Must have ‘bulletproof’ communications security

Architecture and Design

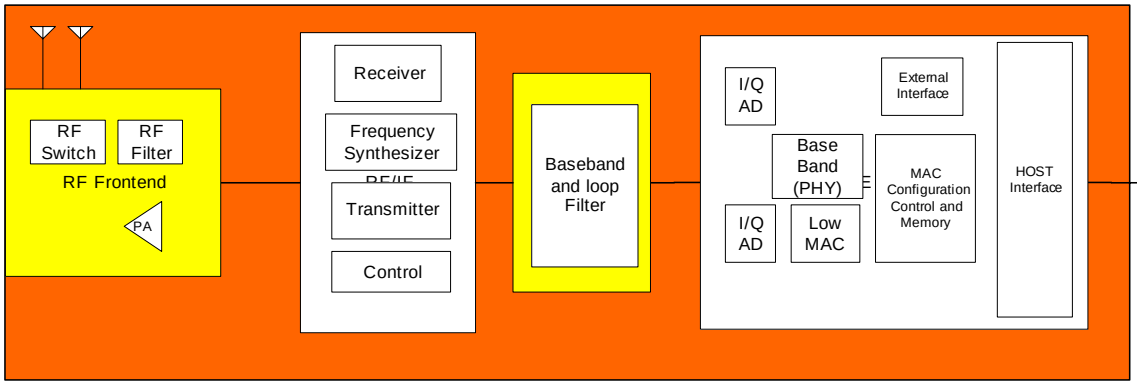
- Architecture is network based to support:
  - Many applications
  - Comm for other vehicle computers
  - Latest version of TCP/IP: IPv6
- Existing IPv4 devices can be supported via gateways
- “Internet” can also be a private network



