5.9 GHz DEDICATED SHORT RANGE COMMUNICATION (DSRC) OVERVIEW

5.9 GHz DSRC QUESTIONS

What is it?

Who developed it?

When would it be advantageous to use it?

When will products be available?

When will it be available as original equipment in new cars?

What plug replaceable technology can be used for some data transfer applications in the interim?

What model deployments are being planned for next year?

How will this affect Toll Agencies?

When should state agencies start planning to deploy it?

What will be required from the frequency coordinator?

A

WHAT IS IT ???

5.9 GHz DSRC CONCEPT

5.9 GHz DSRC (Dedicated Short Range Communications) is a short to medium range communications service that supports both Public Safety and Private operations in roadside to vehicle and vehicle to vehicle communication environments. DSRC is meant to be a complement to cellular communications by providing very high data transfer rates in circumstances where minimizing latency in the communication link and isolating relatively small communication zones are important.

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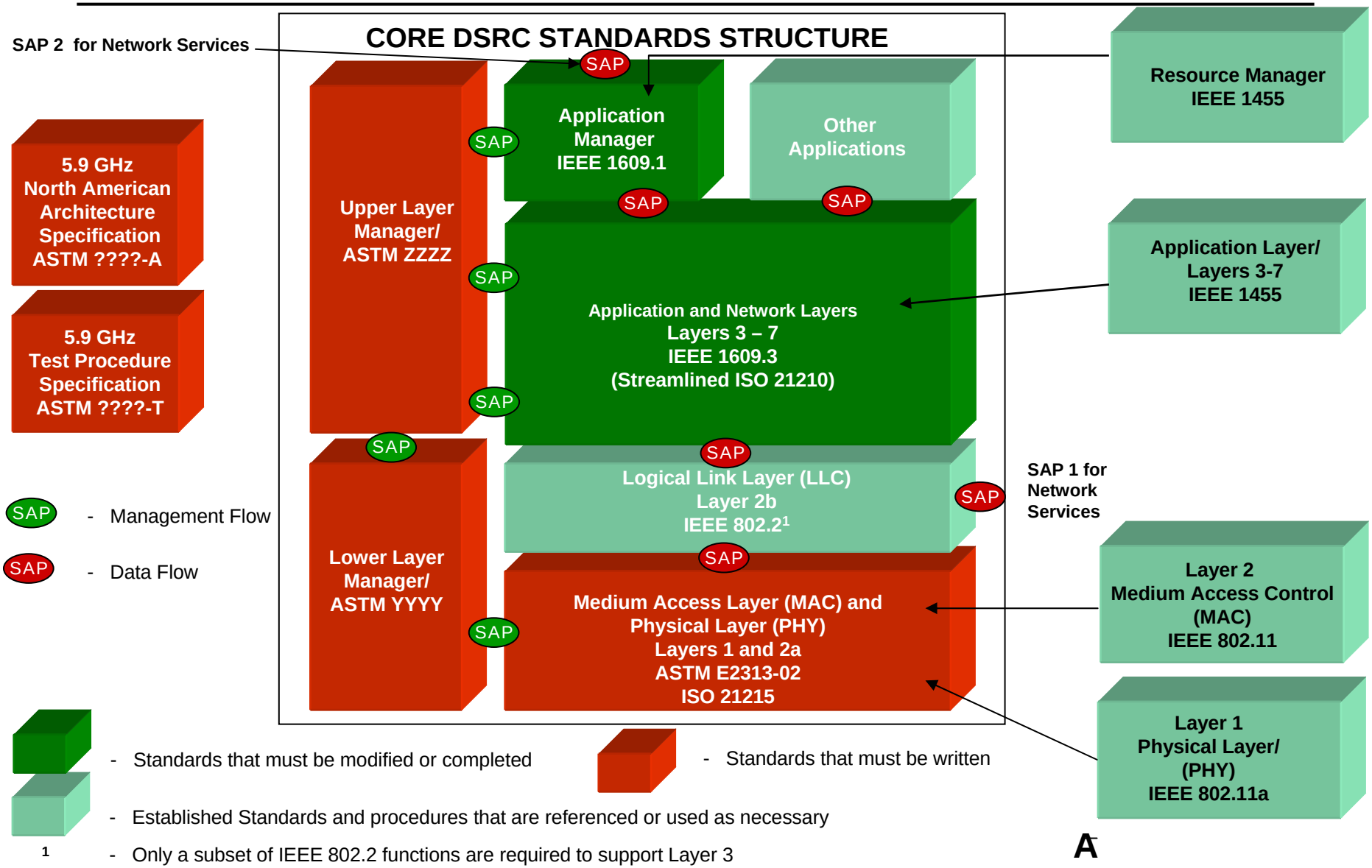
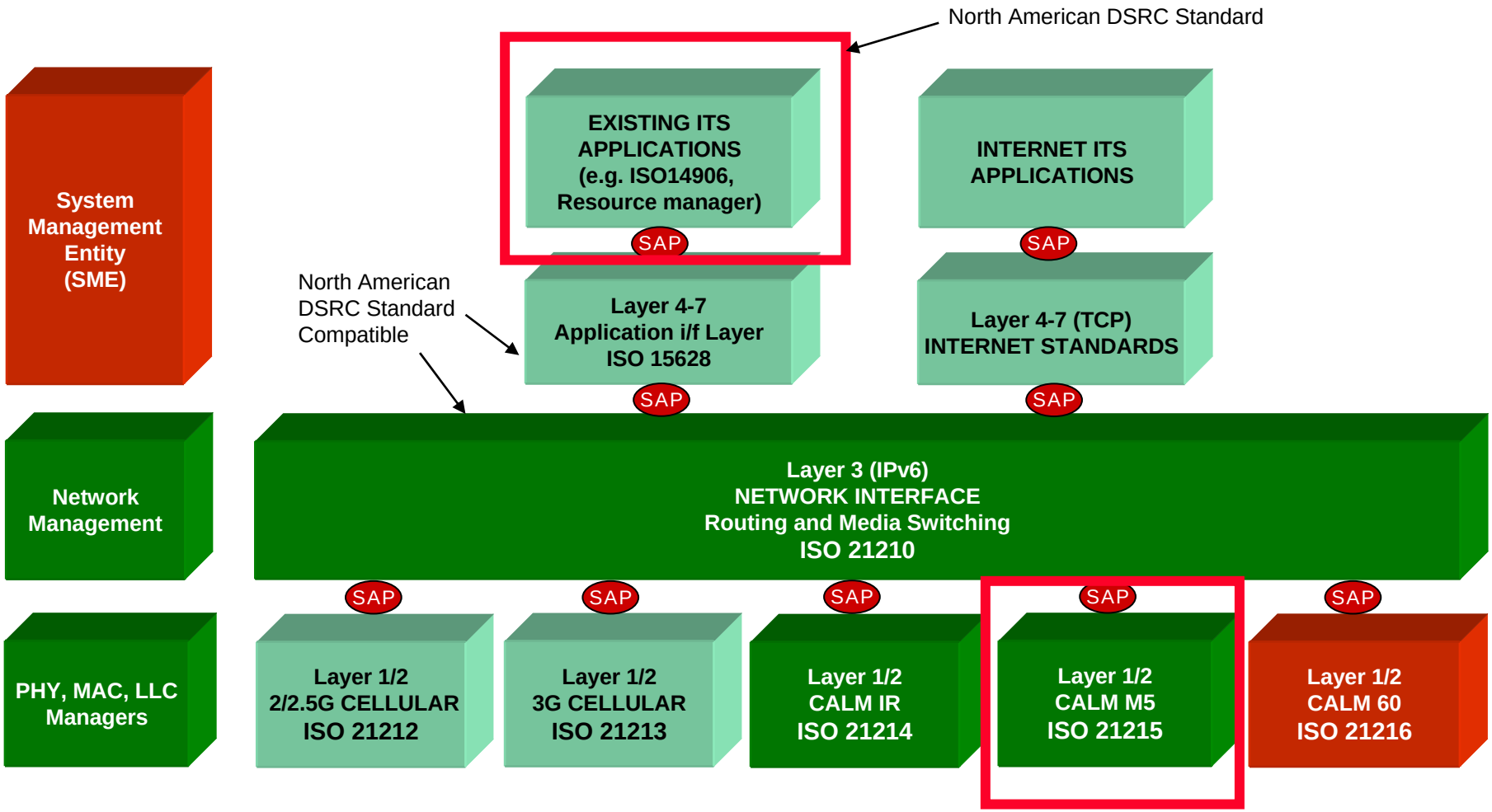
NORTH AMERICAN DSRC STANDARDS STRUCTURE OVERVIEW



ISO TC204 WG-16 CALM ARCHITECTURE



5.9 GHz DSRC TECHNOLOGY CHARACTERISTICS

- **Approach: Active**
- **Bandwidth: 75 MHz (5.850 - 5.925 GHz)**
- **Modulation: QPSK OFDM (with 16QAM and 64QAM options) (**BPSK preamble**)**
- **Channels: 7 - 10 MHz channels (optional combinations of 10 and 20 MHz channels)**
- **Data Rate: 6, 9, 12, 18, 24, and 27 Mbps with 10 MHz Channels (**3 Mbps preamble**)**
- **(or 6, 9, 12, 18, 24, 36, 48, and 54 Mbps with 20 MHz Channel option) (**6 Mbps preamble**)**
- **Max Tx Pwr: 28.8 dBm (at the antenna input)**
- **RSU EIRP: Nominal 0 - 33 dBm (1 mW - 2 W) / Max. 44.8 dBm (30 W)**
- **OBU EIRP: Nominal 0 - 20 dBm (1 - 100 mW) / Max. 44.8 dBm (30 W)**
- **RSU and OBU Sensitivity: - 82 dBm (QPSK) / - 65 dBm (64QAM)**
- **C/I: 4 - 6 dB (for QPSK @ 10^{-4} BER coded) / 16 - 17 dB (for 64QAM @ 10^{-4} BER coded)**
- **Band Sharing Strategy - Frequency Coordination. Selection of alternate channels for adjacent zones. Use CSMA to prevent interference between users in the channel.**

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RSU - Roadside Unit; OBU - Onboard Unit; EV - Emergency Vehicle; EIRP - Effective Isotropic Radiated Power; CSMA - Carrier Sense Multiple Access

DSRC CAPABILITIES COMPARISON

(in the designated ITS RADIO SERVICE bands)

PARAMETERS	902 - 928 MHz Band	5850 - 5925 MHz Band
SPECTRUM USED	12 MHz (909.75 to 921.75 MHz)	75 MHz
DATA RATE	0.5 Mbps	6 Mbps - 27 Mbps
COVERAGE	One communication zone at a time	Overlapping communication zones
ALLOCATION STATUS	No protection	Primary Status (high protection)
INTERFERENCE POTENTIAL	Many 900 MHz Phones, Many Rail Car AEI Readers, Many Spread Spectrum Devices, Wind Profile Radars	Sparsely located Military Radars, Very Sparsely located Satellite Uplinks
MAXIMUM RANGE	300 ft (at required- 30 dBm sensitivity)	1000 m (~ 3000 ft)
MINIMUM SEPARATION	1500 ft (except where carefully planned)	50 ft (on small zone channels)
CHANNEL CAPACITY	1 to 2 channels	7 channels
POWER (Downlink)	Nominally less than 40 dBm (10 W)	Nominally less than 33 dBm (2 W)*
POWER (Uplink)	Nominally less than 6 dBm (< 4mW)	Nominally less than 33 dBm (2 W)*

RED – Substantial Limitation
GREEN – Substantial Advantage

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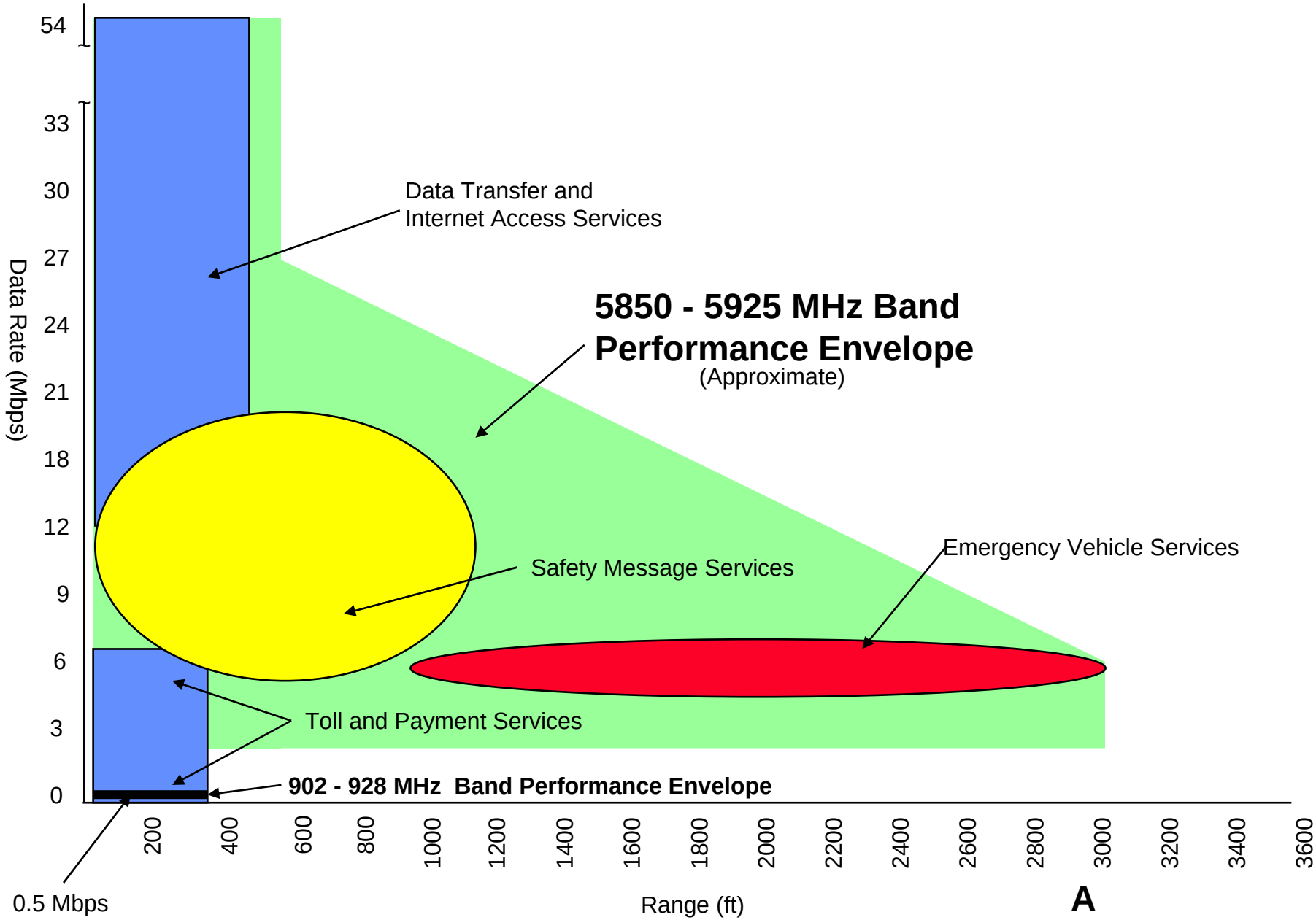
ITS RADIO SERVICE is the FCC Part 90 designation for the 915 MHz and 5.9 GHz DSRC spectrum
*Note - As a special case up to 44.77 dBm (30 W) may be use for qualified public safety applications.

DSRC PERFORMANCE ENVELOPES



5.9 GHz DSRC
BASIC OPERATING FACTORS

- **PUBLIC SAFETY and PRIVATE APPLICATIONS share the band**
- **INTEROPERABILITY**
- **LICENSED OPERATION**
- **PUBLIC SAFETY INSTALLATION PRIORITY**
- **NON-MUTUAL EXCLUSIVITY FOR PRIVATE INSTALLATIONS**
- **LIMITED RANGE FOR PRIVATE OPERATIONS**
- **FREQUENCY COORDINATOR USED TO ASSIGN LICENSES**

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5.9 GHz DSRC BASIC CONCEPTS

- **Channels in 5.850 to 5.925 GHz follow FCC CFR part 90 and Industry Canada rules**
- **10 MHz channels, optional capability to combine 2 channel sets into 20 MHz channels**
- **RSU EIRP Limit 44.8 dBm (Public Safety), 33 dBm (Private)**
- **OBU Device EIRP Limit 44.8 dBm (Public Safety), 33 dBm (Private)**
- **Out of channel emission – 25 dBm (All devices)**
- **Dedicated Control Channel for announcements and warnings**
- **Control Channel transmissions comply with ASTM/IEEE XXXX standard**
- **A dedicated channel is reserved for Vehicle to vehicle communications.**
- **Intersection application operations are conducted in a dedicated channel.**
- **2 small zone Service Channels are designated for extended data transfers.**
- **2 medium zone Service Channels are designated for extended data transfers.**
- **Channels in the UNII band may be used as unlicensed Service Channels.**
- **OBUs follow RSU instructions in Service Channels.**
- **OBUs implement a time limit on Service Channel transactions.** **A**

CFR - Code of Federal Regulations

HARMONIZED 5.9 GHz DSRC BAND PLAN

Canadian Special License Zones*

US Spread Spectrum Allocation

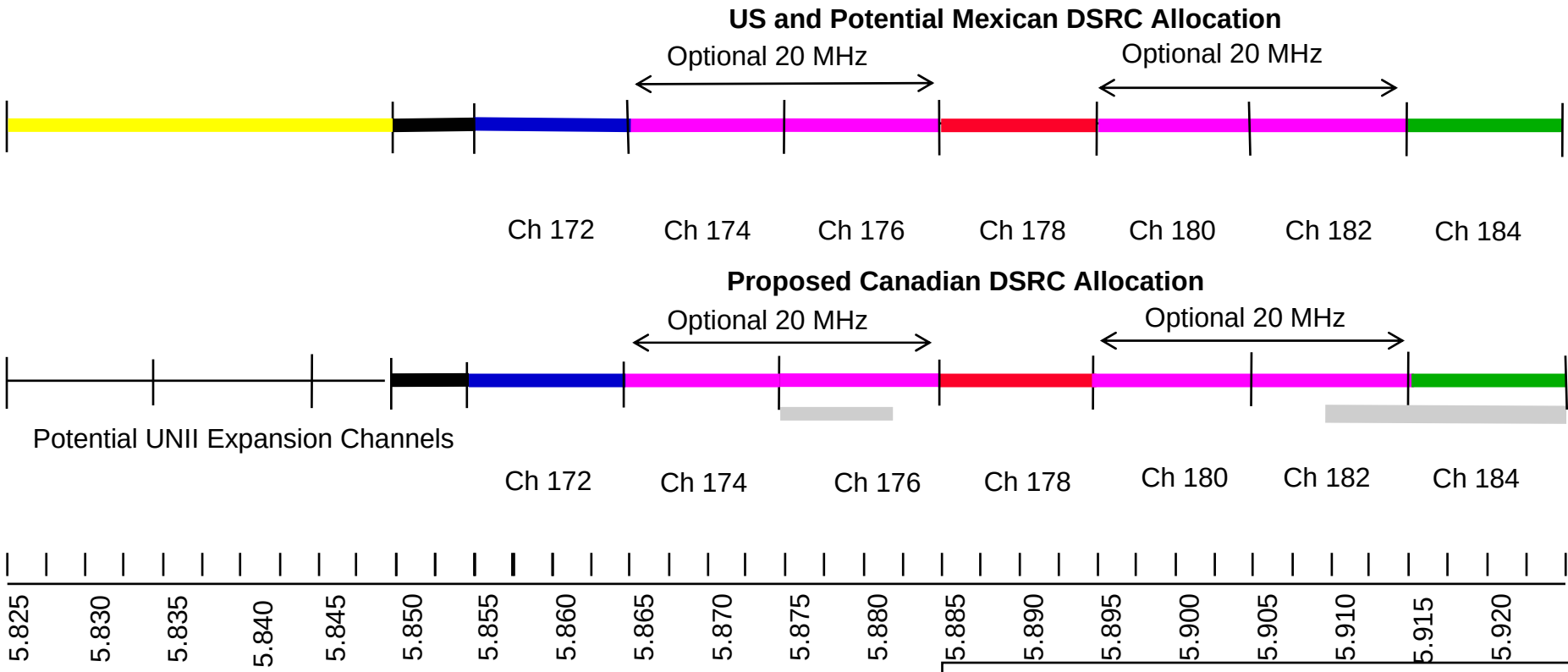
"Reserved" for harmonization with potential extension of the UNII band

Control Channel

Service Channels

Vehicle to Vehicle

Primarily Public Safety High-power App.



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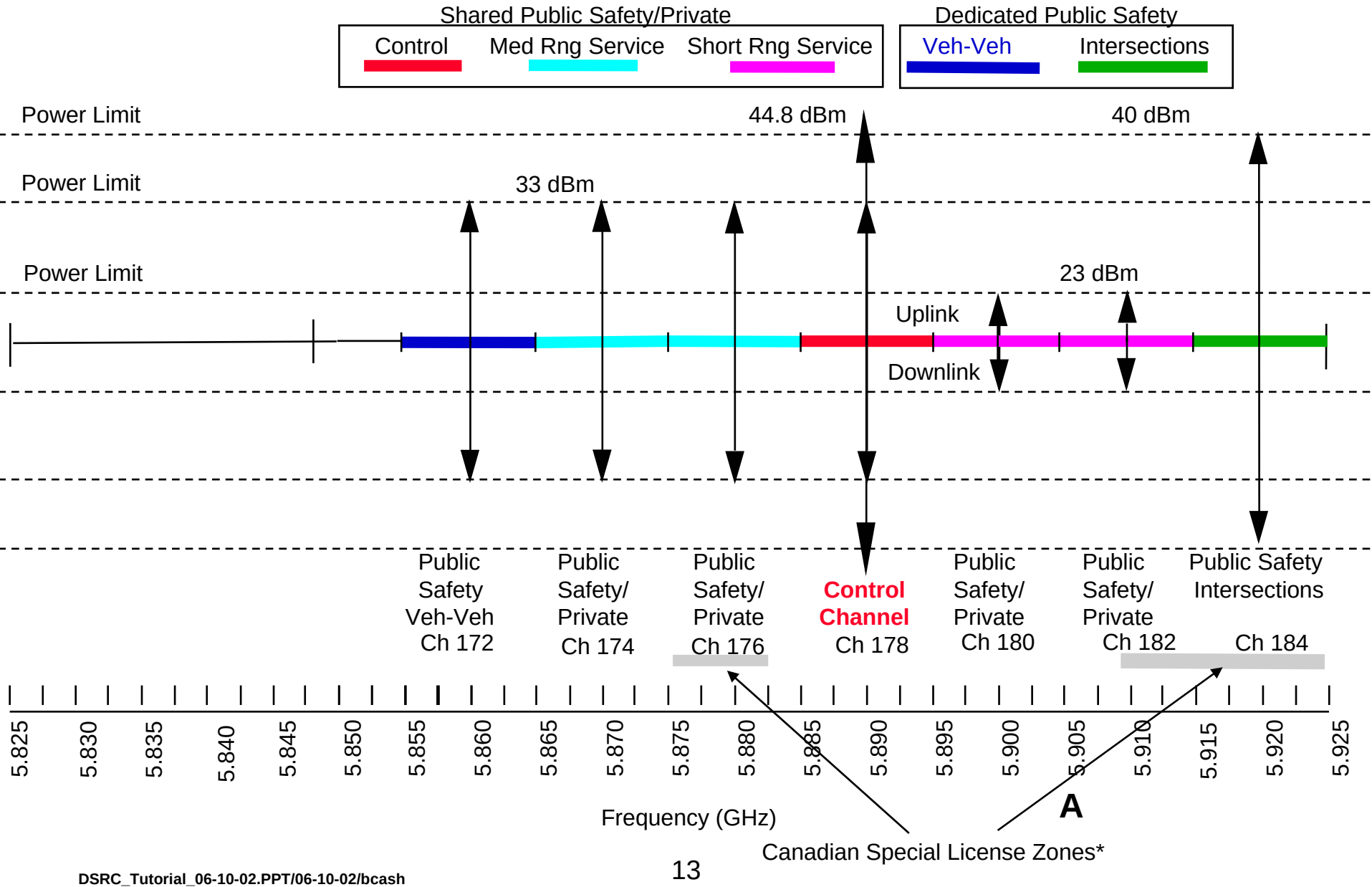
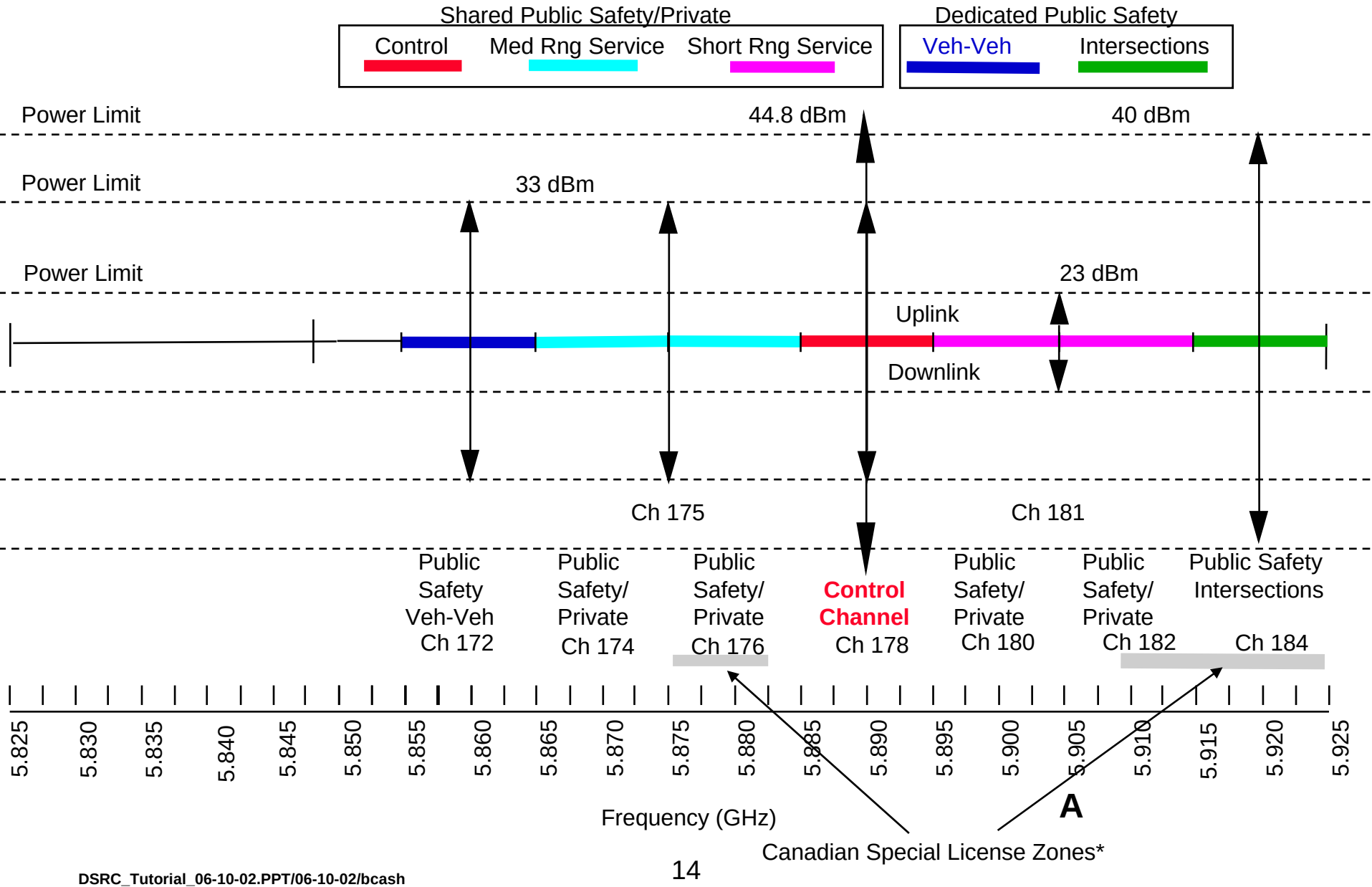
* - The use of channels overlapping these zones may be restricted in some locations in Canada.

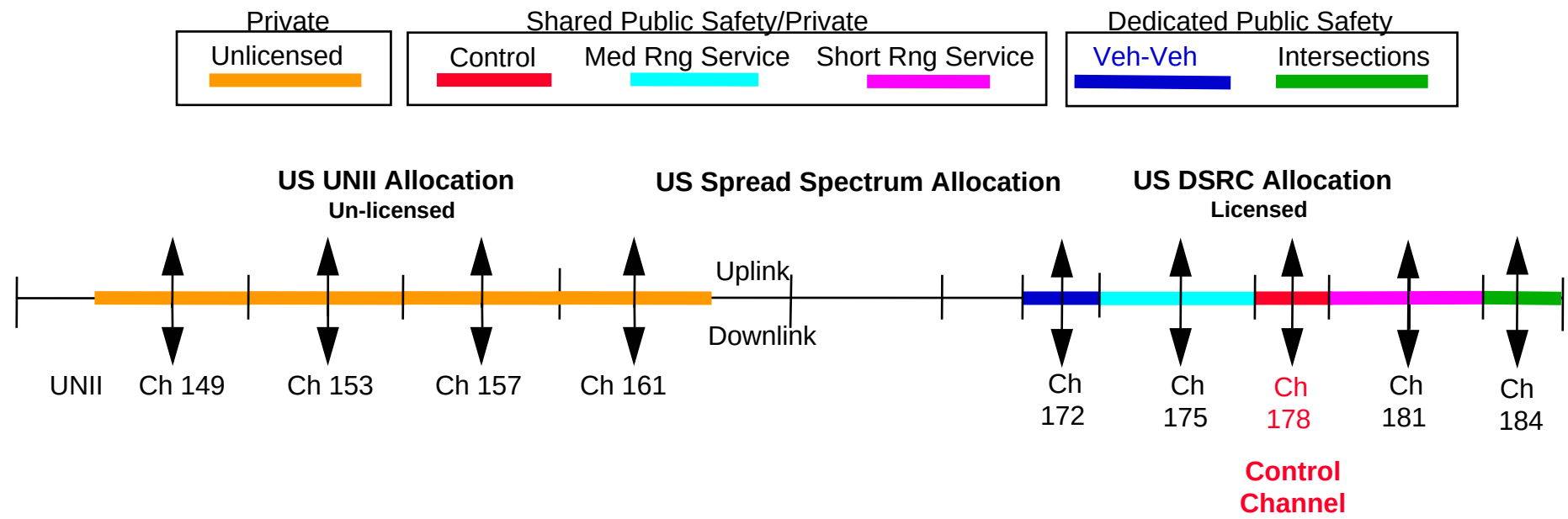
5.9 GHz DSRC BAND PLAN with 10 MHz CHANNELS & POWER LIMITS

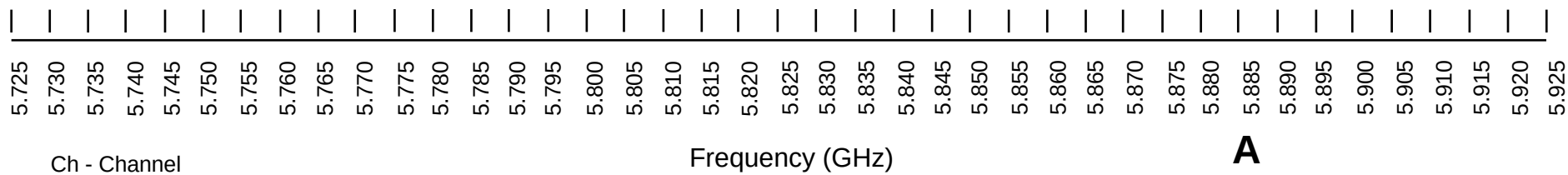


5.9 GHz DSRC BAND PLAN with 20 MHz CHANNELS & POWER LIMITS



5.7250 to 5.925 GHz
DSRC and UNII CHANNELS





Ch - Channel

Frequency (GHz)

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WHO DEVELOPED IT ???

