SSI Technologies – Application Note AT-AN6

Acu-Trac™ Off Vehicle Applications and Fuel Data Messaging

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1 Introduction

As shown in the figure 1, the Acu-Trac™ fuel level sensor provides the missing ingredient to form a comprehensive Fleet Fuel Management System. In conjunction with Qualcomm Omni TRACS® system, Acu-Trac™ provides fuel-related data such as fuel level and drive MPG on request. In addition, Acu-Trac™ provides real-time notification of fuel adds, fuel losses, idle fuel, low fuel warnings, and more.

2 Applications

This document focuses on the applications for the fuel-related data items. These applications include:

1. Fuel Purchase Optimization
2. Low Fuel Warnings to Prevent Running Out of Fuel
3. Fuel Fraud Detection
4. Fuel Tax Odometer Support
5. Fuel Tax Idle Fuel Rebates
6. Fuel Usage Report containing Tank MPG and Idle Fuel.

Details on the algorithms and the required data flow are presented to aid in the development of Host Computer Fuel Management Software that supports these applications.

This document also provides the binary message formats needed to request and parse the Acu-Trac™ fuel related messages.

The Host Computer Fuel Management Software is called the “Fuel-trac” application in this document for brevity.

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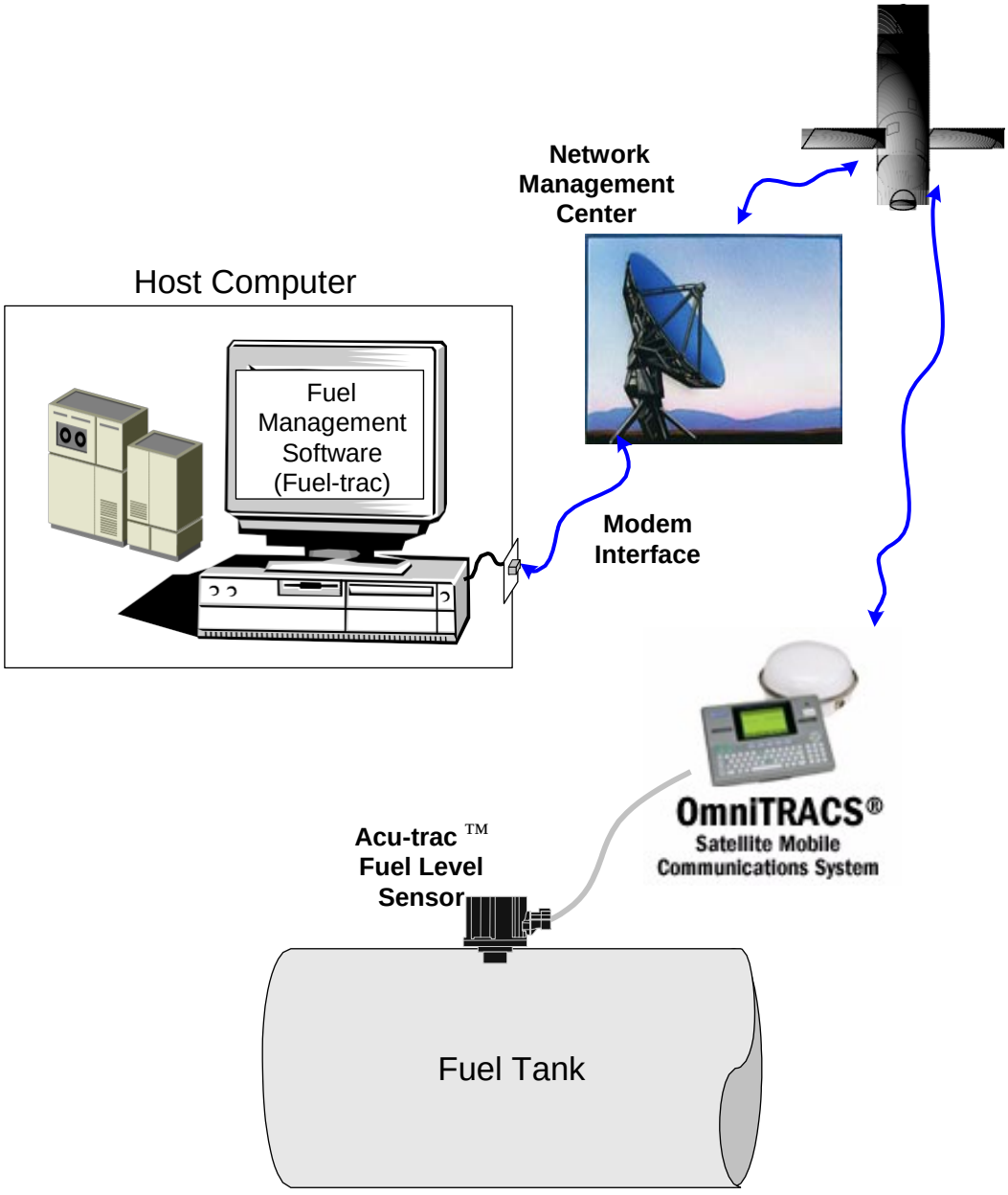

Figure 1 Fleet Fuel Management System

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2.1 Fuel Purchase Optimization Application

2.1.1 Overview of Process

Figure 2 below shows a data flow diagram of a typical fuel optimization process. The driver sends an Empty Call Macro in order to receive a new dispatch. The driver includes an indication of the fuel level, typically a number from one to eight that is based on the number of eighths the fuel gauge indicates. Appended to the Empty Call Macro is the current truck location. The Dispatch Software assigns the truck a new dispatch, which includes the pick-up and delivery locations. This data is feed into the Fuel Optimization Software when the new dispatch is created. The fuel optimization software reads Truck MPG, Truck Tank Capacity, and Fuel Network data and creates an optimized route with fuelling recommendations. The optimized route and fuel recommendations are sent back to the driver using the on-vehicle satellite communications system.