The design task is completed

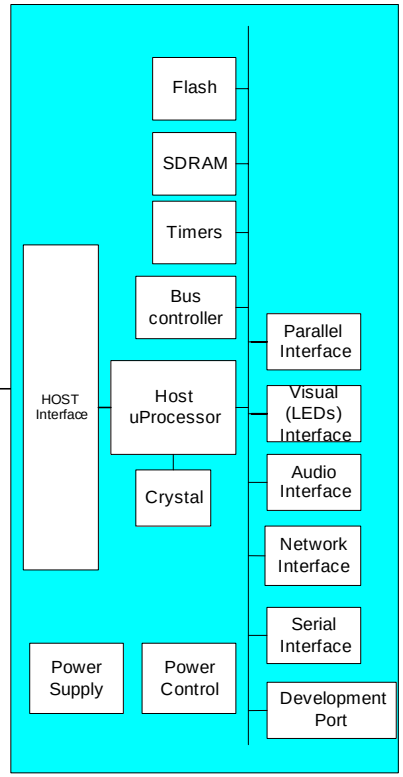
Hardware Platform – Division of Task

Common hardware for OBU and RSU



The Radio

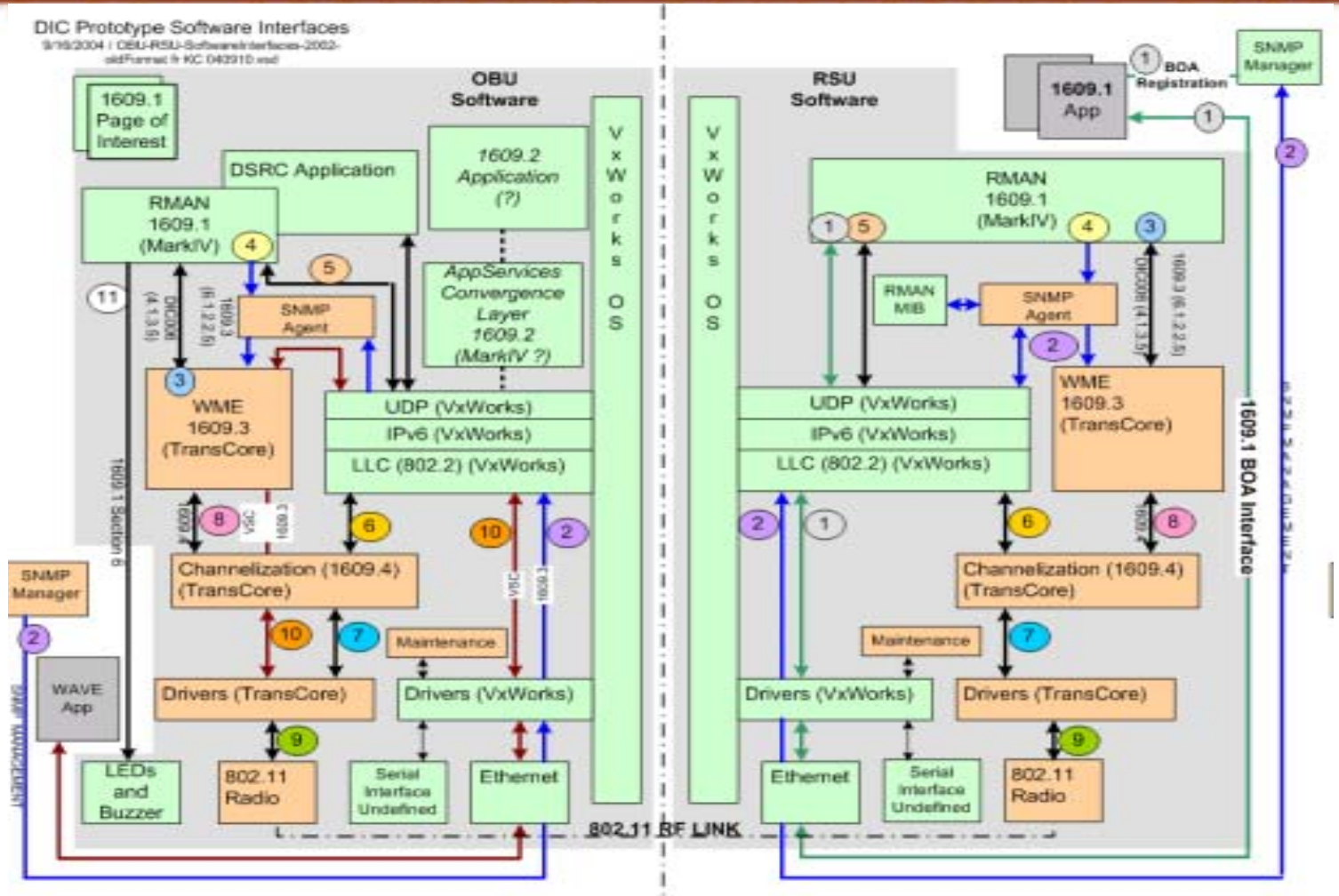
(Developed by TransCore)



The Controller

(Developed by Mark IV)

