IEEE P802.11
Wireless LANs

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| Use Cases Requiring Fast Initialization |
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Abstract

There are multiple applications/uses for 802.11 devices that require extremely low latency when establishing a new link. The uses cases described herein will be the basis for defining specific system requirements to be used in creating the TGai draft amendment to 802.11.

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# Applications that would use Fast Initial Link Set-up (FI)

As a general rule, what distinguishes uses required FI are those involving devices that are operating while mobile (e.g a device mounted in a car) as opposed to devices that may be mobile but operate while stationary (e.g. the typical laptop computer). A non-exhaustive list of applications that would benefit from FI are given in the following table, summarized following, with more detailed description of each provided in the annexes (one annex for each application).

### **Vehicular:**

* PROBE DATA COLLECTION
* TRAFFIC INFORMATION
* TOLL COLLECTION
* TRAVELER INFORMATION
* IN-VEHICLE SIGNING
	+ WORK ZONE WARNING
	+ HIGHWAY/RAIL INTERSECTION WARNING
	+ ROAD CONDITION WARNING
* INTERSECTION COLLISION AVOIDANCE
* VEHICLE TO VEHICLE
	+ VEHICLE STOPPED or SLOWING WARNING
* ROAD INFRASTRUCTURE SUPPORT (e.g. Signal Timing Optimization, Corridor Management Load Balancing, and Winter Maintenance)
* ROLLOVER WARNING
* LOW BRIDGE WARNING
* MAINLINE SCREENING
* BORDER CLEARANCE
* RAMP METERING
* ON-BOARD SAFETY DATA TRANSFER
* DRIVER’S DAILY LOG
* VEHICLE SAFETY INSPECTION
* TRANSIT VEHICLE DATA TRANSFER (gate)
* TRANSIT VEHICLE SIGNAL PRIORITY
* EMERGENCY VEHICLE SIGNAL PREEMPTION
* EMERGENCY VEHICLE VIDEO RELAY
* ACCESS CONTROL
* GAS PAYMENT
* DRIVE-THROUGH PAYMENT
* PARKING LOT PAYMENT
* NAVIGATION
* DATA TRANSFER (PCI, IDB, J1708, J1939, etc.)
	+ ATIS DATA
	+ DIAGNOSTIC DATA
	+ REPAIR-SERVICE RECORD
	+ VEHICLE COMPUTER PROGRAM UPDATES
	+ MAP and MUSIC DATA UPDATES
* RENTAL CAR PROCESSING
* UNIQUE CVO FLEET MANAGEMENT
* TRANSIT VEHICLE DATA TRANSFER (yard)
* TRANSIT VEHICLE REFUELING
* LOCOMOTIVE FUEL MONITORING
* LOCOMOTIVE DATA TRANSFER

**Non Vehicular:**

Pedestrian Internet access

Pedestrian Information Access/Distribution

[Managing Pedestrians During Evacuation of Metropolitan Areas](http://www.its.dot.gov/its_publicsafety/pedevac/index.htm)

## Use Case Summary Descriptions

DSay-1 Use Case # Day-1 Use Case

PROBE DATA COLLECTION

Vehicles collect various types of data such as average speeds, weather information, and recent hard braking experiences to a roadside data collection point for various traffic management purposes.Data must be transferred at highway speeds while within the range of a roadside device that then transfers this data to a central facility (the data may be pre-analyzed prior to forwarding).

TRAFFIC INFORMATION

A roadside device broadcasts relevant traffic information to all passing cars. Operation is similar to, but typical much more involved than, existing variable message signs on highways. The roadside device will use a directional antenna to communicate only with cars traveling in a given direction on a particular section of road.

TOLL COLLECTION

Comparable to existing electronic toll collection systems with the additional need to support open road tolling. Open road tolling system do not use conventional toll booths but instead have the roadside units mounted on gantrys over the roadway, collecting the tolls as the vehicles pass underneath while at normal highway speeds.

* TRAVELER INFORMATION
* IN-VEHICLE SIGNING
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2.2.1 Advisory Message Distribution

The VII Advisory Message Distribution Service (AMDS) provides the Network User with the

ability to send advisory messages to Mobile Users in targeted geographic locations for a

specified time interval. The AMDS provides the Roadside Infrastructure User the ability to send

advisory messages to Mobile Users in the User’s local geographic area and provides the PSMU

the ability to send advisory messages to Roadside Infrastructure Users in the PSMU’s local

area. Messages will be delivered in a prioritized order. It also supports cancellation of advisory

messages by an authorized or originating Network User or Roadside Infrastructure User.