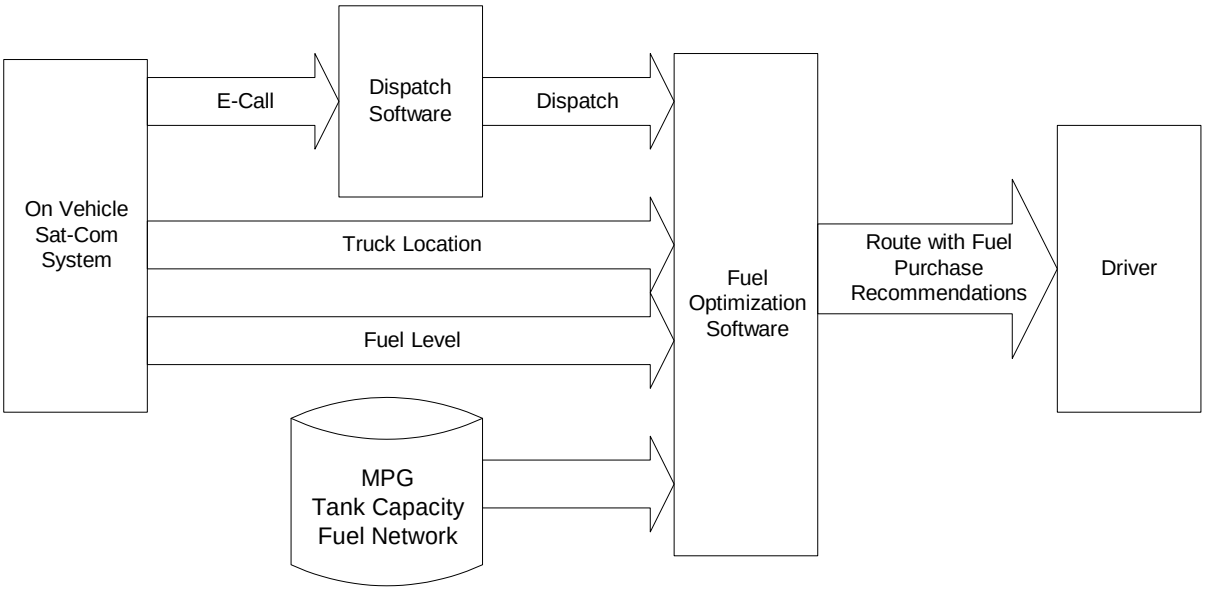

Figure 2 Fuel Optimization Data Flow Diagram.

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2.1.2 Process with Acu-Trac™ Fuel Level Sensor

Figure 3 shows the fuel optimization process using the Acu-Trac™ Fuel Level Sensor. Data from the Acu-Trac™ Fuel Level Sensor's Fuel Add message is used to perform the optimization. The Acu-Trac™ Fuel Level Sensor sends in Fuel Level, Drive MPG, and Odometer at the time of each Fuel Add. This data is saved into the Fuel-trac database.

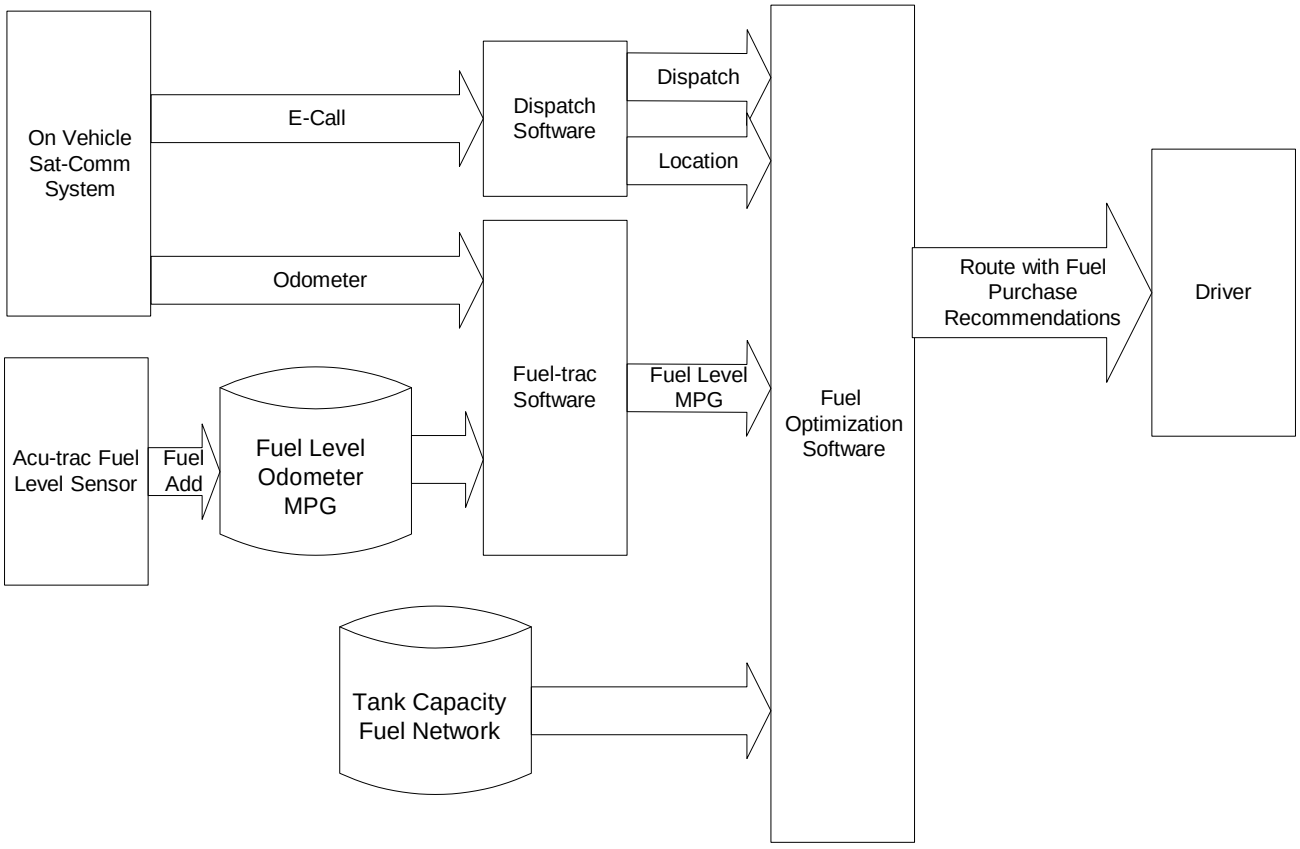

Figure 3. Fuel Optimization System with Acu-Trac™ Fuel Level Sensor.