ASTM and IEEE 5.9 GHz DSRC STANDARDS WRITING GROUP PARTICIPATION

- 3-M
- AASHTO
- ACUNIA
- AMTECH
- ARINC
- ARMSTRONG CONSULTING
- ATHEROS
- CALTRANS
- DAIMLER-CHRYSLER
- DENSO
- GM
- GTRI
- HIGHWAY ELECTRONICS
- HITACHI
- IDMICRO
- IMEC
- INTERSIL
- ITS-A
- JHU/APL
- KING COUNTY METRO TRANSIT
- MARK IV
- MiCOM Spa
- MICHIGAN STATE DOT
- MITRETEK
- MOTOROLA
- NISSAN
- N.Y. THRUWAY AUTHORITY
- OKI ELECTRIC
- PATH
- RAYTHEON
- SIRIT
- SUMITOMO ELECTRIC
- TECHNOCOM
- TOSHIBA
- TRANSCORE
- VISTEON
- WASHINGTON STATE DOT
- Wi-LAN

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ASTM and IEEE 5.9 GHz DSRC STANDARDS DEVELOPMENT ACTIVITY

MEETINGS SINCE REPORT AND ORDER

- **October 1999**
- **December 1999**
- **February 2000**
- **March 2000**
- **May 2000**
- **June 2000**
- **July 2000**
- **September 2000**
- **October 2000**
- **November 2000**
- **December 2000**
- **January 2001**
- **March 2001**
- **April 2001**
- **May 2001**

MEETINGS SINCE REPORT AND ORDER

- **June 2001**
- **July 2001**
- **August 2001***
- **October 2001**
- **December 2001**
- **January 2001**
- **February 2002**
- **March 2002**
- **May 2002**
- **June 2002**

MEETINGS CURRENTLY SCHEDULED

- **July 2002**
- **August 2002**
- **September 2002**

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***** - Technology Selection Meeting

5.9 GHz DSRC TECHNOLOGY SELECTION

- **The final selection between the Motorola entry and the OFDM forum entry was made by the ASTM E17.51 DSRC Standards Writing Group on August 24, 2001. THE WINNER was the OFDM forum entry.**

- **The writing group selection was confirmed by letter ballot vote of the Larger ASTM E17.51 subcommittee in October 2001.**

- **The ASTM DSRC STD E2313-02 was approved on 5/10/02.**

- **The ASTM DSRC STD E2313-02 will undergo validation and verification testing as well as further review which is expected to result in another version with slight modifications by 12/02.**

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When would it be advantageous to use it?

5.9 GHz DSRC APPLICATIONS

DSRC APPLICATIONS
PUBLIC SAFETY and PRIVATE

PUBLIC SAFETY

- **APPROACHING EMERGENCY VEHICLE (WARNING) ASSISTANT (3)**
- **EMERGENCY VEHICLE SIGNAL PREEMPTION**
- **ROAD CONDITION WARNING**
- **LOW BRIDGE WARNING**
- **WORK ZONE WARNING**
- **IMMINENT COLLISION WARNING (D)**
- **CURVE SPEED ASSISTANCE [ROLLOVER WARNING] (1)**
- **INFRASTRUCTURE BASED – STOP LIGHT ASSISTANT (2)**
- **INTERSECTION COLLISION WARNING/AVOIDANCE (4)**
- **HIGHWAY/RAIL [RAILROAD] COLLISION AVOIDANCE (10)**
- **COOPERATIVE COLLISION WARNING [V-V] (5)**
- **GREEN LIGHT - OPTIMAL SPEED ADVISORY (8)**
- **COOPERATIVE VEHICLE SYSTEM – PLATOONING (9)**
- **COOPERATIVE ADAPTIVE CRUISE CONTROL [ACC] (11)**
- **VEHICLE BASED PROBE DATA COLLECTION (B)**
- **INFRASTRUCTURE BASED PROBE DATA COLLECTION**
- **INFRASTRUCTURE BASED TRAFFIC MANAGEMENT – [DATA COLLECTED from] PROBES (7)**
- **TOLL COLLECTION**
- **TRAFFIC INFORMATION (C)**
- **TRANSIT VEHICLE DATA TRANSFER (gate)**
- **TRANSIT VEHICLE SIGNAL PRIORITY**
- **EMERGENCY VEHICLE VIDEO RELAY**
- **MAINLINE SCREENING**
- **BORDER CLEARANCE**
- **ON-BOARD SAFETY DATA TRANSFER**
- **VEHICLE SAFETY INSPECTION**
- **DRIVER'S DAILY LOG**

PRIVATE

- **ACCESS CONTROL**
- **DRIVE-THRU PAYMENT**
- **PARKING LOT PAYMENT**
- **DATA TRANSFER / INFO FUELING (A)**
  - **ATIS DATA**
  - **DIAGNOSTIC DATA**
  - **REPAIR-SERVICE RECORD**
  - **VEHICLE COMPUTER PROGRAM UPDATES**
  - **MAP and MUSIC DATA UPDATES**
  - **VIDEO UPLOADS**
- **DATA TRANSFER / CVO / TRUCK STOP**
- **ENHANCED ROUTE PLANNING and GUIDANCE (6)**
- **RENTAL CAR PROCESSING**
- **UNIQUE CVO FLEET MANAGEMENT**
- **DATA TRANSFER / TRANSIT VEHICLE (yard)**
- **TRANSIT VEHICLE REFUELING MANAGEMENT**
- **LOCOMOTIVE FUEL MONITORING**
- **DATA TRANSFER / LOCOMOTIVE**

ATIS - Advanced Traveler Information Systems
CVO - Commercial Vehicle Operations
EV - Emergency Vehicles
IDB - ITS Data Bus
THRU – Through
V-V – Vehicle to Vehicle
(#) – Applications Submitted by GM/Ford/Chrysler
(A- Z) – Applications Submitted by Daimler-Chrysler

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DSRC APPLICATIONS by COMMUNICATION CATEGORIES

ALL VEHICLES - Short Range (0 – 15 m)

- ACCESS CONTROL
- TOLL COLLECTION
- DATA TRANSFER / INFO FUELING (A)
- TRAFFIC INFORMATION (C)
- DRIVE-THRU PAYMENT
- PARKING LOT PAYMENT
- INFRASTRUCTURE BASED PROBE DATA COLLECTION
- RENTAL CAR PROCESSING

ALL VEHICLES - Extended Range (90 – 335 m)

- CURVE SPEED ASSISTANCE [ROLLOVER WARNING] (1)
- INFRASTRUCTURE BASED - STOP LIGHT ASSISTANT (2)
- INTERSECTION COLLISION WARNING/AVOIDANCE (4)
- COOPERATIVE COLLISION WARNING [V-V] (5)
- VEHICLE BASED PROBE DATA COLLECTION (B)
- COOPERATIVE ADAPTIVE CRUISE CONTROL (ACC)
- COOPERATIVE VEHICLE SYSTEM – PLATOONING (9)
- HIGHWAY/RAIL [RAILROAD] COLLISION AVOIDANCE (10)
- IMMINENT COLLISION WARNING (D)
- EMERGENCY VEHICLE VIDEO RELAY
- ROAD CONDITION WARNING
- WORK ZONE WARNING

APPLICABILITY UNDER INVESTIGATION

- ENHANCED ROUTE PLANNING and GUIDANCE (6)
- INFRASTRUCTURE BASED TRAFFIC MANAGEMENT – [DATA COLLECTED from] PROBES (7)

ALL VEHICLES – Short - Medium Range (0 – 90 m)

- TOLL COLLECTION
- DATA TRANSFER / INFO FUELING (A)
- DATA TRANSFER / CVO / TRUCK STOP
- DATA TRANSFER / TRANSIT VEHICLE (yard)
- DATA TRANSFER / LOCOMOTIVE

CVO – Short - Medium Range (0 – 90 m)

- MAINLINE SCREENING
- BORDER CLEARANCE
- ON-BOARD SAFETY DATA TRANSFER
- UNIQUE CVO FLEET MANAGEMENT
- DRIVER'S DAILY LOG
- VEHICLE SAFETY INSPECTION
- TRANSIT VEHICLE DATA TRANSFER (gate)
- TRANSIT VEHICLE REFUELING MANAGEMENT
- LOCOMOTIVE FUEL MONITORING
- ROLLOVER WARNING
- LOW BRIDGE WARNING

PUBLIC SAFETY - Long Range (300 – 1000 m)

- APPROACHING EMERGENCY VEHICLE ASSISTANT (3)
- EMERGENCY VEHICLE SIGNAL PREEMPTION
- TRANSIT VEHICLE SIGNAL PRIORITY
- GREEN LIGHT - OPTIMAL SPEED ADVISORY (8)

(#) – Applications Submitted by GM/Ford/Chrysler
(A) – Applications Submitted by Daimler-Chrysler

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DSRC INTEROPERABILITY

- **The “E-ZPass”, “Title 21”, ASTM V6, and “Sandwich Specification” equipment will continue to be used where cost and regional/national mandates or both require continued operation for those applications that fall within the performance envelope.**

- **The 5.9 GHz Standards and Equipment will be used for applications that cannot be done with the 915 MHz technology and where service providers want to take advantage of OBUs being built into the vehicles.**

- **INTEROPERABILITY will be achieved by implementing 5.9 GHz equipment in all DSRC installations. This means adding 5.9 GHz equipment to operate in conjunction with 915 MHz equipment in current and future 915 MHz operations.**

- **Roadside 5.9 GHz equipment will cost much less than current 915 MHz equipment and per lane installations are few, making dual mode installations very cost effective.**

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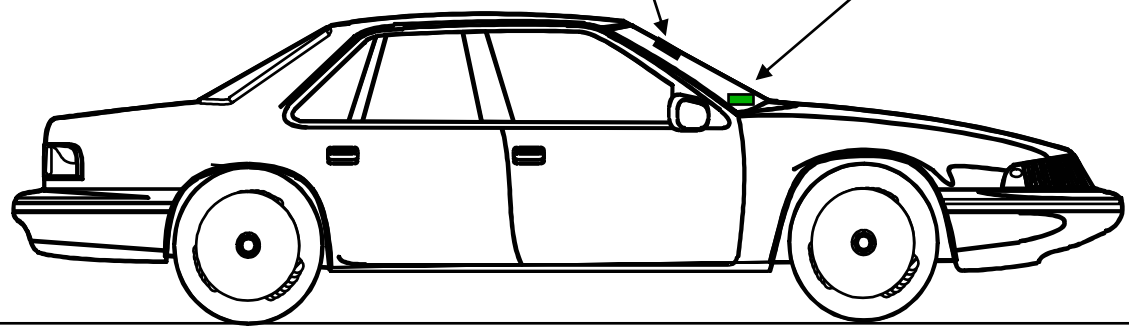
POSSIBLE IN–VEHICLE CONFIGURATIONS

Common Vehicle
On-Board Equipment (Basic Configuration Example 1)



Other ITS Communications Equipment

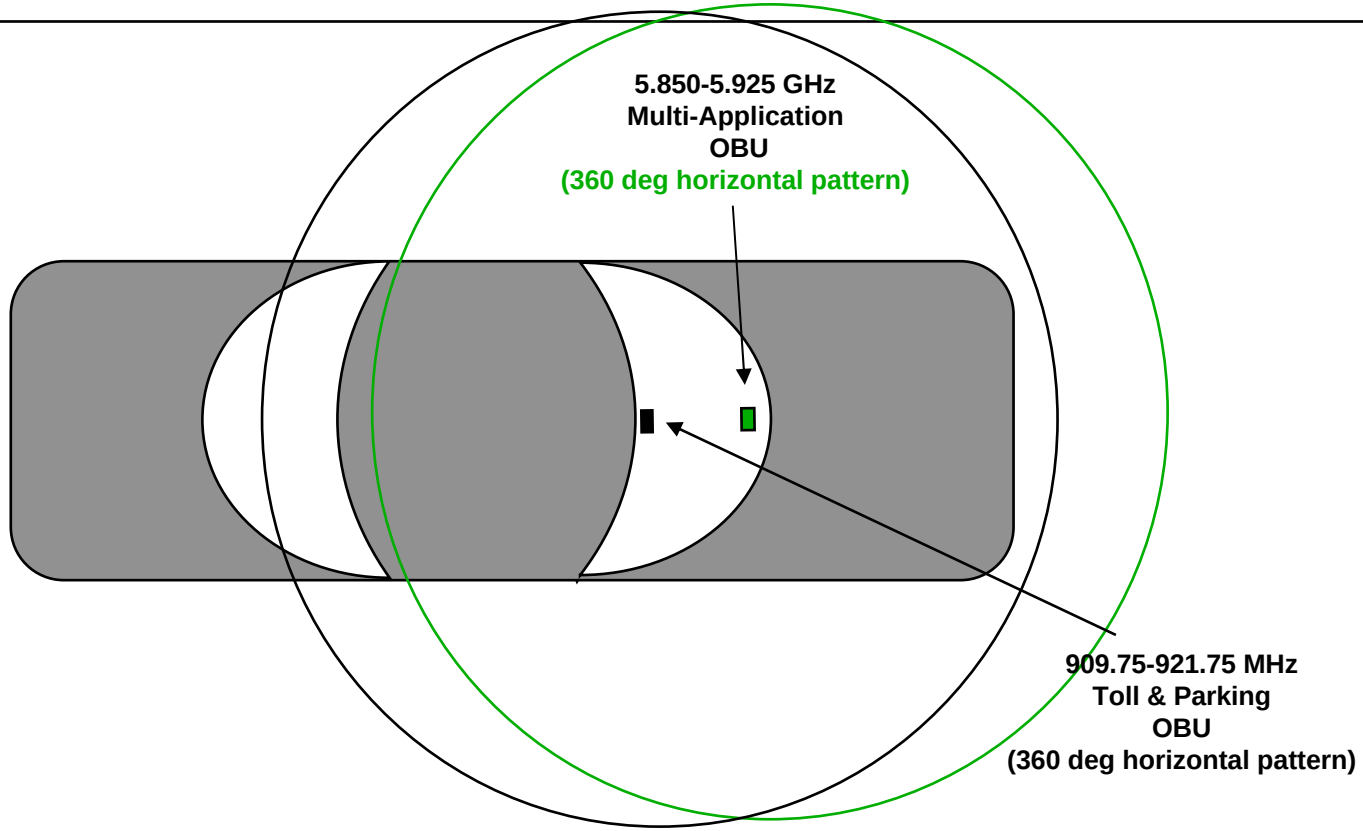
- 87.5-107.9 MHz FM sub carrier
- 800 to 900 MHz Cellular Phone
- 1575.42 MHz GPS Receiver
- 1800 to 1900 MHz PCS Phone
- 2322.5-2345 MHz for XM Radio Satellite Radio band
- Multiple Bands Two-way Radio
- 76-77 GHz Collision Avoidance Radar

Not to scale

A

Common Vehicle On-Board Equipment (Basic Pattern Example 1)

The multi-application OBUs use a 360 deg. horizontal pattern for all applications.



Not to scale

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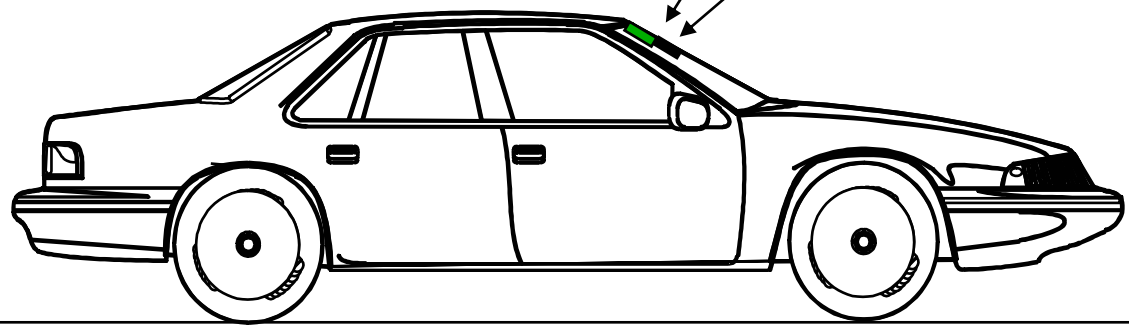
Common Vehicle
On-Board Equipment (Basic Configuration Example 2)

5.850-5.925 GHz
Multi-Application
OBU
(factory or retrofit installation)

909.75-921.75 MHz
Toll & Parking
OBU
(Add-on when needed)



Other ITS Communications Equipment

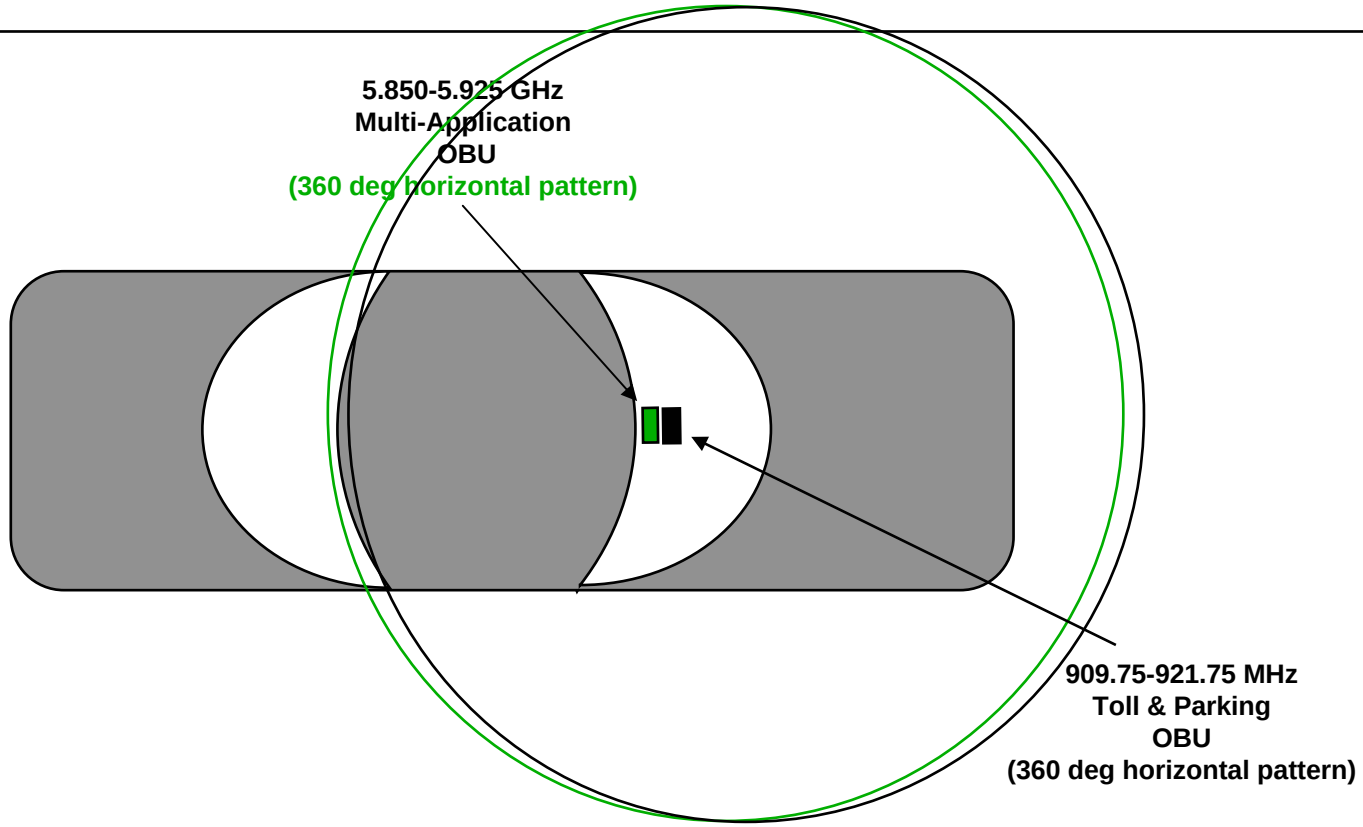
- **87.5-107.9 MHz FM sub carrier**
- **800 to 900 MHz Cellular Phone**
- **1575.42 MHz GPS Receiver**
- **1800 to 1900 MHz PCS Phone**
- **2322.5-2345 MHz for XM Radio Satellite Radio band**
- **Multiple Bands Two-way Radio**
- **76-77 GHz Collision Avoidance Radar**

Not to scale

A

Common Vehicle On-Board Equipment (Basic Pattern Example 2)

The multi-application OBUs use a 360 deg. horizontal pattern for all applications.



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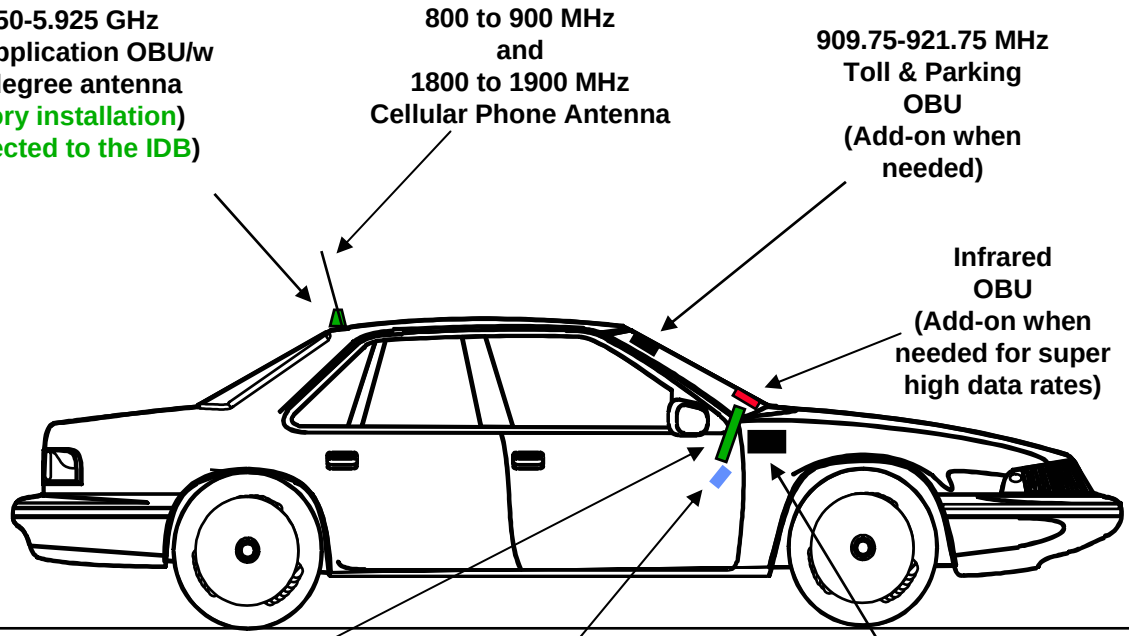
Common Vehicle On-Board Equipment (Enhanced Configuration Example)



5.850-5.925 GHz
Multi-Application OBU/w
360 degree antenna
(factory installation)
(connected to the IDB)

800 to 900 MHz
and
1800 to 1900 MHz
Cellular Phone Antenna

909.75-921.75 MHz
Toll & Parking
OBU
(Add-on when
needed)

Infrared
OBU
(Add-on when
needed for super
high data rates)

Interface Devices
(Built-in Display, Annunciator,
Microphone, Keypad, etc.
connected to the Computer,
which is connected to the
IDB)

1800 to 1900 MHz
2.5/3G PCS Phone
(which is connected to the
IDB)

Computer
(factory installation)
(connected to the IDB)

Other ITS
Communications
Equipment

87.5-107.9 MHz
FM sub carrier

1575.42 MHz
GPS Receiver

2322.5-2345 MHz
for XM Radio
Satellite Radio band

Multiple Bands
Two-way Radio

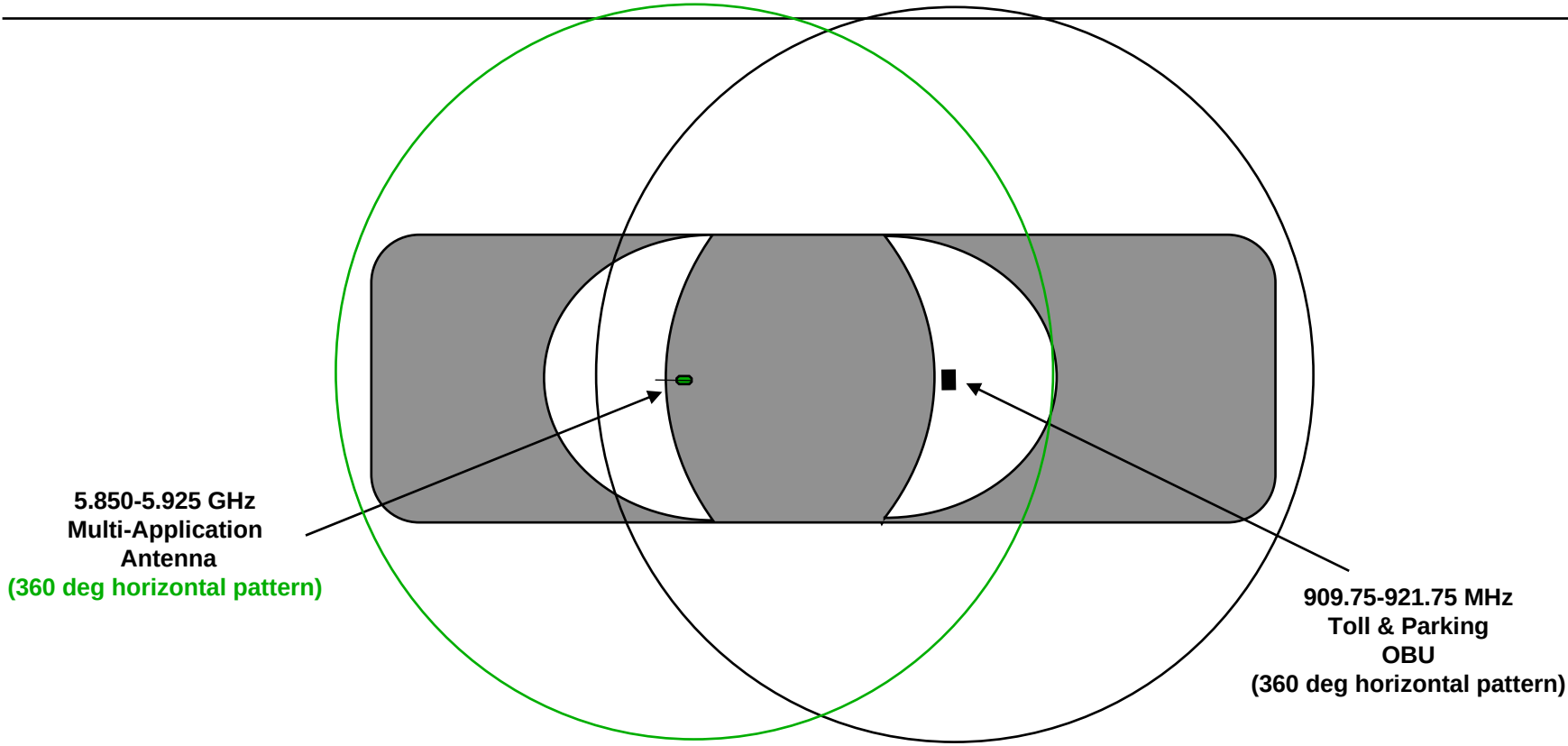
76-77 GHz
Collision
Avoidance Radar

Not to scale

A

Common Vehicle On-Board Equipment (Enhanced Pattern Example)

The multi-application OBUs use a 360 deg. horizontal pattern for all applications.



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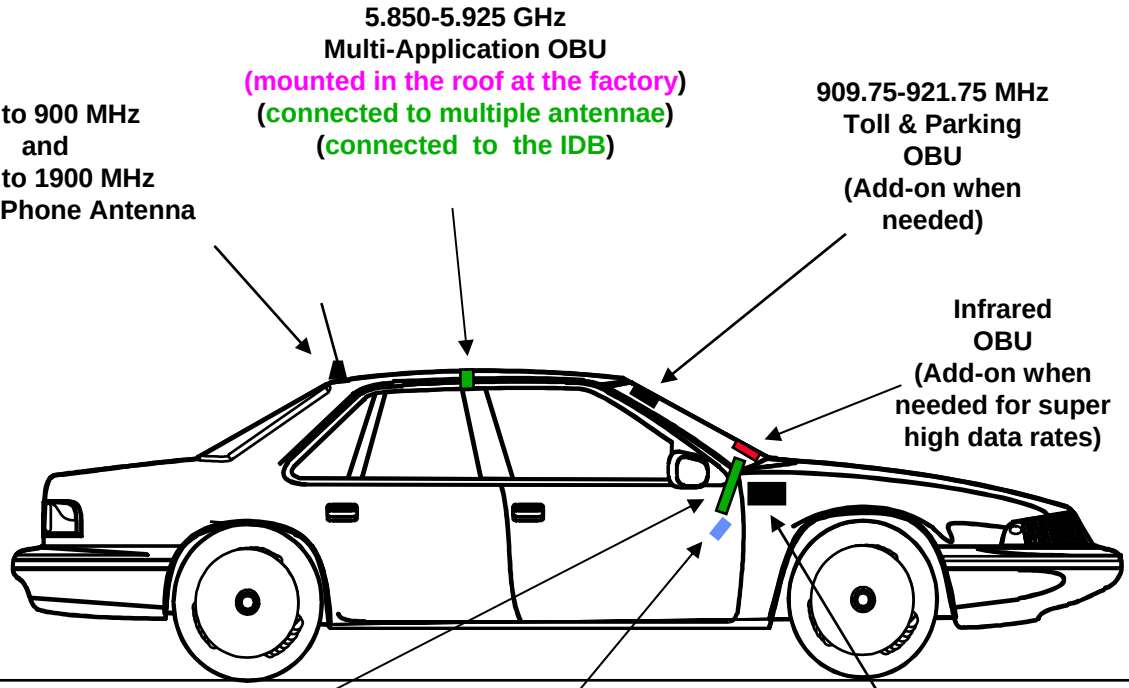
Common Vehicle On-Board Equipment (Alternate Configuration Example)



Other ITS Communications Equipment

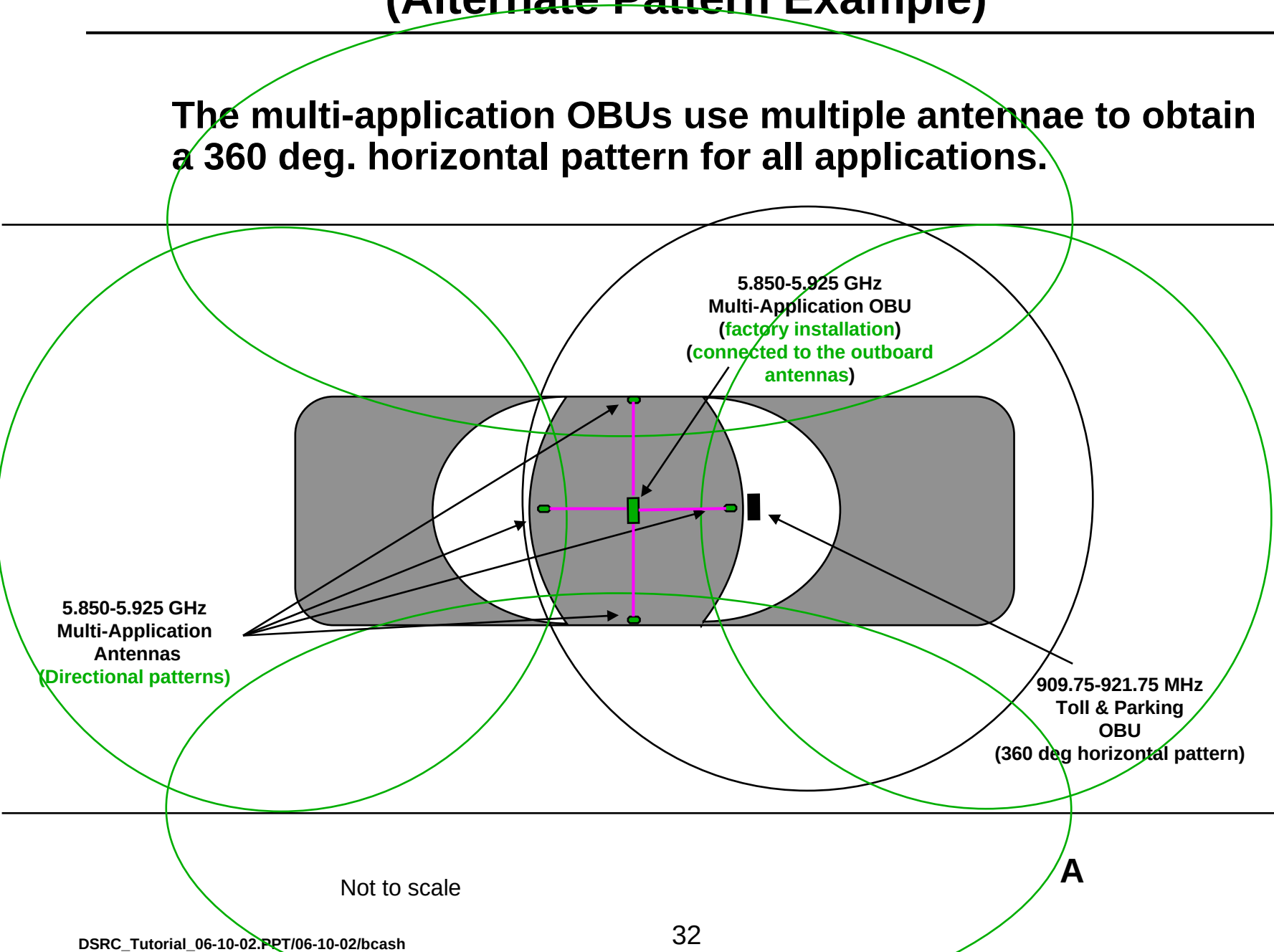
- 87.5-107.9 MHz FM sub carrier
- 1575.42 MHz GPS Receiver
- 2322.5-2345 MHz for XM Radio Satellite Radio band
- Multiple Bands Two-way Radio
- 76-77 GHz Collision Avoidance Radar

Not to scale

A

Common Vehicle On-Board Equipment (Alternate Pattern Example)

The multi-application OBUs use multiple antennae to obtain a 360 deg. horizontal pattern for all applications.



