TECHNOLOGY DEVELOPMENT AND SYSTEM INTEGRATION FOR A VEHICLE MILES TRAVELED BASED REVENUE COLLECTION SYSTEM PROTOTYPE

SUB-TASKS 2.3, 3.3:
FUNCTIONAL REQUIREMENTS AND TECHNICAL SPECIFICATIONS FOR GPS/AVI-BASED AND ODOMETER/AVI-BASED ON-VEHICLE VMT COLLECTION AND TRANSFER DEVICES, AND THEIR TECHNOLOGY CONFIGURATIONS

VERSION 1.3

FINAL REVISIONS TO: FUNCTIONAL REQUIREMENTS AND TECHNICAL SPECIFICATIONS FOR GPS/AVI-BASED AND ODOMETER/AVI-BASED ON-VEHICLE VMT COLLECTION AND TRANSFER DEVICES, AND THEIR TECHNOLOGY CONFIGURATIONS VERSION 1.2

Developed for

The Oregon Department of Transportation
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1.0. INTRODUCTION

The Oregon Department of Transportation (ODOT) is required by House Bill 3946 to begin the implementation of pilot alternative revenue collection system in the year 2003. These pilot systems are to be designed to test alternatives to the current system of taxing highway use through fuel taxes. One alternative being considered is a Vehicle Miles Traveled (VMT) based fee.

This project will focus on technology development and system integration as required to develop a working prototype of an *electronic* revenue collection system based on the VMT principle. This working prototype consists of both the technologies used and their integration into a working system. A specific combination of technologies and their integration into a working system will be referred to as a *technology configuration.* The technology configurations developed in this project will incorporate multiple concepts for on-vehicle devices, and fee calculation and collection. Both the on-vehicle technology and methods of data collection, fee calculation and collection, are referred to as *concepts* because none are currently commercially available or implemented.

The objectives of this project are to develop, integrate, test, and document specific technology configurations that incorporate multiple concepts for on-vehicle devices, and fee calculation and collection. The purpose is to demonstrate the feasibility of an electronic revenue collection system, and to gain further understanding of the actual advantages and disadvantages of various concepts. Also, since Commercial-Off-The-Shelf (COTS) on-vehicle devices with the required functionality are not currently available, these will need to be developed as part of this project.

As is common in product and technology development, this project will also involve the development of customer and functional requirements and technical specifications. The functional requirements and technical specifications are documented in this report.

1.1. FUNCTIONAL REQUIREMENTS AND TECHNICAL SPECIFICATIONS

The work plan developed for this project is documented in Kim and Porter (2003). This work plan organizes the development of two prototype VMT electronic revenue collection system technology configurations into a series of tasks and subtasks. Subtask 1.2, which is documented here, is the development of functional requirements and technical specifications for two technology configurations.

Functional requirements are the various functions that must be executed by a technology configuration and its components in order to successfully implement the electronic VMT based revenue concept. Functional requirements document what functions must occur but not the details of how these functions will be *implemented* (Ulrich and Eppinger, 1995). An exception to this is that certain assumptions have been made regarding the fundamental technology to be used to perform mileage collection. The two technology configurations to be developed in this project evolved around using global positioning system (GPS) technology and current odometer technology, as methods for VMT collection.

Technical specifications are measurable parameters that describe how various functions must perform. For example, a functional requirement may be that an on-vehicle mileage collection device be "turned off" wirelessly when the vehicle leaves the State of Oregon. A technical specification for this function is that 99.9% of the vehicles are turned off successfully and that this reliability can be maintained when vehicles leaving the State are traveling at speeds up to 90 miles per hour.

Since the overall objective of this project is to generate knowledge about the technology configurations and their system components, some of the technical specifications may not be known but will be generated as a product of this project. As an example, it is not known what level of VMT accuracy a cost-effective GPS can provide as part of a VMT based revenue collection system.

The objective of developing functional requirements and technical specifications is to develop a record of the technology configurations and their components such that various companies will have sufficient information to implement the technology configurations.

1.2. TERMINOLOGY AND DEFINITIONS

Table 1 defines various terms and concepts that are used throughout this report.

Table 1. Relevant Terms and Concepts for the VMT-based Technology Configurations.

Terminology	Definition
Automatic Vehicle Identification	Technology designed to uniquely identify a vehicle at a specific location at a particular time. Automatic Vehicle Identification technology is mature and can be classified under four main categories: laser, infrared, video, and radio frequency.
Central Computer/Database	A single computer that receives requests for vehicle mileage data from host computers at service stations, and sends "paid for" zone mileage back to the service station host computer.
Commercial Off-The-Shelf	Technology with specific functionality that exists as a current commercial product.
Fuel Dispenser	The device at service stations that is used to fuel vehicles. A dispenser includes the pump and flow management systems. For the purpose of this project, the definition of a fuel dispenser also includes the electronics/interface with the Point-of-Sale system, and may also include a payment system such as a credit card reader.

Functional Requirement	A function that a particular system component in a technology configuration must execute to successfully complete a task or a portion of a task.
Geographic Information Systems	Geographic Information Systems are systems that synthesize a variety of types of geographic data for specific purposes. An example would be a computer system that on request can display different “views” of specific regions of Oregon. A view may be a population density map, a highway system map, or a vegetation map. At the heart of any such system is the geographic data.
Global Positioning System	A navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, utilizing signals sent from 24 GPS satellites. A GPS receiver contains a computer that "triangulates" its own position by getting bearings from three out of four satellites. The result is provided in the form of a geographic position - longitude and latitude.
Host Computer	A computer residing at a service station that interfaces with: data readers that read mileage data from vehicles, the service station point-of-sale system, and the central computer system (if present in the technology configuration).
Odometer	A mileage collection device used on vehicles. An odometer functions by obtaining information from a vehicle speed sensor about the number of wheel revolutions that have occurred. Using this information and knowing the tire circumference, the mileage traveled is calculated and collected.
Odometer Tag	An "Odometer Tag" is a radio frequency device that interfaces with a vehicle's speed sensor for purposes of measuring mileage traveled. Mileage data is stored within the device, and then read from the device wirelessly by radio frequency readers.
On Board Diagnostic and OBDII	Vehicle on board diagnostic computer and engine control system. OBDII refers to the Society of Automotive Engineers standard for such systems.
Point-of-Sale System	The hardware and software that works with fuel dispensers to administer and manage transactions with customers.

Radio Frequency Tag	Radio Frequency Tags (sometimes also referred to as *transponders*) represent the actual data-carrying device of a Radio Frequency-based system. A tag is intended for attachment to an item that a user wishes to manage. It is capable of storing a tag ID number and other data regarding the tag or item, and of communicating this information to the reader. Tags can be classified by operating frequency and power source.
Technical Specification	Specific metrics and values that precisely describe how a functional requirement must be performed.
Technology Configuration	A specific combination of technologies and their integration into a working system. The technology configurations developed in this project will incorporate multiple concepts for on-vehicle devices, and fee calculation and collection.
Vehicle Miles Traveled	The amount of road use for a vehicle measured in miles. Vehicle Miles Traveled may be divided into separate predefined zones.
Vehicle Speed Sensor	A device that is used to estimate a vehicle's wheel rotation. There are a variety of methods used to estimate a vehicles wheel rotation in today's vehicle speed sensors.

1.3. ACRONYMS

Table 2 defines various acronyms that are used throughout this report.

Table 2. Relevant Acronyms for the VMT-based Technology Configurations.

Acronym	Definition
AVI	Automatic Vehicle Identification
COTS	Commercial-Off-Shelf
GPS	Global Positioning System
OBD	On Board Diagnostic
POS	Point-of-Sale
RF	Radio Frequency
RFID	Radio Frequency Identification
RUFTF	Road User Fee Task Force
SAE	Society of Automotive Engineers
TAC	Technical Advisory Committee (used in OSU work order to refer to ODOT Team members)
VMT	Vehicle Miles Traveled
VSS	Vehicle Speed Sensor

1.4. ORGANIZATION OF THE DOCUMENT

Section 2 is an overview of the technology configurations for which the functional requirements and technical specifications have been developed. Section 3 presents the functional requirements for the GPS-based technology configuration, and Section 4 presents the functional requirements for the Odometer-based technology configuration. This is followed by technical specifications for these functional requirements in Section 5.

1.4.1. Numbering System

In this section, the numbering scheme that has been adopted to organize the functional requirements is explained. Each functional requirement will be represented by the following coding scheme:

FR #.#.#.#.#

- Letter code that orders the functional requirements within a specific level.
- The functional requirements for a technology configuration and viewpoint were organized into levels of increasing detail. This position in the code denotes functional requirements at the 2nd level that have additional (i.e., 3rd level) detailed functional requirements. Depending on the level of detail, this code position may not be used.
- Denotes functional requirements at the highest level that have additional (i.e., 2nd level) detailed functional requirements.
- Denotes a viewpoint or perspective adopted when developing the functional requirements. There were two viewpoints adopted for each technology configuration. Viewpoint **1** is the functional requirements as seen from the perspective of the on-vehicle device. Viewpoint **2** is the functional requirements as seen from the perspective of the service station.
- Designates a technology configuration number. The GPS-based technology will be represented by a 1, and the Odometer/AVI-based technology configuration by a 2.
- FR stands for *functional requirement*.

For example, **FR 1.1.b.** refers to the second functional requirement (denoted by the letter **b**), from the on-vehicle device viewpoint in the GPS-based technology configuration. In contrast, **FR 2.2.1.c.** refers to the third functional requirement within the first 2nd level of requirements, from the service station viewpoint in the Odometer/AVI-based technology configuration.

2.0. OVERVIEW OF THE TECHNOLOGY CONFIGURATIONS

Two different technology configuration prototypes will be developed. These will be based on two different on-vehicle technologies for collecting VMT and two different concepts for computing and collecting VMT fees. The functional requirements and technical specifications have been developed for these technology configurations. Overviews of these technology configurations are presented next.

2.1. OVERVIEW OF THE GPS-BASED TECHNOLOGY CONFIGURATION

In this technology configuration, the on-vehicle device that collects VMT will use GPS technology. The GPS-based prototype device will have one-way wireless RF communications ability for VMT data transfer. Users will pay a VMT fee as part of fuel purchases.

The GPS-based VMT collection devices will *compute* and *accumulate* mileage within a predefined number of zones, where a zone is a combination of a geographic area and time period (e.g., downtown Portland between 4 and 6 PM). These zones will be held within the memory of the device. The on-vehicle device may use GPS technology to allocate VMT (collected by odometer technology) to zones, or the GPS technology may be used to both collect VMT and allocate it to zones.

In this technology configuration, a hybrid system that combines features of both a centralized and decentralized fee calculation and collection system will be developed. A wireless data reader at or near a fuel dispenser will read the stored VMT data from a vehicles device (1-way communication) and send these to a host computer. The host computer will send a request for the vehicles prior "paid for" zone mileage to a central processing computer. The central computer will send this information back to the host computer located at the service station, which will compute the VMT fee. The host computer will interface with the existing service station POS system and direct the POS system to incorporate the proper fee into the fuel purchase transaction and notify the host computer of a completed transaction. The host computer then communicates with the central computer that the transaction was completed, and transfers the latest zone mileage to the central computer for updating.

The host computer will obtain from the POS system, for each fueling transaction, the amount of fuel purchased, and the VMT fee or per gallon fuel tax paid (if the vehicle is not equipped with a VMT collection device). Since service stations will have already paid a per gallon fuel tax on the gas they purchase from distributors, this data will be used to determine if the VMT fees collected are more or less than the fuel tax paid. The difference will then be reconciled between the State and the service station.

The use of a local host computer creates a single point interface for different POS systems. The use of a central computer provides violation detection capability as well as the ability to change fee rates easily. The GPS-based technology configuration concept is shown in Figure 1.