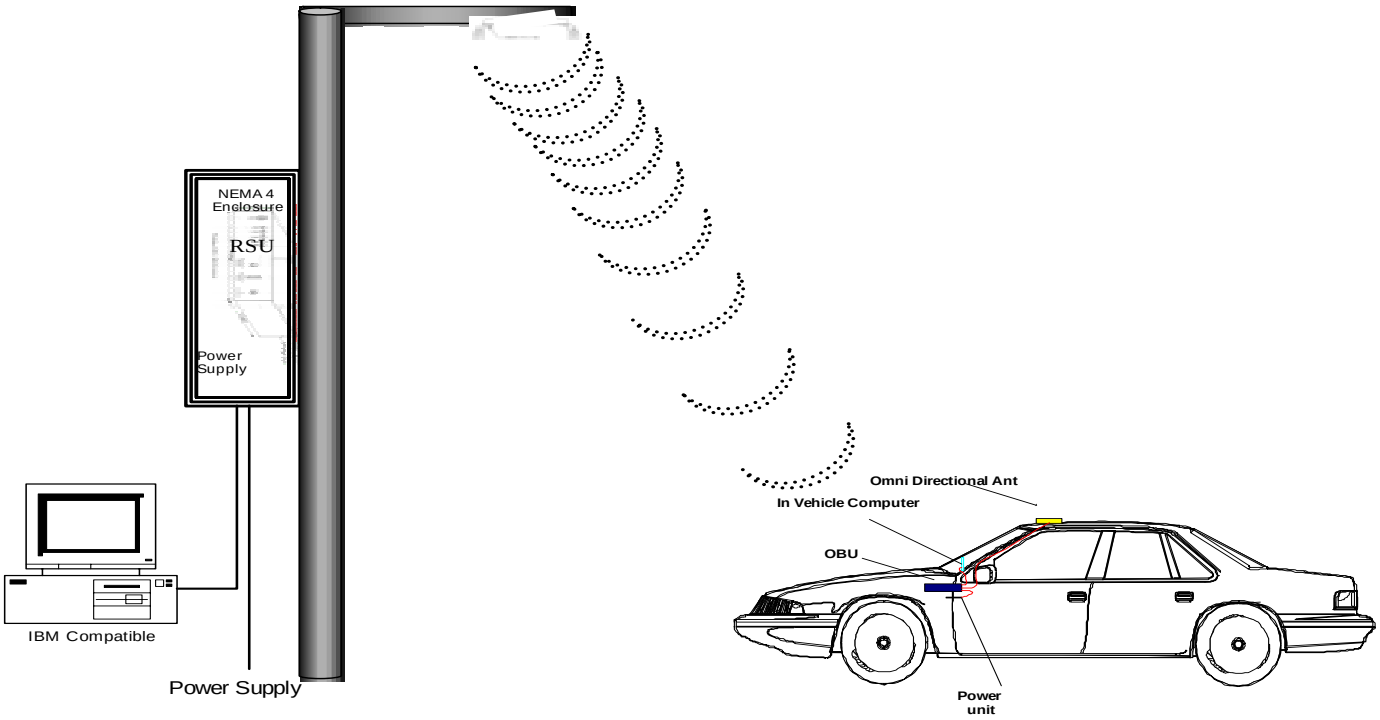
Software Platform – Division of Task



Green: To be delivered by MarkIV
Orange: To be delivered by TransCore
Grey: Third-party software to be used later

Hardware Development

Realistic Design Considerations



Prototype / test article status affects the design

Key Requirements are Defined

- Environmental
  - Temperature, humidity, vibration, shock, etc.
  - Electrical characteristics
- Installation
  - Mounting provisions & limitations
  - Cabling, connectors, etc.
- Antennas
- Memory allocations
  - Bus width, transfer speed, memory size
- Interfaces
  - Internal & external