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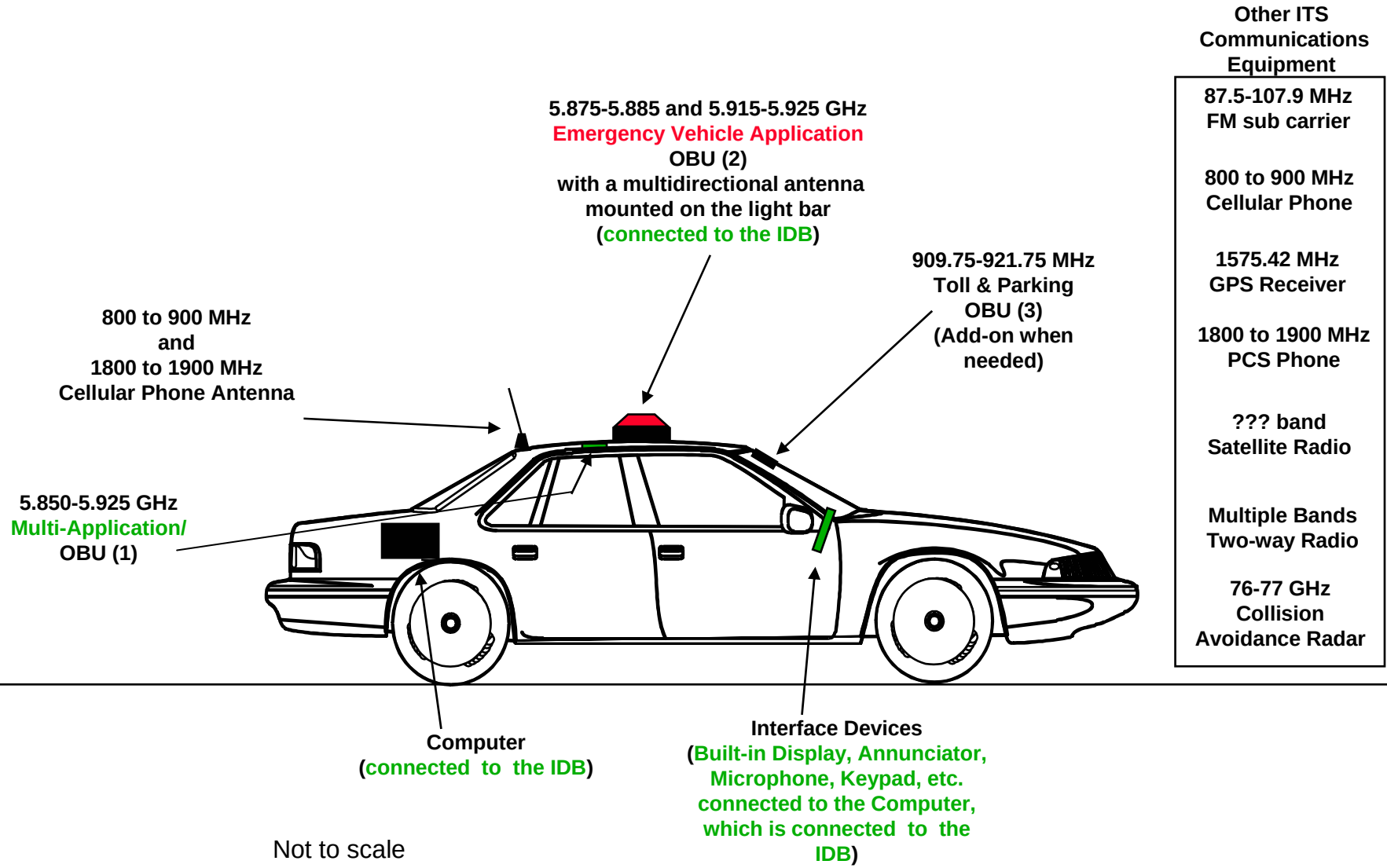
Common Vehicle On-Board Equipment (Emergency Vehicle Configuration Example)



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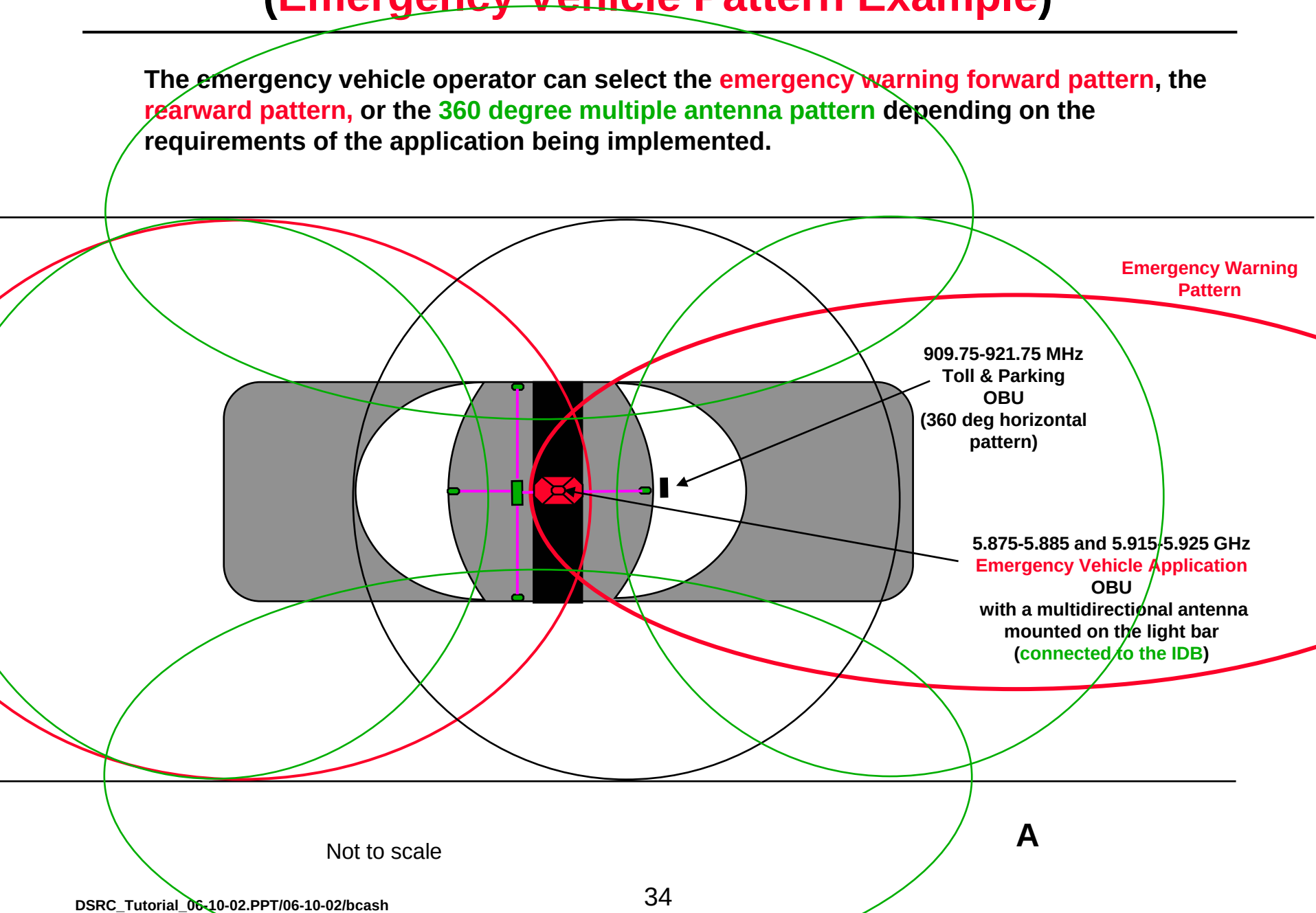
Common Vehicle On-Board Equipment (Emergency Vehicle Pattern Example)

The emergency vehicle operator can select the emergency warning forward pattern, the rearward pattern, or the 360 degree multiple antenna pattern depending on the requirements of the application being implemented.



Not to scale

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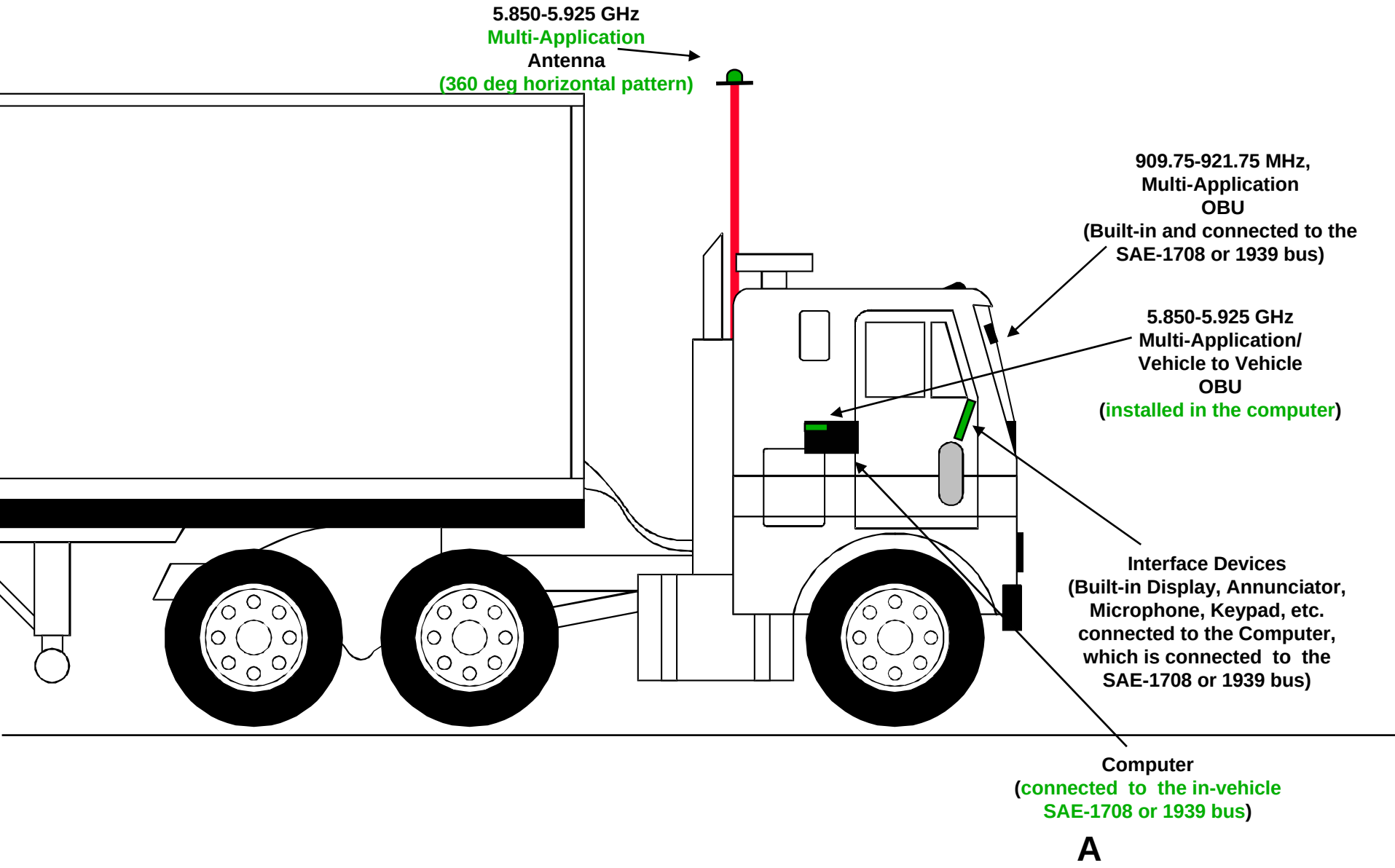
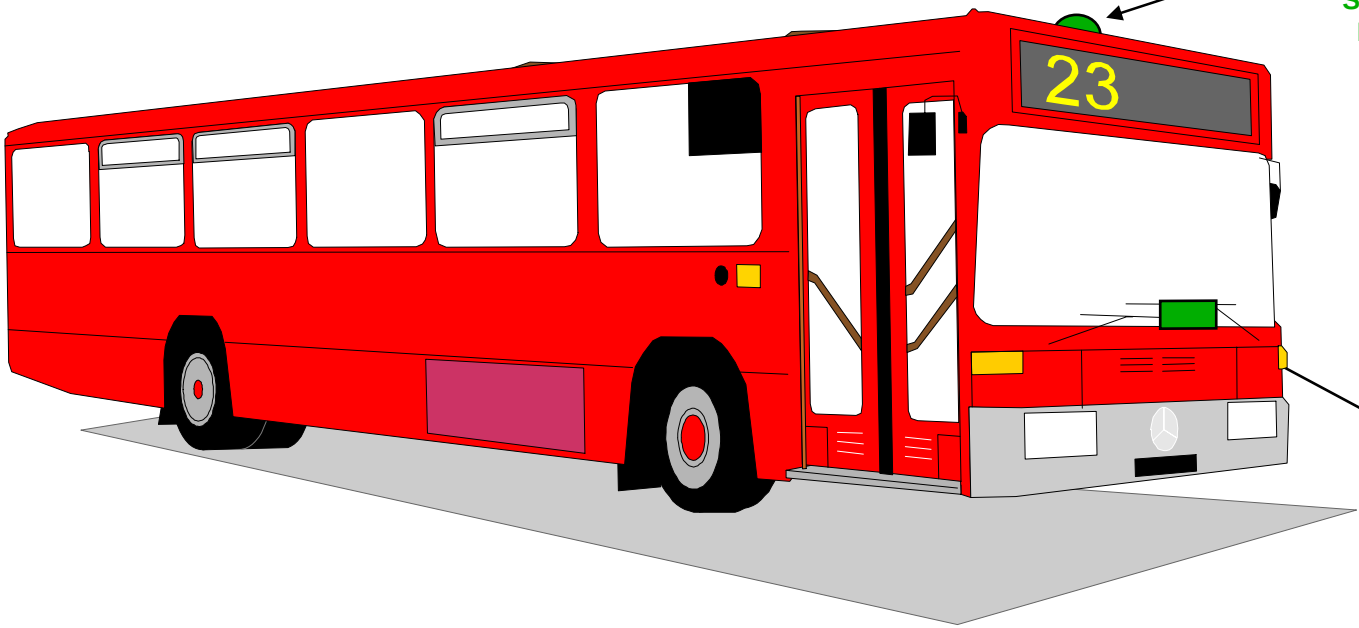
CVO
On-Board Equipment



TRANSIT
On-Board Equipment



5.850-5.925 GHz
Multi-Application
OBU
(360 deg horizontal pattern)

(Built-in and connected to the SAE-1708, 1939, or EIA-709 LonWorks interface bus)

Interface Devices
(Built-in Display, Annunciator, Microphone, Keypad, etc. connected to the Computer, which is connected to the SAE-1708, 1939, or EIA-709 LonWorks interface bus)

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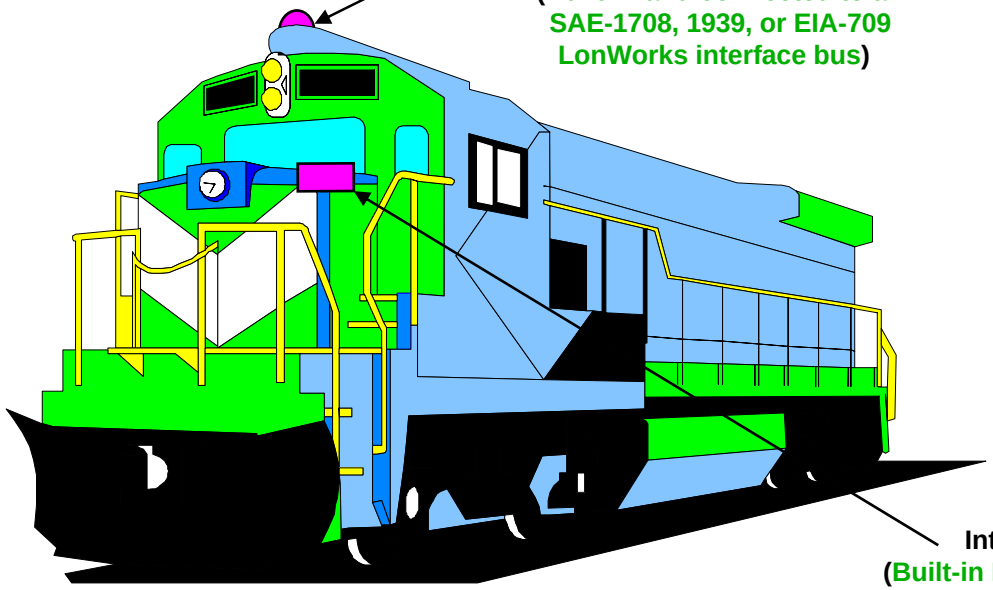
RAIL ENGINE
On-Board Equipment



5850-5.925 GHz Multi-Application OBU
(360 deg horizontal pattern)

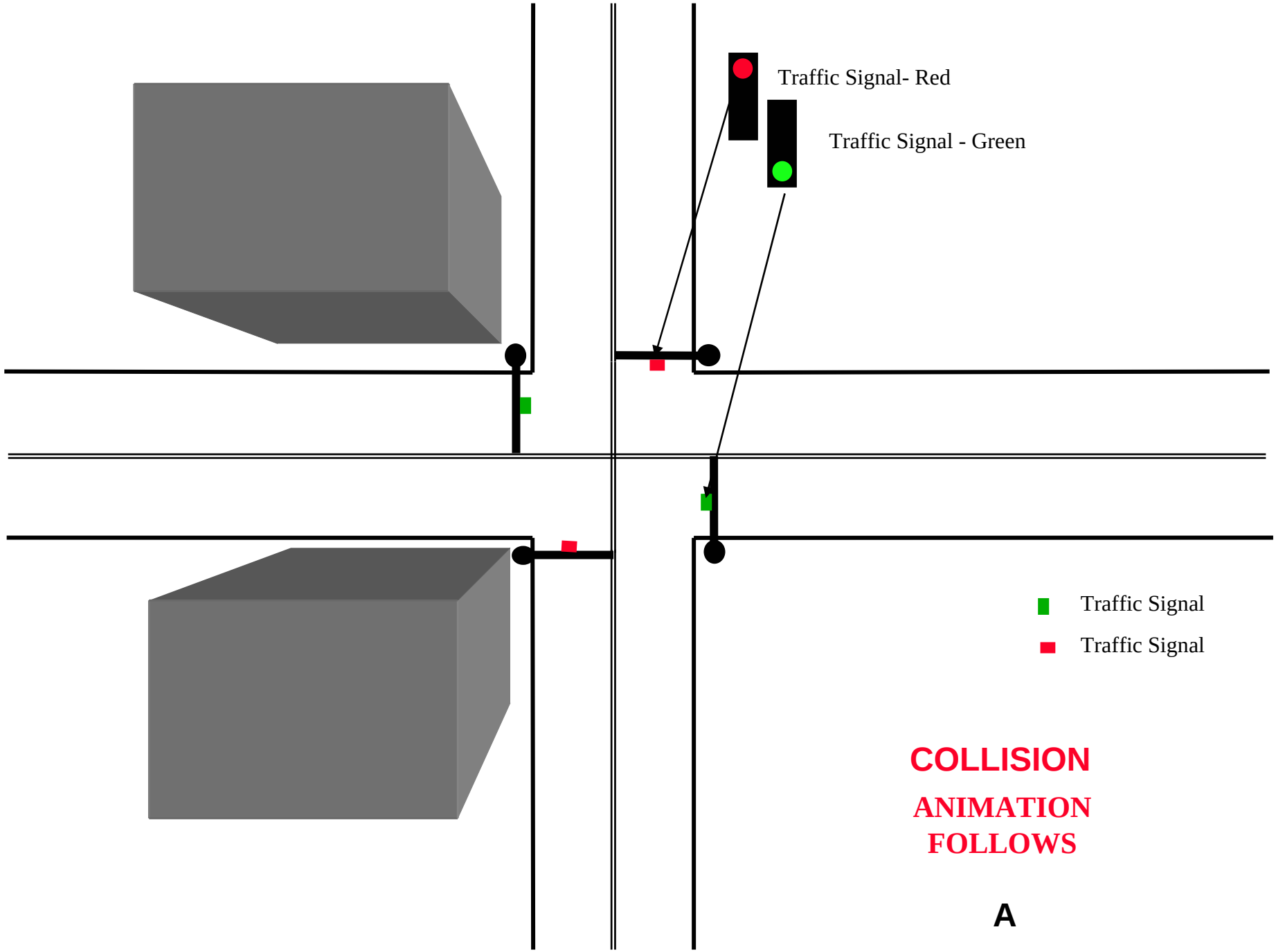
(Built-in and connected to an SAE-1708, 1939, or EIA-709 LonWorks interface bus)

Interface Devices
(Built-in Display, Annunciator, Microphone, Keypad, etc. connected to the Computer, which is connected to an SAE-1708, 1939, or EIA-709 LonWorks interface bus)

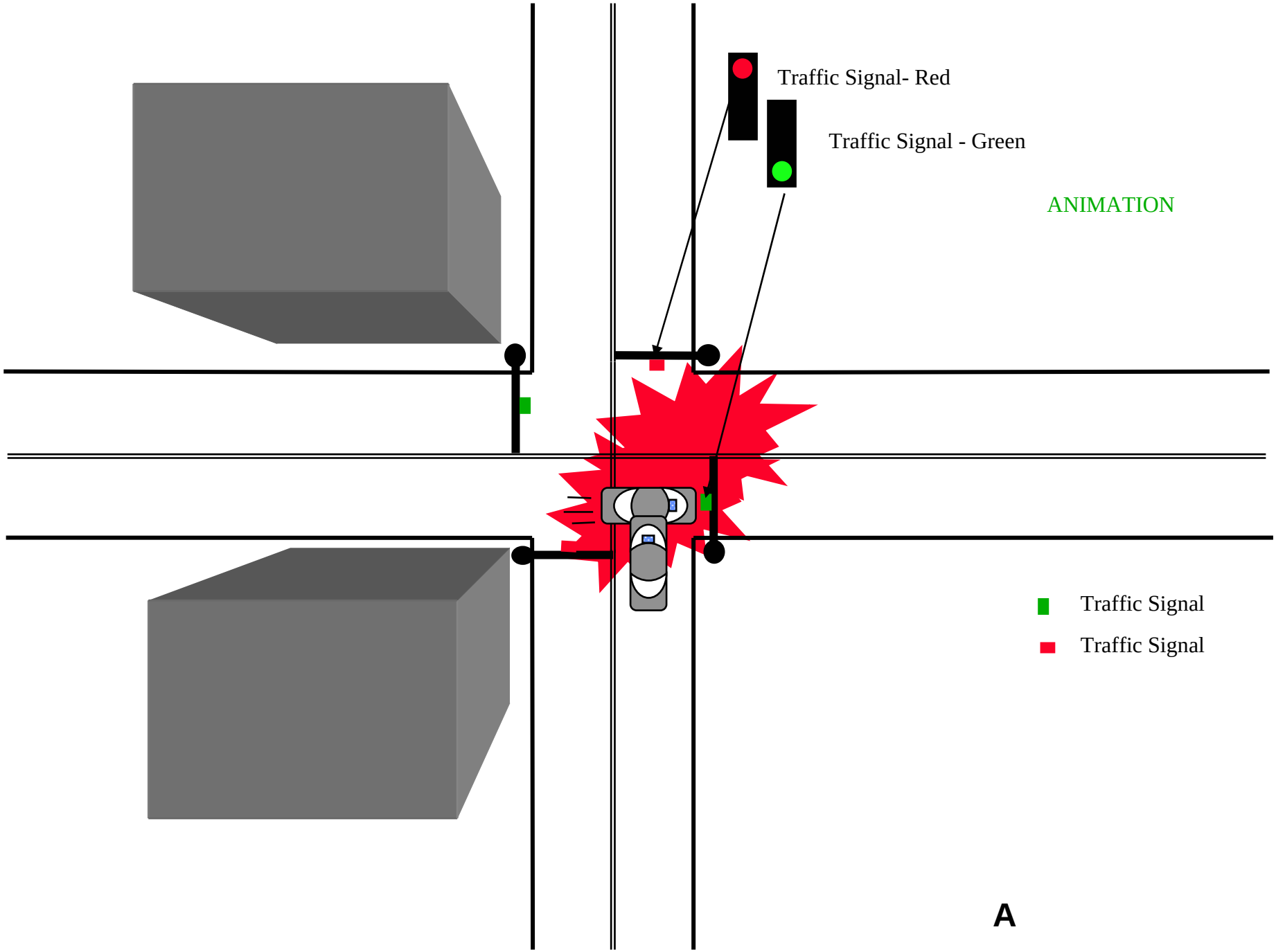
A

URBAN/SUBURBAN APPLICATIONS

TYPICAL INTERSECTION

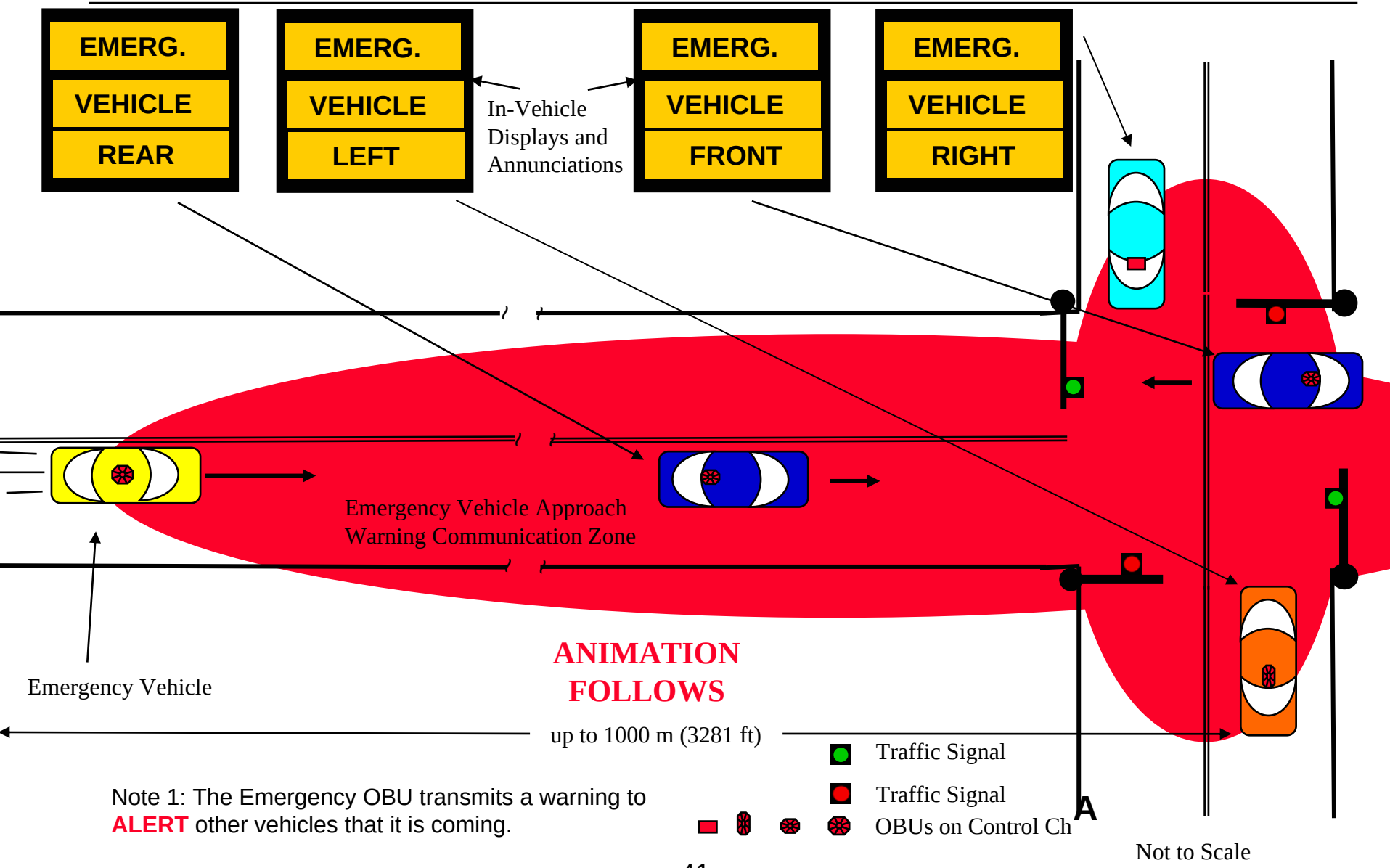


NO COLLISION AVOIDANCE SYSTEM IN OPERATION



5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

EMERGENCY VEHICLE APPROACH WARNING

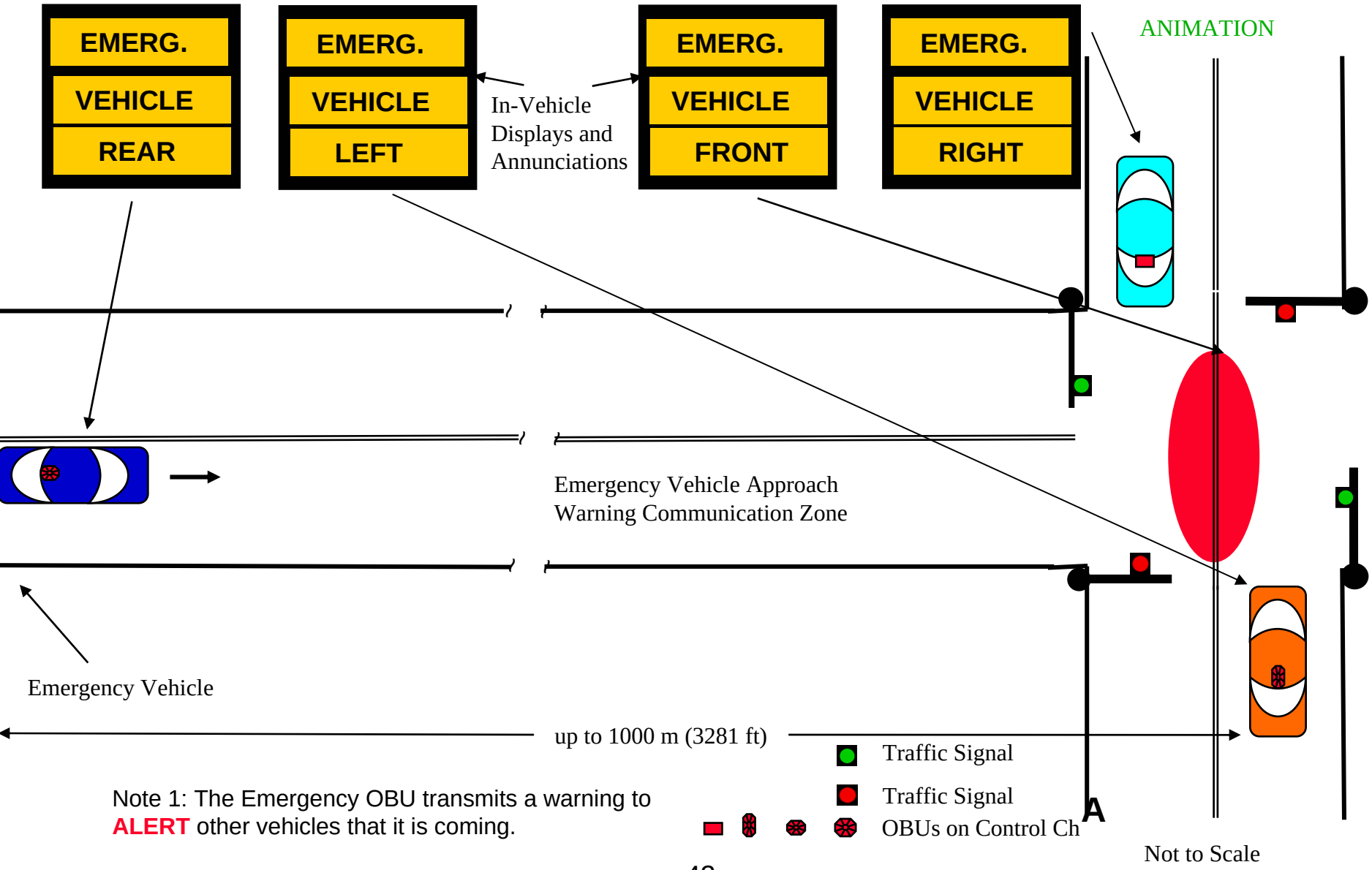


Note 1: The Emergency OBU transmits a warning to **ALERT** other vehicles that it is coming.