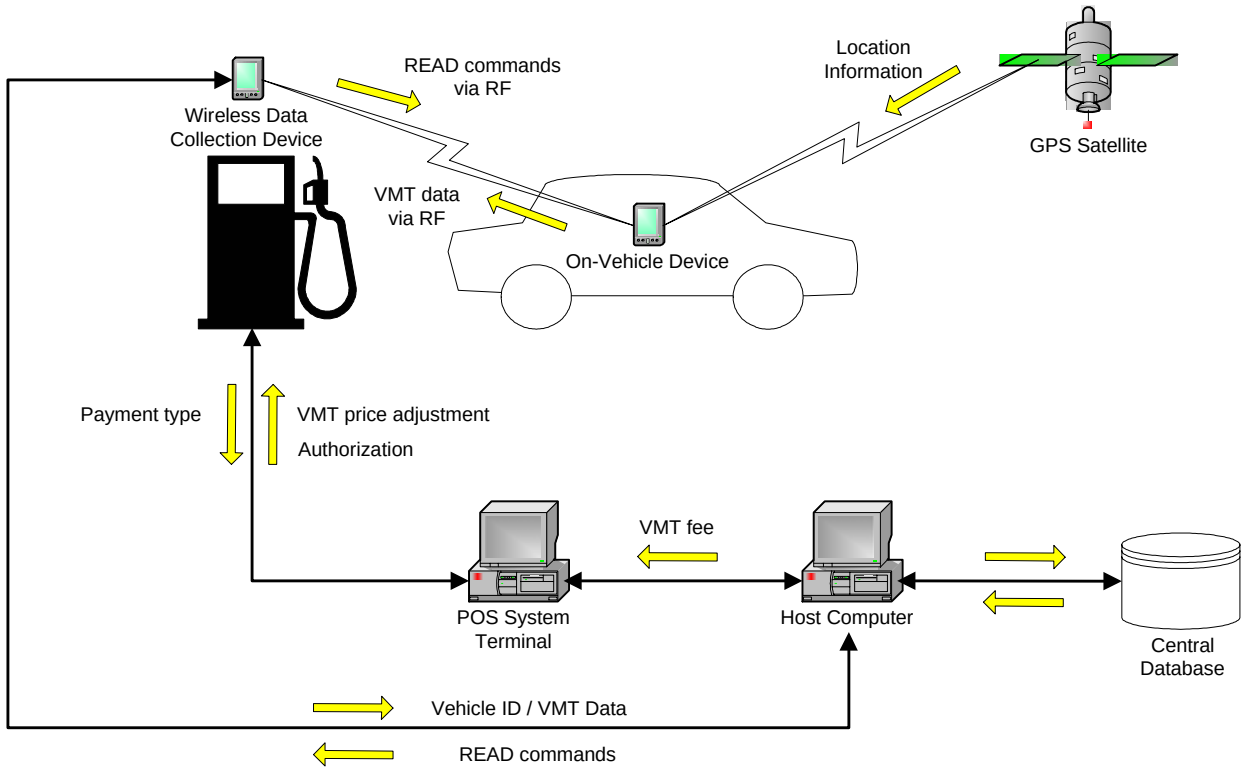

Figure 1. GPS-based Technology Configuration Concept.

2.2. OVERVIEW OF THE ODOMETER/AVI-BASED TECHNOLOGY CONFIGURATION

In this technology configuration, the on-vehicle device will use current odometer technology to collect VMT data. The Odometer/AVI-based device will have two-way wireless communications ability for the transfer and updating of VMT data. Users will pay a VMT fee as part of fuel purchases.

The Odometer/AVI-based VMT data collection device will collect and store *accumulated* mileage in three different categories:

1. Non-Oregon VMT
2. Oregon VMT
3. Paid-for Oregon VMT

The storage of these three mileage figures will facilitate fee violation detection and fee conflict resolution.

Because the Odometer/AVI-based on-vehicle devices use wheel rotation as a basis for mileage collection, this technology configuration requires additional hardware to collect VMT data within a predefined geographic area (e.g., Oregon). In addition to devices on board vehicles, wireless communication devices must direct the device to switch mileage collection to category

1 (above) when a vehicle leaves OR, and switch mileage collection to category 2 when the vehicle enters OR. This will require wireless communication devices at Oregon border crossings.

In this technology configuration, a decentralized system concept will be developed for fee calculation and collection. Wireless data readers at or near a fuel dispenser will read the Oregon VMT and Paid-for Oregon VMT mileage readings from the device. This data will be passed to a local host computer. The host computer will calculate the difference between the two mileage readings and compute the proper VMT fee. This data will be made available to the POS system, which will include it into the fuel purchase transaction. After completing the transaction, the host computer will instruct the Odometer/AVI-based on-vehicle device to copy the OR VMT mileage reading to the Paid-for Oregon VMT category.

The host computer will obtain from the POS system, for each fueling transaction, the amount of fuel purchased, and the VMT fee or per gallon fuel tax paid (if the vehicle is not equipped with a VMT collection device). Since service stations will have already paid a per gallon fuel tax on the gas they purchase from distributors, this data will be used to determine if the VMT fees collected are more or less than the fuel tax paid. The difference will then be reconciled between the State and the service station.

The use of a local host computer creates a single point interface for different POS systems. It may also be used to store a specified amount of transaction data for reporting purposes. The odometer-based technology configuration concept is shown in Figure 2.

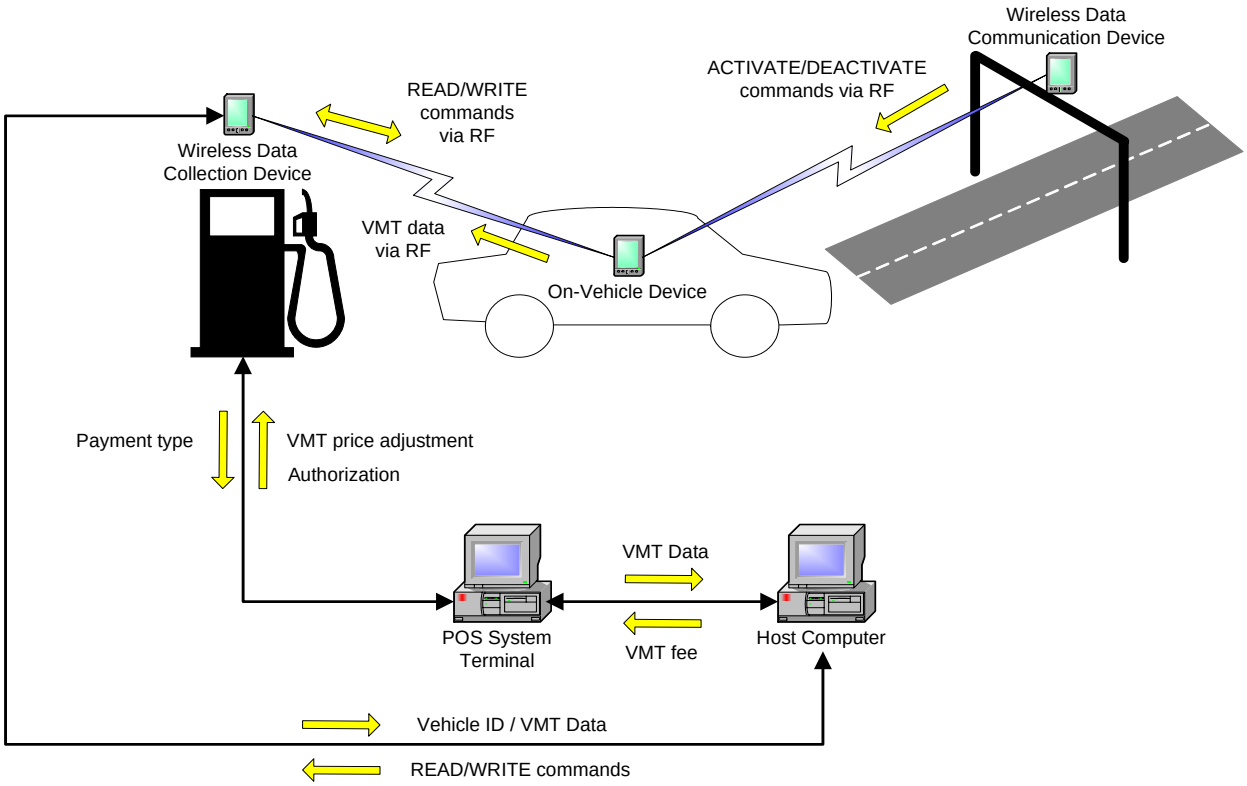

Figure 2. Odometer/AVI-based Technology Configuration Concept.

2.3. TECHNOLOGY CONFIGURATION – SALIENT FEATURES

The GPS-based and Odometer/AVI-based technology configurations incorporate several different features into two prototype electronic VMT revenue collection systems. These include two different methods for mileage collection, fee payment as part of fuel purchases, and a centralized and local computer system for VMT calculation and fee calculation. The technology configurations will test and validate the effectiveness of 1-way and 2-way RF communications as used in such revenue collection systems, and also two methods for collecting mileage within geographic zones. This is summarized in the following table.

Table 3. Summary of Different Concepts and Features Found in the Technology Configurations.

Function	Concept/Method	GPS Based	Odometer/AVI Based
Vehicle Mileage Collection	GPS	✓	
	Odometer	✓	✓
VMT Calculation and Fee Calculation	Centralized	✓	
	Local	✓	✓
Device Communication Capability	1-Way		✓
	2-Way	✓	
Zone Mileage Collection	GPS	✓	
	Zone “beacons”		✓

3.0. GPS-BASED TECHNOLOGY CONFIGURATION FUNCTIONAL REQUIREMENTS

This section outlines the functional requirements for the GPS-based technology configuration. These functional requirements will be defined from two different, but interrelated viewpoints:

1. The on-vehicle device viewpoint, and
2. The service station viewpoint

3.1. ON-VEHICLE DEVICE FUNCTIONAL REQUIREMENTS

The flowchart depicted in Figure 3 shows the high-level functions that must be performed by the GPS-based technology configuration as seen from the on-vehicle GPS-based device's perspective. This technology configuration uses the concept of a vehicle's *trip* as the framework to define functionality. A vehicle's *trip* may begin within or outside the State of Oregon's borders. Similarly, a vehicle's *trip* may end within or outside the State of Oregon's borders. The on-vehicle GPS-based device must be capable of collecting accurate VMT data for all possible scenarios. Blocks highlighted in yellow in Figure 3 indicate additional levels of functionality that will be described in the sections written next to them.

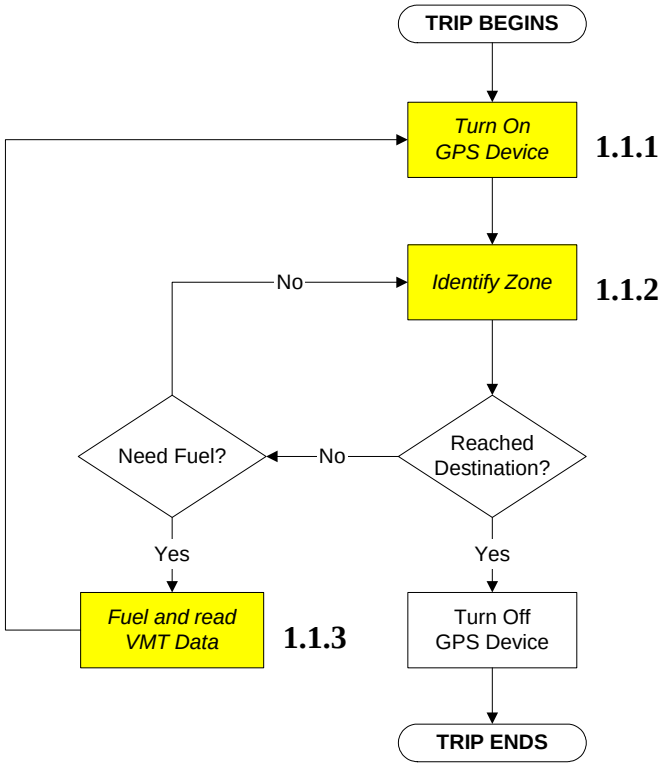

Figure 3. High-level Functions of the GPS-based Technology Configuration – On-Vehicle Device's Perspective.

Needed functional requirements:

FR 1.1.a.	A vehicle's trip begins when its engine is turned on. This action shall also turn on the GPS-based device installed on the vehicle.
FR 1.1.b.	Once the on-vehicle GPS-based device is turned on, it shall identify the zone it is located in by acquiring a GPS signal and match it to one of several pre-defined zones.
FR 1.1.c.	The on-vehicle GPS-based device shall collect and store VMT data corresponding to the l zone it is located in as long as the vehicle has not reached the end of its trip.
FR 1.1.d.	The on-vehicle GPS-based device shall frequently match its current location and time against the pre-defined zones to determine if it has moved into a new zone.
FR 1.1.e.	When a vehicle enters a service station to get fuel, the on-vehicle GPS-based device shall be turned off when the vehicle's engine is turned off.
FR 1.1.f.	The VMT data collected in each of the pre-defined zones that is stored in the on-vehicle GPS-based device shall be read off the device by a wireless data collection device located at the fuel dispenser prior to the vehicle fueling.
FR 1.1.g.	After the fueling operation is complete, the on-vehicle GPS-based device shall be turned back on when the vehicle's engine is re-started.
FR 1.1.h.	The on-vehicle GPS-based device shall be turned off when the vehicle reaches the end of its trip. . Mileage data should be collected and stored such that the data is preserved if the on-vehicle device loses power.