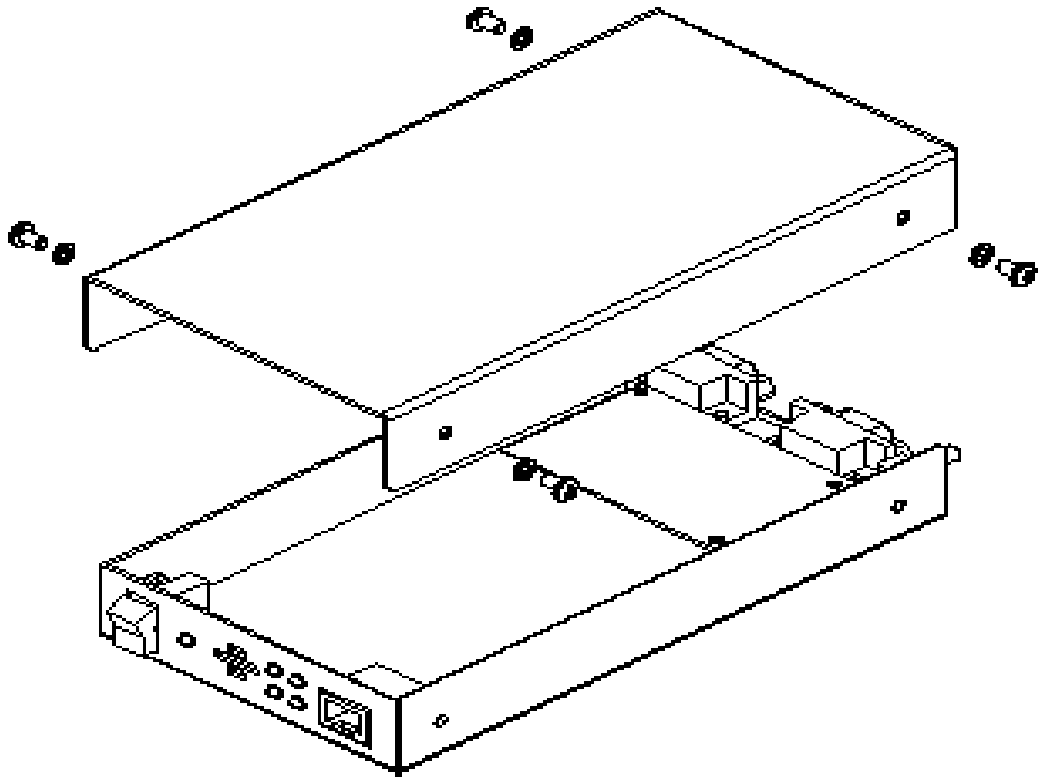
Major system Elements are Selected

- Radio chipset
- Microprocessor
- Operating System

These decisions enable the selection of myriad secondary components and allow start of circuit board layouts.

Numerous tasks underway now.

Prototype Packaging Concept



Software Development

Software

It’s always the biggest & hardest job

- Requirements pretty well defined
- Software architecture taking shape
- Certain software decisions dependent on un-made hardware decisions

Software functionality being defined

- **Basic Use Cases**
  - RSU/OBU – OBU Broadcast service
  - RSU – OBU Transaction service (2-way message exchange)
  - Support for prioritized applications
- **Network services**
  - IPv6 network access for the RSU and the OBU
  - Simple network management protocol
- **WAVE Management Entity**
  - PST/UST exchange and processing
  - Channelizer management (Control/service channel switching)
  - Device and application configuration management
- **MAC Layer**
  - Random MAC address generation
  - IEEE 802.11e Priority control
  - IEEE 802.11h Channel switching

Test Planning

Testing Methodology

- Initial Test Process Development of DRSC Technology:
  - Identify Test Equipment and Test Software
  - Develop Test Procedures (not Certification)
- Verification Testing of the Prototypes per the Requirements:
  - IEEE 802.11a/p
  - IEEE 1609
  - ASTM E2213
  - DSRC Prototype Specifications
- Test UUT for Functionality and Minimum Durability (environmental screening)
- Demonstrate key application use cases and scenarios

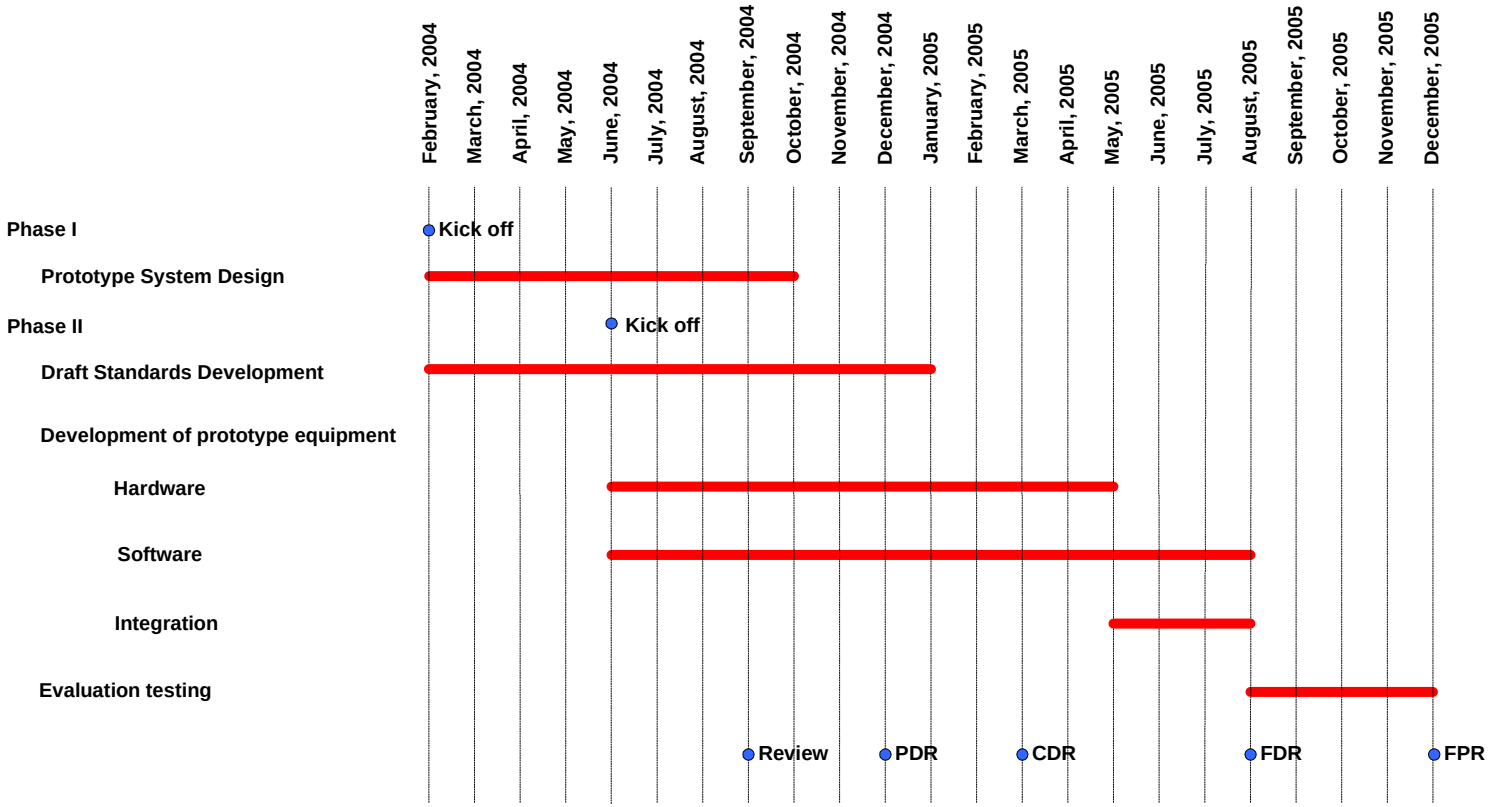
* **Selection Criteria:** Test, Analysis, Modelling, Simulation & Inspection