Not to Scale

5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

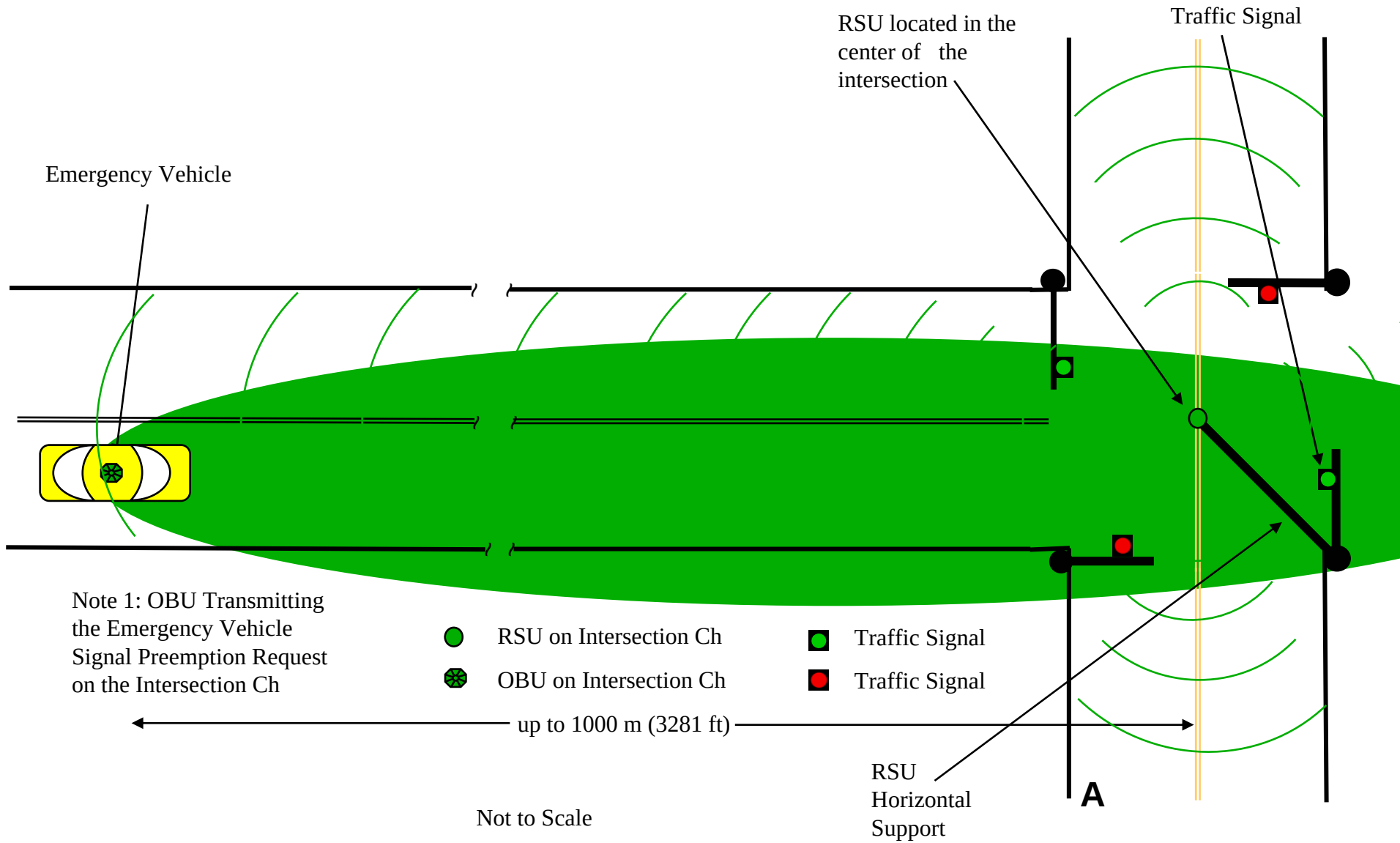
EMERGENCY VEHICLE APPROACH WARNING



Note 1: The Emergency OBU transmits a warning to **ALERT** other vehicles that it is coming.

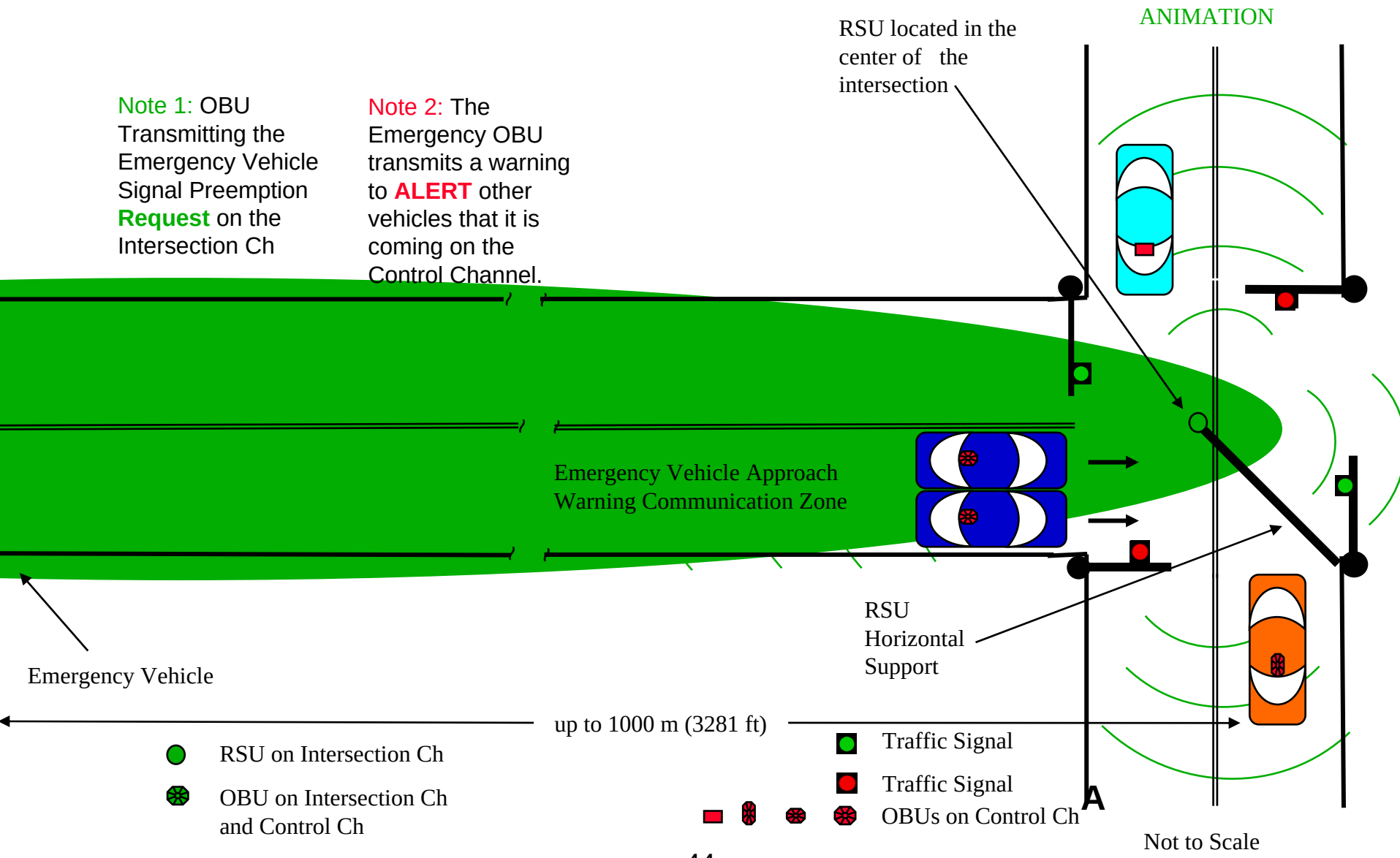
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

EMERGENCY VEHICLE SIGNAL PREEMPTION



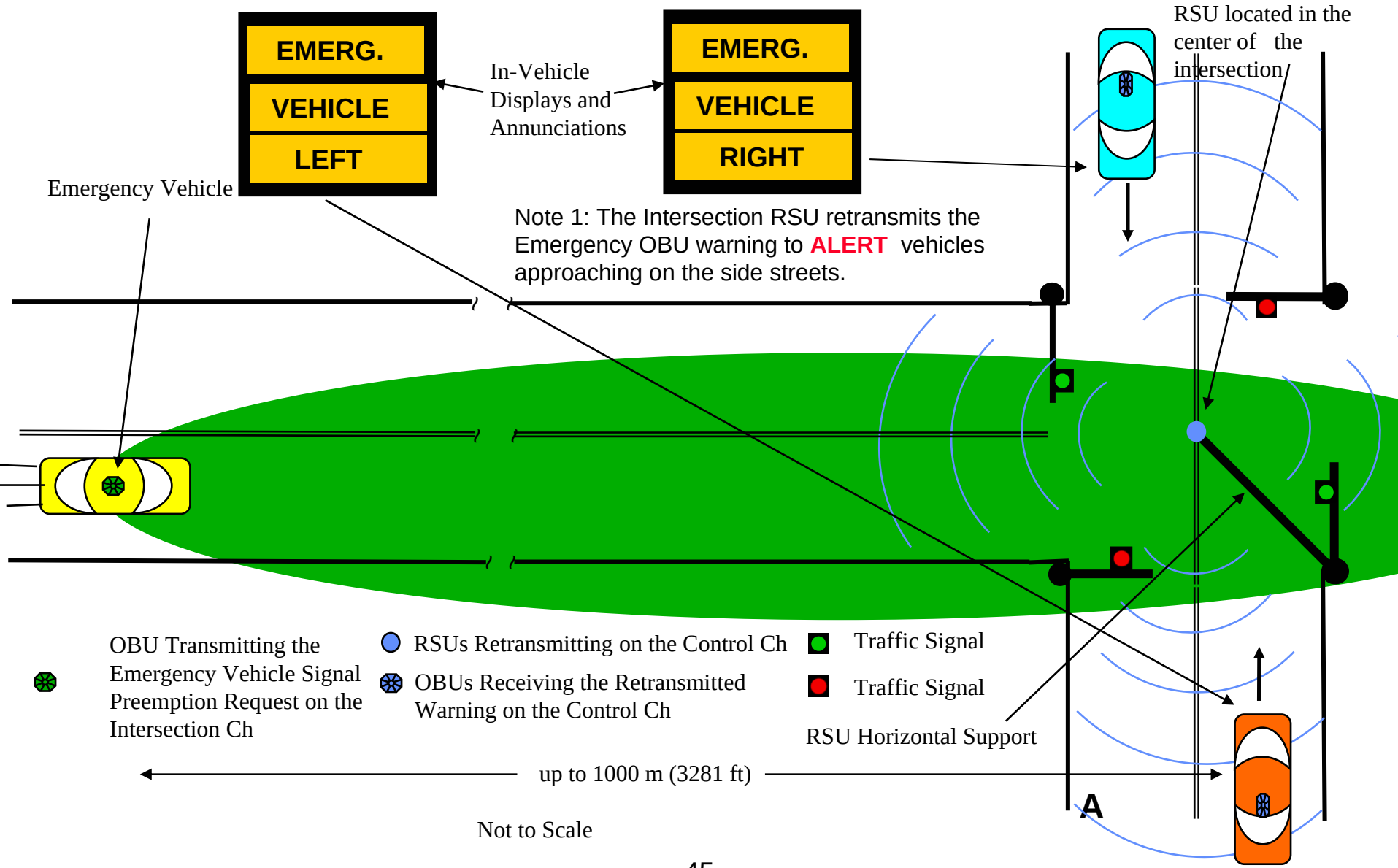
5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