3.1.1. Turning On the On-Vehicle GPS-Based Device

Figure 4 depicts a flowchart that describes the steps involved in turning on the on-vehicle GPS-based device.

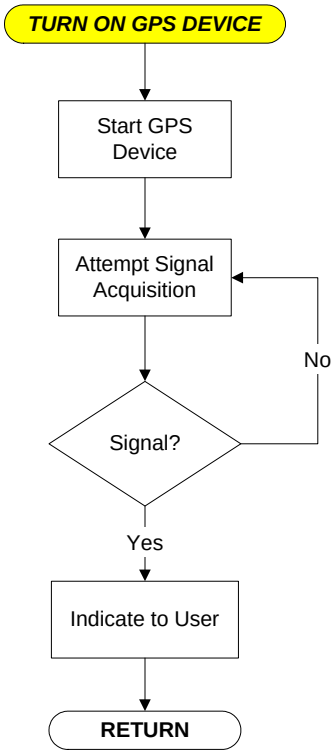

Figure 4. Turning on the On-Vehicle GPS-Based Device.

Needed functional requirements:

FR 1.1.1.a.	Once the on-vehicle GPS-based device is turned on, it shall attempt to acquire a GPS signal.
FR 1.1.1.b.	The signal acquisition process shall be repeated by the on-vehicle GPS-based device until a GPS signal is acquired.
FR 1.1.1.c.	Once a GPS signal is acquired, an indication shall be made to the driver of the vehicle.

3.1.2. Identifying a Zone

Figure 5 depicts a flowchart that describes the steps involved in identifying a pre-defined zone.

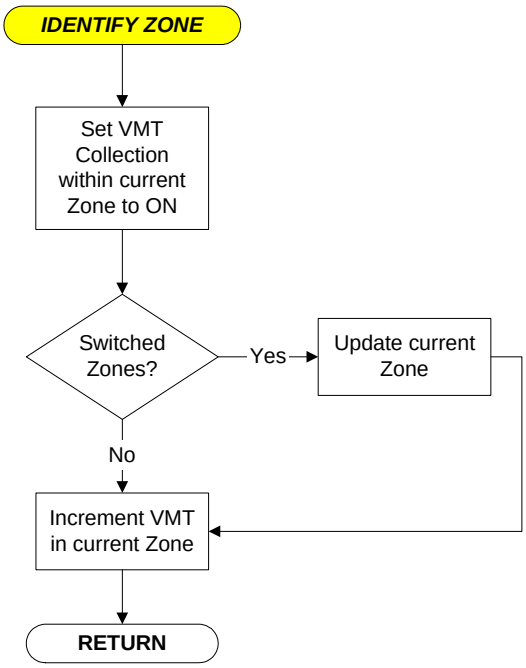

Figure 5. Identifying a Pre-Defined Zone.

Needed functional requirements:

FR 1.1.2.a.	Once the on-vehicle GPS-based device has successfully acquired a GPS signal, it shall determine its location relative to one of various pre-defined zones.
FR 1.1.2.b.	As the on-vehicle GPS-based device collects VMT data within the "current" zone, it shall frequently verify whether or not the vehicle has moved into a new pre-defined zone.
FR 1.1.2.c.	If the vehicle has indeed moved into a new zone, the on-vehicle GPS-based device shall update the "current" zone information and accumulate VMT data for the new zone. Mileage data should be collected and stored such that the data is preserved if the on-vehicle device loses power.
FR 1.1.2.d.	This process shall be repeated until the vehicle reaches the end of its trip.

3.1.3. Fueling and Reading VMT Data

Figure 6 depicts a flowchart that describes the steps involved in fueling and reading VMT data off the on-vehicle GPS-based device. As can be seen in Figure 6, the flowchart is divided into two sections. The left hand side of the flowchart describes the steps involved if the vehicle fuels within the State of Oregon's borders. The right hand side describes the steps involved if the vehicle fuels outside of the State of Oregon, in which case the VMT data will not be collected from the on-vehicle GPS-based device. These two processes only differ in the flowchart block labeled as *Interface with Wireless Data Collection Device*, which is highlighted in blue in Figure 6 to indicate an additional level of functionality that will be described in the section written next to it.

Needed functional requirements:

FR 1.1.3.a.	The process begins when a vehicle approaches a fuel dispenser. The on-vehicle GPS-based device shall be turned off when the vehicle's engine is turned off.
FR 1.1.3.b.	After the driver has selected the type and amount of fuel as well as type of payment, the on-vehicle GPS-based device shall interface with the wireless data collection device to transmit the VMT data collected in the pre-defined zones.
FR 1.1.3.c.	Once the fueling operation is complete, the driver shall be given a receipt that displays the VMT fee assessed.
FR 1.1.3.d.	The on-vehicle GPS-based device shall be turned back on when the vehicle's engine is turned on.

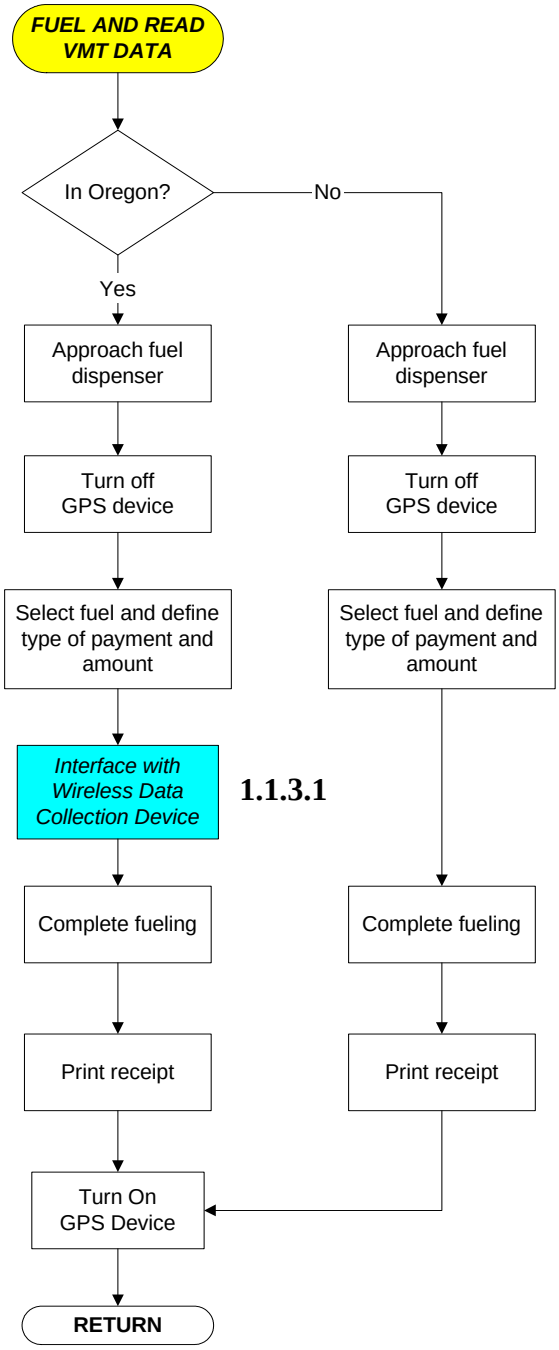

Figure 6. Fueling and Reading VMT Data off the On-Vehicle GPS-based Device.

3.1.4. Interfacing with Wireless Data Collection Device

Figure 7 depicts a flowchart that describes the steps involved in interfacing with a wireless data collection device installed at a fuel station.

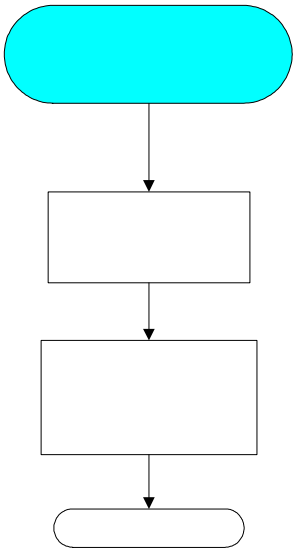

Figure 7. Interfacing with Wireless Data Collection Device.

Needed functional requirements:

FR 1.1.3.1.a.	The interaction between the on-vehicle GPS-based device and the wireless data collection device (WDCD) starts when the latter issues a command to retrieve mileage data.
FR 1.1.3.1.b.	Next, the on-vehicle GPS-based device shall respond by transmitting the mileage accumulated in each of the pre-defined zones.

3.2. SERVICE STATION FUNCTIONAL REQUIREMENTS

The flowchart depicted in Figure 8 shows the high-level functions that must be performed by the GPS-based technology configuration as seen from the service station's perspective. Blocks highlighted in yellow in the flowchart indicate additional levels of functionality that will be described in the sections written next to them.

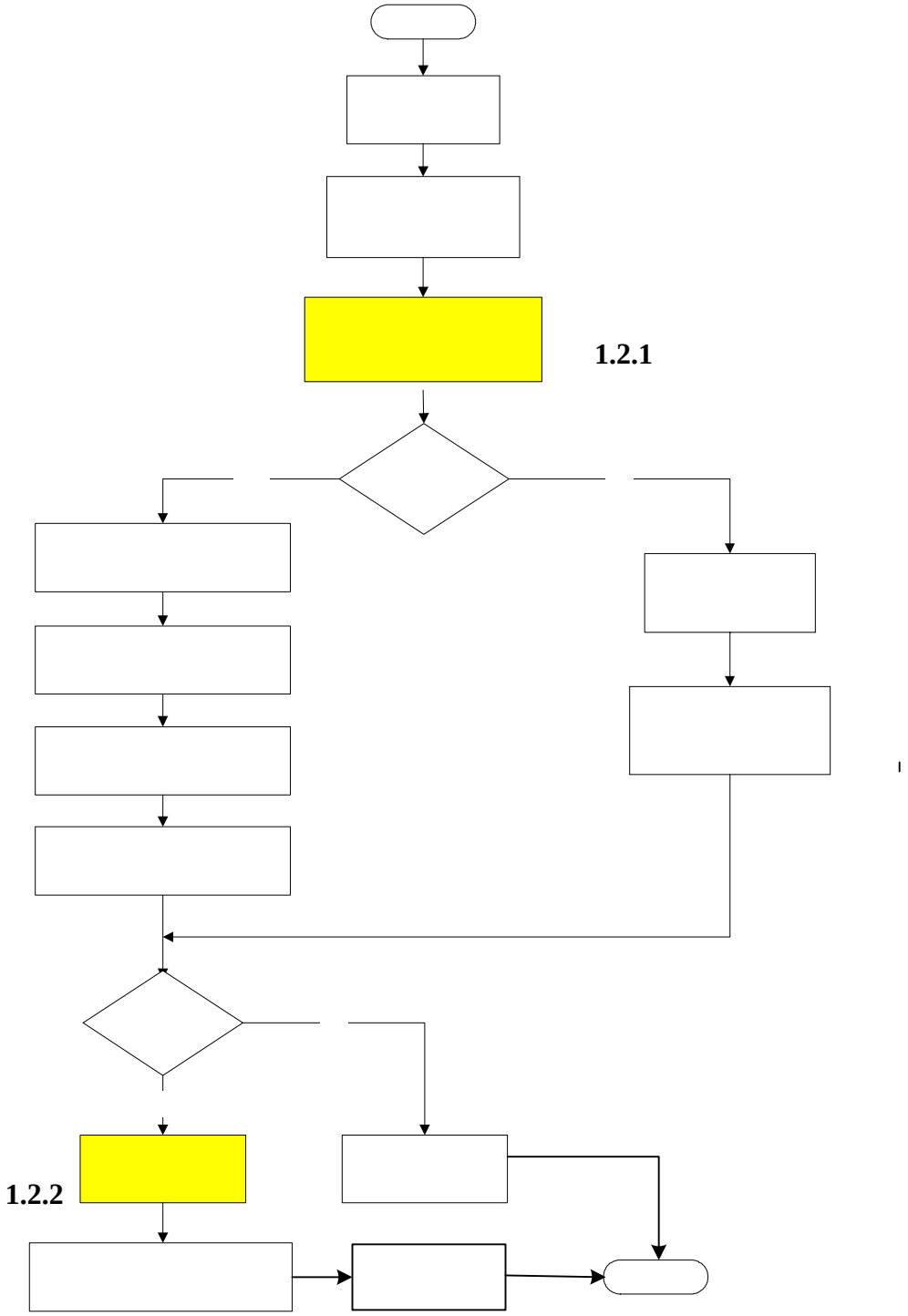

Figure 8. High-level Functions of the GPS-based Technology Configuration – Service Station's Perspective.