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Again, the driver sends an Empty Call Macro in order to receive a new dispatch. The current truck odometer is appended to the Empty Call Macro using Qualcomm's Auto Fill Fields feature along with the current truck location. The Fuel-trac software picks up the odometer reading and performs the following calculation:

Current Fuel Level = Fuel Add Fuel Level – (Current Odometer – Fuel Add Odometer)/Drive MPG

The Current Fuel Level and Drive MPG are sent to the Fuel Optimization Software when the new dispatch is created by the Fuel-trac software. The fuel optimization software reads Truck Tank Capacity and Fuel Network data and creates an optimized route with fuelling recommendations. The optimized route and fuel recommendations are sent back to the driver using the on-vehicle satellite communications system.

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2.1.3 Closing the Fuel Optimization Loop

Figure 4 shows the data flow diagram for closing the fuel optimization loop.

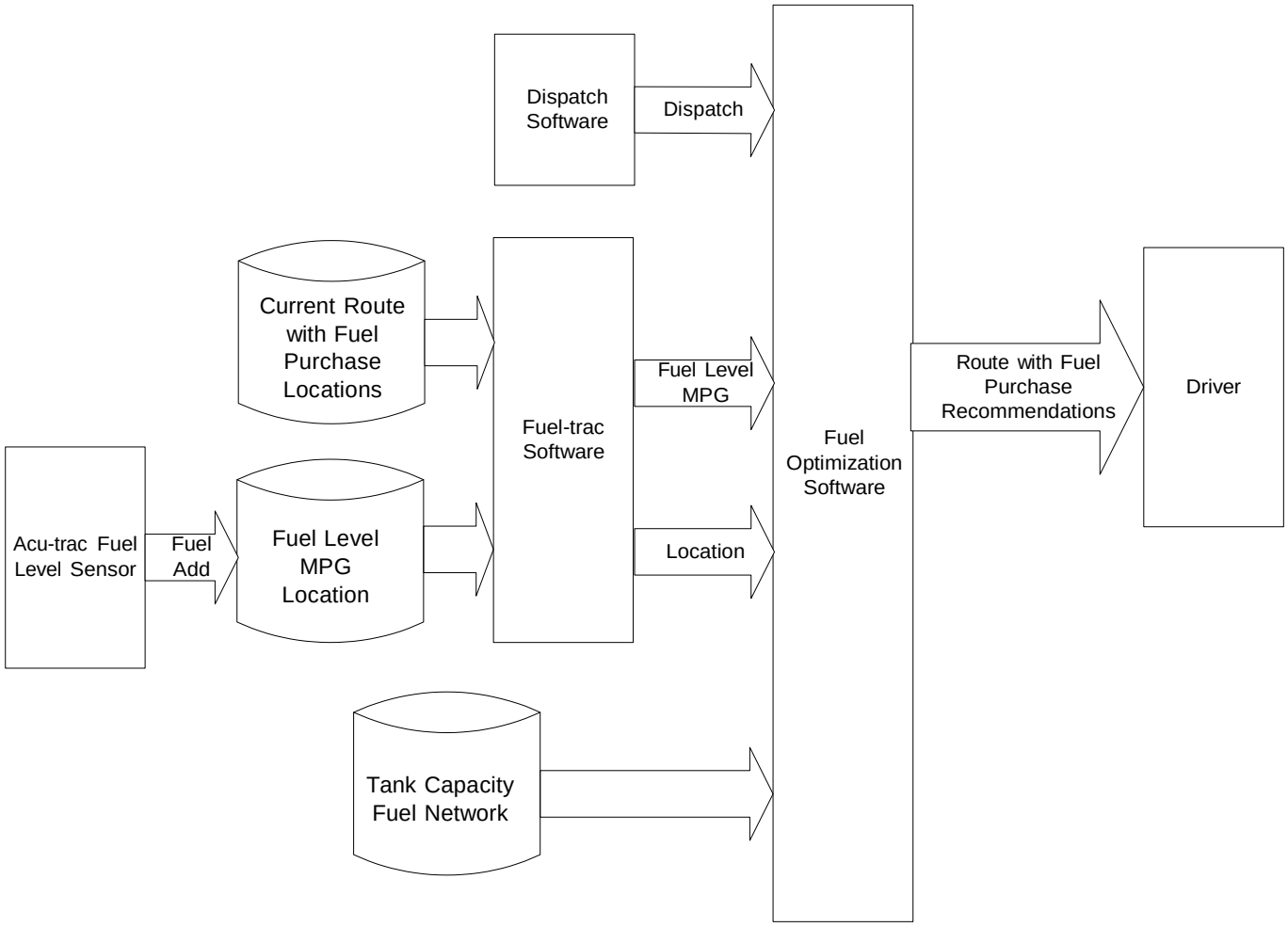

Figure 4 Closing the Fuel Optimization Loop Data Flow Diagram.