EMERGENCY VEHICLE SIGNAL PREEMPTION with APPROACH WARNING



5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

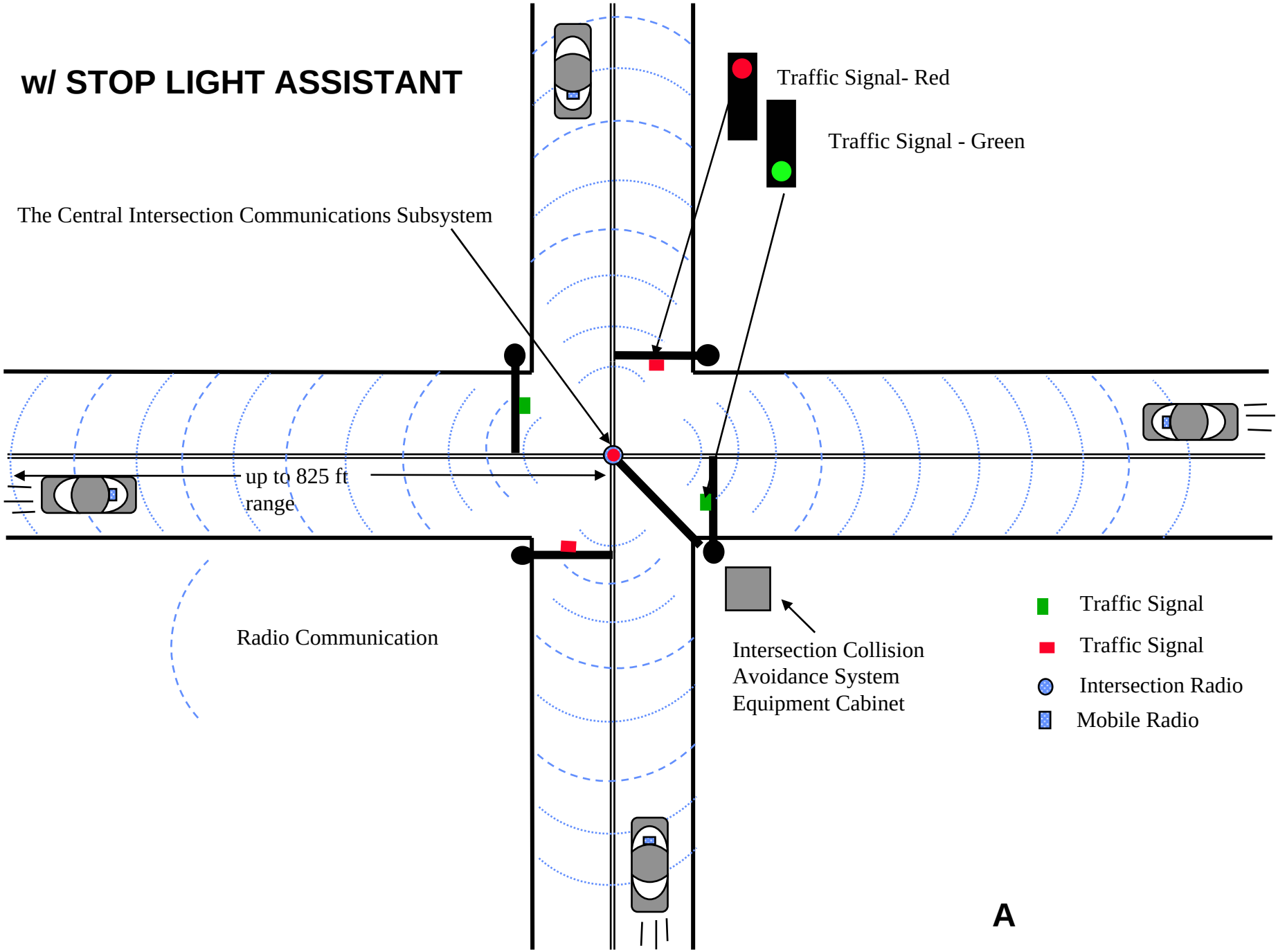
EMERGENCY VEHICLE APPROACH WARNING - INTERSECTION RELAY



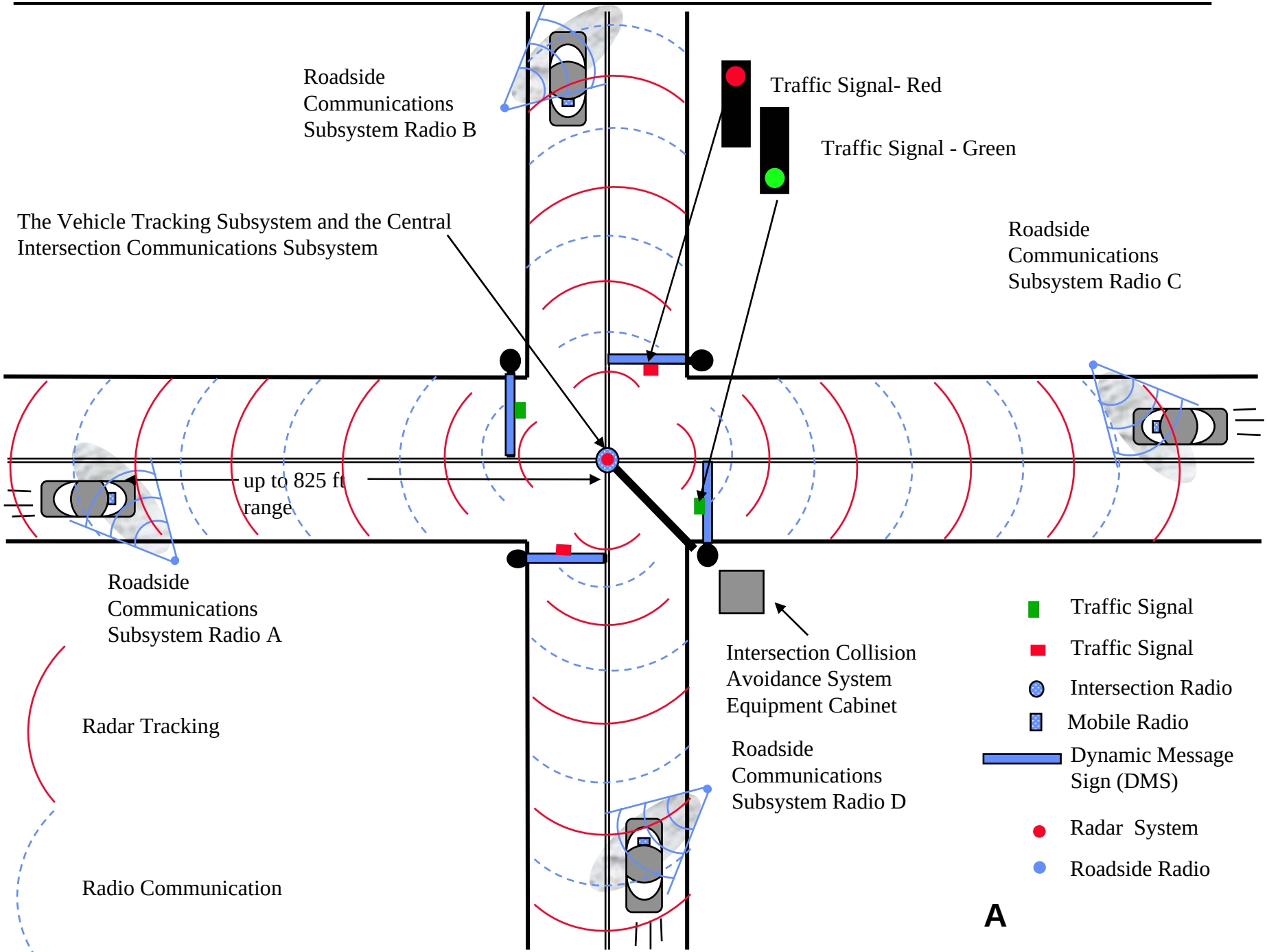
Not to Scale

VEHICLE BASED / INFRASTRUCTURE ASSISTED COLLISION AVOIDANCE

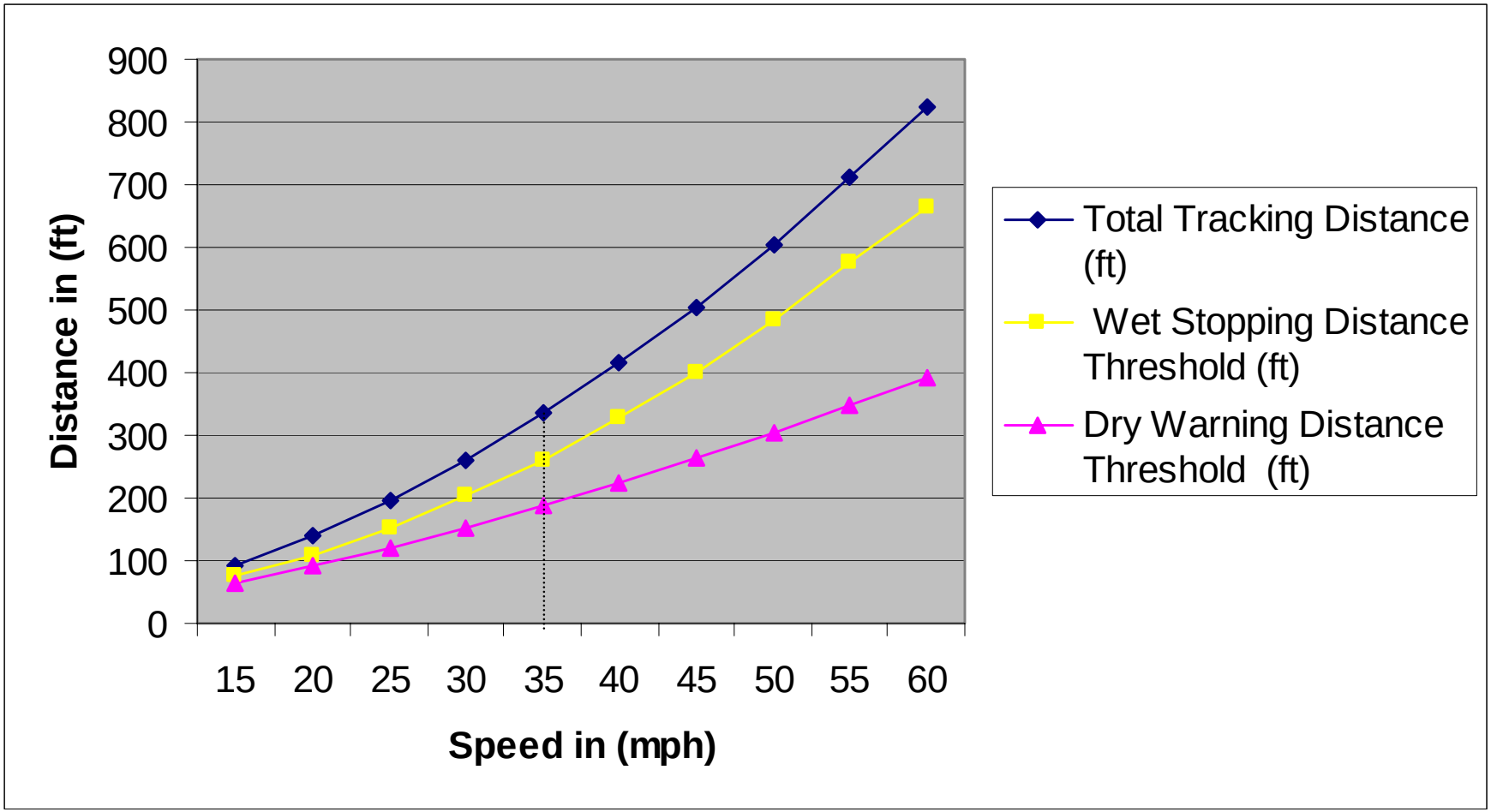
w/ STOP LIGHT ASSISTANT



INFRASTRUCTURE ASSISTED COLLISION AVOIDANCE

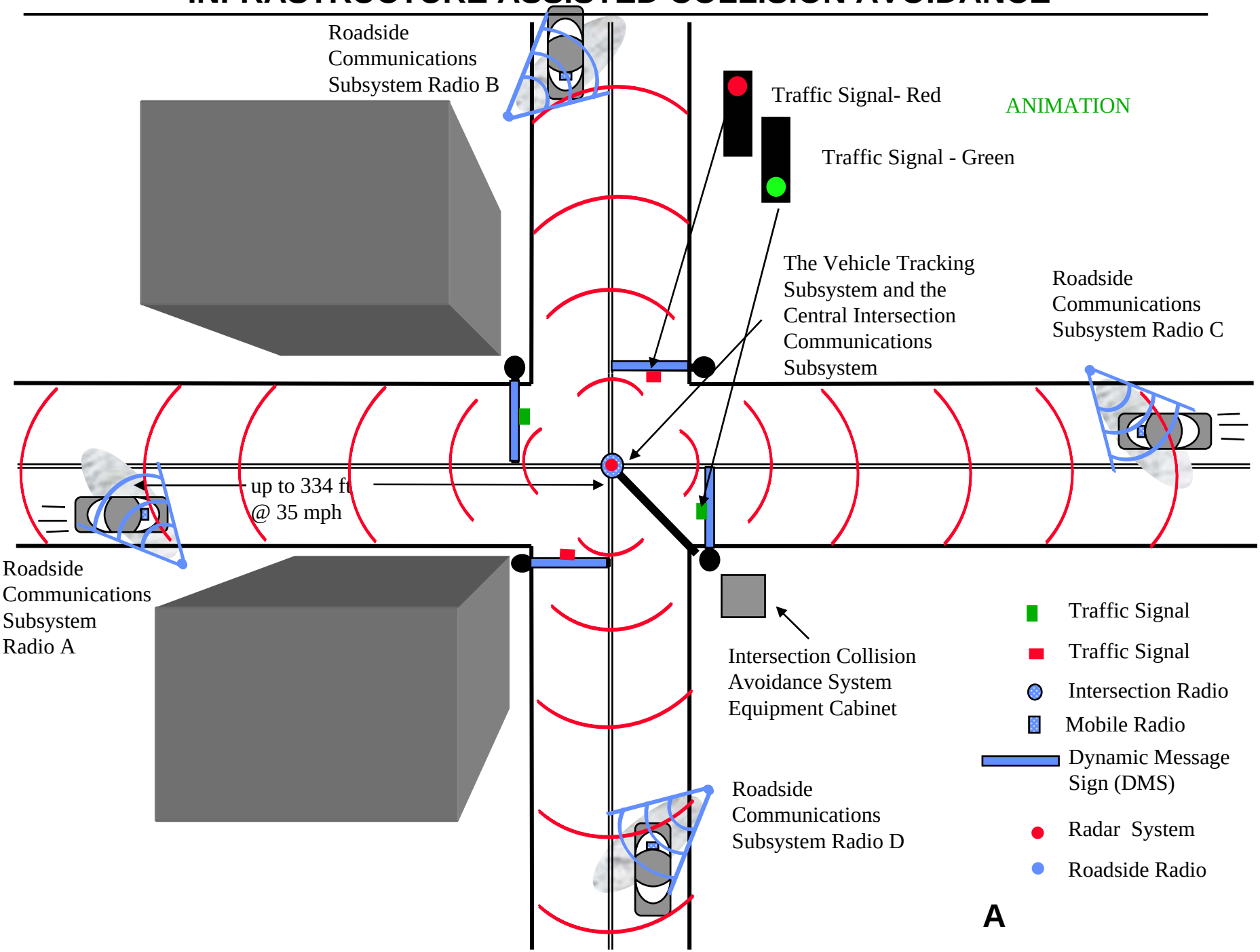


ALL ICA DISTANCES

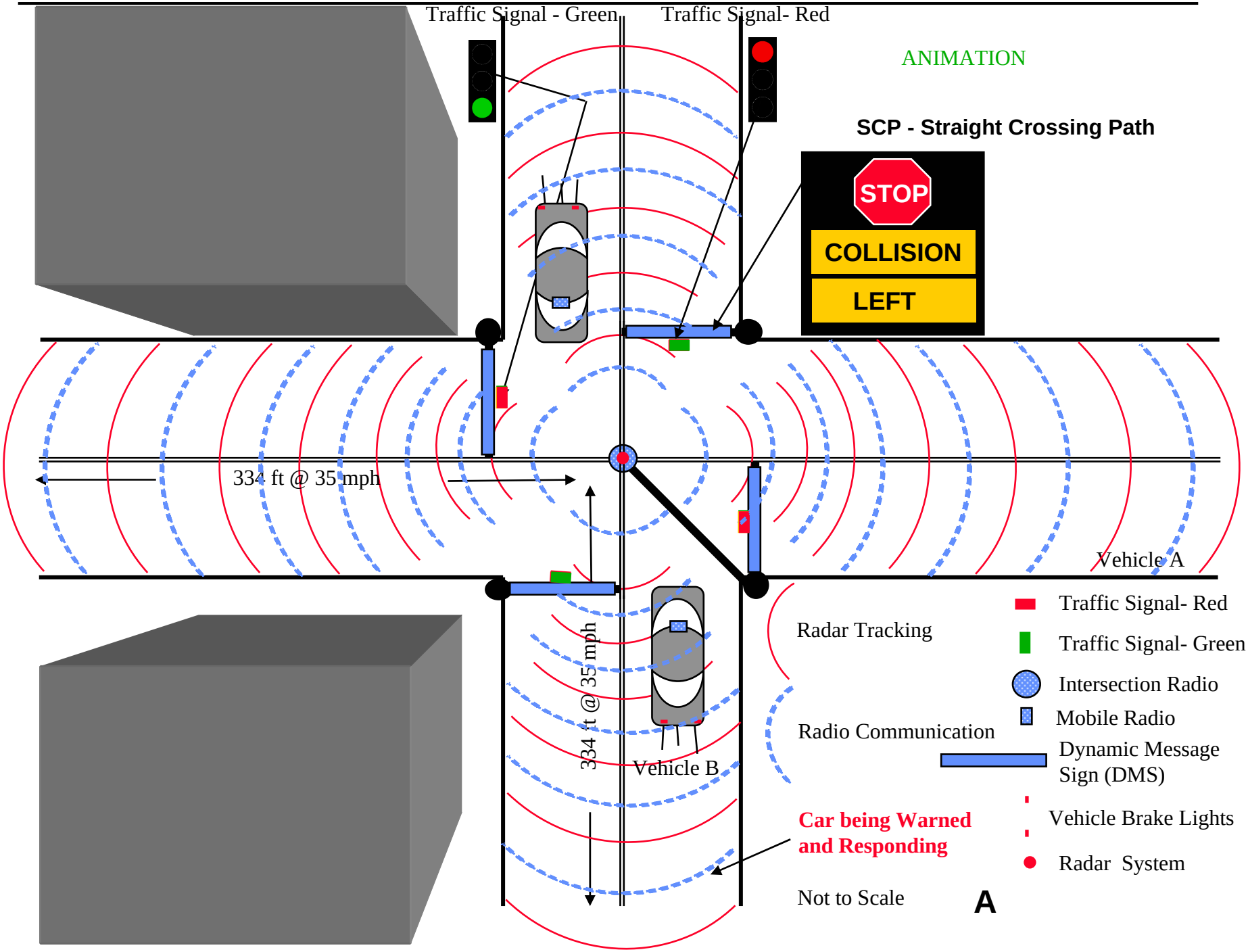


A

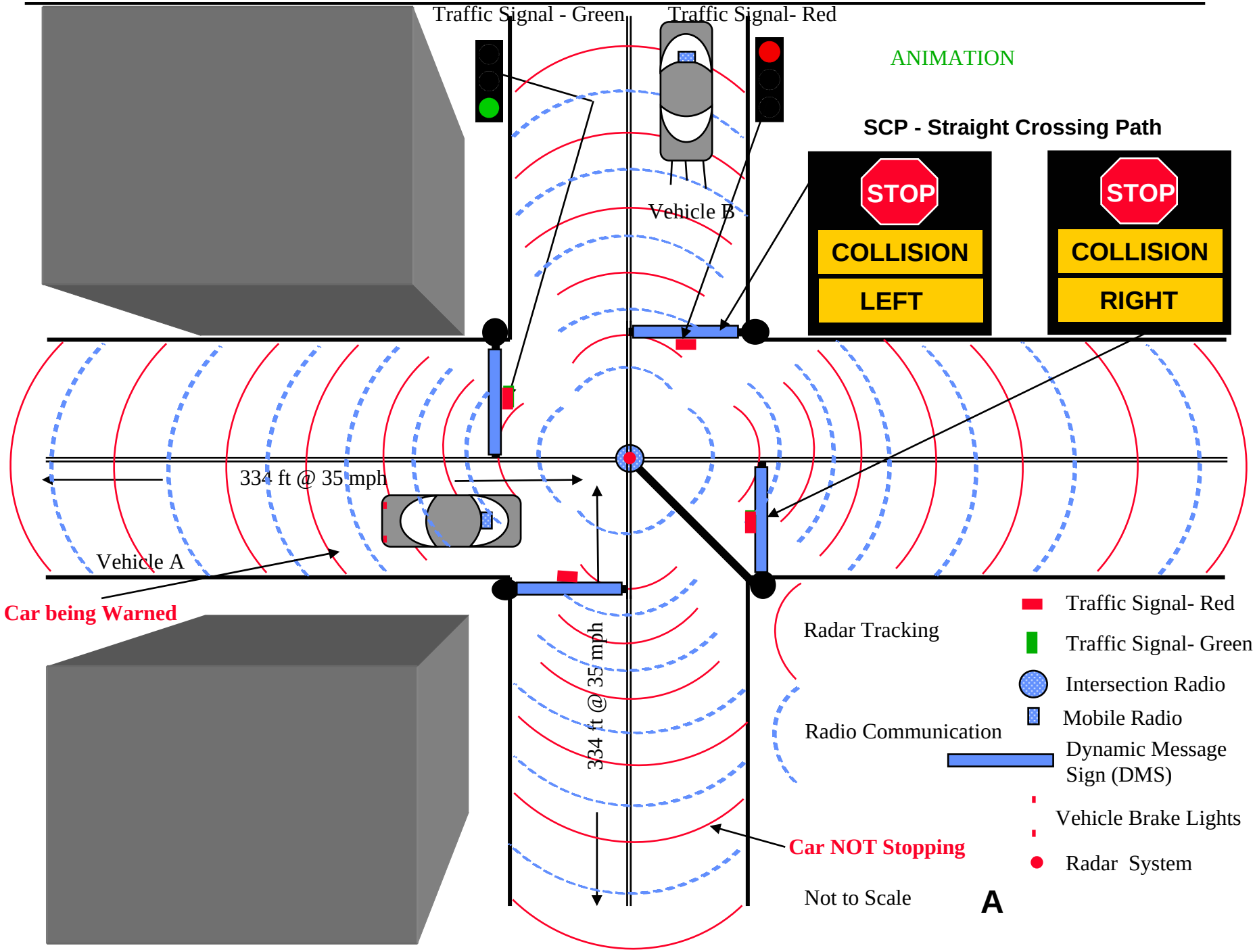
INFRASTRUCTURE ASSISTED COLLISION AVOIDANCE



INFRASTRUCTURE ASSISTED COLLISION AVOIDANCE

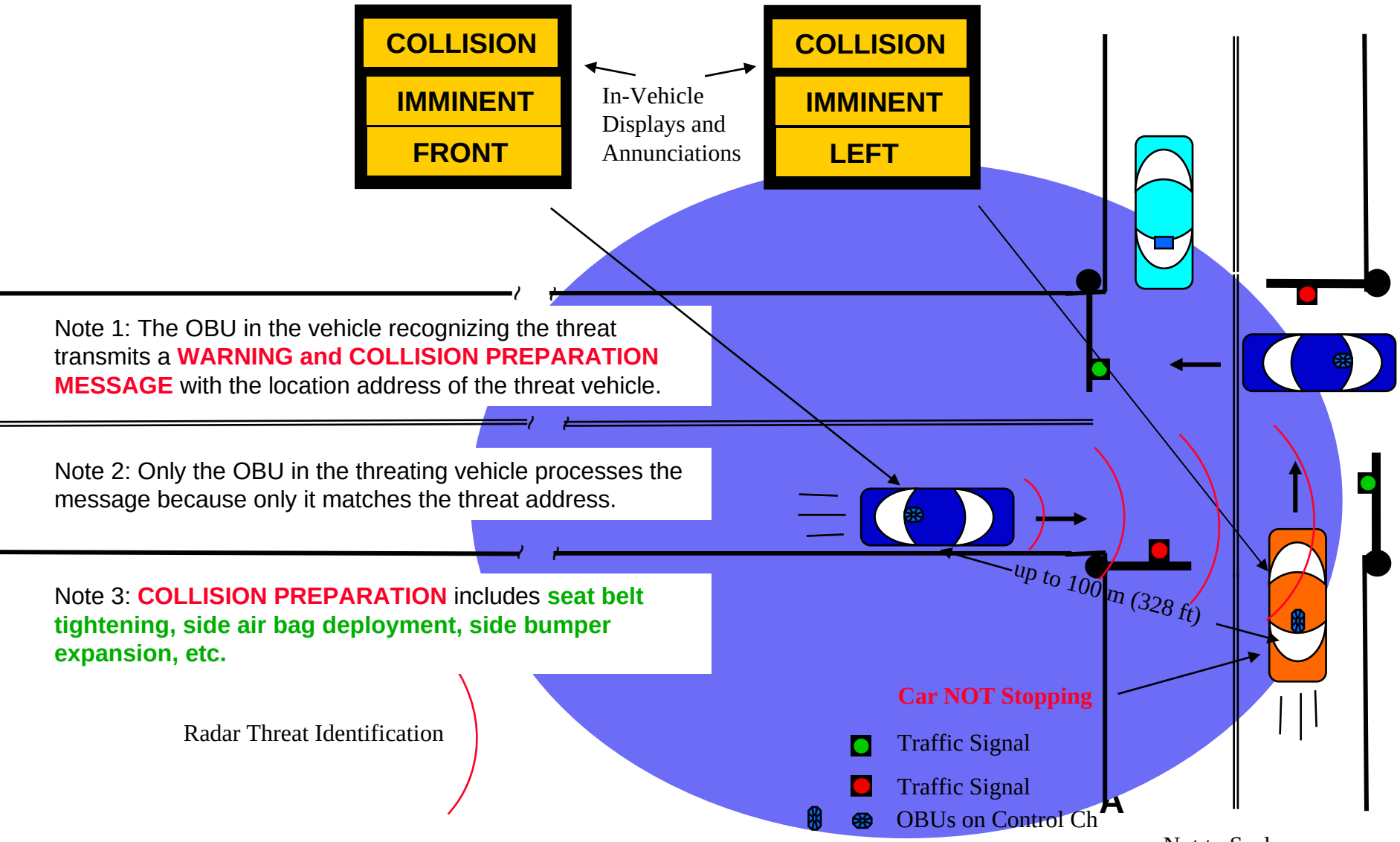


INFRASTRUCTURE ASSISTED COLLISION AVOIDANCE



5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

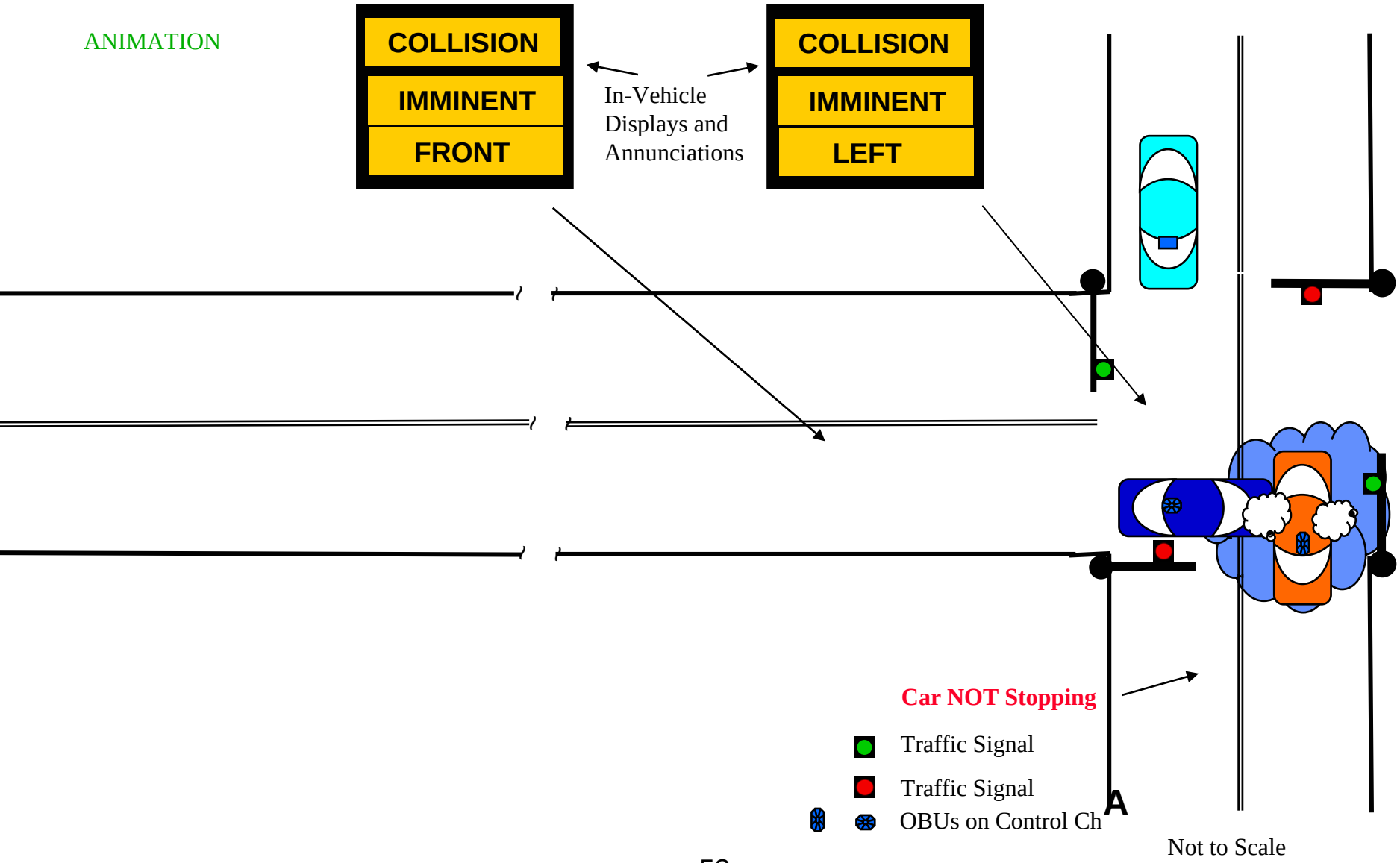
IMMINENT COLLISION WARNING



5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

IMMINENT COLLISION WARNING

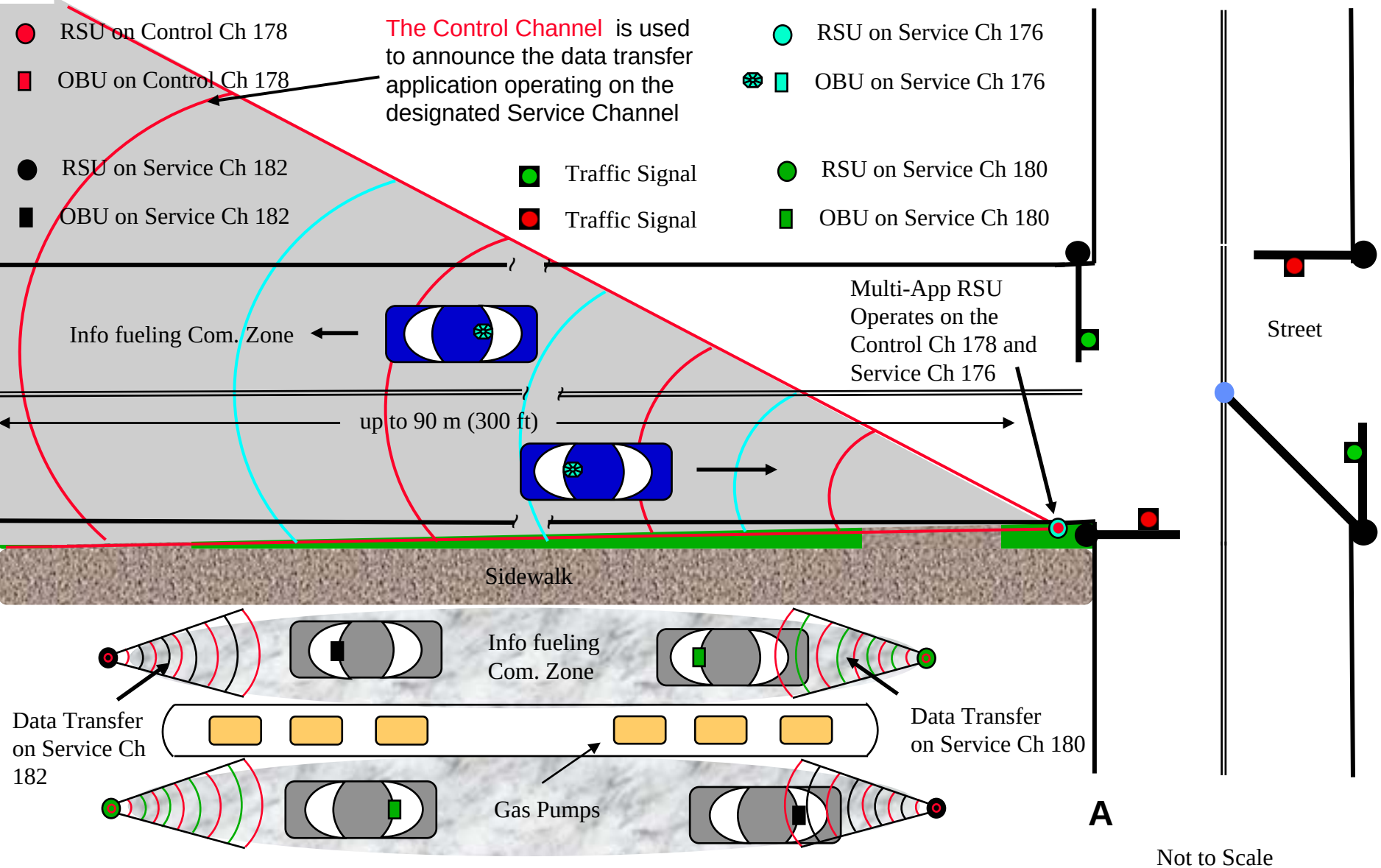
ANIMATION



5.9 GHz DSRC ROADSIDE EQUIPMENT

ANIMATION FOLLOWS

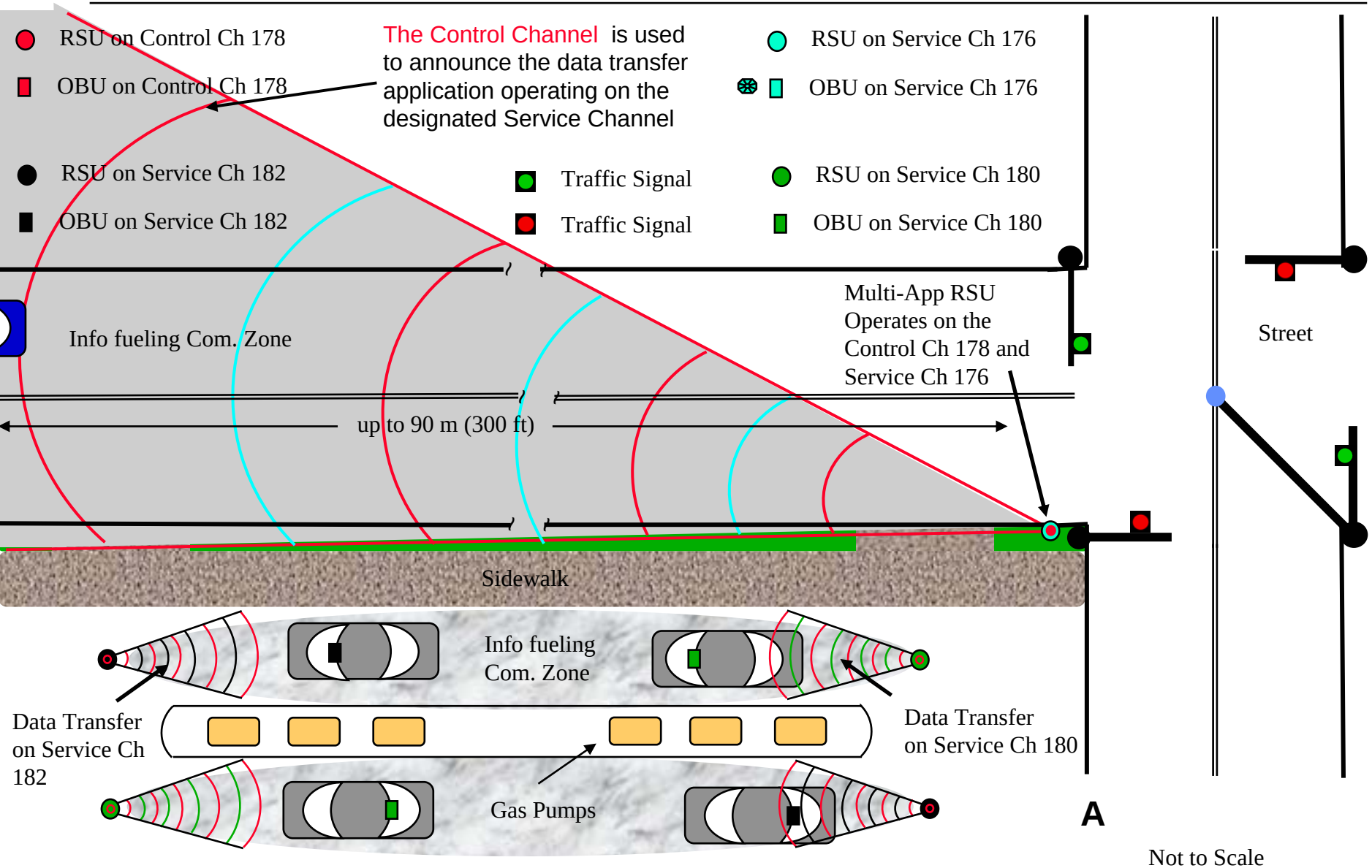
ON-ROAD INFO FUELING and GAS STATION INFO FUELING



5.9 GHz DSRC ROADSIDE EQUIPMENT

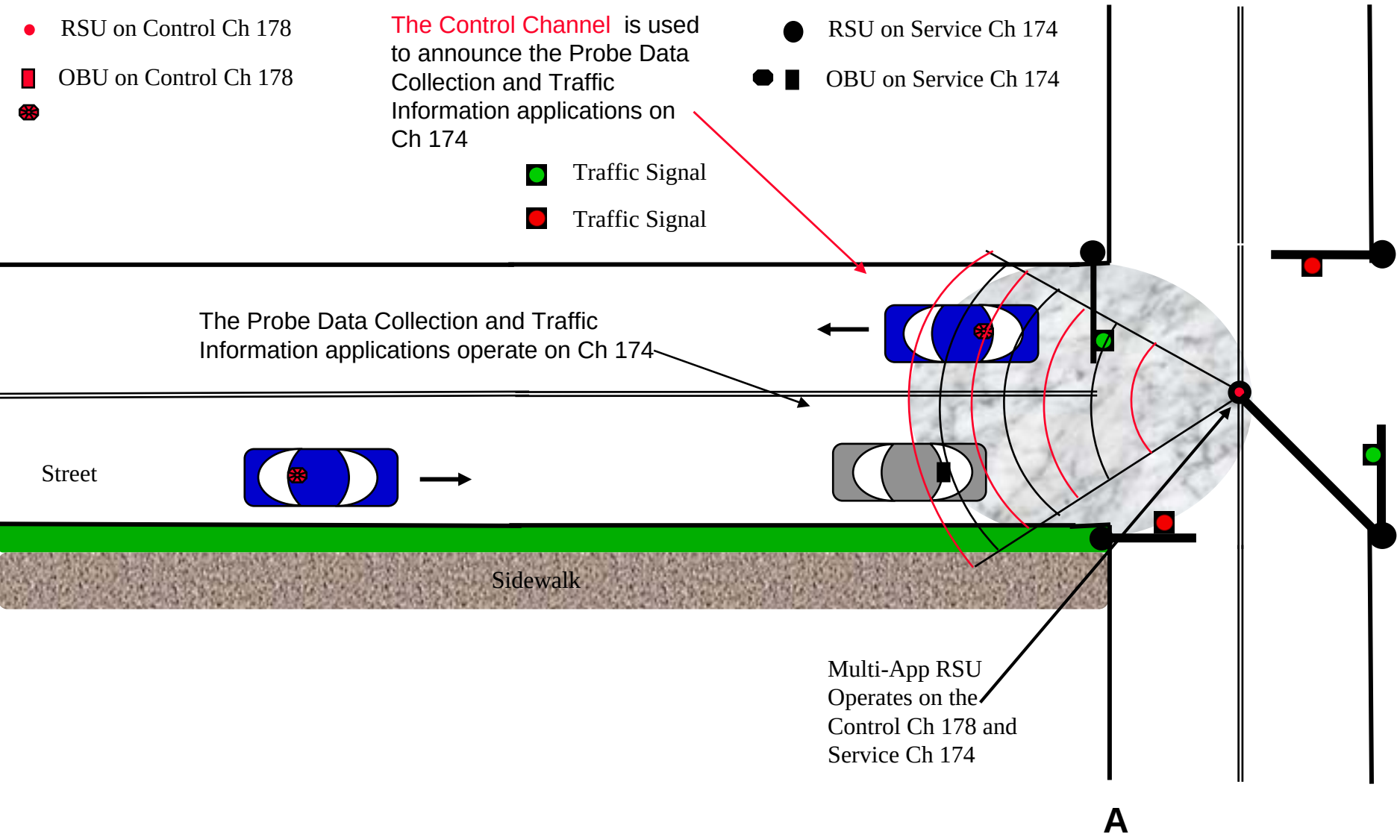
ANIMATION

ON-ROAD INFO FUELING and GAS STATION INFO FUELING



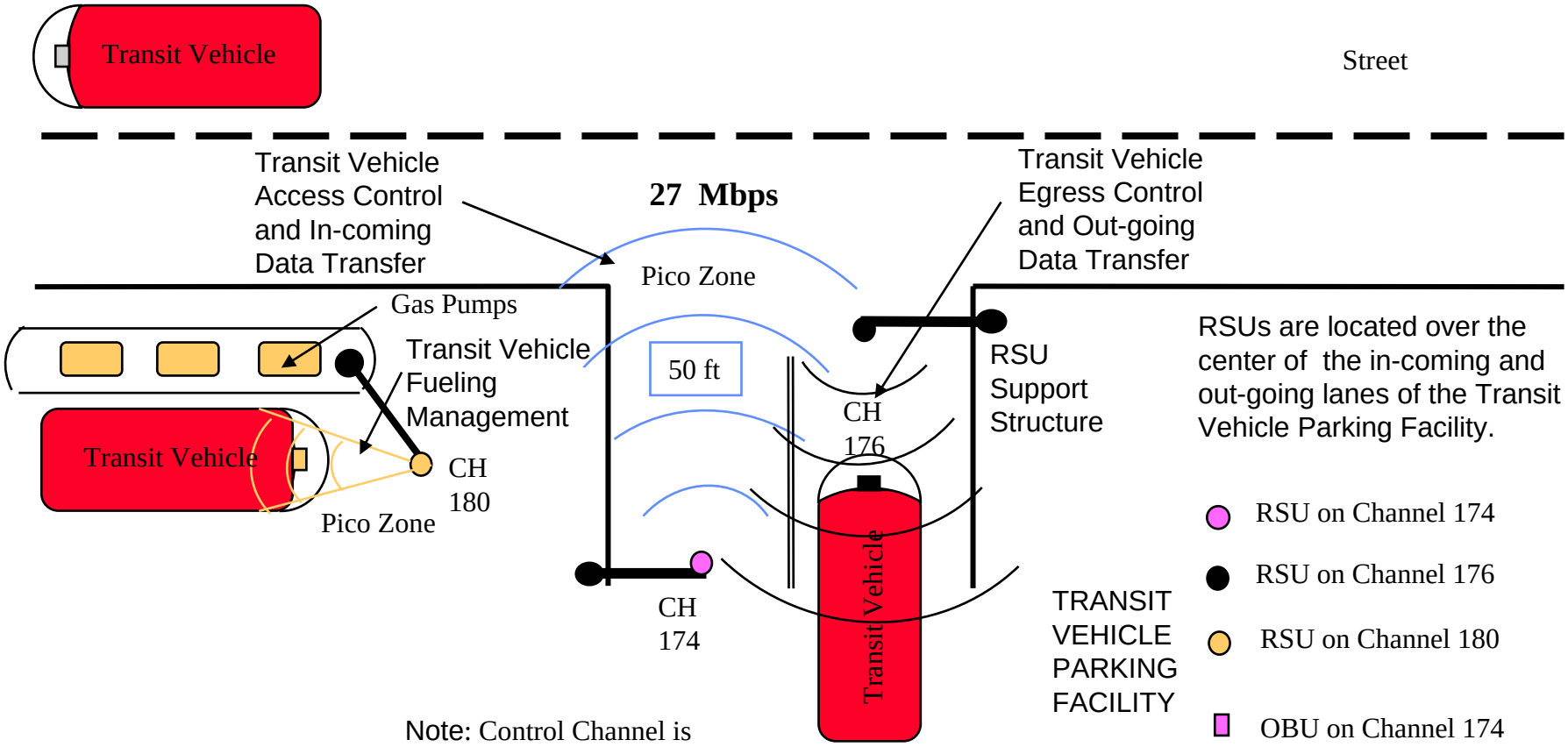
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

PROBE DATA COLLECTION and TRAFFIC INFORMATION



5.9 GHz DSRC ROADSIDE EQUIPMENT

TRANSIT VEHICLE ACCESS, FUELING CONTROL, and DATA TRANSFER (GATE)



Note: Control Channel is used periodically by each RSU to announce the presence of the applications operating on the Service Channels

Not to Scale

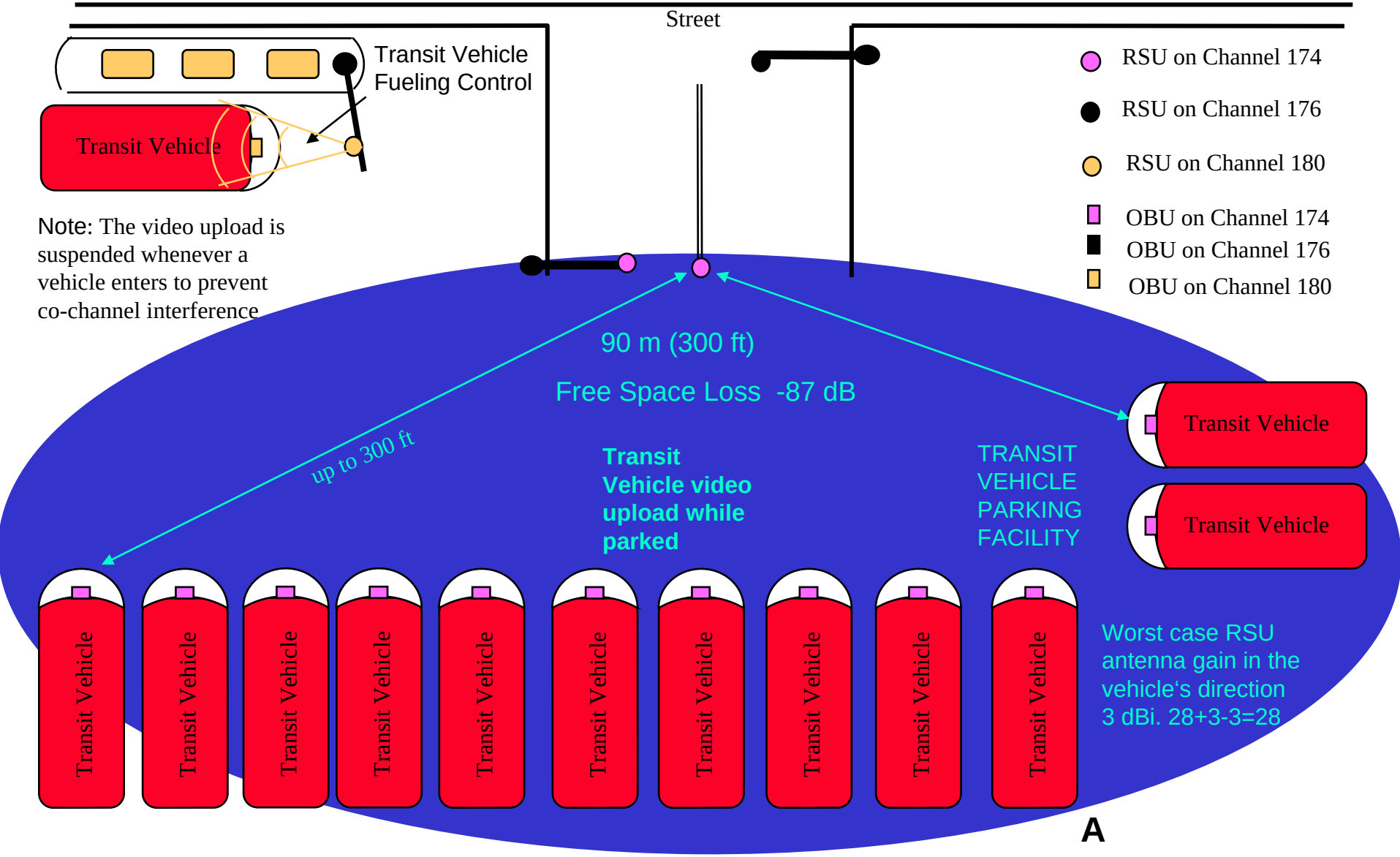
A

5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

= communication zone

Not to Scale

TRANSIT VEHICLE DATA TRANSFER (YARD)



RSU on Control Ch 182

OBU on Control Ch 182

The Control Channel is used to announce the data transfer application operating on the designated Service Channel

RSU on Service Ch 180

OBU on Service Ch 180

5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

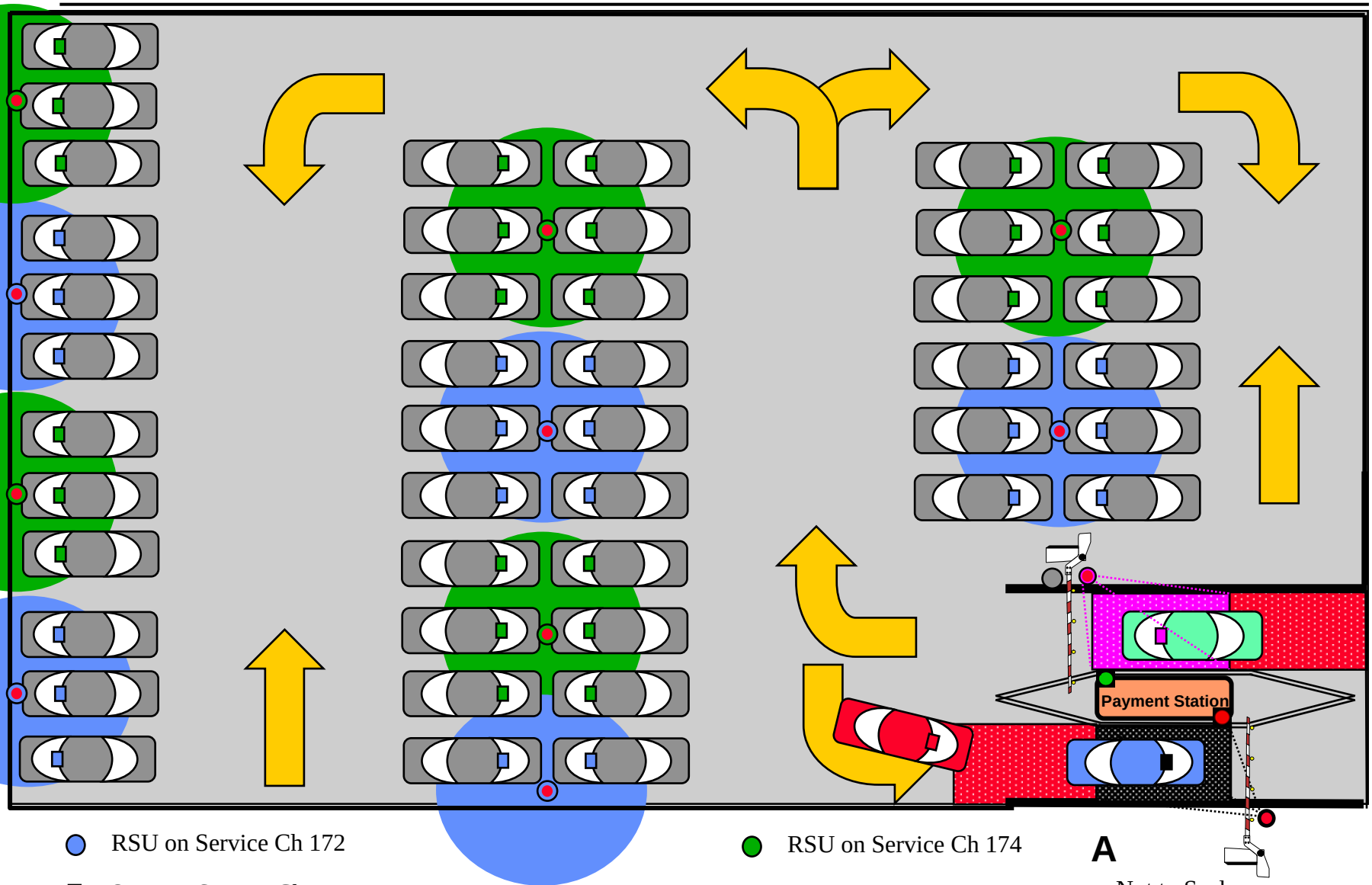
Traffic Signal

Traffic Signal

RSU on Control Ch 178

= communication zones

SURFACE LEVEL PARKING LOT



RSU on Service Ch 172

OBU on Service Ch 172

RSU on Service Ch 174

OBU on Service Ch 174

A

Not to Scale

RSU on Control Ch 182

OBU on Control Ch 182

The Control Channel is used to announce the data transfer application operating on the designated Service Channel