The process at the service station begins when a vehicle parks next to a fuel dispenser. This also assumes that the vehicle's engine has been turned off and, consequently, that the on-vehicle GPS-based device has also been turned off.

Needed functional requirements:

FR 1.2.a.	The activation of the fuel dispenser shall indicate to the point-of-sale (POS) system that a fueling operation has begun.
FR 1.2.b.	The POS system shall instruct the host computer to initiate a wireless read.
FR 1.2.c.	The wireless data collection device (WDCD) shall interface with the on-vehicle GPS-based device.
FR 1.2.d.	The service station attendant shall receive a visual confirmation on the fuel dispenser's display when the WDCD and the on-vehicle GPS-based device have finished their interaction.
FR 1.2.e.	If the wireless data collection device is not able to retrieve the VMT data from the on-vehicle GPS-based device (which may indicate that the vehicle either does not have an on-vehicle GPS-based device or that the device is malfunctioning), the host computer shall set the VMT fee to zero and a normal fuel transaction should proceed (i.e., select the type and amount of fuel, and define type of payment).
FR 1.2.f.	If the wireless data collection device is able to retrieve VMT data from the on-vehicle GPS-based device, the host computer shall send data request for the vehicles prior zone mileage to the central database. The VMT data shall be used by the host computer to calculate the VMT fee that will be assessed to the driver. The host computer shall send the VMT fee to the POS system. The POS system shall display the VMT fee on the fuel dispenser's display as feedback to the driver. The driver then selects fuel type, defines type of payment and amount fuel to purchase.
FR 1.2.g.	Depending upon the value of the VMT fee, a driver may or may not decide to complete the fueling operation. If the driver decides not to continue with the fueling transaction, the transaction will be terminated.
FR 1.2.h.	If the driver decides to continue the transaction, then the POS system shall complete the fueling transaction and produce a receipt that displays the VMT fee assessed if a VMT fee was paid.
FR 1.2.i.	The POS system will send a signal for a completed transaction to the host computer along with the amount of fuel purchased and the VMT fee or fuel tax paid
FR 1.2.j.	The host computer will pass updated zone mileage data, the VMT fee or fuel tax, and the amount of fuel purchased to the central database and instruct it to update the appropriate records.

3.2.1. Wireless Data Collection Device Interfaces with On-Vehicle GPS-Based Device

Figure 9 depicts a flowchart that describes the steps involved when a wireless data collection device installed at a fuel station interfaces with the on-vehicle GPS-based device

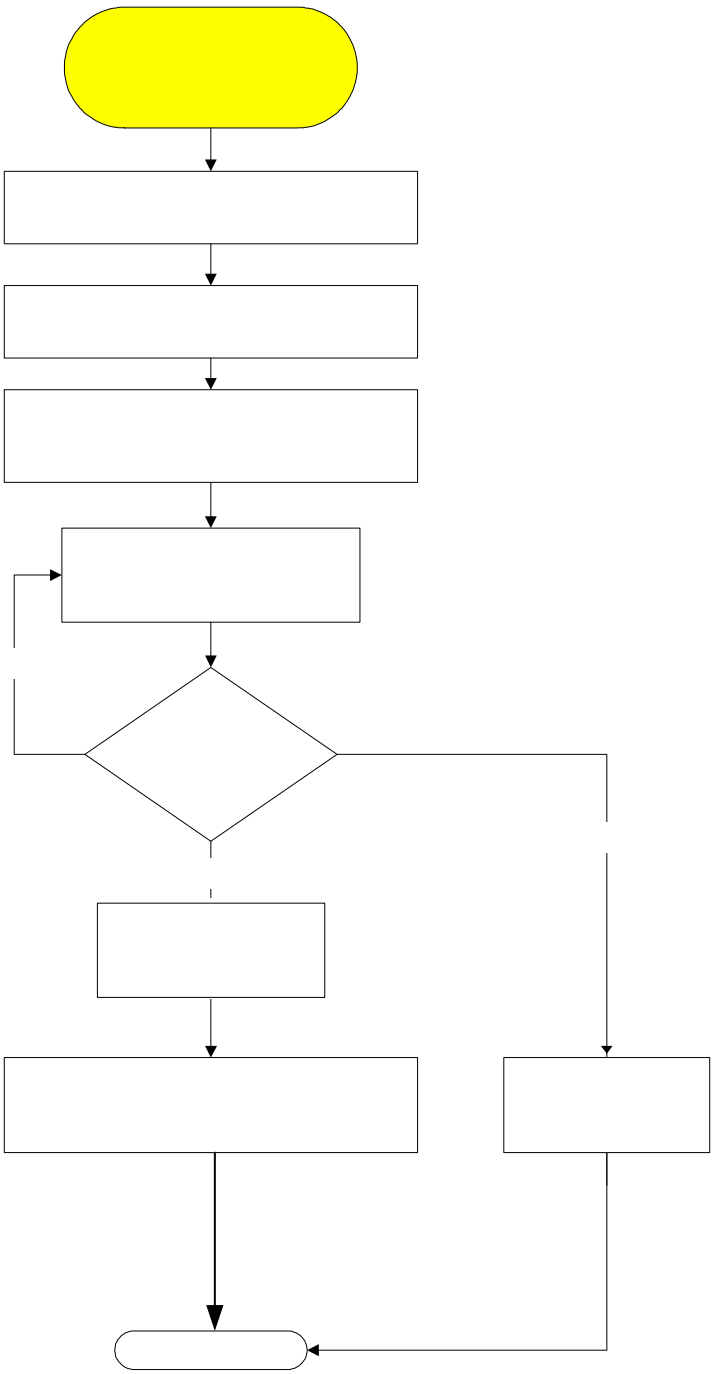

Figure 9. Wireless Data Collection Device Interfaces with On-Vehicle GPS-Based Device.

Fuel dis

Host co

Host
Collec

Needed functional requirements:

FR 1.2.1.a.	The fuel dispenser shall communicate with the POS system to indicate that a fuel transaction has begun.
FR 1.2.1.b.	The POS system shall then communicate with the host computer so that this can instruct the wireless data collection device (WDCD) to issue a read data command.
FR 1.2.1.c.	The WDCD shall wait for the on-vehicle GPS-based device to respond with its ID number and mileage data. If the WDCD is unsuccessful in retrieving the on-vehicle GPS-based device's data after several attempts, the host computer should instruct the POS system that the fuel tax should be applied to the transaction.
FR 1.2.1.d.	If the WDCD successfully reads the mileage data, the WDCD shall send the VMT data to the host computer.

3.2.2. Complete POS Transaction

Figure 10 depicts a flowchart that describes the steps involved in completing a POS transaction.

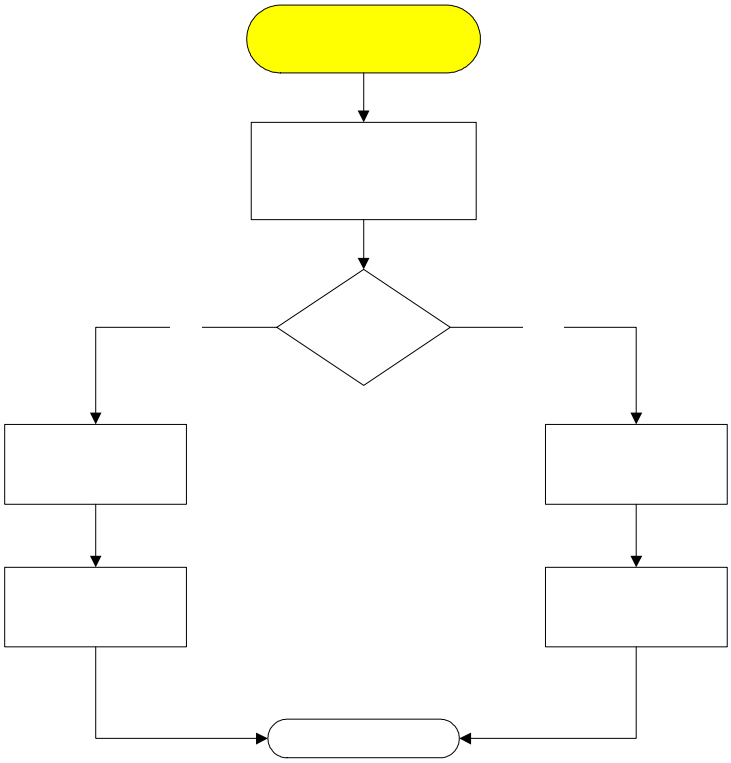

Figure 10. Completing a POS Transaction.

Needed functional requirements:

FR 1.2.2.a.	The POS system shall retrieve the VMT fee from the host computer.
FR 1.2.2.b.	If the VMT fee is greater than zero, the POS system shall add it to the fuel price. The POS system shall then instruct the central database to rollover the record that corresponds to this transaction.
FR 1.2.2.c.	If the VMT fee is zero, the POS system shall compute the fuel tax and add it to the fuel price.
FR 1.2.2.d.	The POS shall send the amount of fuel purchased to the host computer and signal that the transaction has been completed.

4.0. ODOMETER/AVI-BASED TECHNOLOGY CONFIGURATION FUNCTIONAL REQUIREMENTS

This section outlines the functional requirements for the Odometer/AVI-based technology configuration. These functional requirements will be defined from two different, but interrelated viewpoints:

1. On-vehicle device, and
2. Service station

4.1. ON-VEHICLE DEVICE FUNCTIONAL REQUIREMENTS

The flowchart depicted in Figure 11 shows the high-level functions that must be performed by the Odometer/AVI-based technology configuration as seen from the on-vehicle Odometer/AVI-based device's perspective. This technology configuration also uses the concept of a vehicle's *trip* as the framework to define functionality. As indicated in Section 3.0, a vehicle's *trip* may begin within or outside the State of Oregon's borders. Similarly, a vehicle's *trip* may end within or outside the State of Oregon's borders. The on-vehicle Odometer/AVI-based device must be capable of collecting accurate VMT data for all possible scenarios. Blocks highlighted in yellow in Figure 11 indicate additional levels of functionality that will be described in the sections written next to them.