2.2.2 Communications

The VII System will provide communications facilities sufficient to allow Mobile Users to

exchange information with the Network User, with the Roadside Infrastructure User, and with

other Mobile Users. These facilities may provide varying levels of service, depending on the

operational characteristics of the Mobile User, its environment, and the type of information being

exchanged.

2.2.5 Map Element Distribution

The VII Map Element Distribution Service (MEDS) distributes approved5 localized micro-maps,

small maps containing accurate roadway geometry and lane features to Mobile Users in support

of lane-based safety applications. The MEDS uses a set of reference maps, augmented with

map elements derived from or verified by probe data, to generate and update these micromaps.

The approved micro-maps are distributed to Mobile Users near the map location as

needed to support end-user applications.

2.2.7 Probe Data

The VII Probe Data Service collects anonymous probe data from all Mobile Users and

distributes it to any authorized Network User or Roadside Infrastructure User that requests it.

Probe messages will conform to the SAE J2735 standard (see References, Table 1-2). Probe

data distribution will occur in near real time subject to latencies with Mobile User interactions

with Roadside Equipment (RSE) and with internal message processing; the VII System stores

probe data only long enough to distribute it to requesting authorized users

**Requirements for ITS Vehicle to Vehicle and Vehicle to Infrastructure**

**Safety Applications**

* Very low network access times
* Low latency
* High reliability and availability
* Good security and privacy protection
* Adequate bandwidth (at least 48 MHz, preferably 75 MHz)
* Limited range (1,000’s of meters) to allow spectrum reuse and limit interference

3 System Requirements

This section of the document lists the VII System requirements. The requirements will be

categorized as follows:

Constraint Constraint requirements specify predefined behaviors or

characteristics of the VII System and its services.

Functional Functional requirements specify actionable behaviors of VII

System services.

Environmental

(TBD)

Environmental requirements specify environmental constraints

under which VII System services must operate.

Performance Performance requirements specify quantifiable characteristics of

VII System service operations.

System (External)

Interface

External interface requirements define VII System interfaces to

non-VII Systems.

3.1.10 Security

The following tables contain the functional and performance requirements for the Security

service.

Table 3-19: VII Security Service Functional Requirements

Req. # VII Security Service Functional Requirements

VF-SEC-01 The VII System shall allow an authorized System User to access VII System

services and stored information.

VF-SEC-02 The VII System shall prevent an unauthorized System User from accessing

VII System services and stored information.

VF-SEC-03 The VII System shall implement means to minimize the impact of

transmission of messages from a false or otherwise unauthorized Network

User, Administrative User, Roadside Infrastructure User, or Mobile User.

VF-SEC-04 The VII System shall provide means to authenticate messages.

VII National System Requirements V1.3.1

V1.3.1 This is a draft document subject to the disclaimer stated on the title page.

It is not a completed work representing a deployable VII System.

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Req. # VII Security Service Functional Requirements

VF-SEC-05 The VII System shall not provide any information that is identified with a

specific Private Mobile User to any public or private entity, unless that Private

Mobile User has explicitly agreed to share such information.

VF-SEC-06 The VII System shall provide means for a specific Network or Administrative

User to obtain information stored by the VII System about that Network or

Administrative User.

VF-SEC-07 The VII System shall monitor, detect, report, log, and respond to security

incidents.

VF-SEC-08 The VII System shall implement means to terminate access to the VII System

for any System User, Infrastructure Service Provider Management System,

or External Data Source.

VF-SEC-09 The VII System shall implement means to reinstate access to any System

User, Infrastructure Service Provider Management System, or External Data

Source that has had its access terminated.

VF-SEC-10 The VII System shall provide a means to authenticate messages originating

from a Private Mobile User without disclosing the identity of the Private

Mobile User.

VF-SEC-11 The VII System shall verify the authenticity and integrity of software and

hardware installed in the VII System.

VF-SEC-12 The VII System shall be protected against physical intrusion.

VF-SEC-13 The VII System shall provide access control for physically protected

elements of the VII System.

VF-SEC-14 The VII System shall implement management, operational, and technical

security measures to protect assets and information within the VII System

boundary.

VF-SEC-15 The VII System shall provide a means for encrypting and decrypting data.