RSU on Service Ch 180

OBU on Service Ch 180

5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

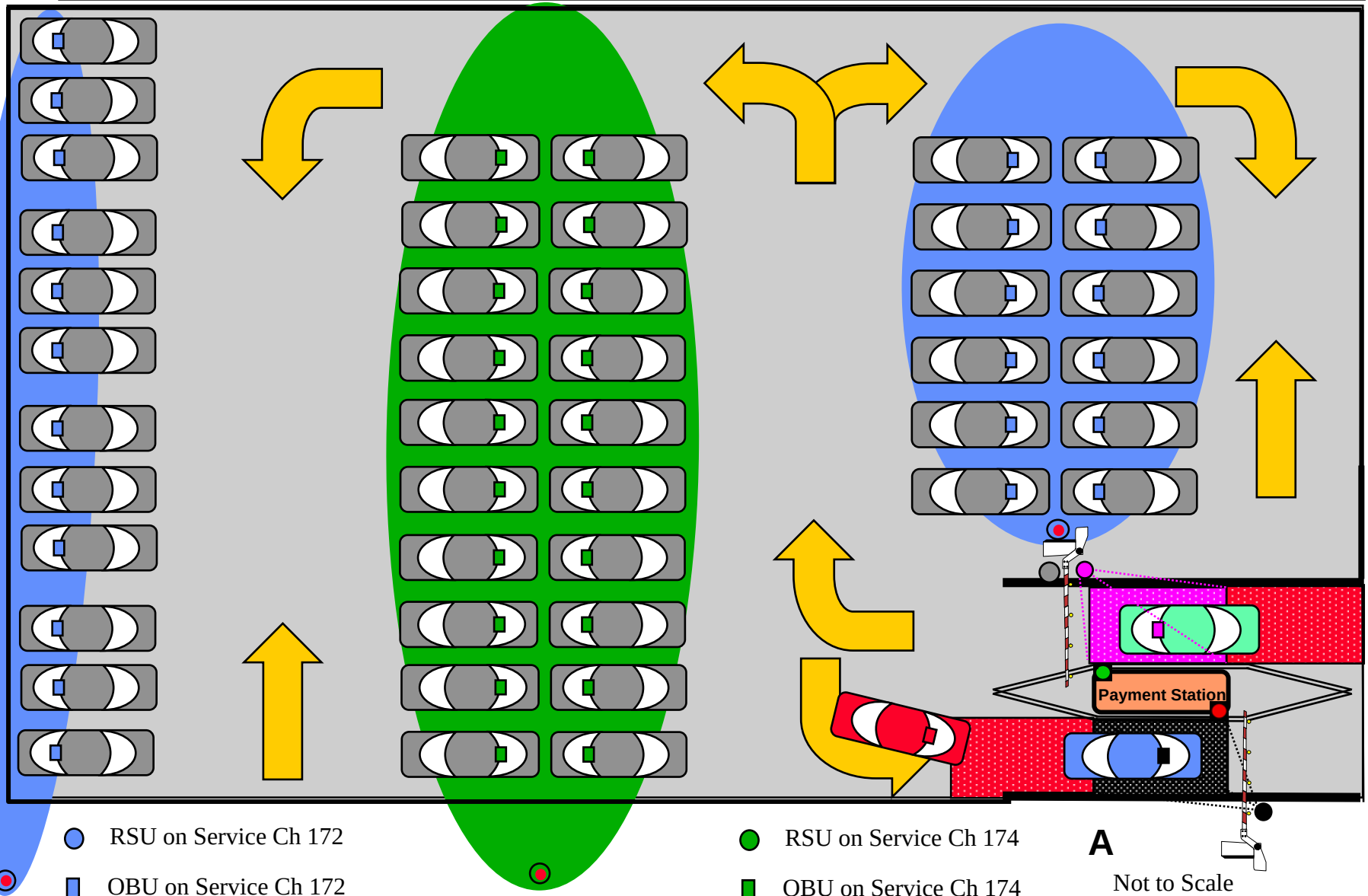
Traffic Signal

Traffic Signal

RSU on Control Ch 178

= communication zones

SURFACE LEVEL PARKING LOT



RSU on Service Ch 172

OBU on Service Ch 172

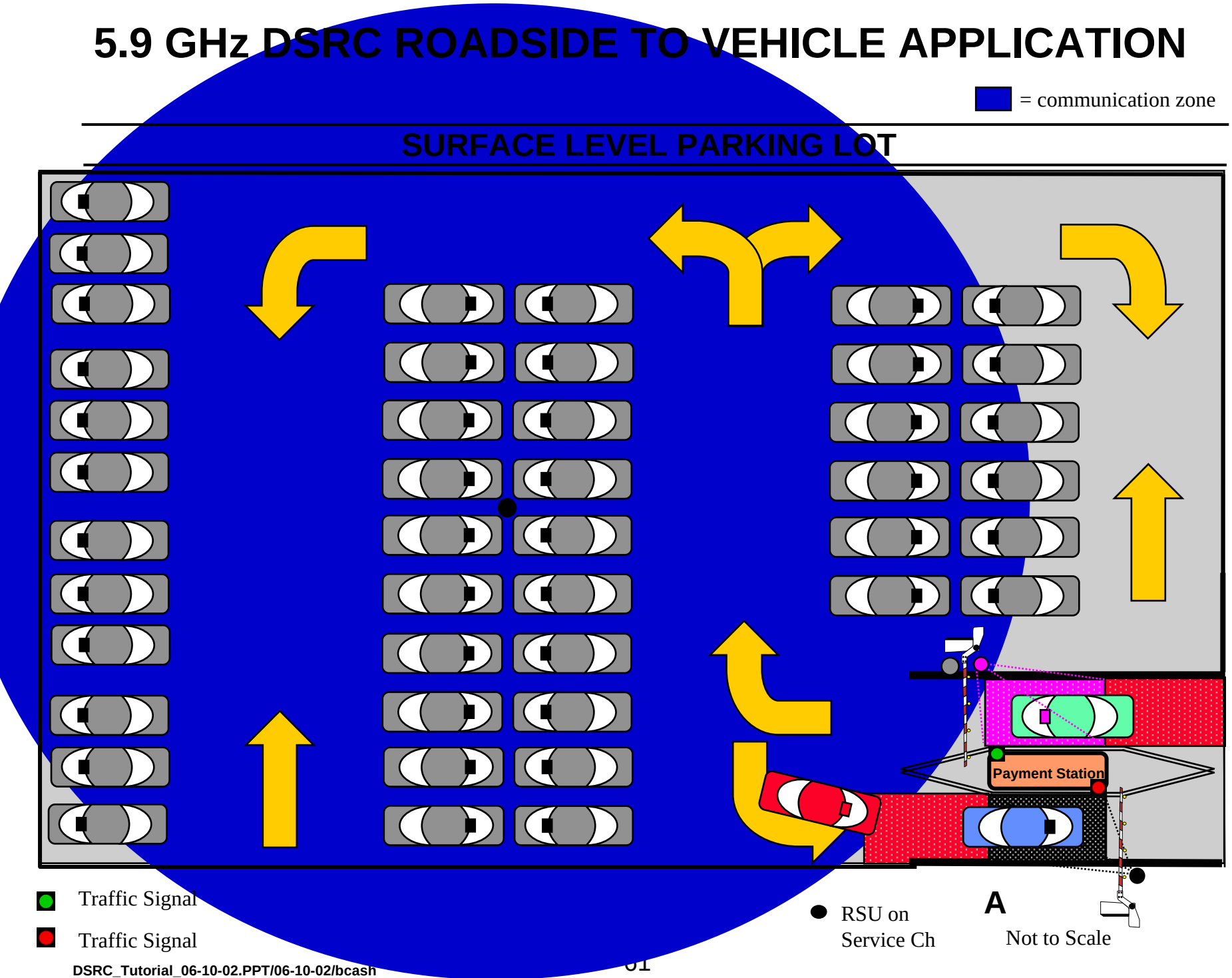
RSU on Service Ch 174

OBU on Service Ch 174

A

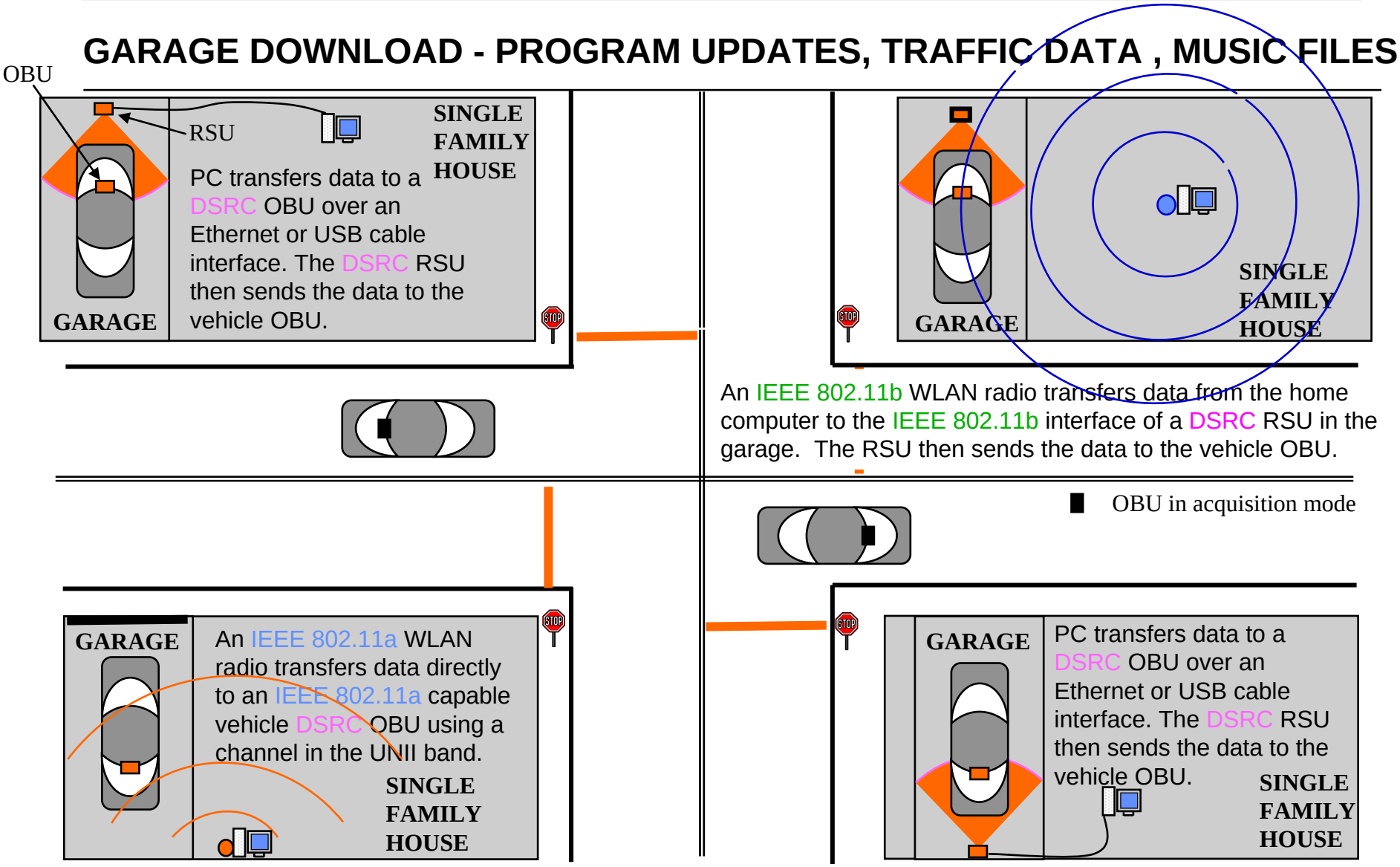
Not to Scale

5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION



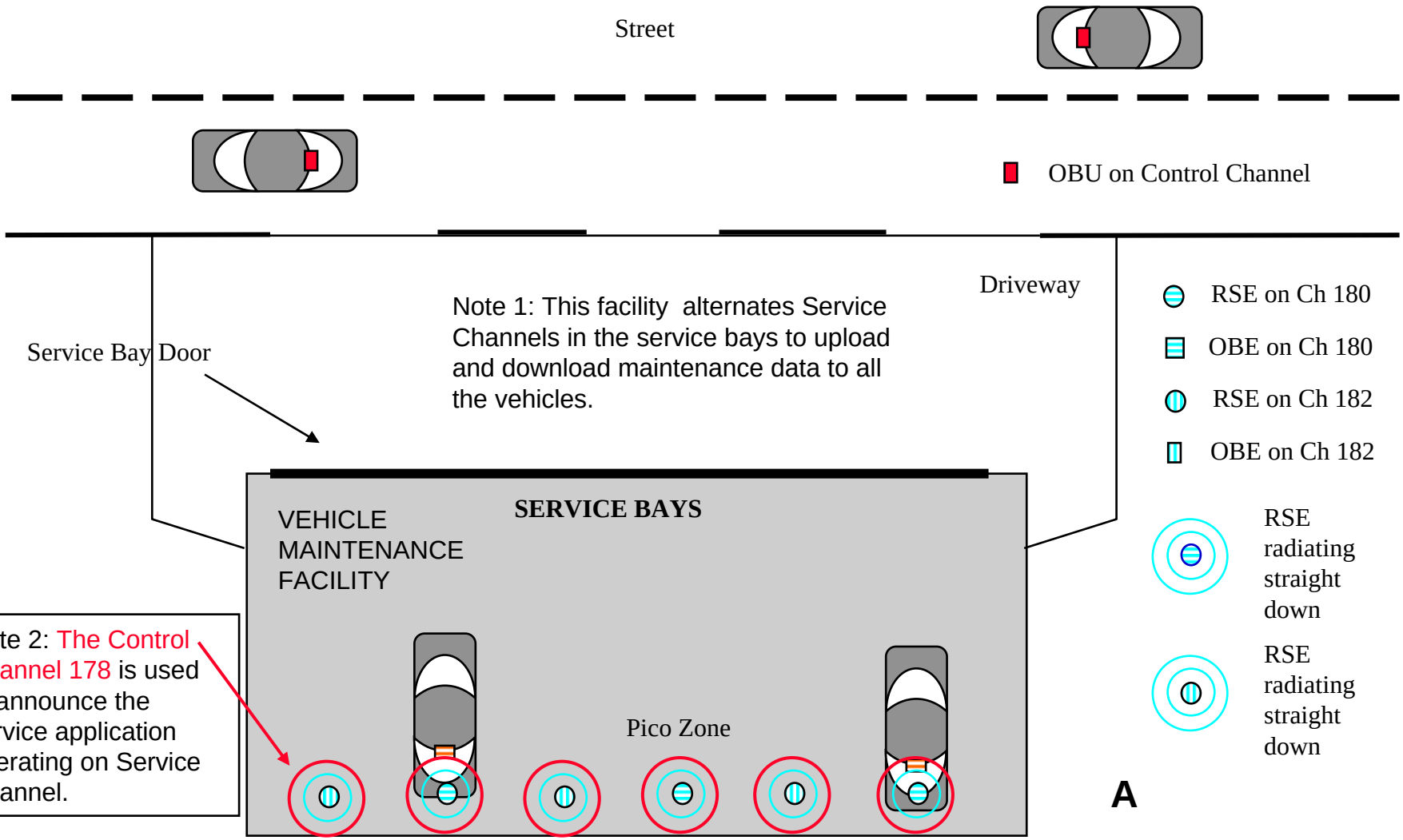
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

GARAGE DOWNLOAD - PROGRAM UPDATES, TRAFFIC DATA , MUSIC FILES



5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

DATA TRANSFER REPAIR SERVICE RECORD

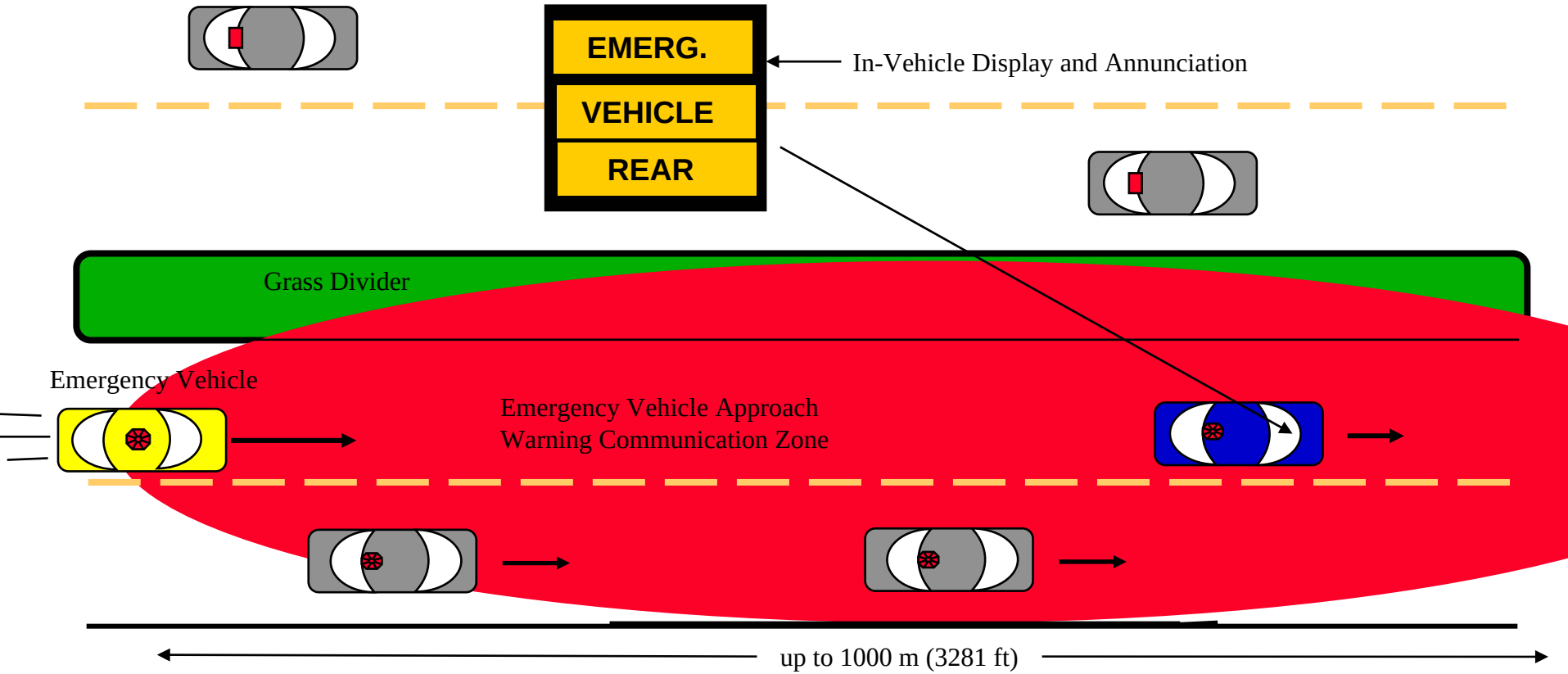


OPEN ROAD APPLICATIONS

5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

EMERGENCY VEHICLE APPROACH WARNING

Note 1: The Emergency Vehicle Warning message is sent every **1 sec**



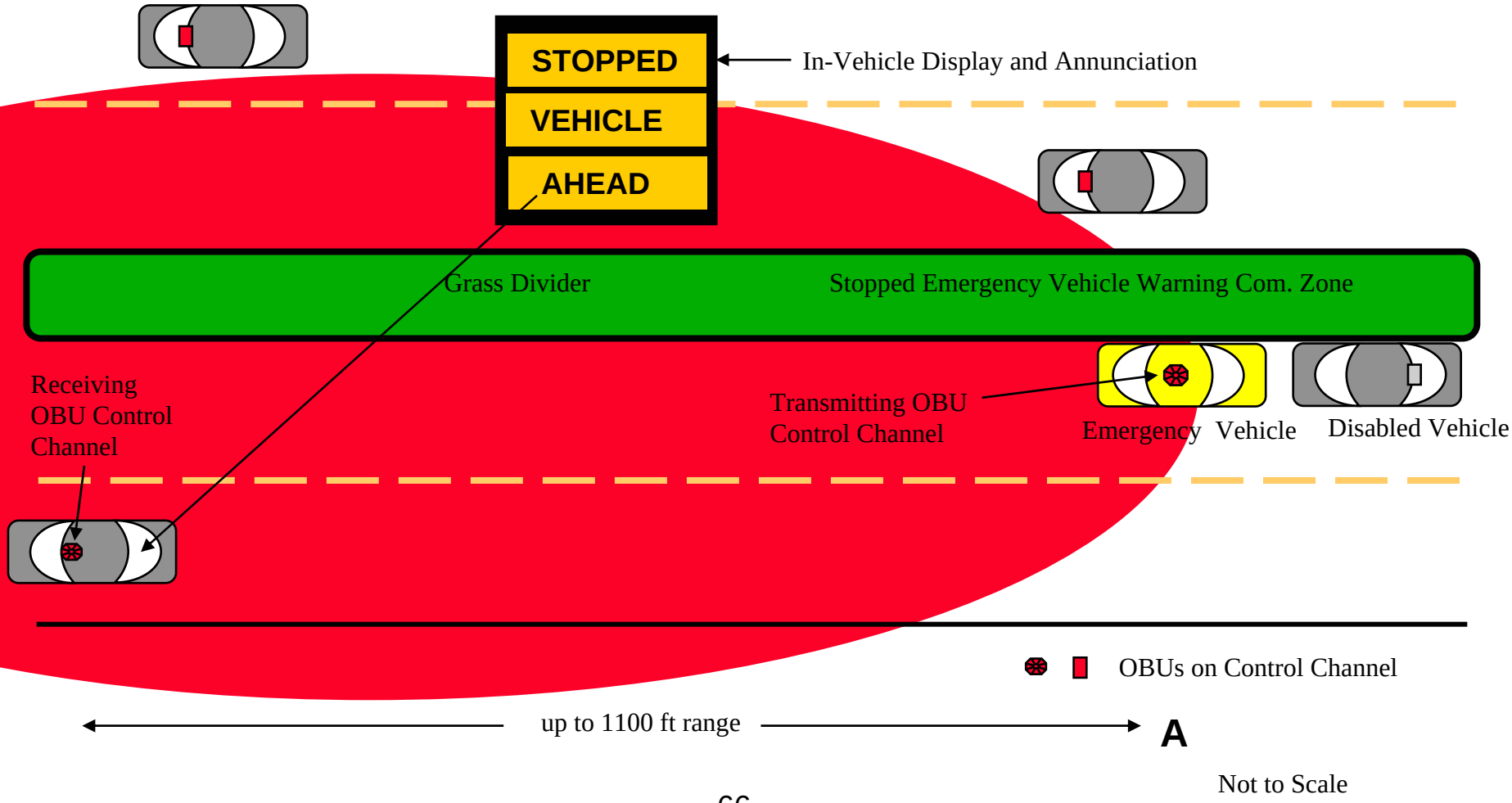
A

Not to Scale

5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

STOPPED EMERGENCY VEHICLE WARNING

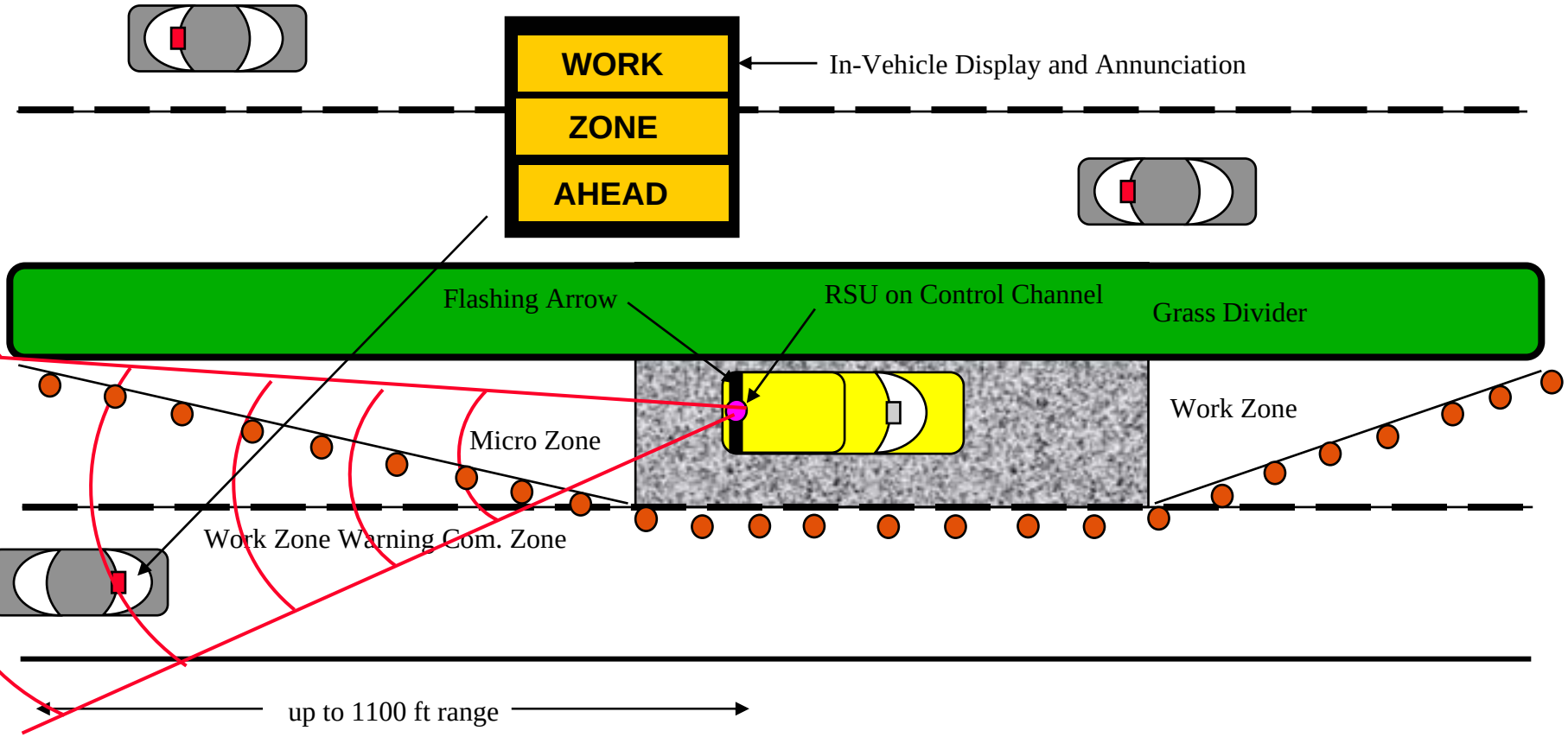
Note 1: The Stopped Vehicle Warning message is sent every **50 ms**



Not to Scale

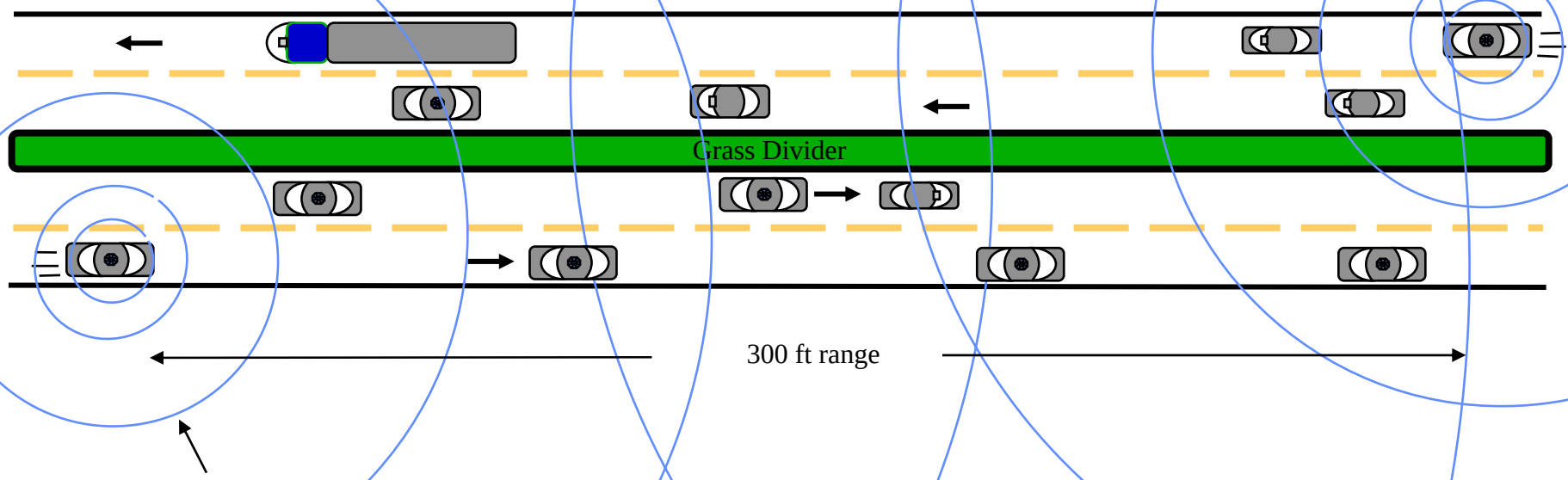
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

WORK ZONE WARNING



5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATIONS

Vehicle to Vehicle Data Transfer



Not to Scale
car = .53
range = 8.29

A

5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATIONS

COOPERATIVE COLLISION WARNING/AVOIDANCE

1) Vehicles with vehicle to vehicle (v-v) communications capability transmit the vehicle's position, speed, direction of travel, and acceleration at 12 Mbps. One transmission will be sent every 300 ms. This transmission is intended for all vehicles within 10 sec travel time, thus the transmit power (range) will vary with vehicle speed up to a maximum range of 300 meters (~1000 ft). The minimum range will be 110 m (~367 ft). For example, vehicles traveling at 60 mph would transmit at a power level appropriate to reach approximately 270 m (~880 ft) and vehicles traveling at 25 mph or lower would transmit at a power level appropriate to reach approximately 110 m (~367 ft). All vehicles capable of doing so (having OBU and with vehicle speed and position data available) will transmit these messages and all OBU will receive these messages.

2) Vehicles that receive these transmissions and have collision avoidance processing capability compute the position and probability of collision for all transmitting vehicles every 100 ms.

3) A Caution is given to drivers when a possibility of collision is computed with an avoidance maneuver requirement that exceeds .35 g or the equivalent acceleration for the conditions.

4) A Warning is given to drivers when a possibility of collision is computed with an avoidance maneuver requirement that meets or exceeds .50 g or the equivalent acceleration for the conditions.

5) If it can be determined that two vehicles are on an intercepting course, both will use the transmission range of the faster vehicle.