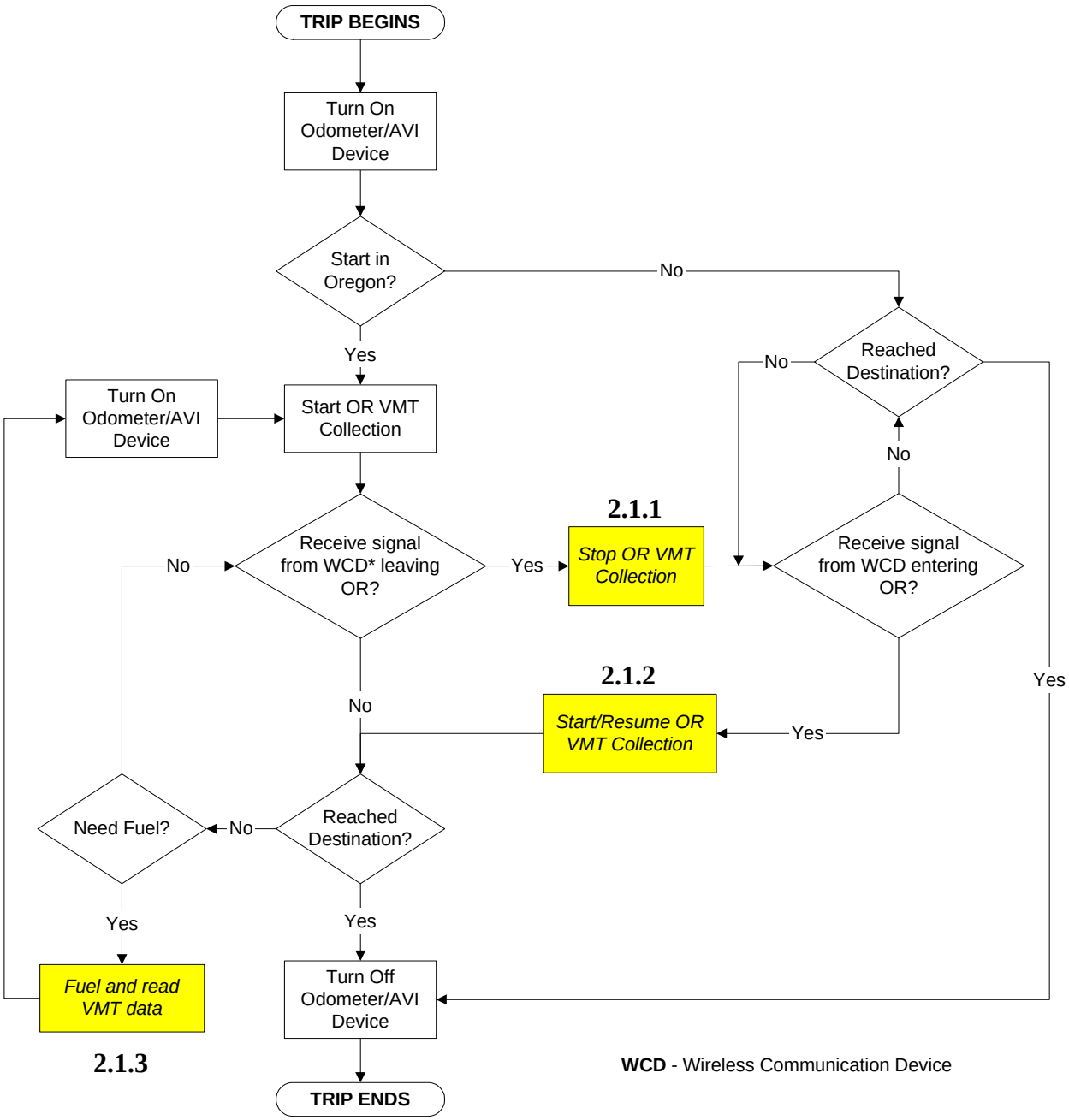

Figure 11. High-level Functions of the Odometer/AVI-based Technology Configuration – On-Vehicle Device's Perspective.

Needed functional requirements:

FR 2.1.a.	A vehicle's trip begins when its engine is turned on. This action shall also turn on the Odometer/AVI-based device installed on the vehicle.
FR 2.1.b.	Once the on-vehicle Odometer/AVI-based device is turned on, it shall determine whether the vehicle is located within or outside Oregon borders.
FR 2.1.c.	The on-vehicle Odometer/AVI-based device shall not accumulate Oregon's VMT data if the vehicle starts its trip outside of Oregon until it is instructed to do so by a wireless communication device (WCD) installed at the entry points of the State of Oregon's highway system.
FR 2.1.d.	If the vehicle reaches its destination while still outside Oregon borders, the on-vehicle Odometer/AVI-based device shall be turned off when the vehicle's engine is turned off.
FR 2.1.e.	If the vehicle starts its trip within Oregon borders, the on-vehicle Odometer/AVI-based device shall start accumulating Oregon VMT data. Data should be stored such that it is retrievable in the event of loss of power.
FR 2.1.f.	If the vehicle leaves the State of Oregon, a WCD shall instruct the on-vehicle Odometer/AVI-based device to stop collecting Oregon VMT data and start non-Oregon mileage collection Data should be stored such that it is retrievable in the event of loss of power.
FR 2.1g.	When a vehicle enters a service station to fuel, the on-vehicle Odometer/AVI-based device shall be turned off when the vehicle's engine is turned off.
FR 2.1.h.	Three pieces of information stored on the on-vehicle Odometer/AVI-based device shall be collected by a wireless data collection device located at the fuel dispenser prior to the vehicle fueling: *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT*.
FR 2.1.i.	After the fueling operation is complete, the on-vehicle Odometer/AVI-based device shall be turned back on when the vehicle's engine is re-started.
FR 2.1.j.	The on-vehicle Odometer/AVI-based device shall be turned off when the vehicle reaches the end of its trip.

4.1.1. Stopping Collection of Oregon VMT

Figure 12 depicts a flowchart that describes the steps involved in instructing the on-vehicle Odometer/AVI device to stop collecting Oregon VMT data. The flowchart block labeled *Interface with Wireless Communication Device at OR's State Exit* in Figure 12 is highlighted in blue to indicate an additional level of functionality that will be described in the section written next to it.

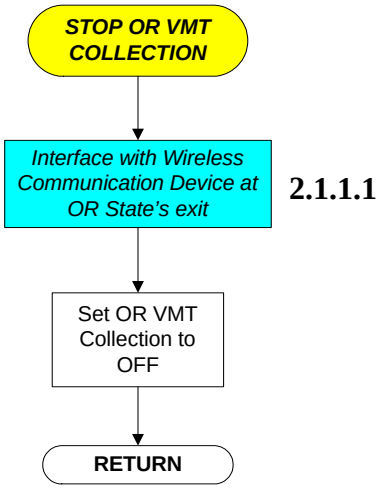

Figure 12. Stopping Oregon VMT Collection.

Needed functional requirements:

FR 2.1.1.a.	The on-vehicle Odometer/AVI-based device shall be instructed by a wireless communication device to stop collecting Oregon VMT data if the vehicle leaves the State of Oregon.
FR 2.1.1.b.	The on-vehicle Odometer/AVI-based device shall immediately stop collecting Oregon VMT data.

4.1.1.1. Interfacing with Wireless Communication Device at Oregon State's Exits

Figure 13 depicts a flowchart that describes the steps involved in interfacing with a wireless communication device at Oregon State's exits.

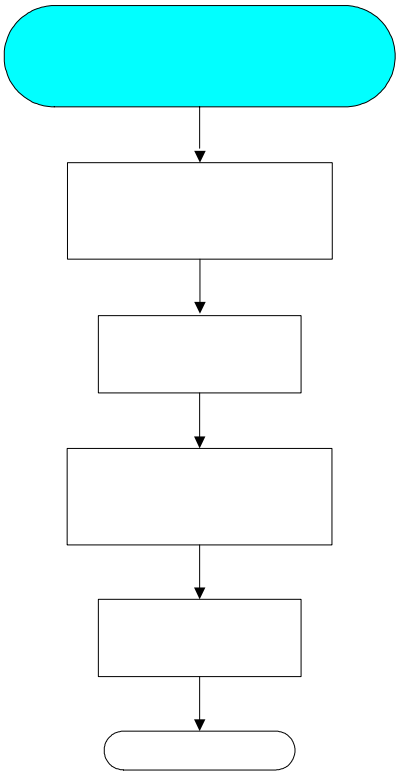

Figure 13. Interfacing with a Wireless Communication Device at Oregon State's Exits.

Needed functional requirements:

FR 2.1.1.1.a.	The interaction between the on-vehicle Odometer/AVI-based device and the wireless communication device (WCD) starts when the latter issues a request for device ID.
FR 2.1.1.1.b.	The on-vehicle Odometer/AVI-based device shall respond to this command by transmitting its ID number back to the WCD.
FR 2.1.1.1.c.	The on-vehicle Odometer/AVI-based device shall receive a STOP VMT COLLECTION command from the WCD.
FR 2.1.1.1.d.	The on-vehicle Odometer/AVI-based device shall stop collecting Oregon VMT data.

4.1.2. Starting/Resuming Collection of Oregon VMT

Figure 14 depicts a flowchart that describes the steps involved in instructing the on-vehicle Odometer/AVI device to start/resume collecting Oregon VMT data. The flowchart block labeled as *Interface with Wireless Communication Device at OR's State Entrance* in Figure 14 is highlighted in blue to indicate an additional level of functionality that will be described in the section written next to it.

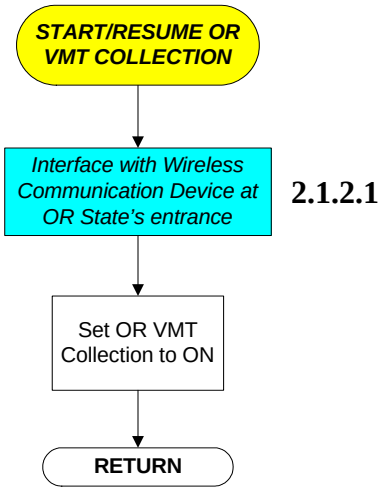

Figure 14. Starting/Resuming Oregon VMT Collection.

Needed functional requirements:

FR 2.1.2a.	The on-vehicle Odometer/AVI-based device shall be instructed by a wireless communication device to start/resume the collection of Oregon VMT data if the vehicle enters/re-enters the State of Oregon.
FR 2.1.2b.	The on-vehicle Odometer/AVI-based device shall immediately start/resume collecting Oregon VMT data.

4.1.2.1. Interfacing with Wireless Communication Device at Oregon State's Entrances

Figure 15 depicts a flowchart that describes the steps involved in interfacing with a wireless communication device at Oregon State's entrances.

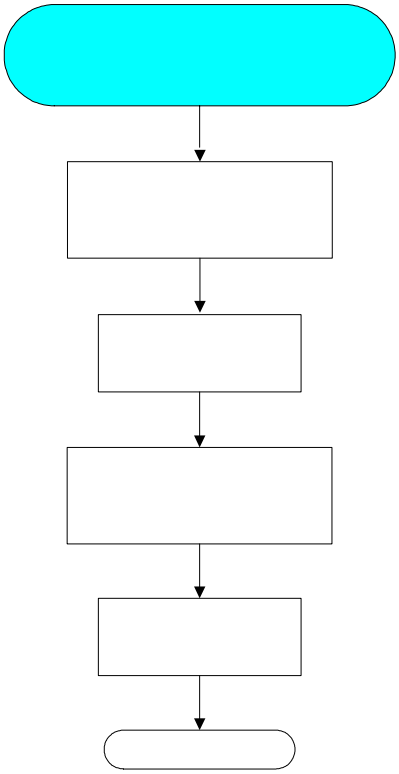

Figure 15. Interfacing with a Wireless Communication Device at Oregon State's Entrances.

Needed functional requirements:

FR 2.1.2.1.a.	The interaction between the on-vehicle Odometer/AVI-based device and the wireless communication device (WCD) starts when the latter issues a request for device ID.
FR 2.1.2.1.b.	The on-vehicle Odometer/AVI-based device shall respond to this command by transmitting its ID number back to the WCD.
FR 2.1.2.1.c.	The on-vehicle Odometer/AVI-based device shall receive a RESUME VMT COLLECTION command from the WCD.
FR 2.1.2.1.d.	The on-vehicle Odometer/AVI-based device shall resume collecting Oregon VMT data.

4.1.3. Fueling and Reading VMT Data

Figure 16 (see next page) depicts a flowchart that describes the steps involved in fueling and reading VMT data off the on-vehicle Odometer/AVI-based device. The flowchart blocks in

Figure 16 labeled *Interface with Wireless Collection Device* and *Interface with Wireless Collection Device to Update Mileage Counters* are highlighted in blue to indicate an additional level of functionality that will be described in the sections written next to them.

Needed functional requirements:

FR 2.1.3.a.	The process begins when a vehicle approaches a fuel dispenser. The on-vehicle Odometer/AVI-based device shall be turned off when the vehicle's engine is turned off.
FR 2.1.3.b.	While the driver is selecting the type and amount of fuel as well as type of payment, the on-vehicle Odometer/AVI-based device shall interface with the wireless data collection device (WDCD) to transmit the following VMT data: *Non-Oregon VMT*, *Oregon VMT*, *Paid-for Oregon VMT*.
FR 2.1.3.c.	Once the fueling operation is complete, the driver shall be given a receipt that displays the VMT fee assessed.
FR 2.1.3.d.	The on-vehicle Odometer/AVI-based device shall interface with the WDCD to write in its memory the updated VMT data: *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT* (*the Paid-for Oregon VMT will be copied to Oregon VMT).*
FR 2.1.3.e.	The on-vehicle Odometer/AVI-based device shall be turned back on when the vehicle's engine is turned on.