VF-SEC-16 The VII System shall monitor, detect, mitigate, and report software

vulnerabilities.

VF-SEC-17 The VII System shall monitor, detect, mitigate, and report malicious software.

VF-SEC-18 The VII System shall provide mechanisms for creating, updating, and

revoking security credentials.

# Annex A. TRAVELER INFORMATION

**4.1. Application Description**

The objective of the Public Sector Traveler Information application is to provide location and situation-relevant information to travelers while in their vehicles using the VII network and WAVE communications standards. Traveler information would be delivered to vehicles based on a standardized “language” consisting of message sets, data frames, and date elements. The public sector traveler information application is to be differentiated from private sector traveler and navigation assistance applications in that the information (messages) are delivered un-encrypted via the open-standard WAVE short message format as currently outlined in SAE J2735. In contrast, private sector traveler information applications would be encrypted and likely delivered via a propriety language. Additionally, unlike the private sector application, it is not envisioned that the public sector traveler information application would provide for maintaining a communications session as the vehicle moves from RSE to RSE (i.e., the application would not utilize “session management” network services with individual vehicles). Rather, all messages from a particular RSE would be broadcast to all vehicles within range of that RSE.

Within the scope of traveler information application, public entities (both state and local) collect information derived from vehicle probe data as well as from traditional traffic monitoring systems, and provide geographically-relevant information to vehicles. While not directly in the scope of the traveler information application, this same information content might be reformatted and delivered to traditional traveler advisory systems such as web sites, dynamic messages signs (DMS), 511 systems, and highway advisory radio (HAR).

The public sector traveler information application is at this point scoped to include the following message categories:

* Traffic Information
* Incident Information
* Local Signage.

Each of these message categories is discussed in more detail in the following sections.

***Traffic Information.*** The application would include provisions for broadcasting basic traffic information on defined roadway links within proximity to the RSE. Examples of traffic information would include average travel speeds, travel time, and other measures of traffic density (e.g., “percent utilization”). The roadway link descriptive information would be generated both through analyses of probe data as well as through more traditional sources of traffic conditions (e.g., CCTV, loop detectors, etc.). The OBE in the vehicle would then store and “assemble” the roadway link data to convey the “local” roadway traffic conditions to the driver.

While OEMs will employ different strategies to this end, it is envisioned that the roadway link information might be overlaid on a GIS map database and displayed to the driver. Alternative methods of conveying traveler information to the driver could be envisioned that are based on predefined threshold events or incidents, combined with voice annunciation (i.e., exceptionbased reporting).

There are, however, several significant design issues that must be addressed:

* How will roadway “links” be defined (e.g., beginning and ending latitude/longitude together with “link name”)? Will digital map notations available from commercial GIS databases be used for the “link name”? Conventions and standards remain to be finalized.
* How is “proximity” to be defined (i.e., what is the geographic coverage for a particular RSE)? How will coverage requirements vary for different RSE location environments (e.g.,
* CBD, suburban, rural settings)?
* Some RSEs in adjacent jurisdictions will likely have overlapping coverage. How will messages from different jurisdictions be coordinated so that vehicles do not receive conflicting data?
* What is the appropriate resolution for a link (i.e., what should be the length of a travel link as reported in a single WAVE traveler information message)? Can this vary with each reported roadway, and by jurisdiction, or is standardization needed?
* What is an appropriate cycle time for repeating traffic information messages? What are the implications for the number of roadway links (i.e., individual J2735 traveler information messages) for which traffic information can be reported from a particular RSE?

***Incident Information***. The public sector traveler information application would also provide for incident reporting, and would include event-driven messages relevant to a particular point location or roadway segment. Examples include location of an accident, blocked lane, and other types of localized traffic disruptions. Incident information may also include more widespread broadcasts related to emergency events.

***Local Signage.*** It should be noted that in previous documentation describing VII applications, local signage was often treated as a separate application. If local signage however is defined as the in-vehicle equivalent of roadside signage that is generally implemented and controlled by local and state governments, then the source of the local signage is in fact the public sector—and this application is arguably a subset of the public sector traveler information application. Local signage messages are intended to convey information that is temporary or periodic (i.e., may vary with time of day, day of week, etc.). Examples would include school zone warning and associated speed limits, work zone warnings/speed limits, cautionary warnings in place due to special events or conditions such as reduced speed due to surface conditions or fog. Detour information and road closures are also examples of local signage.