A

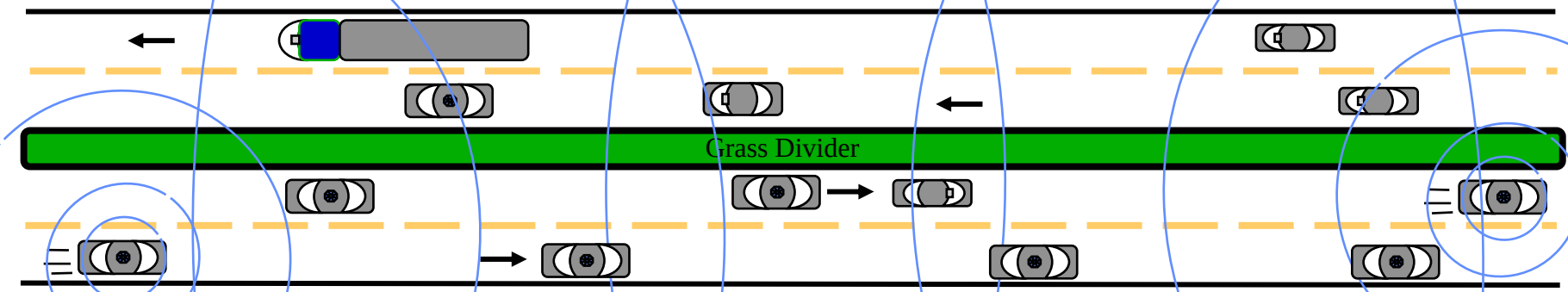
5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATIONS

COOPERATIVE COLLISION WARNING/AVOIDANCE

(with closely spaced vehicles @ 60 mph)

- OBU Receiving on the Vehicle to Vehicle channel
- OBU Transmitting and Receiving on the Vehicle to Vehicle channel @ **12** Mbps

Note: The vehicle's position, speed, direction and acceleration message is nominally sent every **300 ms with a range of 300 m (~1000 ft).**



Routine position, speed, direction messages

Not to Scale

A

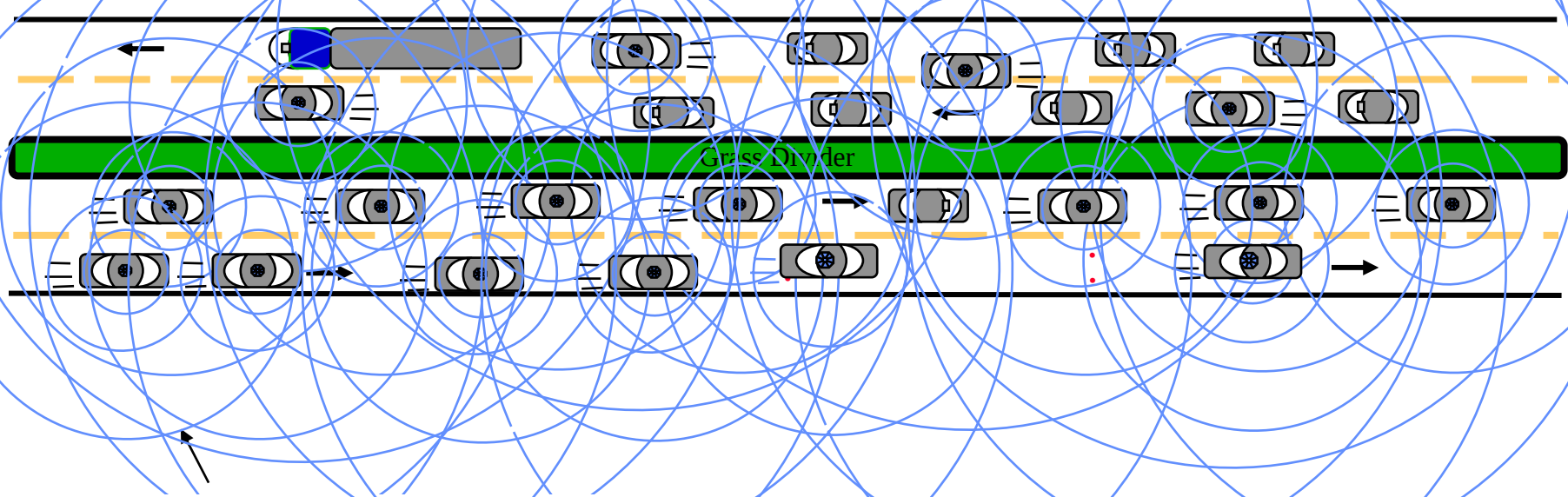
5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATIONS

COOPERATIVE COLLISION WARNING/AVOIDANCE

(with closely spaced vehicles @ 25 mph)

- OBU Receiving on the Vehicle to Vehicle channel
- OBU Transmitting and Receiving on the Vehicle to Vehicle channel @ **12** Mbps

Note: The vehicle's position, speed, direction and acceleration message is nominally sent every **300 ms with a range of 110 m (~367 ft).**



Routine position, speed, direction messages

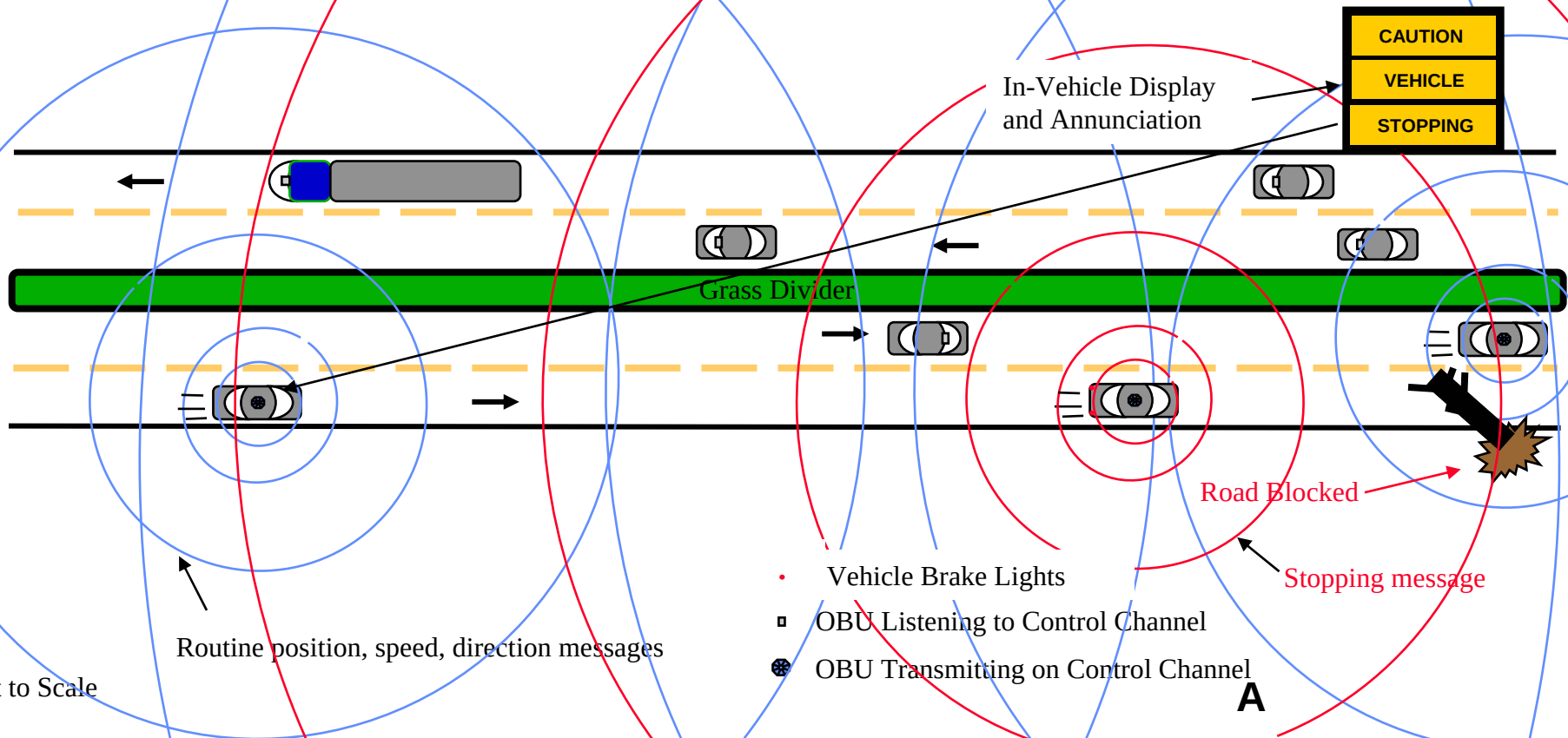
Not to Scale

A

5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATIONS

COOPERATIVE COLLISION WARNING/AVOIDANCE

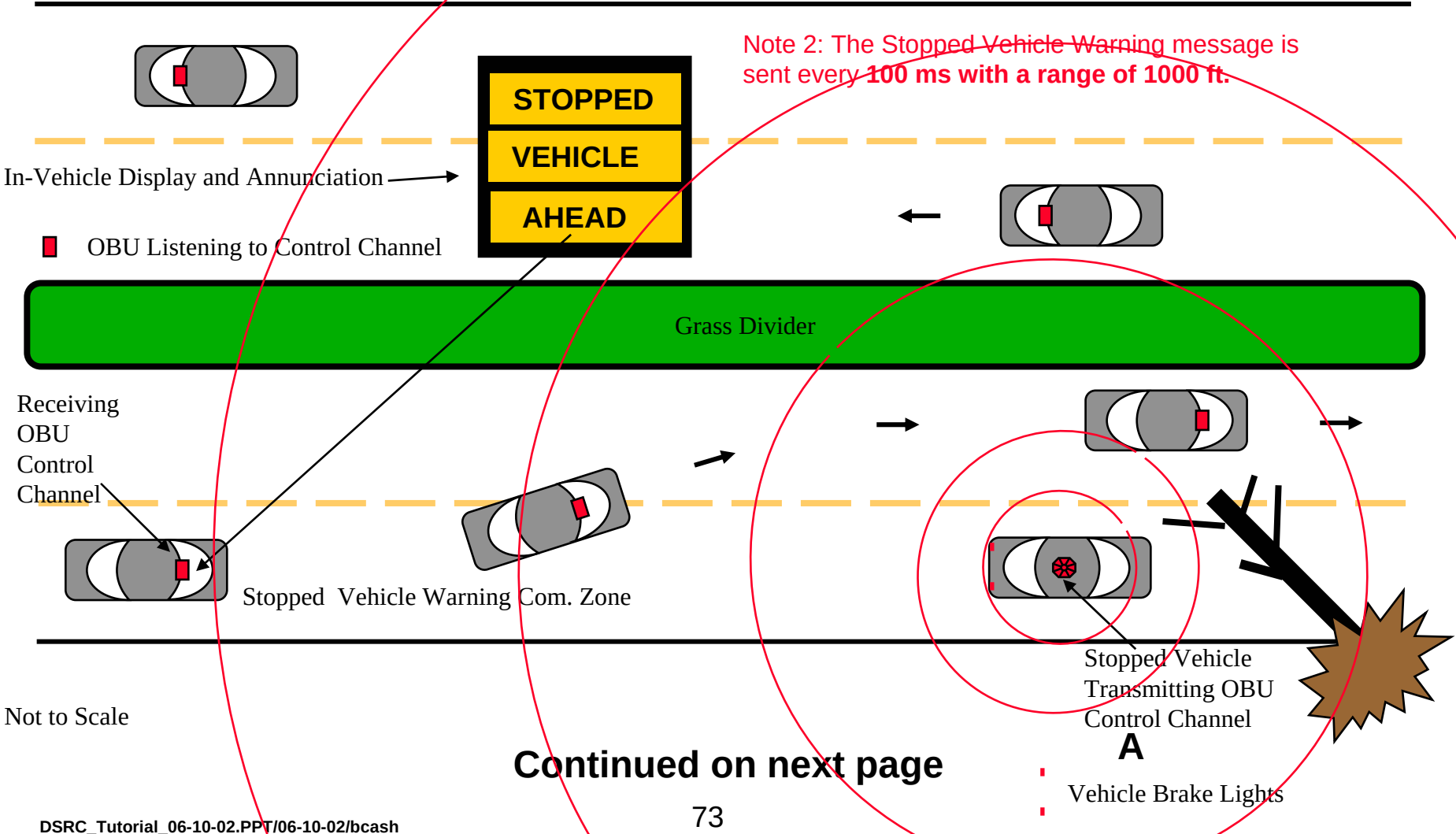
STOPPING VEH. WARNING



5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

COOPERATIVE COLLISION WARNING B - STOPPED VEHICLE WARNING

Note 1: The Stopped Vehicle Warning message is sent in the direction of arriving traffic when the stopping vehicle's brakes are being applied and its speed drops **20 mph** below the speed limit of the road or its speed drops below **5 mph**.

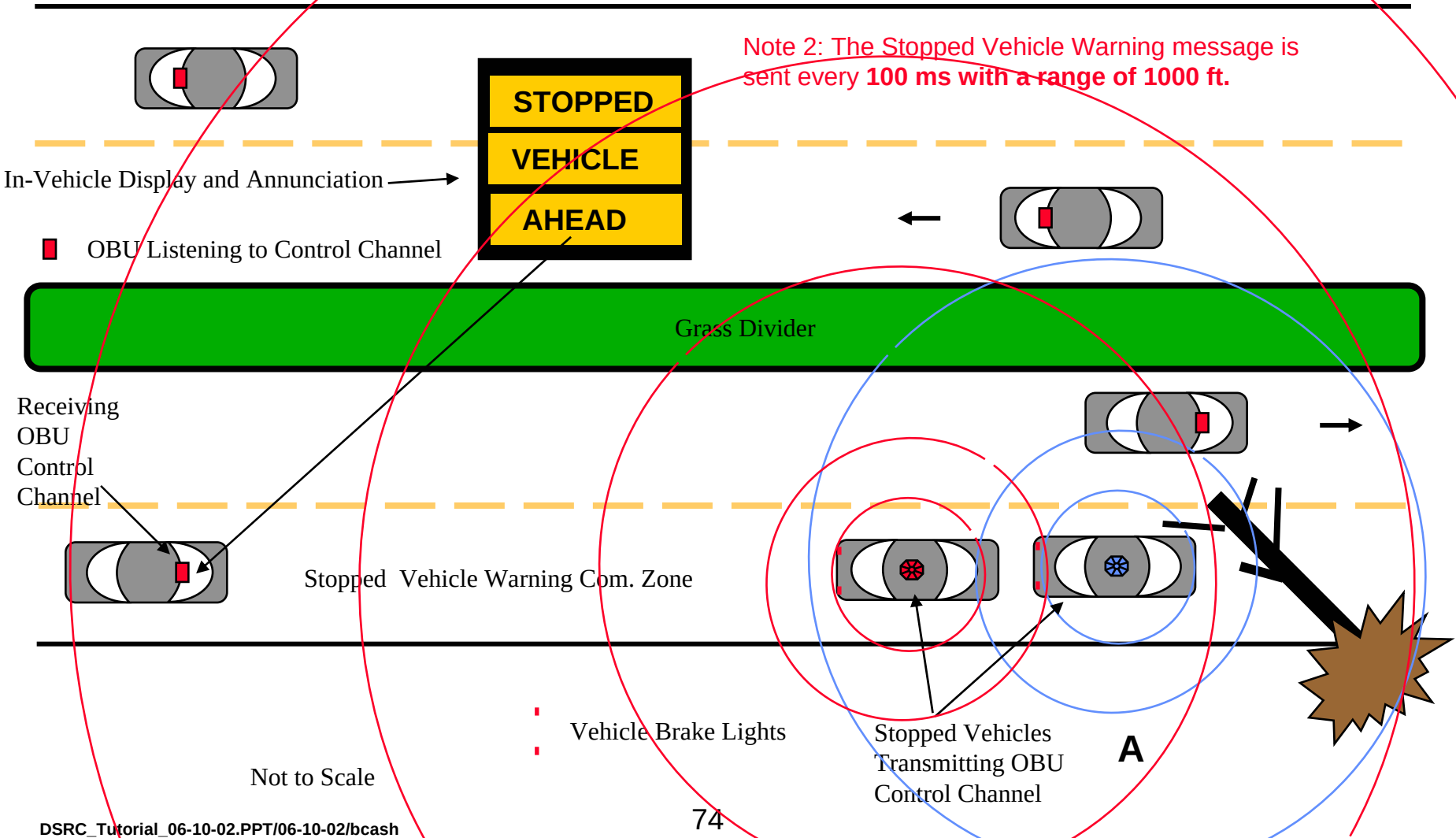


Continued on next page

5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATION

COOPERATIVE COLLISION WARNING B - SECOND STOPPED VEHICLE

Note 2: Once another stopped vehicle, immediately to the rear, starts transmitting the stopped vehicle message the first vehicle reverts to the original position, speed, and direction message. The range will reach the second stopped vehicle.



5.9 GHz DSRC VEHICLE TO VEHICLE APPLICATIONS

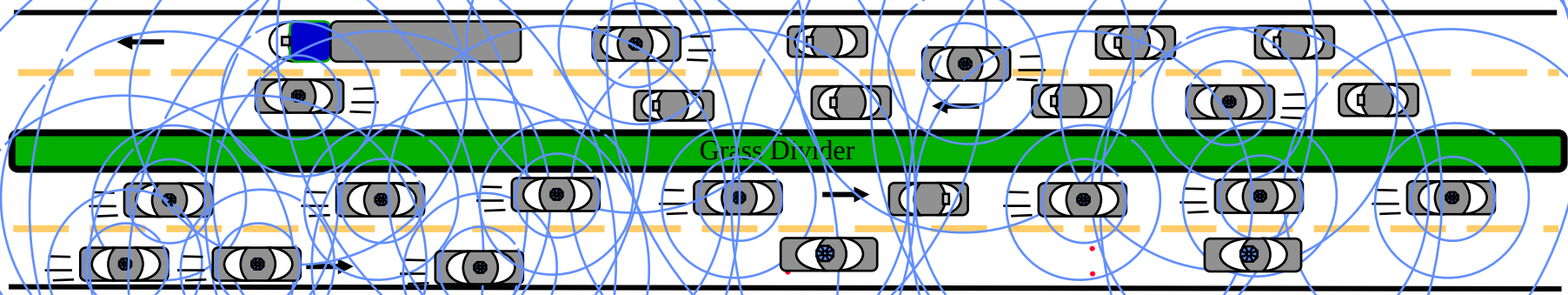
COOPERATIVE COLLISION WARNING/AVOIDANCE

SLOWED OR STOPPED TRAFFIC

Note 1: Once traffic slows to 10 mph or below the vehicles transmit the position, speed, and direction message every 100 ms at 15 m range.

- OBU Receiving on the Vehicle to Vehicle channel
- OBU Transmitting and Receiving on the Vehicle to Vehicle channel @ **12** Mbps

Note 2: The vehicle's position, speed, direction and acceleration message is sent every **100 ms with a range of 15 m (~50 ft) but 300 m (1000 ft) when receiving a faster vehicle's signal.**



Routine position, speed, direction messages

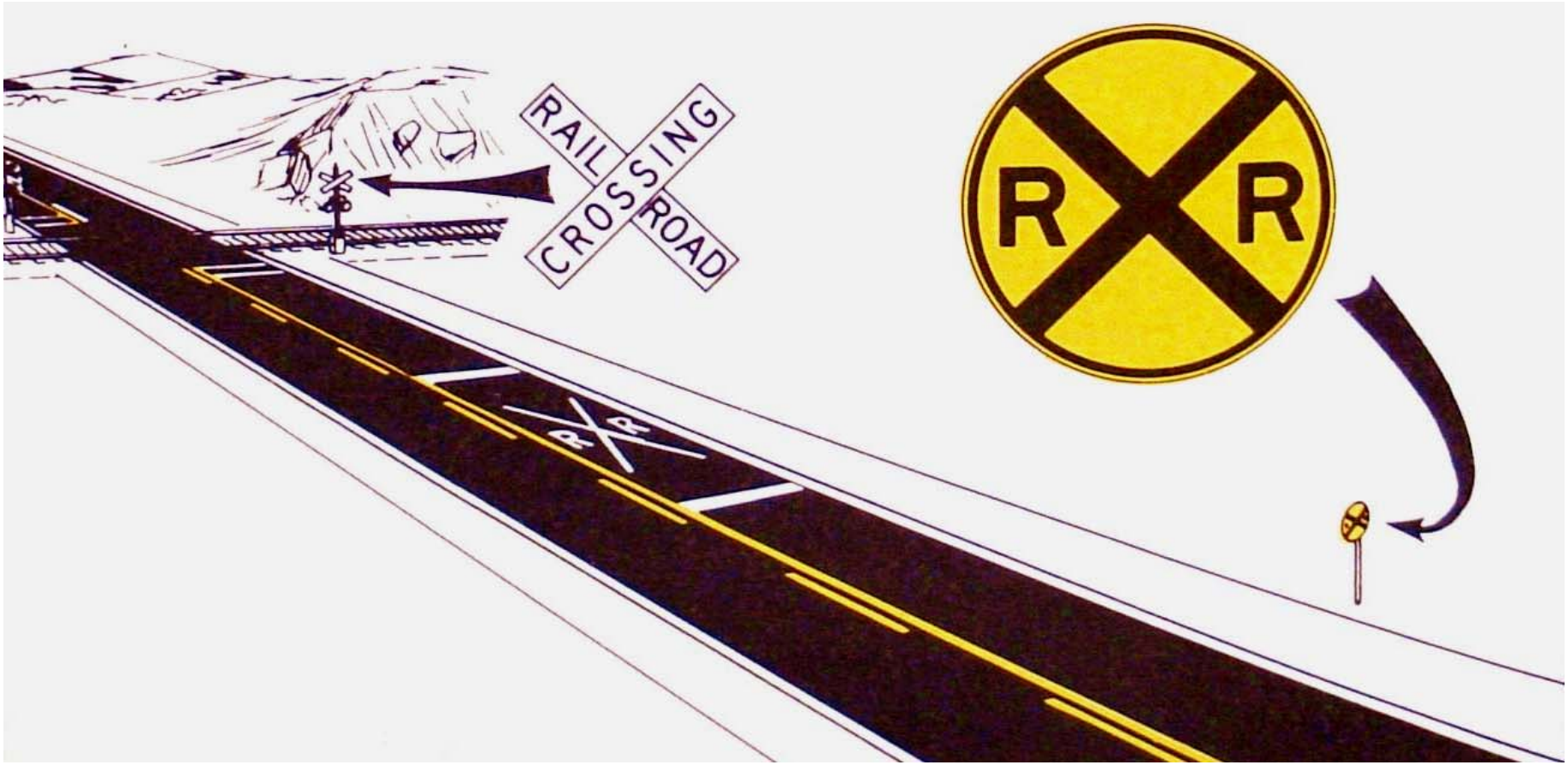
- OBU Listening on the Control Channel
- OBU Transmitting on the Control Channel

Not to Scale

5.9 GHz DSRC ROADSIDE EQUIPMENT

HIGHWAY/RAIL INTERSECTION WARNING

Note 1: The Manual on Uniform Traffic Control Devices states that, “A warning sign is placed in advance of the condition to which it calls attention.” (1988 edition, Para. 2A-25)



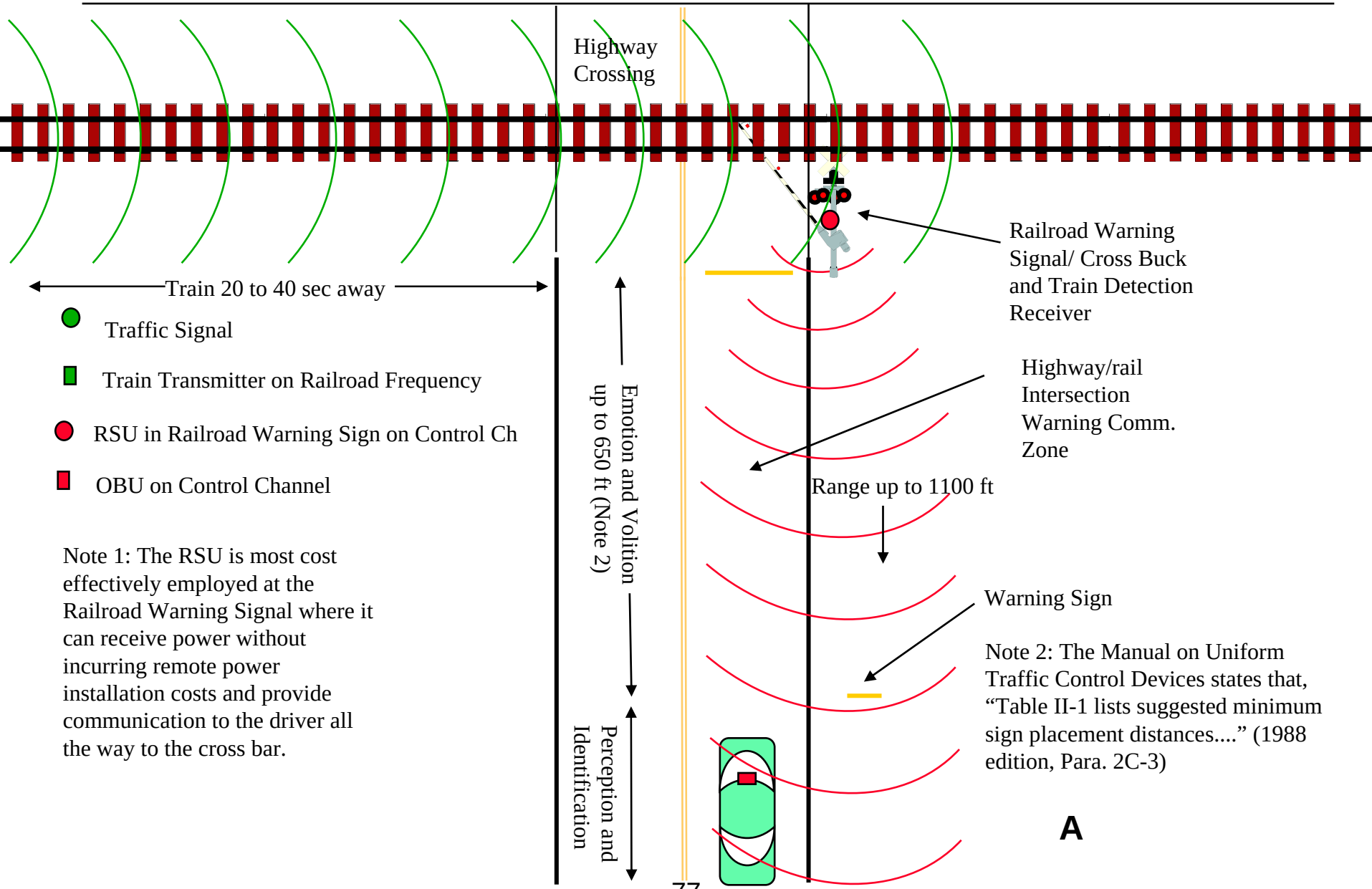
Note 2: The above figure is from the Manual on Uniform Traffic Control Devices, 1988 edition, fig. 2-5, page 2A-20.

A

EXAMPLE MICRO/PICO-CELL COMMUNICATION ZONES

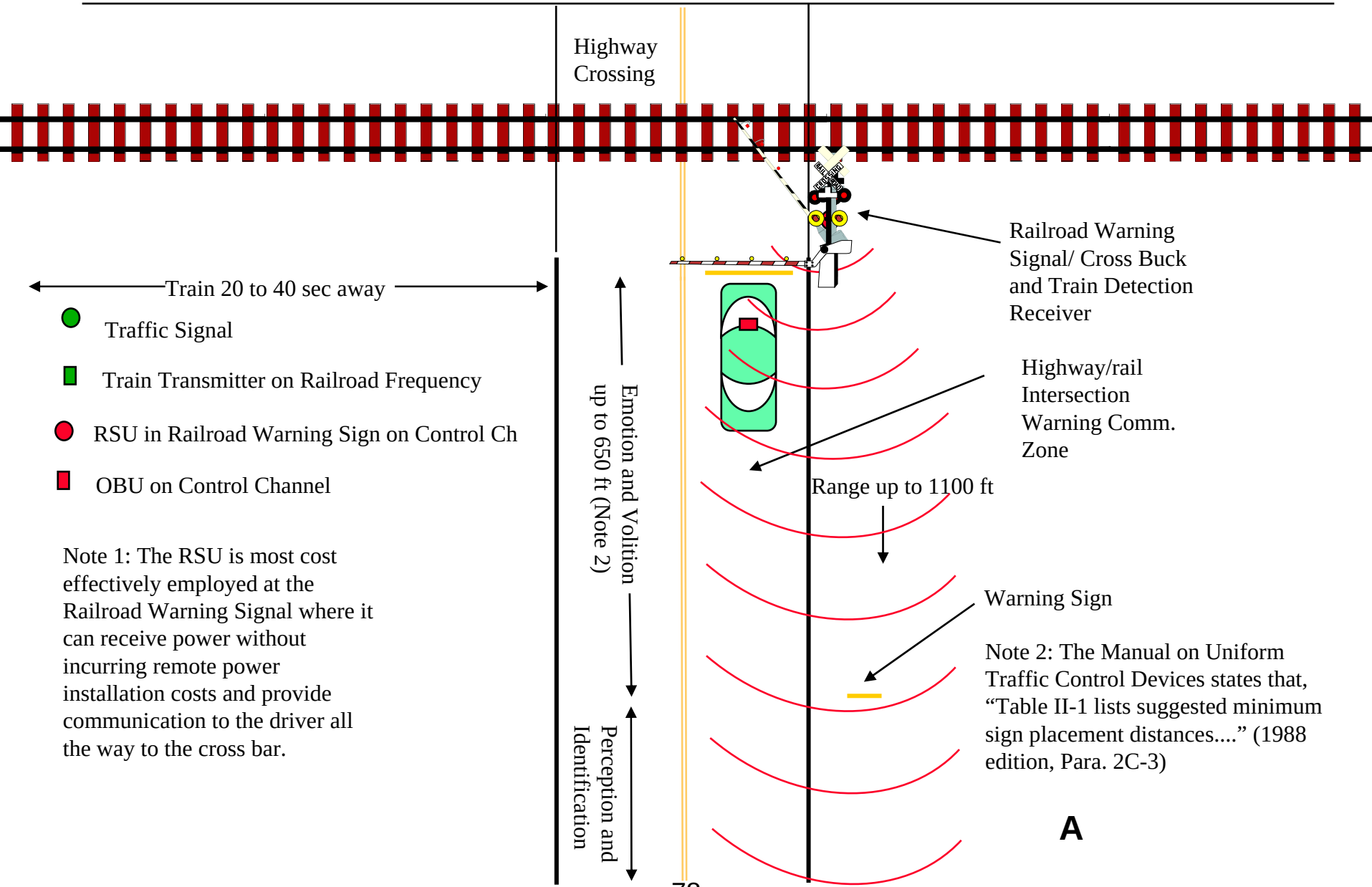
ANIMATION FOLLOWS

HIGHWAY/RAIL INTERSECTION WARNING



EXAMPLE MICRO/PICO-CELL COMMUNICATION ZONES

HIGHWAY/RAIL INTERSECTION WARNING



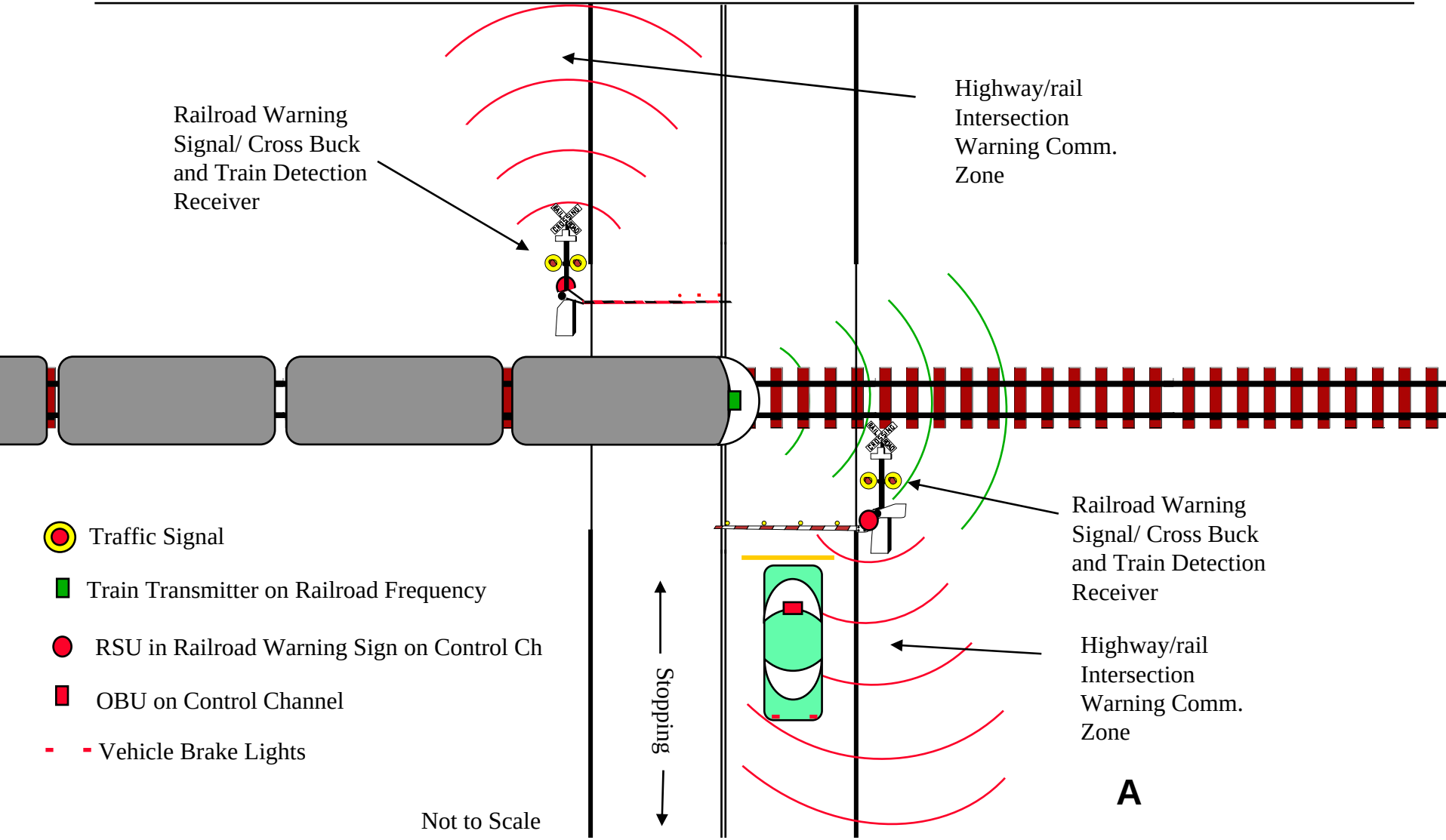
Note 1: The RSU is most cost effectively employed at the Railroad Warning Signal where it can receive power without incurring remote power installation costs and provide communication to the driver all the way to the cross bar.