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2.1.4 Fueling Location is Different than the Recommended/No Optimization in Place

The Acu-Trac™ Fuel Level Sensor's Fuel Add Message contains the location of each fuel purchase. The Fuel-trac software determines the Latitude/Longitude of the recommended stop using the Zip Code from the Current Route with Fuel Purchase Recommendations database. If no Fuel Purchase Recommendation is found for this truck, the Fuel-trac software will immediately send a message to the driver manager. The Fuel Purchase Recommendation Zip Code is used to look up Latitude/Longitude for the Fuel Purchase Location from the Zip Code to Latitude/Longitude Database. Using the Latitude/Longitude contained in the Fuel Add Message for "lat2", the following equation is performed:

Approximate distance in miles = sqrt(x * x + y * y)

where x = 69.1 * (lat2 - lat1)
and y = 69.1 * (lon2 - lon1) * cos (lat1/57.3)

The above equation assumes that the Latitude and Longitude are in degrees and the cos function requires radians.

After completing the calculation, if the distance is greater than a preset distance (default 100 miles), then the driver fueled at a location other than the one recommended by the optimizer. The Fuel-trac software then requests a new optimization.

Note: The 100-mile distance is used to allow tank equalization. For trucks with two fuel tanks, if the driver adds fuel to only one tank, a period of time as long as an hour is required for the tanks to equalize. The Acu-Trac™ Fuel Level Sensor monitors the fuel in a single tank and detects the tank equalization condition. The Acu-Trac™ Fuel Level Sensor waits until the tanks have equalized before sending out the Fuel Add Message.

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2.1.5 Preventing Low Fuel Blown Optimizations/Skipped Fuel Stops

The Acu-Trac™ Fuel Level Sensor's Fuel Add Message contains the Fuel Level after the fuel purchase and the current Drive MPG for the truck. The Fuel-trac software determines the validity of the current optimization by checking the projected fuel level at the next fuel stop. Again, the Latitude/Longitude of the previous completed fuel stop is found using the Zip Code from the Current Route with Fuel Purchase Recommendations database. The Latitude/Longitude of the next fuel stop is found in the same manner. Using the Latitude/Longitude of each of the fuel stops, the following equation is performed:

Approximate distance in miles = sqrt(x * x + y * y)

where x = 69.1 * (lat2 - lat1)
and y = 69.1 * (lon2 - lon1) * cos (lat1/57.3)

The above equation assumes that the Latitude and Longitude are in degrees and the cos function requires radians.

After completing the calculation, the projected fuel at the level at the next stop is calculated as follows:

Projected Fuel Level = Previous Fuel Level – Distance/Drive MPG.

If the Projected Fuel Level is less than a preset level (default 40 gallons) then the fuel level will be too low. The Fuel-trac software then requests a new optimization.

In addition the Maximum Fuel Add is calculated using the following formula:

Maximum Fuel Add = Tank Capacity – Projected Fuel Level.

If the Maximum Fuel Add is less than a preset level (default 50 gallons) then the fuel level will be too high coming into the stop. The Fuel-trac software then requests a new optimization.

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2.2 Low Fuel Warnings Application

Figure 5 shows the data flow diagram for detection of Low Fuel conditions. The Acu-Trac™ Fuel Level Sensor sends out a Low Fuel Warning Message based on a configurable fuel threshold. The message contains the Fuel Level, MPG and Truck Location. The Fuel-trac software immediately requests a re-optimization on receiving this message. The Fuel-trac software sends a Low Fuel Warning Message to the Driver Manager and a Low Fuel Warning Macro to the Driver.