Test Phases

- Alpha Testing of Radio modules and Development units:
  - Test basic functionality and operation of modules and units.
- Lab Testing and Evaluation of DSRC Prototypes:
  - Test transmitter and receiver (air interface) for compliance to required standards.
  - Test functionality of prototype for message transmission protocol compliance.
- Field Testing of DSRC Prototypes:
  - Range (driving) tests for distance, speed, and throughput requirements.
  - Testing of key use cases for end-to-end message and data transmission compliance.
- Environmental Testing of Final Prototypes:
  - Temperature testing over required range.
  - FCC Pre-screening, but not full certification for prototypes.
- Customer Witness Testing of Final Prototypes per Test Plan

Schedule

Prototype Program Schedule



Potential Rollout Scenario

Realism –Present Activities

- Mid-2004 through mid-2006
  - Finish standards, test them, re-work as needed
  - Finish the prototype program
  - Test prototypes to exhaustion
  - Design realistic antennas
  - Develop certification procedures

Realism – Next Activities

- Mid-2006 through mid-2008
  - Larger scale tests
    - MDIs (3?)
    - Thousands of OBUs, hundreds of RSUs
    - Stressing the system
  - Design re-works based on above
  - Productizing hardware and software

Leading to …..

Deployment Decision in mid-2008

(Both Infrastructure & Vehicles)

*Announced position of both DOT and Vehicle OEMs

A Realistic Scenario – DOT Infrastructure

Assumption: Mid-2008 deployment decision

- First safety priority: Intersections
- Current plan: Equip 400,000 intersections with DSRC beacons over 6 years
- Those years likely to be: 2009 through 2014

A Realistic Scenario – Vehicle Implementation

Assumption: Mid-2008 deployment decision

- Normal OEM design/implement cycle: 3 years
  - Some indications this could happen in 2 years
  - Therefore, first vehicles could appear in 2010
- Normal model deployment cycle: Start in high-end vehicles & push down
  - Some indications this pushdown could occur more rapidly than usual

Vehicle Implementation Scenario

- Using the most optimistic assumptions, a possible scenario is (in millions):

Year	Vehicles	Cumulative
2010	1	1
2011	4	5
2012	8	13
2013	12	25
2014	16	41
2015	16	57

……out of a U.S. vehicle population of 250-300 million

*Schnacke - educated guesstimate

Summary

- The 5.9 GHz DSRC Prototype Program is alive and well
- Prototypes will have capabilities well beyond any present-day systems.
- Prototypes will become available in late 2005 and will feed into numerous application evaluation projects
- For more information:

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