Note 2: The Manual on Uniform Traffic Control Devices states that, "Table II-1 lists suggested minimum sign placement distances...." (1988 edition, Para. 2C-3)

A

EXAMPLE MICRO/PICO-CELL COMMUNICATION ZONES

HIGHWAY/RAIL INTERSECTION WARNING



5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

- **Warning signs should provide adequate time for the driver to perceive, identify, decide, and perform any necessary maneuver. This is generally referred to as PIEV.**

- **PIEV**
  - **Perception**
  - **Identification/ understanding**
  - **Emotion/ decision making**
  - **Volition / execution of decision**

- **The PEIV time can vary from about 3 seconds for general warning signs to 10 seconds for high driver judgement condition warning signs. (This includes sign legibility distance and braking or maneuvering distance.)**

- **Reference: The Manual on Uniform Traffic Control Devices, 1988 edition, Para. 2C-3.**

A

5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

NARROW BRIDGE - WARNING SIGN

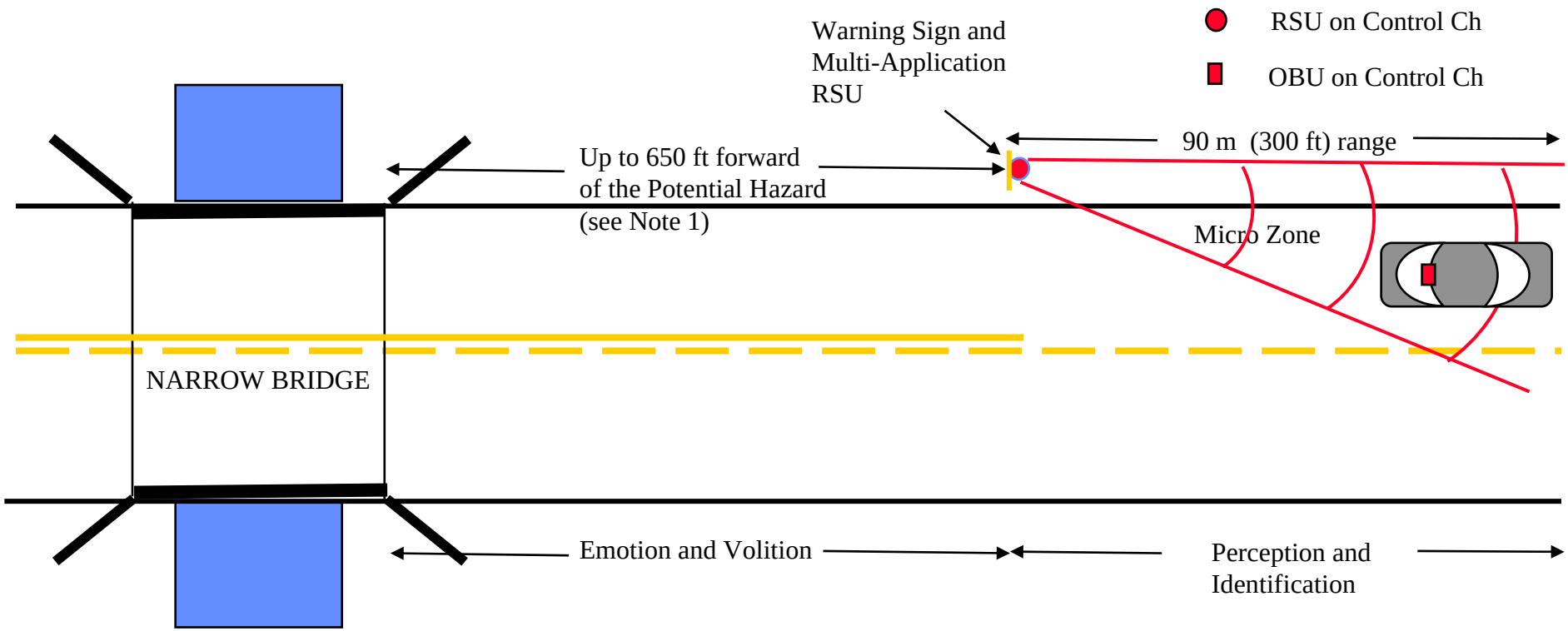
Note 1: The Manual on Uniform Traffic Control Devices states that, “A warning sign is placed in advance of the condition to which it calls attention.” (1988 edition, Para. 2A-25)

Note 2: The above figure is from the Manual on Uniform Traffic Control Devices, 1988 edition, fig. 2-5, page 2A-20.

A

5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

NARROW BRIDGE - WARNING SIGN + DSRC RSU



Note 1: The Manual on Uniform Traffic Control Devices states that, "Table II-1 lists suggested minimum sign placement distances...." (1988 edition, Para. 2C-3)

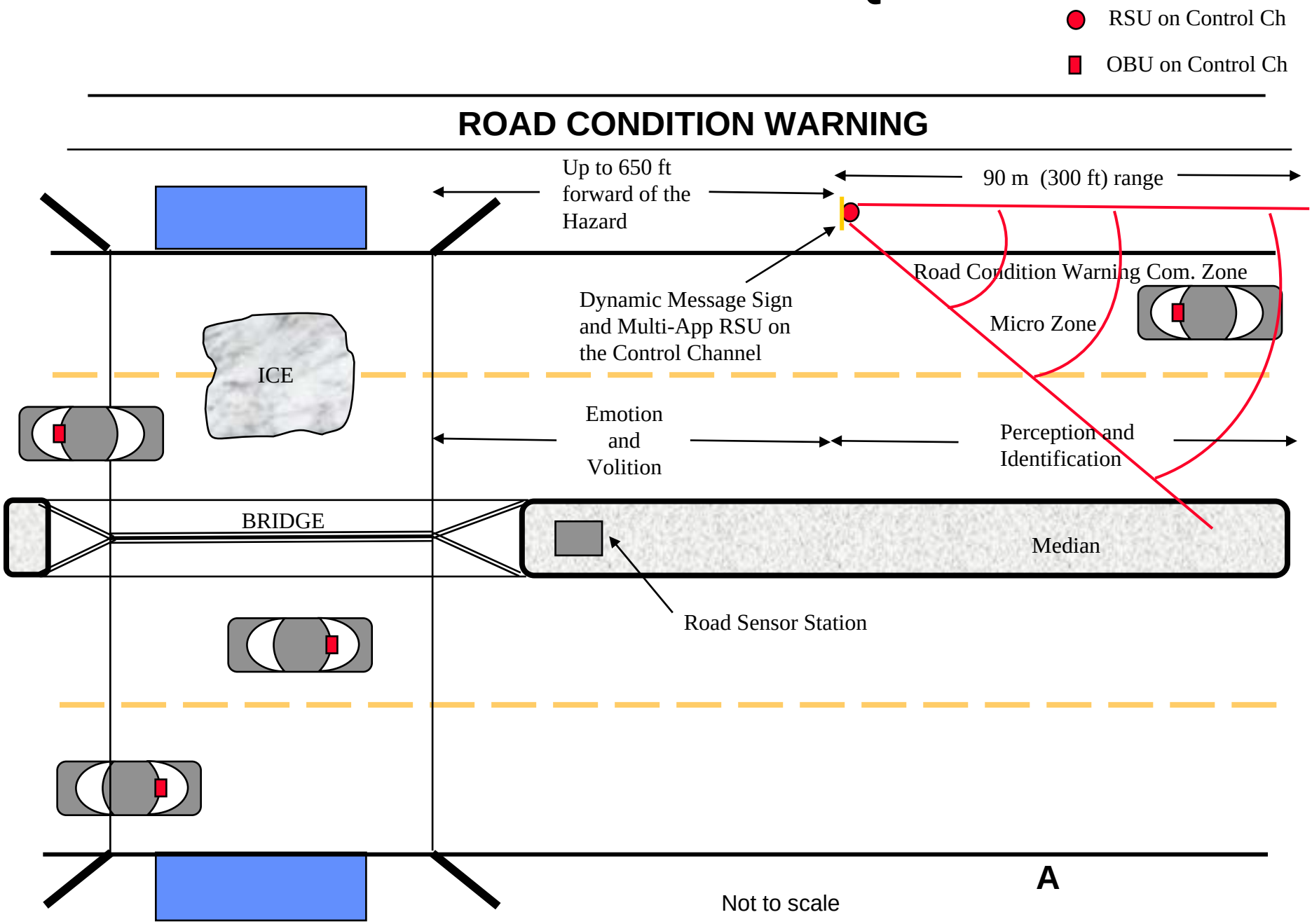
Note 2: The Sight distance of the sign is usually 125 to 200 ft.

Note 3: The RSU can be configured to have a range of up to 1100 ft

A

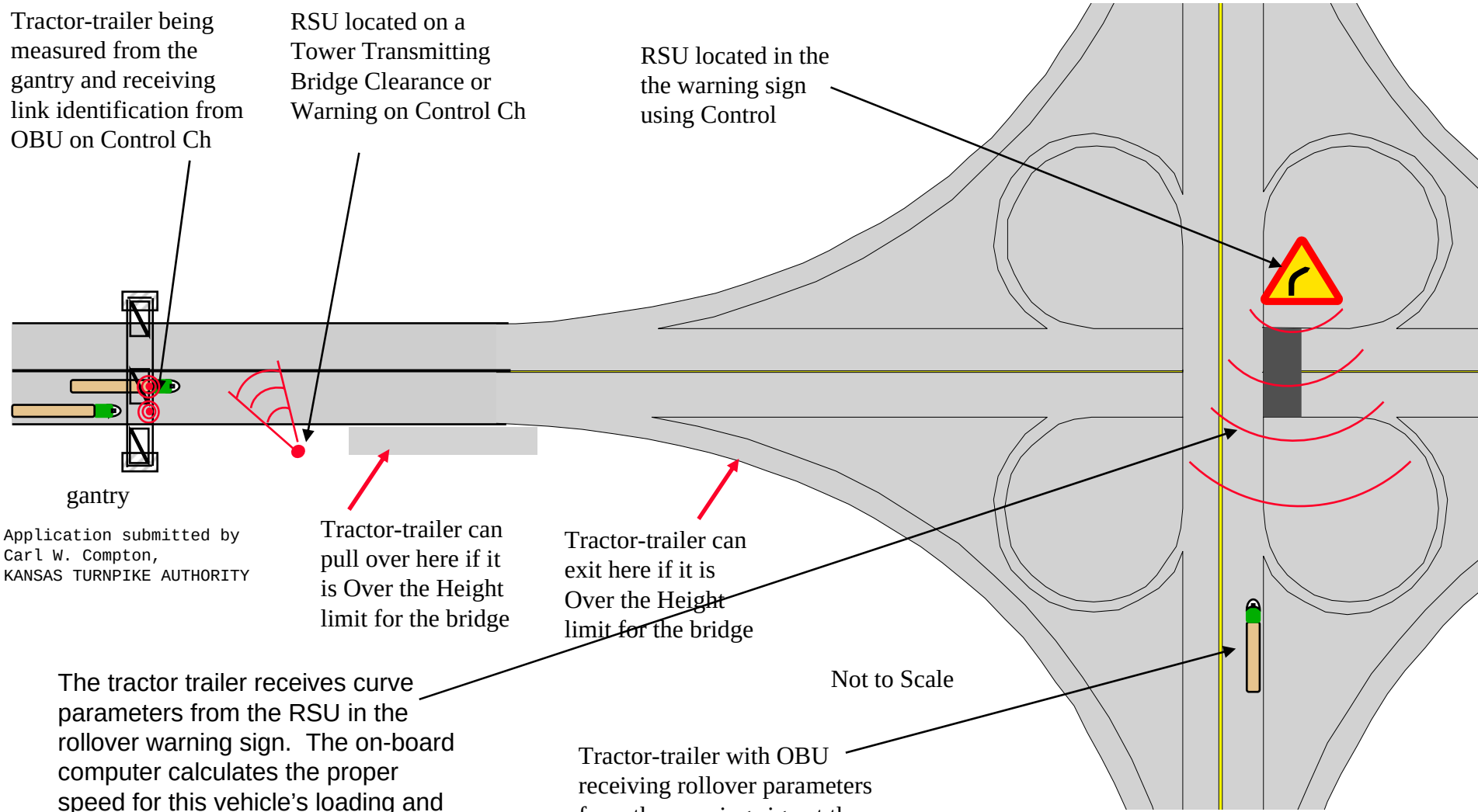
Not to scale

5.9 GHz DSRC ROADSIDE EQUIPMENT



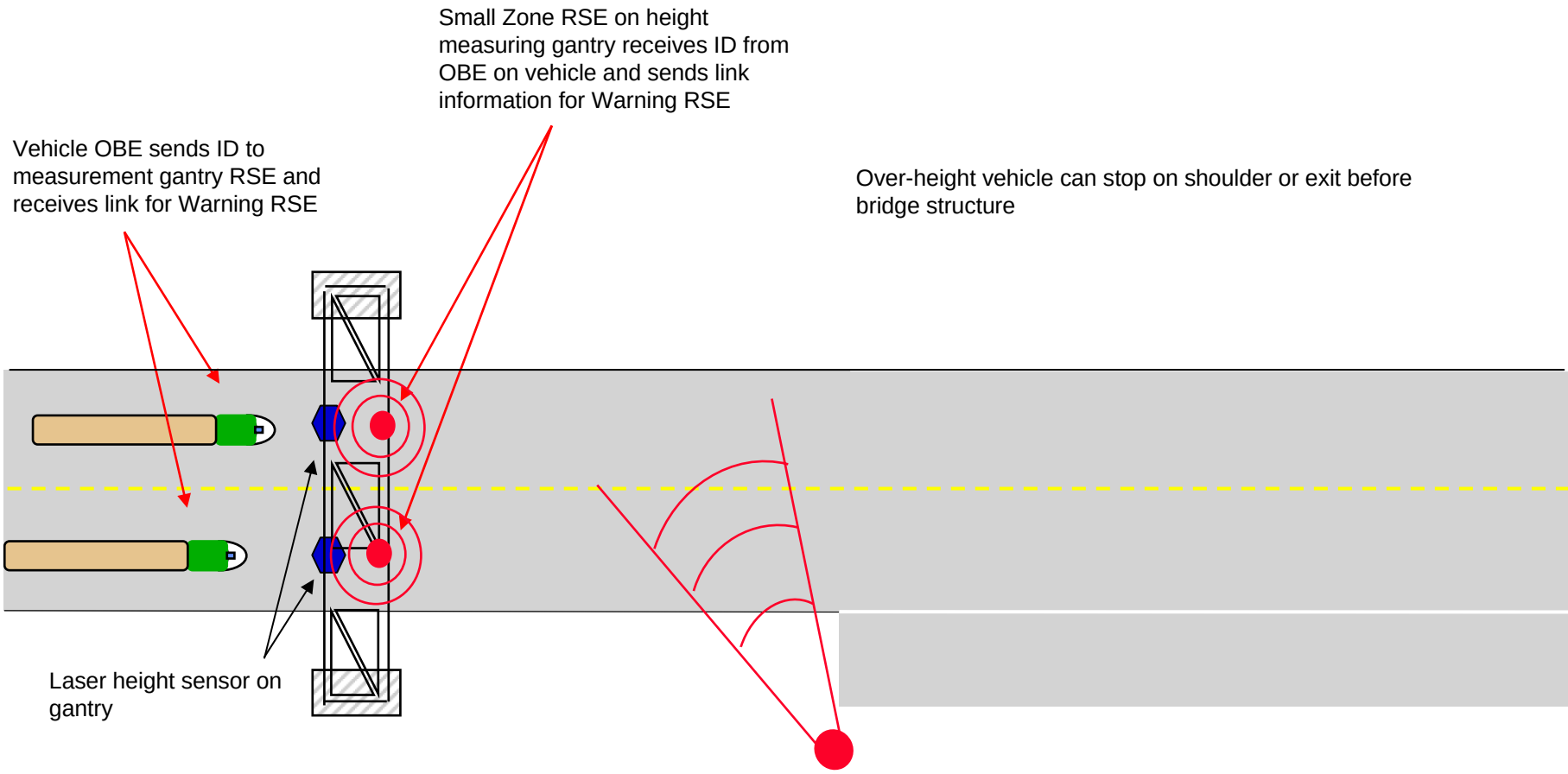
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

LOW BRIDGE WARNING and ROLL OVER WARNING



5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

LOW BRIDGE WARNING and ROLL OVER WARNING



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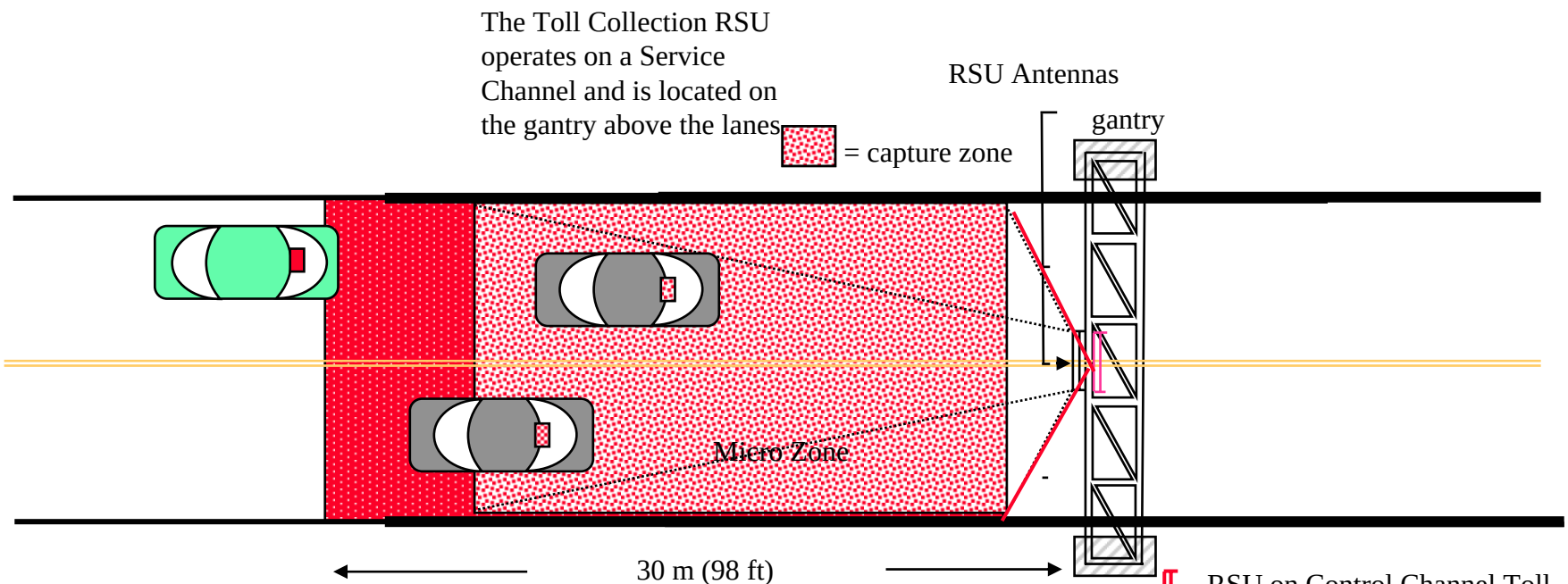
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

TOLL COLLECTION (Open Road) in service channel



Note1: OBU approaching the toll zone are instructed to switch to a service channel in order to conduct the transaction.

Note 2: Users are allowed to proceed at highway normal speeds while the toll is paid.

Note 3: Implementers use Time Division to isolate vehicle communications and angle of signal arrival to locate vehicle.

OBU on Control Channel

RSU on Control Channel Toll Zone Announcement

RSU on Channel 174

OBU on Channel 174 slot A

OBU on Channel 174 slot B

A

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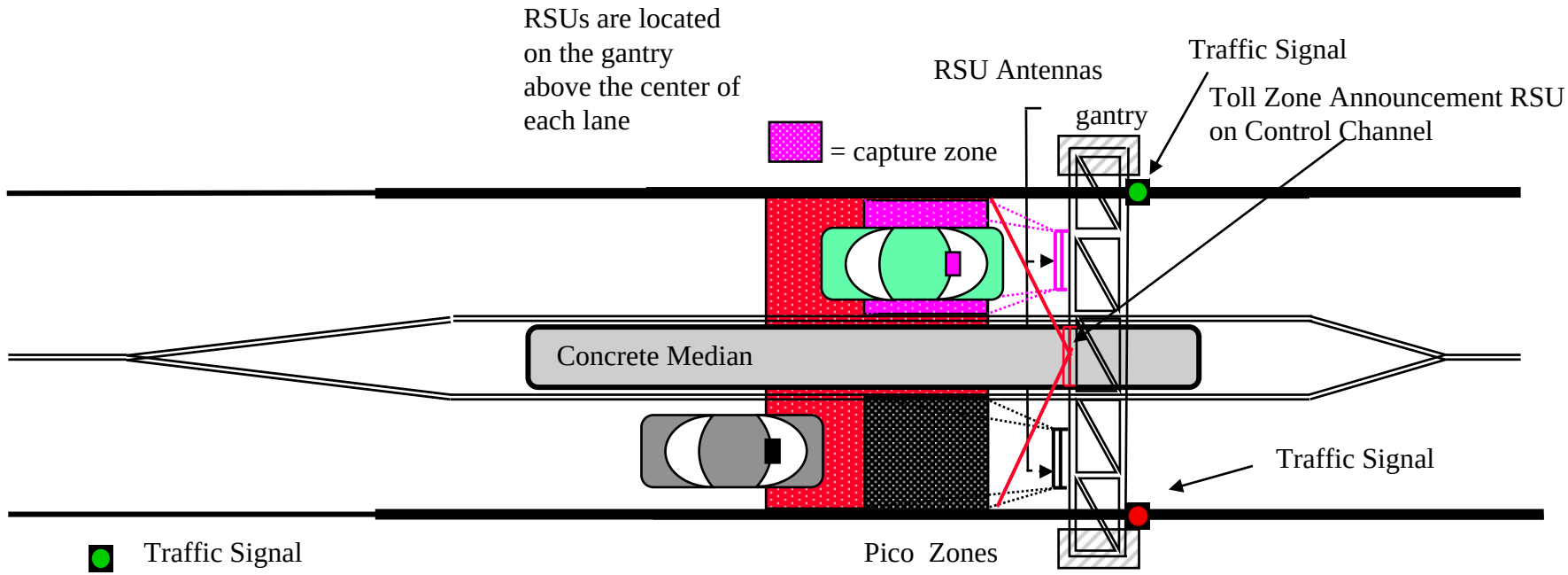
5.9 GHz DSRC ROADSIDE EQUIPMENT

TOLL COLLECTION (Lane Based) on the Service channels



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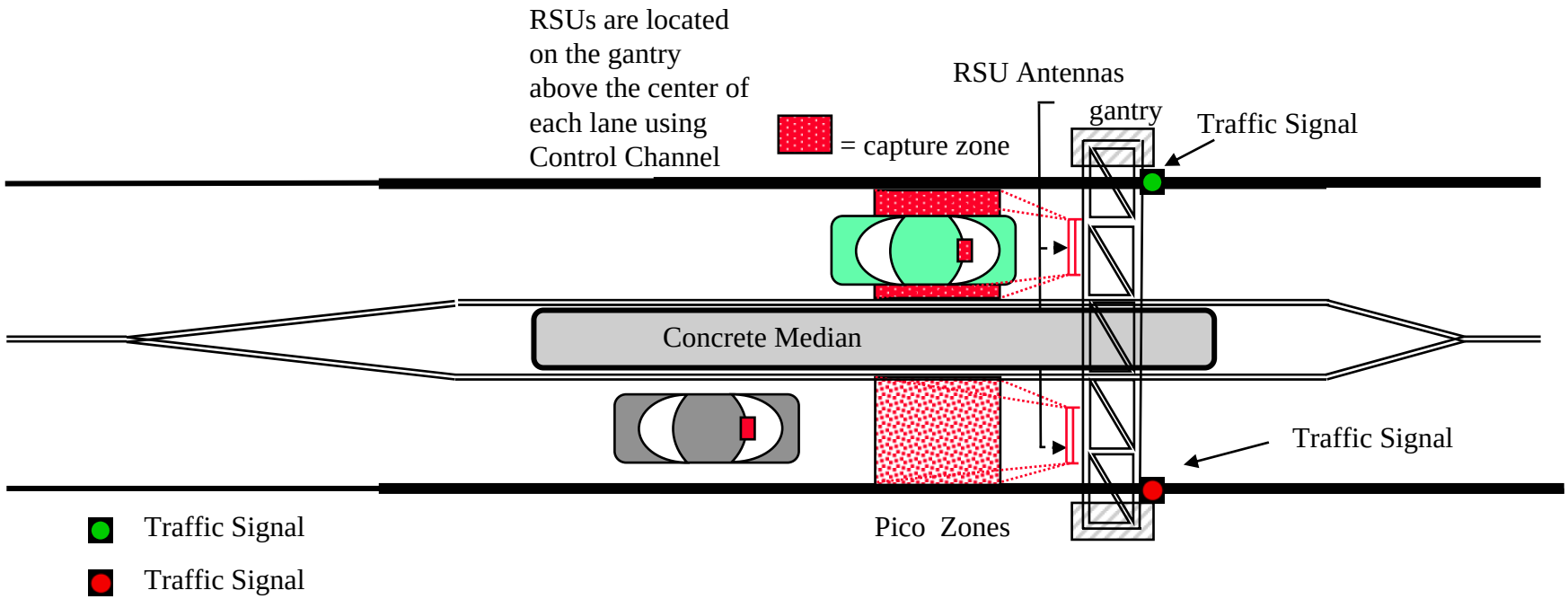
5.9 GHz DSRC ROADSIDE EQUIPMENT

TOLL COLLECTION (Lane Based) on the Control channel



Not to Scale

Note 1: Users must slow down to pay the toll and may proceed only when the light is green.

Note 2: Implementers may use Time Division to isolate lanes.

RSU on Control Ch slot A

RSU on Control Ch slot B

OBU on Control Ch slot A

OBU Listening Control Ch

A

5.9 GHz DSRC ANSWERS

What is it? Short to medium range, low latency, high data rate communications.

Who developed it? Government and Industry in ASTM and IEEE standards groups.

When would it be advantageous to use it? Any situation requiring short to medium range communications between vehicles and the roadside or between vehicles where the environment is changing or data needs to be transferred at high rates (See the example Applications). Think short-range highway advisory radio.

When will products be available? Estimated Mid 2004.

When will it be available as original equipment in new cars? Estimated 2006 to 2008.

What plug replaceable technology can be used for some data transfer applications in the interim? IEEE 802.11a.

What model deployments are being planned for next year? DIRECT by Michigan DOT.

How will this affect Toll Agencies? North American Interoperability.

When should state agencies start planning to deploy it? Early 2003.

What will be required from the frequency coordinator? Application processing, channel recommendations, interference mitigation where necessary.
See slide below.

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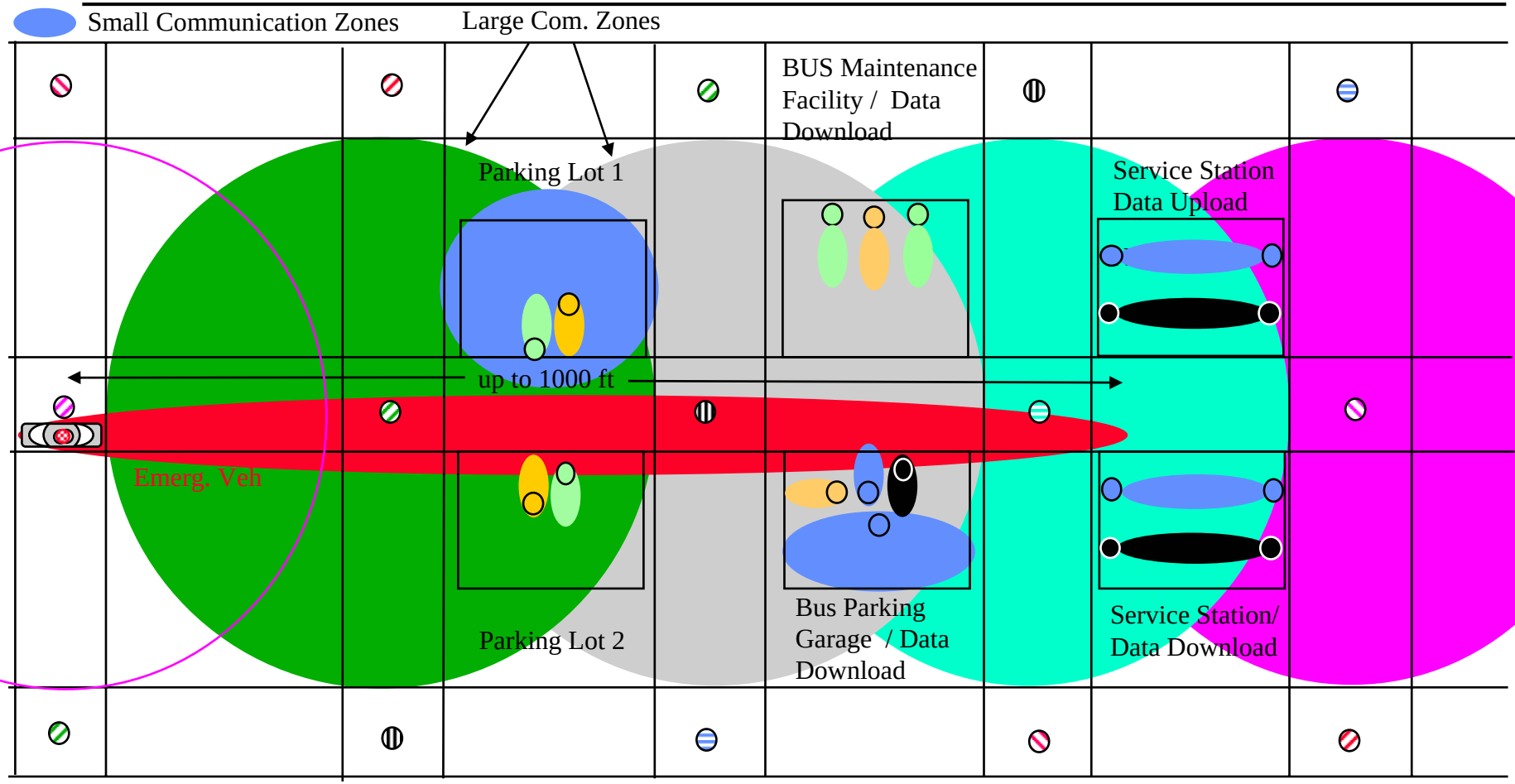
5.9 GHz DSRC ROADSIDE TO VEHICLE APPLICATION

OVERLAPPING COMMUNICATIONS ZONE URBAN APPLICATION MAP



INFORMATION

- **http://www.leearmstrong.com/DSRC%20Home/DSRC%20Home%20set.htm**
- **Broady Cash, 410-266-4413, bcash@arinc.com**
- **Lee Armstrong, 617-244-9203, LRA@tiac.net**
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