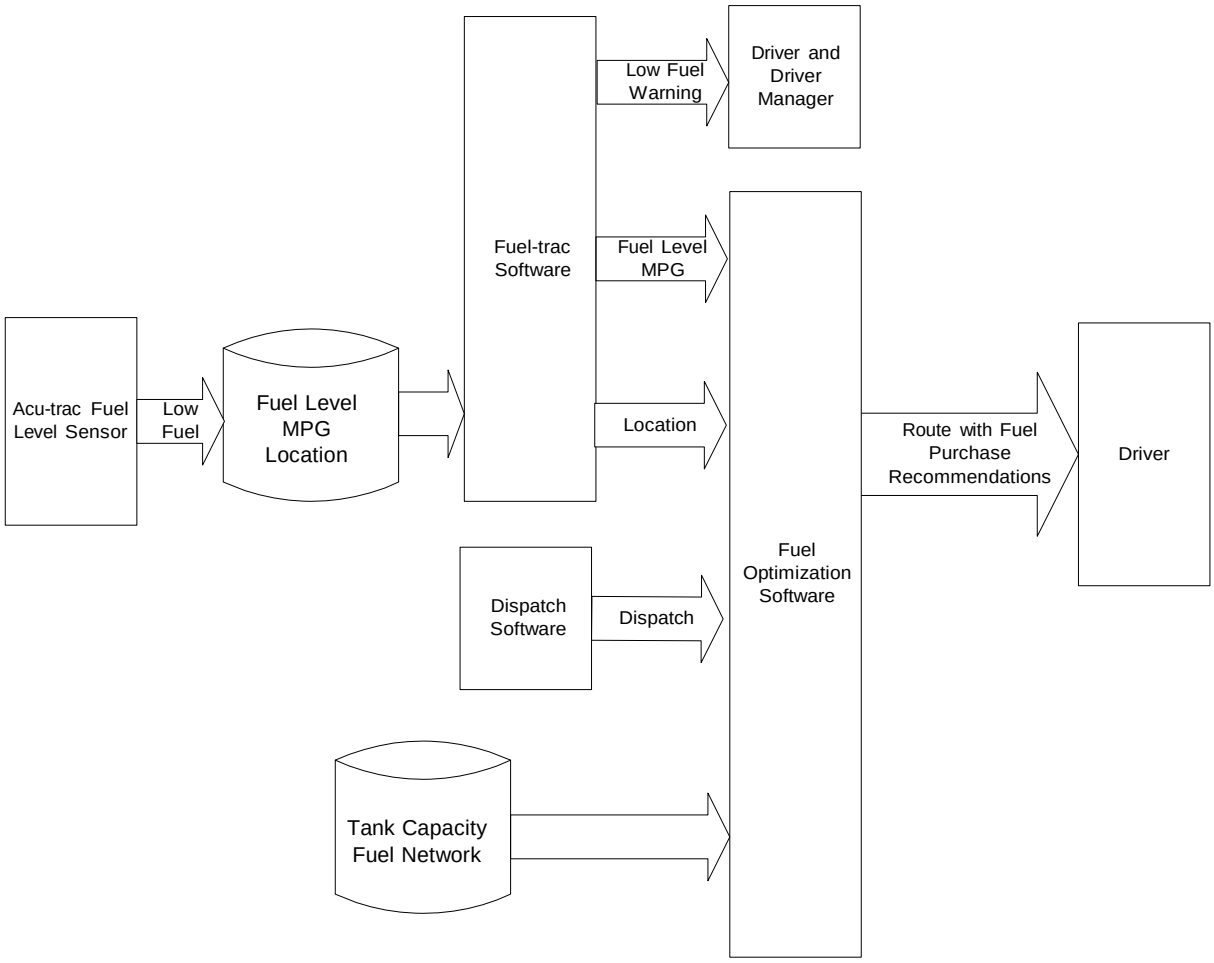

Figure 5 Low Fuel Warning Data Flow Diagram

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2.3 Fuel Fraud Detection

2.3.1 Fuel Purchase Exceptions/Fuel Loss

Figure 6 shows the data flow diagram for generation of the Fuel Loss Report and the Fuel Purchase Exceptions Report.

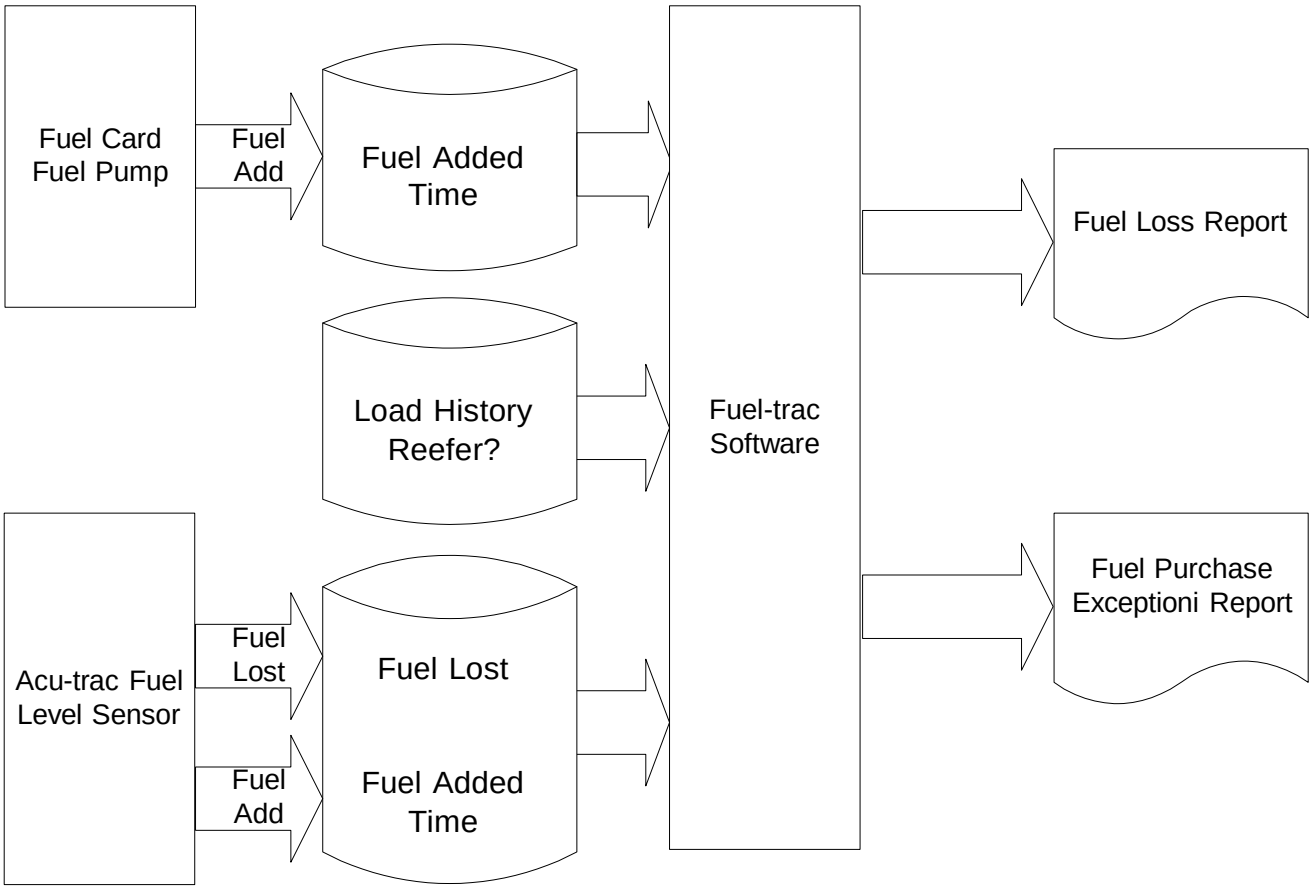

Figure 6 Fuel Purchase Exceptions/ Fuel Loss Data Flow Diagram.

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2.3.2 Fuel Loss Report

The Acu-Trac™ Fuel Level Sensor sends out a Fuel Loss message based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Lost, Time/Date and Truck Location. The Fuel-trac software allows user input of a date range. The Fuel-trac software generates a Fuel Loss Report. An example of the Fuel Loss Report is shown in Figure 7.