**Annex B. SIGNAL TIMING OPTIMIZATION**

**5.1. Application Description**

***Overview.*** At Day-1, VII will provide the ability to gather traffic related information necessary to monitor and refine the operation of traffic signals. When combined with other existing traffic data sets, more effective timing plans could be produced for both isolated and coordinated signal systems. VII data will provide detailed vehicle snapshots, including timestamp, position and speed, as well as the vehicle’s trajectory through the intersection. These data will be archived and analyzed to identify when a range of negative conditions occurs that currently cannot be efficiently measured using conventional traffic detection technologies. Automatic identification of these negative conditions will provide support for developing signal timings and daily schedules for coordinated signal systems.

In the future (beyond “Day-1”), as higher penetrations of VII equipped vehicles enter the market, traffic responsive (TRSP) and fully adaptive traffic signal control based on vehicle probe data could also be enabled. However, signaling systems that are capable of responding to real time traffic flow measurements do not have a high deployment rate in the U.S. Therefore VIIaugmented TRSP applications would likely not see high deployment rates. Additionally the TRSP application would require significant penetration rates of VII vehicles, along with a familiarization and confidence in VII data by practitioners. In addition, fully Adaptive traffic signal control is a very new concept that is not governed by any standard practices or technologies. Utilizing VII data to implement adaptive signal control may require partial or total revision of basic signal control concepts and architecture. Adaptive signal control that is enabled by VII technology is therefore not a Day-1 application and is not covered in this Application Development Plan.

For a more detailed discussion of traditional traffic signal control systems, see Appendix B.

***Background: Signal Timing Optimization Goals***

There is no general consensus on what constitutes good traffic signal operation. Some optimization tools are based on reducing stops and delay in various combinations, others on maximizing capacity. Still others are based on some surrogate performance measure such as progression. In practice, most agencies desire to please their motorists in order to minimize citizen complaints. Because the motoring public in a given region has been conditioned by the operation of that region, basing success on citizen complaints allows wide regional divergence. For example, some regions routinely use cycle lengths in the range of two to four minutes, while other agencies with equally congested networks would never implement a cycle over two minutes. Motorist opinion in congested areas is usually strongly held and vigorously expressed, and drivers accustomed to one system might find the operation of another system intolerable.

Despite these regional effects, motorists generally complain when they are forced to stop unexpectedly or for a longer period than they believe is “fair.” They often complain when forced to wait through more than one green period. Finally, they complain when queue lengths block access to intermediate intersections and driveways, or force turning lanes to spill out into through lanes. Thus, most skilled practitioners seek signal timings that minimize the following: queuing, unexpected and unexpectedly long stops, cycle failures, and queue spillover

***Implementation and Operation of Traffic Signal Systems***

Traditionally, traffic signal timings are developed on the basis of the volume of vehicles making each movement at each intersection. These counts are usually collected manually; although, during peak periods, some can be collected using a system of vehicle detectors if they are favorably configured. However, most agencies do not configure detectors for counting vehicles because such configurations are not necessarily the most effective arrangement for normal “calling” and “extending” functions that are part of actuated signal control. (see Appendix B for explanation of signal phasing, calling, and extending functions).

Data collected for signal timing plans also usually includes 24-hour vehicle counts made with temporarily located automatic traffic counters. These provide traffic volume data to support the initial development of signal timing (or phasing) plans for various periods throughout the day (i.e. daily schedules).

These data are programmed into signal timing optimization software that use volume-based delay and saturation equations, or volume-based macroscopic simulation, to optimize operation according to the objective function associated with the particular tool.

The signal timings as calculated by the optimization software are then scrutinized by the practitioners, refined as needed, and then installed into the local signal controllers. Daily schedules (i.e., the distinct periods throughout the day for which signal timing plans are changed) are typically implemented based on a visual review of 24-hour count data.

Thus, the operation of most traffic signal systems is based on a limited sample of data collected days, weeks, or months before timing implementation, and they remain in operation potentially for years thereafter.

Once installed, the signal timings are observed in the field for effective operation. Signal timing professionals will determine whether traffic is behaving as expected and therefore achieving the desired optimal operation. Inevitably, adjustments are made to fine-tune both the timing plans and the daily schedule, based on observation over a period of one or more days. The objective of those adjustments is to achieve operation that is visually effective from the perspective of the agency practitioner. That effectiveness is usually based on achieving *smooth flow* and *minimizing queue formation* and congestion. Both are visual manifestations of reduced delay and stops. Those objectives are generally not measurable using traditional traffic detectors (which only measure vehicle presence in a predetermined detection zone).