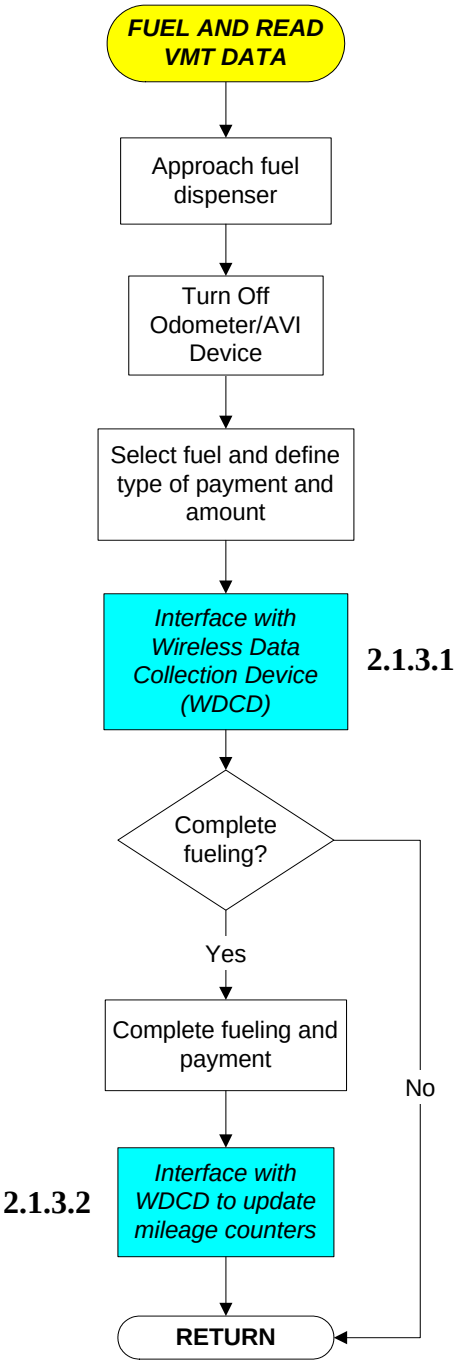

Figure 16. Fueling and Reading VMT Data.

4.1.3.1. Interface with Wireless Data Collection Device

Figure 17 depicts a flowchart that describes the steps involved in interfacing with a wireless data collection device installed at a fuel station.

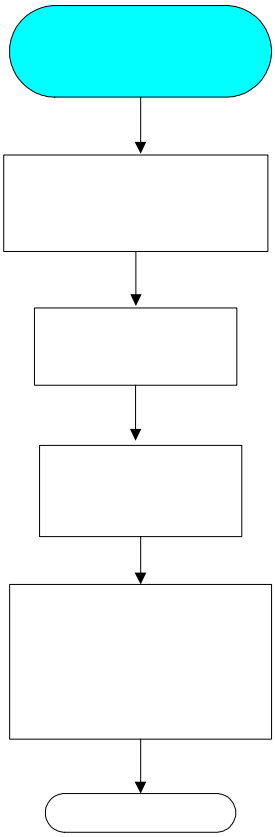

Figure 17. Interface with Wireless Data Collection Device.

Needed functional requirements:

FR 2.1.3.1.a.	The interaction between the on-vehicle Odometer/AVI-based device and the wireless data collection device (WDCD) starts when the latter issues a request for device ID.
FR 2.1.3.1.b.	The on-vehicle Odometer/AVI-based device shall respond to this command by transmitting its ID number to the WDCD.
FR 2.1.3.1.c.	Next, the on-vehicle Odometer/AVI-based device shall receive a READ command from the WDCD and shall transmit the current values for the *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT*.

4.1.3.2. Interface with Wireless Data Collection Device to Update Mileage Counters

Figure 18 depicts a flowchart that describes the steps involved in interfacing with a wireless data collection device installed at a fuel station.

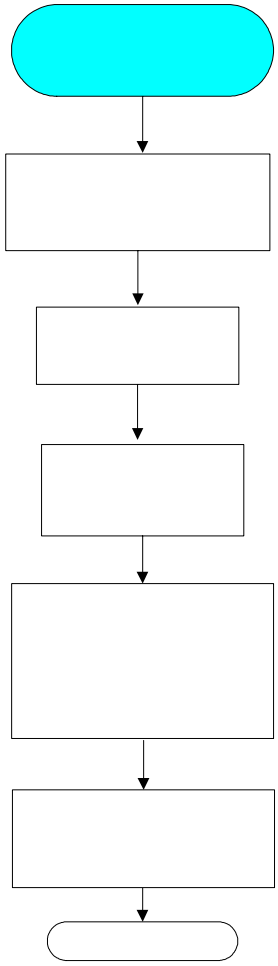

Figure 18. Interface with Wireless Data Collection Device to Update Mileage Counters.

Needed functional requirements:

FR 2.1.3.2.a.	The interaction between the on-vehicle Odometer/AVI-based device and the wireless data collection device (WDCD) starts when the latter issues a request for device ID.
FR 2.1.3.2.b.	The on-vehicle Odometer/AVI-based device shall respond to this command by transmitting its ID number to the WDCD.
FR 2.1.3.2.c.	Next, the on-vehicle Odometer/AVI-based device shall receive a WRITE command from the WDCD to update the values for the *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT*.
FR 2.1.3.2.d.	The on-vehicle Odometer/AVI-based device shall write the updated values for the *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT* in its memory. It will copy the *Paid-for Oregon VMT* to *Oregon VMT*.

4.2. SERVICE STATION FUNCTIONAL REQUIREMENTS

The flowchart depicted in Figure 19 shows the high-level functions that must be performed by the Odometer/AVI-based technology configuration as seen from the service station's perspective. Blocks highlighted in yellow in Figure 19 indicate additional levels of functionality that will be described in the sections written next to them.

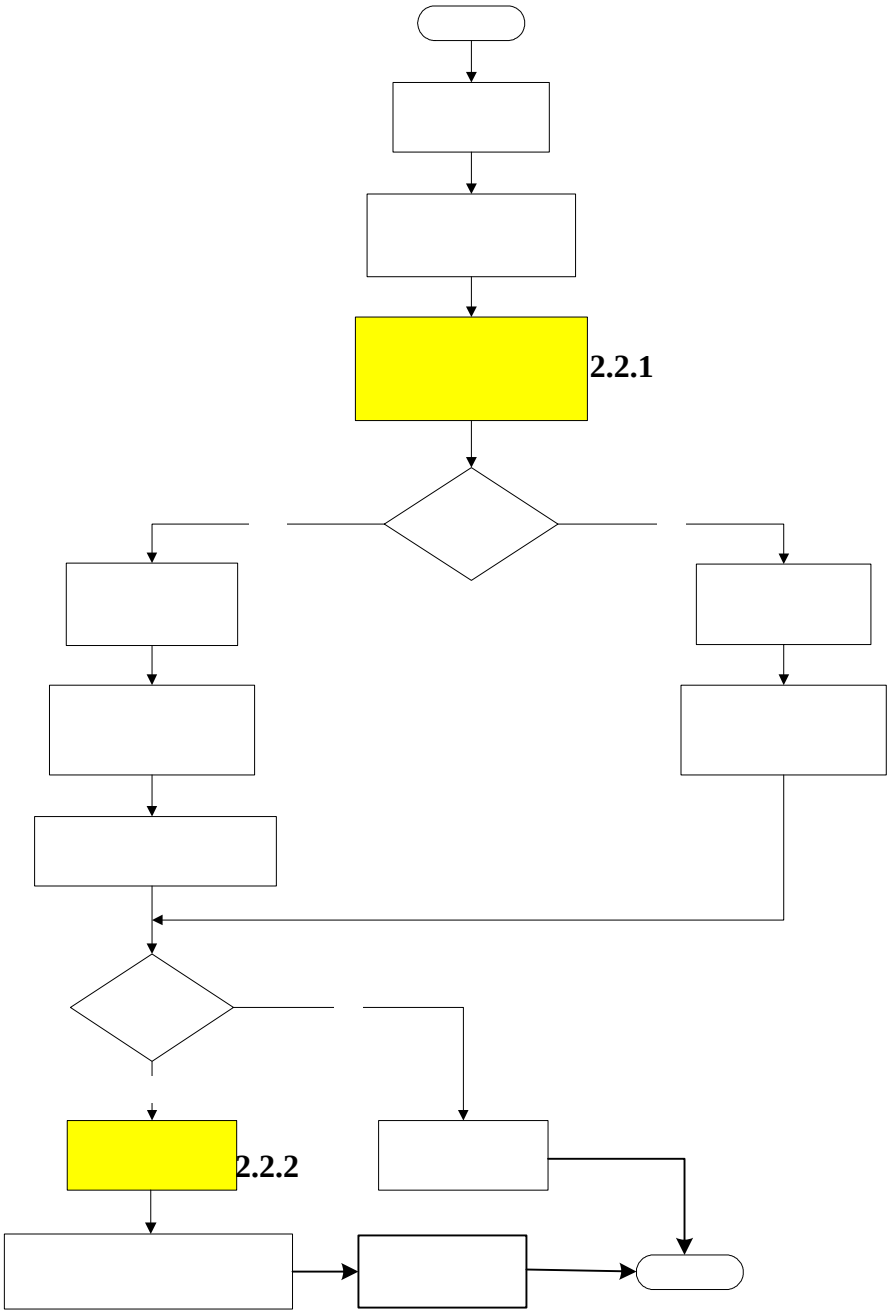

Figure 19. High-level Functions of the Odometer/AVI-based Technology Configuration – Service Station's Perspective.

The process at the service station begins when a vehicle parks next to a fuel dispenser. This also assumes that the vehicle's engine has been turned off and, consequently, that the on-vehicle Odometer/AVI-based device has also been turned off.

Needed functional requirements:

FR 2.2.a.	The activation of the fuel dispenser shall indicate to the point-of-sale (POS) system that a fueling operation has begun.
FR 2.2.b.	The wireless data collection device (WDCD) shall interface with the on-vehicle Odometer/AVI-based device.
FR 2.2.c.	The service station attendant shall receive a visual confirmation on the fuel dispenser's display when the WDCD and the on-vehicle Odometer/AVI-based device have finished their interaction.
FR 2.2.d.	If the WDCD <u>is not able</u> to retrieve the VMT data from the on-vehicle Odometer/AVI-based device (which may indicate that the vehicle either does not have an on-vehicle Odometer/AVI-based device or that the device is malfunctioning), the host computer shall set the VMT fee to zero and a normal fuel transaction should proceed (i.e., select the type and amount of fuel, and define type of payment).
FR 2.2.e.	If the WDCD <u>is able</u> to retrieve the VMT data (i.e., *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT*) from the on-vehicle Odometer/AVI-based device, the host computer shall use this information to calculate the VMT fee. The VMT fee shall then be sent back to the host computer. The host computer shall send the VMT fee to the POS system. The POS system shall show the VMT fee on the fuel dispenser's display as feedback to the driver. The driver then selects fuel type, defines type of payment and amount fuel to purchase.
FR 2.2.f.	Depending upon the value of the VMT fee, a driver may or may not decide to complete the fueling operation. If the driver decides <u>not</u> to continue with the fueling transaction, the *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT* shall not be updated in the on-vehicle Odometer/AVI-based device's memory.
FR 2.2.g.	If the driver decides to continue the transaction, then the POS system shall complete the fueling transaction and produce a receipt that displays the VMT fee assessed. The amount of fuel purchased shall be sent to the host computer along with a signal that the transaction has been completed.
FR 2.2.h.	The host computer shall update its records on the total VMT fees collected and the total amount of fuel purchased.

4.2.1. Wireless Data Collection Device Interfaces with On-Vehicle Odometer/AVI-Based Device

Figure 20 depicts a flowchart that describes the steps involved when a wireless data collection device installed at a fuel station interfaces with the on-vehicle Odometer/AVI-based device.