Fuel Level Sensor Fuel Loss Report
Date: 10/01/01 – 10/30/01

Truck ID	Date	Time	Location	Fuel Level	Fuel Lost
43578	10/01/01	10:22	Green Bay, WI	120.3	23.4
21897	10/05/01	1:43	Chicago, IL	88.8	34.2
19273	10/11/01	12:33	Atlanta, GA	26.3	25.8
68350	10/19/01	14:55	Phoenix, AZ	93.2	40.3
50329	10/28/01	20:23	Portland, OR	143.2	56.3
33221	10/30/01	0:23	Dallas, TX	89.3	44.9

Figure 7. Fuel Loss Report Example.

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2.3.3 Fuel Purchase Exception Report

The Acu-Trac™ Fuel Level Sensor sends out a Fuel Add Message based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Added, Time/Date, Odometer, and Truck Location. The Fuel-trac software allows user input of a date range. The Fuel-trac software generates a Fuel Purchase Fraud Report using the following procedure.

1. Searching backwards from the end date of the report, for each Fuel Purchase reported by the Fuel Card System (COMDATA, TCHECK, etc.), get the time/date of the purchase.

2. Using the time/date of the purchase, search the Acu-Trac™ Fuel Add Database for the Fuel Add that occurs immediately (within 24 hours) after this time/date.

3. If no Fuel Add is found, report the exception using "-"for Fuel Add Sensor and Fuel Level.

4. Compare the Fuel Add quantity from the Acu-Trac™ Fuel Add Database to the Fuel Purchase quantity.

5. If the fuel purchase quantity is greater than the Fuel Add quantity from the Acu-Trac™ Fuel Add Database by a User entered threshold (ten gallons or more), then the discrepancy is reported.

6. Search the Load History Database to determine if the Trailer was a reefer. If so place "Yes" in the Reefer Column. Otherwise "No".

An example of the Fuel Purchase Exception Report is shown in Figure 8.

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Fuel Level Sensor Fuel Purchase Fraud Report
Date: 10/01/01 – 10/30/01

Truck ID	Refer	Date	Fuel Purch Time	Location	Fuel Level	Fuel Purch	Fuel Add Sensor	Fuel Missing
53578	Yes	10/02/01	10:22	Green Bay, WI	185.6	113.7	80.3	33.4
31897	No	10/06/01	1:43	Chicago, IL	-	83.2	-	83.2
29273	Yes	10/12/01	12:33	Atlanta, GA	119.3	82.1	56.3	25.8
78350	Yes	10/18/01	14:55	Phoenix, AZ	93.2	103.9	63.6	40.3
60329	Yes	10/27/01	20:23	Portland, OR	123.2	128.4	72.1	56.3
43221	No	10/30/01	0:23	Dallas, TX	95.3	114.2	69.3	44.9

Figure 8 Fuel Purchase Exception Report

2.4 Fuel Tax Odometer Support

The Acu-Trac™ Fuel Level Sensor sends out a Fuel Add Message based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Added, Time/Date, Odometer and Truck Location. The Fuel-trac software provides Odometer support for Fuel Tax using the following procedure.

1. For each Fuel Purchase reported by the Fuel Card System (COMDATA, TCHECK, etc.), get the time/date of the purchase.

2. Using the time/date of the purchase, search the Acu-Trac™ Fuel Add Database for the Fuel Add that occurs immediately after this time/date.

3. Use the corresponding odometer value from the Acu-Trac™ Fuel Add Database as the Fuel Tax Odometer entry.

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2.5 Fuel Tax Idle Fuel Rebates

Figure 9 shows the data flow diagram for odometer capture in support of Fuel Tax Reporting and for the generation of the Idle Fuel Rebate Reports.

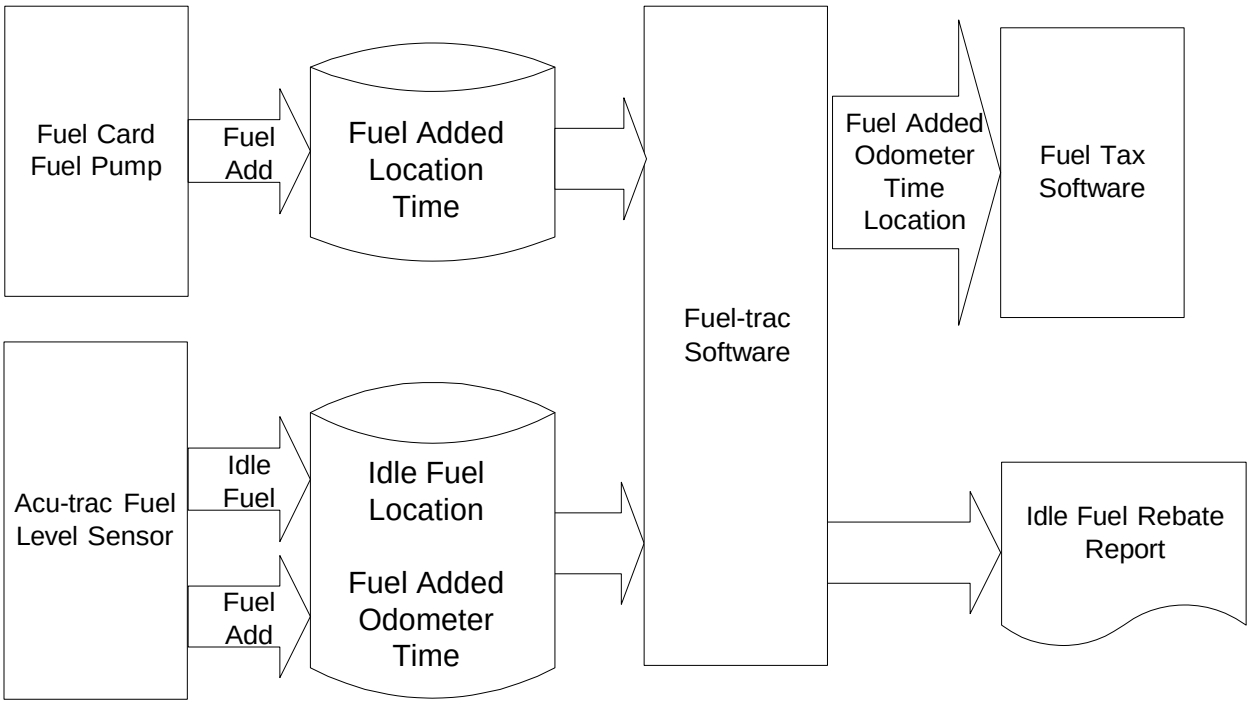

Figure 9 Data Flow Diagram for Fuel Tax Support.