***Opportunities for Leveraging VII Probe data***

As noted, a critical activity is fine-tuning the signal timings when they are implemented, calibrating the daily schedule, and then evaluating the signal timing patterns over time. Currently, most agencies depend on direct field observations for all these activities which presents a resource challenge to many agencies.

VII probe data can be used to evaluate signal system operation in support of fine-tuning and evaluating signal timing patterns, and in support of calibrating the daily schedule to achieve the desired operation.

In particular, agencies fine-tune their signal timings to:

* Minimize unexpected stops and starts of the traffic stream
* Minimize intersection delay (and thus travel time)
* Minimize cycle failures
* Minimize queue spillover.

Depending on the manner in which probe data is coded, generated, and collected, it could, theoretically, support measuring time-in-queue by movement, deceleration, start of queue position, and unserved queues. These measurements could then be used to support control strategies that would fine-tune the signaling system. VII probe data can also be used to support the ability to supplement detector data in response to detector faults, even if providing an improvement on normal fail-on detector failure modes. Essentially, the probe data would offer a much more efficient means of measuring the effectiveness of the existing signal timing plans compared to manual counts and labor intensive observation by signal timing professionals.

It is possible that offline optimization algorithms can be crafted to use probe-based measures of effectiveness directly, rather than manually collected turning-movement counts. This would require extensive experimentation to develop optimization approaches that would be competitive with traditional methods. In practice, making the probe data available might attract support from the research and software community who have developed these optimization approaches.

Probe data can also evaluate whether progression is working properly by identifying approaches where large platoons arrive while the light is red. This can be used both to evaluate offset values and also to select a pattern that uses offsets more suited to progression in the direction of the problem.

***Supporting Traffic Responsive Signal Plans (TRSP).*** Most practitioners will try to optimize operations using conventional signal timing and daily schedule dimensions before developing traffic-responsive capability. Those agencies that have the resources and face the situations that allow for traffic-responsive operation will use appropriately designed systems to collect a range of volume and occupancy data from the designated system detectors. This historical data will be used to develop thresholds and/or traffic pattern profiles (depending on the system software), to which real-time detection data will be compared for pattern selection during normal operation. These thresholds (for changing signal timing patterns) will be fine-tuned in the same way that daily schedules are fine-tuned—so as to achieve pattern transitions at appropriate times to track the changes in demand patterns throughout the day.

Another opportunity for VII is to provide an alternative to the use of volumes and detector occupancies for traffic-responsive pattern selection. For example, queue spillover is usually a sign of a capacity issue, which is often addressed by engaging a pattern with a longer cycle (up to a point) to increase the capacity. Queue spillover may be detected as increases in occupancy on system detectors, but only if the system detector is ideally placed. The spatial perspective of VII likely makes evaluating the size of the queue far easier.

Clearance intervals provide another opportunity for VII. Timing professionals calculate clearance intervals on the basis of the approach speed and grade. Wet roads are assumed, and this assumption may be unnecessarily conservative during dry conditions and not conservative enough during wet conditions. Existing literature includes research on the necessary clearance intervals under various conditions, but measuring those conditions requires expensive environmental sensing at a wide variety of locations. Such data are not currently available to operating agencies. However, probe data from VII vehicles could be used to pinpoint when deceleration rates declined at certain intersections (in conditions of poor traction) and increase when conditions improve. VII vehicles could also yield useful data such as anti-lock brake actuation, the use of windshield wipers, and/or temperature data which might be used to support changing clearance intervals to track current environmental conditions.

***Supporting Adaptive Signal Systems***. Adaptive signal algorithms based on the ability to detect queue formation have been developed in the past, but were never implemented because queue data have been unavailable. VII probe data can be incorporated directly into adaptive algorithms to address this issue, but it requires designing the adaptive algorithm in light of the available data. Measuring queue lengths consistently and reliably enough to support adaptive control may require a higher penetration of VII-equipped vehicles than is anticipated for Day-1 implementation or demonstration. Moreover, at Day-1, traffic volume estimates using probe data will not be practical due to the limited, as well as fluctuating, number of VII vehicles within the total vehicle population. It is not envisioned that VII data would replace the traditional processes for developing signal timings initially. Traffic volume requires a predictable penetration, which assumes high penetration rates to minimize error.**References:**