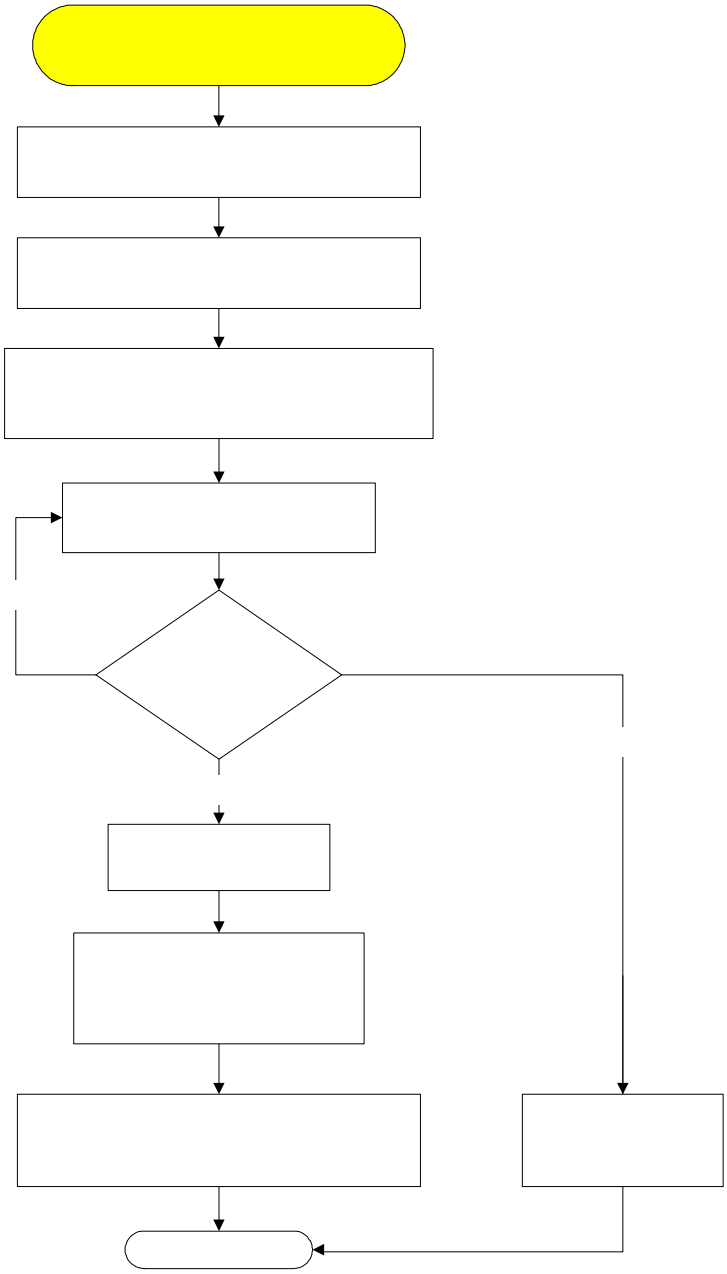

Figure 20. Wireless Data Collection Device Interfaces with On-Vehicle Odometer/AVI-Based Device.

Needed functional requirements:

FR 2.2.1.a.	The fuel dispenser shall communicate with the POS system to indicate that a fuel transaction has been initiated.
FR 2.2.1.b.	The POS system shall then communicate with the host computer so that this can instruct the wireless data collection device (WDCD) to issue a command to read device and mileage data.
FR 2.2.1.c.	The WDCD shall wait for the on-vehicle Odometer/AVI-based device to respond to this command. If the WDCD is unsuccessful in retrieving the on-vehicle Odometer/AVI-based device's data after several attempts, the host computer will direct to WDCD to suspend further read attempts.
FR 2.2.1.d.	If the WDCD receives the on-vehicle Odometer/AVI-based device's data, the WDCD shall send the VMT data to the host computer.

4.2.2. Complete POS Transaction

Figure 21 depicts a flowchart that describes the steps involved in completing a POS transaction.

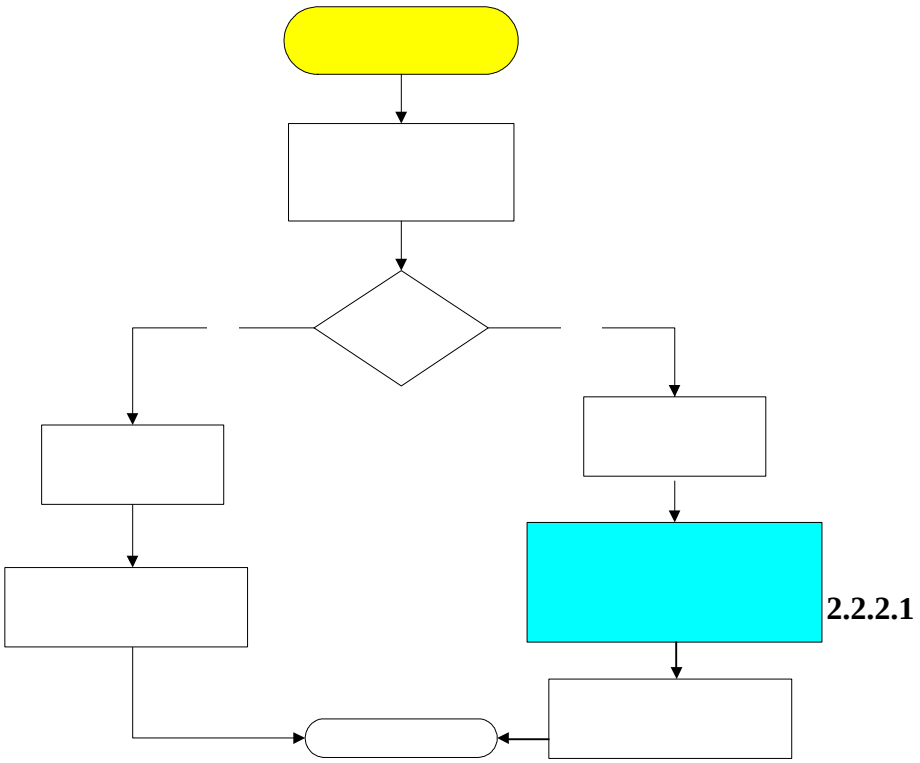

Figure 21. Completing a POS Transaction.

Needed functional requirements:

FR 2.2.2.a.	The POS system shall retrieve the VMT fee from the host computer.
FR 2.2.2.b.	If the VMT fee is greater than zero, the POS system shall add it to the fuel price.
FR 2.2.2.c.	The POS system shall instruct the host computer to send a command to the wireless data collection device so that the mileage counters are updated.
FR 2.2.2.d.	If the VMT fee is zero, the POS system shall compute the fuel tax and add it to the fuel price.
FR 2.2.2.e.	The POS system shall send the amount of fuel purchased to the host computer.

4.2.2.1. Interface with Wireless Data Collection Device to Update Mileage Counters

Figure 22 depicts a flowchart that describes the steps involved when a wireless data collection device installed at a fuel station interfaces with the on-vehicle Odometer/AVI-based device to update the mileage counters.

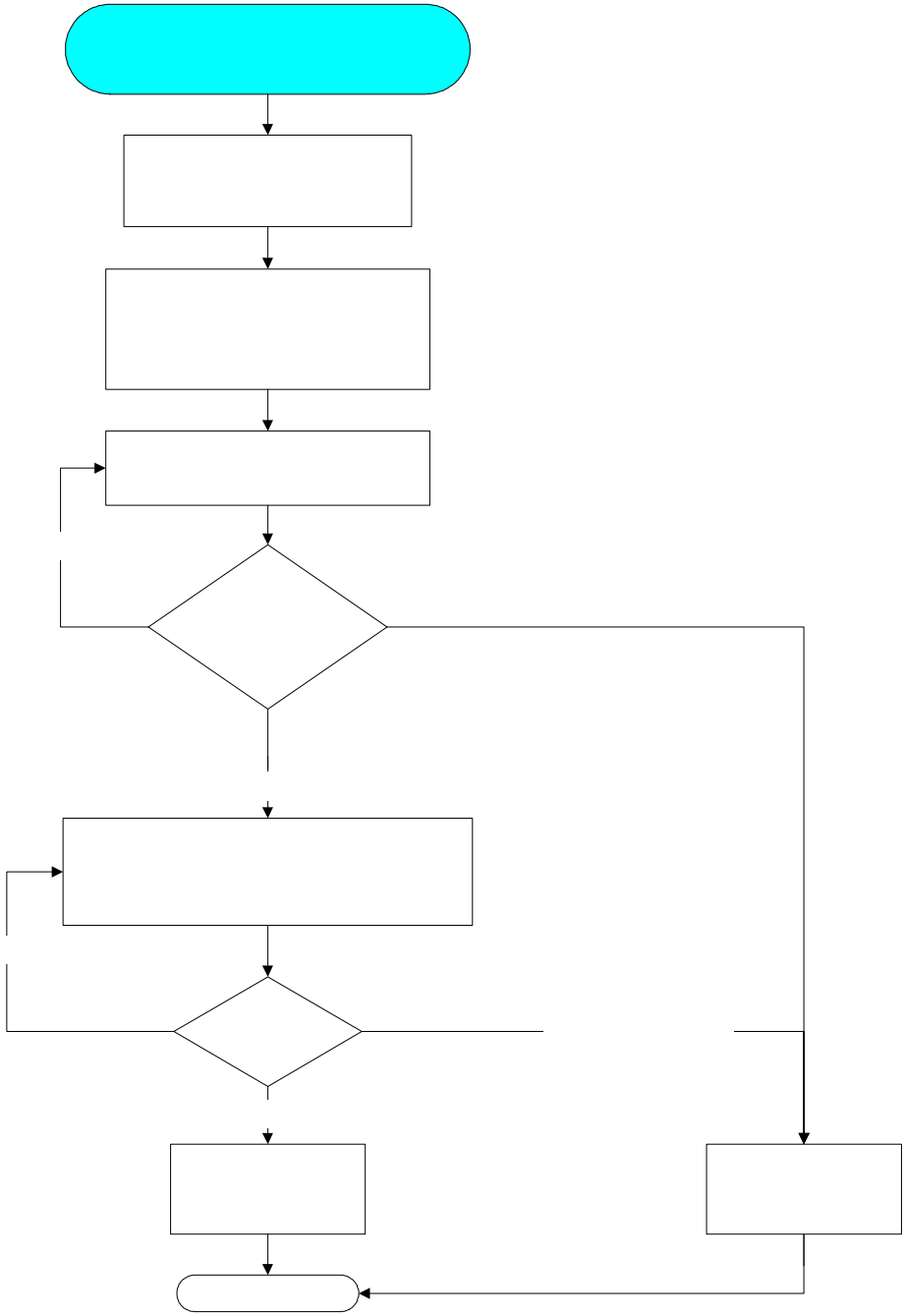

Figure 22. Interface with Wireless Data Collection Device to Update Mileage Counters.

Needed functional requirements:

FR 2.2.2.1.a.	The POS system shall send a request to the host computer to instruct the wireless data collection device (WDCD) to update the VMT mileage counters (i.e., *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT*)
FR 2.2.2.1.b.	The host computer shall instruct the wireless data collection device to identify the device associated with the fuel dispenser.
FR 2.2.2.1.c.	The WDCD shall wait for the on-vehicle Odometer/AVI-based device to respond with its ID number.
FR 2.2.2.1.d.	Once the ID number is received from the on-vehicle Odometer/AVI-based device, the host computer shall confirm that the ID number is correct (i.e., it belongs to the vehicle that was present at the fuel dispenser when the fueling transaction began).
FR 2.2.2.1.e.	If the WDCD is unsuccessful after several tries in retrieving the ID number from the on-vehicle Odometer/AVI-based device, the host computer shall record an incomplete transaction and shall not update the mileage counters.
FR 2.2.2.1.f.	If the ID number received is correct, the host computer shall issue a WRITE command through the WDCD to update the *Non-Oregon VMT*, *Oregon VMT*, and *Paid-for Oregon VMT* values on the on-vehicle Odometer/AVI-based device.
FR 2.2.2.1.g.	If the WRITE operation is successful, the on-vehicle Odometer/AVI-based device shall notify the WDCD.
FR 2.2.2.1.h.	The host computer shall then record that the device data updating as complete.

5.0. TECHNICAL SPECIFICATIONS

This section describes the technical specifications required for both the GPS-based and Odometer/AVI-based technology configurations.

5.1. WIRELESS DATA COLLECTION AND COMMUNICATION SYSTEM

Transfer of VMT data from and to the on-vehicle device shall occur via wireless RF communications. The wireless data collection and communication system that will support this task in both technology configurations includes a *host computer* and *RF equipment*. The host computer runs an application program that controls and interfaces with the RF equipment. The RF equipment includes:

- **Wireless Data Collection Device (WDCD).** The WDCD communicates with the on-vehicle device via antennae. The WDCD controls the protocol, reads data from or writes data to the on-vehicle device, and ensures message delivery and validity.
- **Wireless Communication Device (WCD).** The WCD also communicates with the on-vehicle device via antennae. The WCD controls the protocol and activates or deactivates the on-vehicle device as vehicles enter/leave the State of Oregon, respectively. The WCD ensures message delivery and validity.
- **On-vehicle Device.** The on-vehicle device can store an ID number and VMT data and communicate that information to the RF interrogator.

The wireless data collection and communication system shall provide the following minimum features:

- Identify on-vehicle devices in range
- Read VMT data from the on-vehicle device
- Write VMT data to the on-vehicle device
- Activate/deactivate on-vehicle devices on cars entering/leaving Oregon

The technical specifications described in Section 5.1 are applicable to the functional requirements shown in Table 4.

Table 4. Functional Requirements affected by the Wireless Data Collection System Technical Specifications.