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2.6 Fuel Usage Report Containing Tank MPG and Idle Fuel

2.6.1 Idle/Tamper Fuel Rebate Report

The Acu-Trac® Fuel Level Sensor sends out an Idle/Tamper Fuel message based on a configurable fuel threshold. The message contains the Idle Fuel Used, Tamper Fuel, Time/Date, Odometer and Truck Location. The Fuel-trac software generates the Idle/Tamper Fuel Rebate Report using the following procedure.

1. For each Idle/Tamper Fuel message sent by the sensor, get the time/date of the idle event.

2. Using the time/date of the idle event, search the position records for this truck and get the Truck Position Latitude and Longitude that was reported immediately before this idle event.

3. Using mapping software, enter the latitude and longitude to determine if the idle event occurred off of state maintained roads and rest stops. If the stop occurred on private property, examine the states fuel tax laws for a possible rebate.

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2.6.2 Fuel Usage Report

Figure 10 shows the data flow diagram for generation of the Fuel Usage Report.

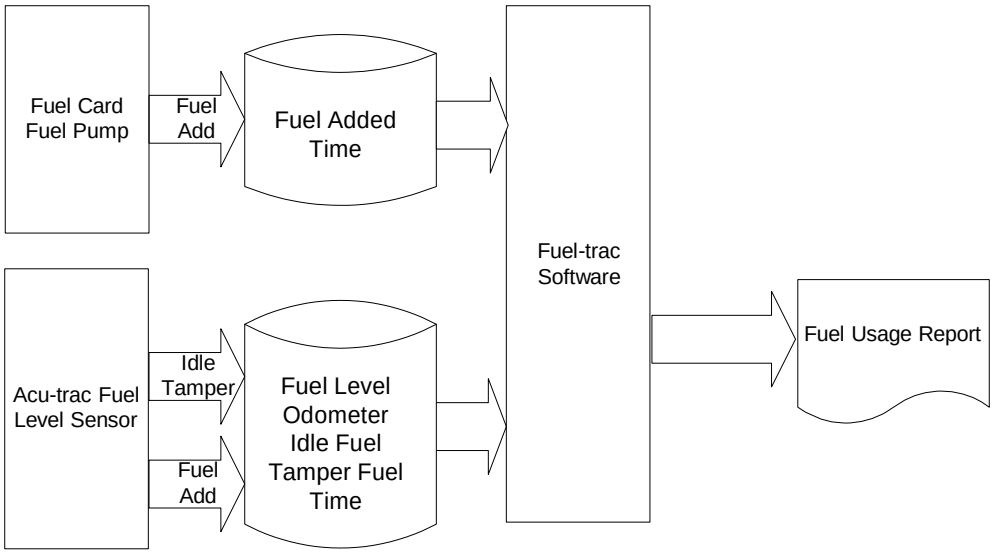

Figure 10 Data Flow Diagram for Generation of the Fuel Usage Report.

The Acu-Trac™ Fuel Level Sensor's Fuel sends out a Fuel Add message based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Added, Time/Date, Odometer, and Truck Location. The Fuel-trac software generates the Fuel Usage Report for a vehicle using the following procedure:

1. For each Fuel Purchase reported by the Fuel Card System (COMDATA, TCHECK, etc.), get the time/date of the purchase.
2. Using the time/date of the purchase, search the Acu-Trac™ Fuel Add Database for the Fuel Add that occurs immediately after this time/date.
3. Search the Acu-Trac™ Fuel Add Database for the previous fuel purchase that occurred for this truck.
4. Calculate the Fuel Burned using the following formula:

Fuel Used = Current Fuel Level – Previous Fuel Level + COMDATA Fuel Added.

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5. Calculate the distance driven using the following formula:

Distance = Current Fuel Add Truck Odometer – Previous Fuel Add Truck Odometer.

6. Tank MPG is then calculated using the following formula:

Tank MPG = Distance/Fuel Used.

7. Calculate the Percent Idle Fuel/Percent Tamper Fuel used by summing the Idle Fuel Quantity/Tamper Fuel Quantity for Idle/Tamper Messages received between the Fuel Adds and dividing by the Fuel Used Quantity.
8. Totals are calculated by summing Fuel Used and Distance. Average MPG over the time period is calculated as follows:

Ave Tank MPG = Summed Distance/Summed Fuel Used.

An example of the Tank MPG Report is shown in Figure 11.

Fuel Level Sensor Fuel Usage Report
Truck 34321 Date: 10/01/01 – 10/30/01

Date	Fuel Used	Percent Idle Fuel	Percent Tamper Fuel	Distance	Tank MPG
10/02/01	185.6	4.3	0.0	1271.4	6.85
10/06/01	108.3	7.4	0.0	792.8	7.32
10/12/01	119.3	0.0	6.7	825.6	6.92
10/18/01	93.2	8.6	0.0	601.1	6.45
10/27/01	123.2	6.5	0.0	834.1	6.77
10/30/01	95.3	0.0	8.4	690.0	7.24
Totals	724.9	4.4	2.2	5015.0	6.92

Figure 11 Tank MPG Report

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3 Message Descriptions

The Acu-Trac™ sensor's off-vehicle fuel data communications capability is set up to operate in conjunction with Qualcomm's OmniTRACS® system. In order to take advantage of the sensors off-vehicle communications you'll need a Qualcomm MCT Firmware version 16.10 or later attached to the vehicle's J1708 serial data bus.