TECHNOLOGY CONFIGURATION	
GPS-based	**Odometer/AVI-based**
FR 1.1.f	**FR 2.1.c, FR 2.1.f, FR 2.1.h**
FR 1.1.3.b	**FR 2.1.1.a, FR 2.1.1.b**
FR 1.1.3.1.a, FR 1.1.3.1.b	**FR 2.1.1.1.a, FR 2.1.1.1.b, FR 2.1.1.1.c, FR 2.1.1.1.d**
FR 1.2.c, FR 1.2.e	**FR 2.1.2.a, FR 2.1.2.b**
FR 1.2.1.b, FR 1.2.1.c, FR 1.2.1.d	**FR 2.1.2.1.a, FR 2.1.2.1.b, FR 2.1.2.1.c, FR 2.1.2.1.d**
	FR 2.1.3.b, FR 2.1.3.d
	FR 2.1.3.1.a, FR 2.1.3.1.b, FR 2.1.3.1.c
	FR 2.1.3.2.a, FR 2.1.3.2.b, FR 2.1.3.2.c, FR 2.1.3.2.d
	FR 2.2.b, FR 2.2.d, FR 2.2.e
	FR 2.2.1.b, FR 2.2.1.c
	FR 2.2.2.1.a, FR 2.2.2.1.b, FR 2.2.2.1.c, FR 2.2.2.1.e, FR 2.2.2.1.f, FR 2.2.2.1.g

5.1.1. Environmental Operating Conditions

RF equipment shall be capable of operating in diverse environments, and under a full spectrum of climatic conditions. RF equipment shall be capable of use in industrial and hazardous environments and in areas with high levels of electromagnetic noise and interference. RF equipment shall operate under conditions where they may be subjected to sun, rain, snow, ice, humidity, blowing dust or sand, salt water, or sudden, severe changes in ambient air pressure. RF equipment shall comply with the following commercial standards for environmental testing: International Electrotechnical Commission (IEC) 60068-1, Environmental Testing, Part 1: General and Guidance, and IEC 60068-2, Environmental Testing, Part 2: Basic Environmental Testing Procedures.

5.1.2. Hazardous Environment

RF equipment shall be certified by Factory Mutual Corporation (FMC) or Underwriters Laboratories (UL) as Intrinsically Safe for operation defined by the National Electrical Code for at least Class 1 Division 2, Groups A, B, C, and D. Detailed definitions and specifications for intrinsically safe operation are outlined by the National Fire Prevention Association, as detailed in the National Electrical Code (NEC), 1999.

5.1.3. Radio Regulatory Compliance

RF equipment shall support non-licensed communication in compliance with the U.S. Department of Commerce National Telecommunication and Information Administration, Manual of Regulation and Procedures for Federal Radio Frequency Management, ANNEX K (Nonlicensed Devices), as well as the U.S. Federal Communications Commission Code of Federal Regulations, Title 47, Part 15, Radio Frequency Devices. RF equipment shall be capable of operating at a frequency and radiated output power that does not require special operational licensing. All equipment included in the wireless data collection system configuration must be

certified by the Federal Communications Commission (FCC) under U.S. Federal Communications Commission Code of Federal Regulations, Title 47, Part 15, Radio Frequency Devices.

5.1.4. Read Reliability Issues

The wireless data collection system shall ensure at least a 99% reliable performance when identifying, reading VMT data from, writing VMT data, activating, and deactivating to the on-vehicle device.

5.1.5. Security of Data Transmission

All the components of the wireless data collection and communication system shall employ adequate techniques to secure network configuration information. In addition, data encryption schemes shall be employed before presenting the vehicle's ID and VMT data to the wireless network.

5.1.6. Compatibility Issues

The wireless data collection and communication system hardware, software, cables, connectors, and peripherals shall maintain backward compatibility, so that as technology changes, older technology can still be read.

5.1.7. Hardware Requirements

5.1.7.1. WDCD and WCD

5.1.7.1.1. Operating Frequency

WDCDs and WCDs shall operate within an Industrial, Scientific, or Medical (ISM) band as defined by the National Telecommunication and Information Administration (NTIA), Annex K and National Committee on Information Technology Standards (NCITS) 256.

5.1.7.1.2. RF Power Requirements

The transmitting power of the WDCDs and WCDs shall not exceed the limits established by the NTIA Annex K using spread-spectrum modulation. Also, the combined transmitting power of the entire system (including all WDCDs and WCDs and any other RF transmitters) shall comply with both human RF health requirements and EMC requirements.

5.1.7.1.3. Read and Write Capabilities

WDCDs shall be able to read VMT data from and write VMT to the on-vehicle device at a minimum unobstructed distance of 15 feet (4.57 meters).

5.1.7.1.4. Activation and Deactivation of On-Vehicle Devices at Oregon Borders

WCDs shall be able to activate or deactivate on-vehicle devices as vehicles enter or leave the State of Oregon, respectively. WCDs shall be capable of performing this task on vehicles traveling at speeds of up to 90 mph (≈ 145 kph). In addition, the WCD devices installed for a single lane shall be able to activate or deactivate on-vehicle devices at maximum rate of 5200 vehicles per hour.

5.1.7.1.5. Application Programming Interface

WDCDs and WCDs shall implement an Application Programming Interface (API) compatible with Microsoft® Windows.

5.1.7.1.6. Power Requirements

WDCDs and WCDs shall operate with a maximum power supply of 120/220Volts, 30 Amperes (50/60 Hz).

5.1.7.1.7. Installation of WDCDs

The WDCDs that will be used to collect identification and VMT data from the on-vehicle device at the service stations shall be external to the fuel dispenser. They shall also have the capability to be associated with a specific fuel dispenser so that VMT fees are incorporated into the fuel transaction for the correct vehicle.

5.1.7.2. On-Vehicle Device

5.1.7.2.1. Operating Frequency

On-vehicle devices shall operate within an Industrial, Scientific, or Medical (ISM) band as defined by the National Telecommunication and Information Administration (NTIA), Annex K and National Committee on Information Technology Standards (NCITS) 256.

5.1.7.2.2. VMT Data Storage Capacity

On-vehicle devices shall have a unique, pre-set serial number or identification number and shall have at least the capability of storing 32, 8-bit bytes of VMT data. The on-vehicle device shall allow partitioning to accommodate storage of various types of information at the data element level.

5.1.7.2.3. Line of Sight

The on-vehicle devices will be installed on an out-of-sight location in the vehicle (note: the exact installation location has not been determined). The on-vehicle device shall provide at least 99% reliable operation when interfacing with the WDCDs and WCDs to perform the tasks of identification, read, write, activation, and deactivation.

5.1.7.2.4. Durability

The on-vehicle devices must be packaged to withstand the environmental conditions present in the installation location. The installation location with the most severe environmental conditions

will be in the engine compartment, in which the device will be exposed to large temperature fluctuations (approximately -30°C – 150°C), vibration, dirt, and moisture. For installation in the passenger compartment, temperature may also be extreme (approximately -30°C to 120°C). For locations in the passenger compartment such as the bottom of the instrument panel, typical maximum temperatures are approximately 70°C.

5.1.7.2.5. Tamper Detectable and Tamper Resistant Packaging

The device packaging shall be designed so that opening the device is not only difficult but also detectable.

5.1.7.2.6. Privacy

The on-vehicle devices shall not store information about vehicle location and time except for the information needed to estimate VMT data. Once the VMT has been estimated, location data not needed for future VMT estimates shall be deleted. The on-vehicle devices shall transfer only a device identification number and VMT data from the device at fueling stations as part of a fuel purchase transaction.

5.1.7.2.7. Size

The device shall be approximately 5" long, 2.5" wide, and 1" in height. These are the approximate dimensions of a COTS odometer tag.

5.1.7.2.8. Power Source

The power source for the on-vehicle devices shall be external to the device and shall be obtained from the vehicle (12V DC).

5.2. ON-VEHICLE GPS-BASED DEVICE

5.2.1. GPS Signal Acquisition

Immediately after the on-vehicle GPS-based device has been turned on, it shall acquire and lock onto a GPS signal. If the signal acquisition process is not successful in the first attempt, the on-vehicle GPS-based device shall repeat this procedure until a signal is acquired or the trip ends. Finally, the difference between the VMT data collected by the on-vehicle GPS-based device and its equivalent vehicle's odometer reading shall be less than 2% for any collection period.

Applicable to functional requirements: **FR 1.1.b**
FR 1.1.1.a, FR 1.1.1.b, FR 1.1.1.c
FR 1.1.2.a

5.2.2. Pre-Defined Zones

Once the on-vehicle GPS-based device has successfully acquired a GPS-signal, it shall determine its location relative to one of various pre-defined zones. Here a zone is defined as a specific combination of geographic area and time period. For the purpose of this project, the on-vehicle GPS-based device shall be able to store the following information for at least three zones:

1. Geographical boundaries of the zone (i.e., absolute latitude, longitude, and altitude).
2. Time period for the zone.
3. Total miles driven in zone.

As the on-vehicle GPS-based device collects VMT data within the *current* zone, it shall verify (at a rate of once every minute) whether or not the vehicle has moved into a new zone. If the vehicle has indeed moved into a new pre-defined zone, the on-vehicle GPS-based device shall immediately update the *current* zone information and accumulate VMT data for the new zone. This process shall be repeated until the vehicle reaches the end of its trip.

Once again, the difference between the VMT data collected in each pre-defined zone by the on-vehicle GPS-based device and its equivalent vehicle's odometer reading shall be less than 2% for any collection period.

Applicable to functional requirements: **FR 1.1.b, FR 1.1.c, FR 1.1.d**
FR 1.1.2.a, FR 1.1.2.b, FR 1.1.2.c, FR 1.1.2.d

5.2.3. File Formats for Storing Pre-Defined Zone Information

The storage of information defining the geographic portion of a zone on the GPS-based on-vehicle device shall be stored using a standard file format.

Applicable to functional requirements: **FR 1.1.b, FR 1.1.c, FR 1.1.d**
FR 1.1.2.a, FR 1.1.2.b, FR 1.1.2.c, FR 1.1.2.d

5.2.4. ODB II Interface ???

The on-vehicle GPS-based device shall be able to interface with vehicles that meet OBD II standard requirements if necessary for mileage collection. Specifically, the on-vehicle GPS-based device shall be able to interface with an ODB II J1962 connector. The three OBD II protocols currently in use on passenger vehicles sold in the United States are ISO 9141 (Chrysler, European imports, most Asian imports), SAE J1850 VPW (General Motors), and SAE J1850 PWM (Ford). These vehicle requirements are incorporated into all passenger vehicles built since January 1, 1996.

5.3. ON-VEHICLE ODOMETER/AVI-BASED DEVICE

5.3.1. Determining Location

Once the on-vehicle Odometer/AVI-based device is turned on, it shall determine whether the vehicle is located within or outside Oregon borders. The on-vehicle Odometer/AVI-based device shall use a 1-bit memory location to determine location (1 = in Oregon, 0 = otherwise).

Applicable to functional requirements: **FR 2.1.b, FR 2.1.c, FR 2.1.d, FR 2.1.f**
FR 2.1.1.a, FR 2.1.1.b
FR 2.1.2.a, FR 2.1.2.b

5.3.2. ODB II Interface (if desired)

The on-vehicle Odometer/AVI-based device shall be able to interface with vehicles that meet OBD II standard requirements. Specifically, the on-vehicle Odometer/AVI-based device shall be able to interface with an ODB II J1962 connector. The three OBD II protocols currently in use on passenger vehicles sold in the United States are ISO 9141 (Chrysler, European imports, most Asian imports), SAE J1850 VPW (General Motors), and SAE J1850 PWM (Ford). These vehicle requirements are incorporated into all passenger vehicles built since January 1, 1996.

5.4. SERVICE STATION COMPONENTS

5.4.1. POS System

The POS system at the service station shall be a mainstream system produced by an acknowledged industry provider company. The POS system shall have the capability to interoperate with the fuel dispensers at the service station and with the wireless data collection and communication system's host computer.

5.4.2. Fuel Dispenser

The fuel dispensers shall be electronically controlled fuel dispensers produced by an industry acknowledged provider (e.g. Gilbarco, Wayne-Dresser).

5.5. CENTRAL DATABASE

The central database that will be used to store and manipulate VMT data shall be a commercially available product that follows a relational model and utilizes the standard query language (i.e., SQL-99) to issue queries, as defined by the ISO/IEC JTC1/SC32, WorkGroup 3, Database Languages committee.

6.0. REFERENCES

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