The remote acquisition of fuel data is facilitated by the sensor's ability to communicate over the J1708 data bus and link through existing communications services. The system provides the capability of receiving the fuel sensor data based on a request or automatically through event driven messages.

Events include the following:

Request – The data can be read on request from the "Host" software.
Fuel Added – The sensor can automatically send the fuel data upon a fuel purchase.
Fuel Lost – The sensor can automatically send the fuel data when a configurable amount of fuel "disappears" from the tank.
Idle Fuel – The sensor can automatically send the fuel data when a configurable amount of idle fuel is burned.
PTO Fuel – The sensor can automatically send the fuel data when a configurable amount of PTO fuel is burned.
Low Fuel Warning – The sensor can automatically send the fuel data when a fuel level is below a configurable limit.

In addition the sensor can be configured to automatically reset the data on successful transmission of the data.

3.1 Qualcomm Binary Messaging

An application program running on a computer at a customer facility creates the binary messages described below. These messages are encapsulated in packets including such header information as the MCT number and the binary channel (in this case always 6). They are then imported into QTRACS for transmission to the NMC through QTRACS External Application Link (EAL). The import packet format is specific to the QTRACS

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platform (e.g. QTRACS/400 or QTRACS/Windows, etc), and is not described in this document; please refer to the appropriate QTRACS documentation. The NMC receives the messages from the customer facility and repackages them for over the air transmission to the MCT.

3.1.1 Initializing the Remote Data Link

The Qualcomm Mobile Communication Terminal, MCT, (located in the vehicle) must first, be programmed to recognize the existence of the Acu-Trac® fuel sensor on the vehicle's J1708 data bus. The programming operation is executed remotely by issuing a free form binary text *Initialization Command* from the base unit over the Qualcomm network to the vehicle's MCT. The following binary message is used to program the Qualcomm MCT for communication to and from the Acu-Trac® fuel sensor MID 143.

10038F0F0001B5070001DD0D0001

Byte	Value	Definition
1	0x10	Device MID Configuration Message
2	0x03	Number of MID's being Configured.
3	0x8F	Fuel Level Sensor MID 143
4	0x0F	Bit packed flag field for Fuel Level Sensor
5-6	0x0001	Maximum Transmission Rate from the Fuel Level Sensor in Minutes
7	0xB5	Satellite Communications MID 181(MCT Sat. Comm. MID)
8	0x07	Bit packed flag field for Satellite Communications
9-10	0x0001	Maximum Transmission Rate from the MCT in Minutes.
11	0xDD	Driver Information Center #2 MID 221(MCT Display MID)
12	0x0D	Bit packed flag field for Driver Information Center #2
13	0x0001	Maximum Transmission Rate from the MCT Display in Minutes.

Table 1 Binary message to program MCT for communications with Acu-Trac™

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The Bit Packed Flag Field is defined in the following table. Note that a bit value of "1" is enabled and a bit value of "0" is disabled.

Bit	Definition	Description
0	Device Information Monitoring Enabled	The MCT will automatically monitor the Device Information from the Fuel Level Sensor and Report changes through a Device Information Message
1	Device ROTA (Return Over the Air) Enable.	The Fuel Level Sensor is enabled to send event-based messages back to the application software program.
2	Device FOTA (Forward Over The Air) Enable.	The MCT is enabled to send messages to the Fuel Level Sensor.
3	Device Freeform Display Enable.	The device is enabled to send display messages.
4-7	Reserved.	Reserved.

Table 2 Flag field for Acu-Trac™ Fuel Level Sensor

Once initialization is complete, the vehicle's MCT will send a Device Information Message for each of the MIDs contained in the Initialization Message (143, 181, and 221). These messages will be returned as binary type 006 messages. The Device Information Message for the fuel level sensor provides the fuel level sensor's serial number, model number, revision level, software part numbers all packaged into an 82 character binary text string:

Please pay particularly close attention to Bytes 4 through 36 (characters 8 through 72), of the Binary Text String. They comprise the Acu-Trac™ fuel sensor's serial number, model number, revision level, software part numbers and revision levels, which must be retained by the user and inserted into the FOTA messages that are sent to the fuel level sensor. These messages are described latter in this chapter.

138F02464C5331320130083032303331303031108F313331373134352A31333136303732E6B4F11EE6

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The definitions and identifications contained within the binary text string are coded as follows (hexadecimal):

Byte	Value	Definition
1	0x13	Device MID Message
2	0x8F	Fuel Sensor MID
3	0x02	Device Information Message
4	**0x46**	**ASCII Sensor Make always "F", 0x46**
5	**0x4C**	**ASCII Make always "L", 0x4C**
6	**0x53**	**ASCII Make always "S", 0x53**
7	**0x31**	**ASCII Make always "1", 0x31**
8	**0x32**	**ASCII Make always "2", 0x32**
9	**0x01**	**Number of Make revision level characters, 1**
10	**0x30**	**ASCII Make revision level, "0"**
11	**0x08**	**Number of Serial # bytes to follow**
12	**0x30**	**ASCII Sensor S/N 1st Character Year "0"**
13	**0x32**	**ASCCII S/N 2nd Character Year "2"**
14	**0x30**	**ASCII S/N 1st Character Day "0"**
15	**0x33**	**ASCII S/N 1st Character Day "3"**
16	**0x31**	**ASCII S/N 1st Character Day "1"**
17	**0x30**	**ASCII S/N 1st Character "0"**
18	**0x30**	**ASCII S/N 1st Character "0"**
19	**0x31**	**ASCII S/N 1st Character "1"**
20	**0x10**	**Number of Software P/N + sensor MID bytes to follow**
21	**0x8F**	**Fuel Sensor MID**
22	**0x31**	**ASCII fuel sensor measurement software P/N, 1st digit, always "1"**
23	**0x33**	**ASCII fuel sensor measurement software P/N, 2nd digit, always "3"**
24	**0x31**	**ASCII measurement software P/N, 3rd, always "1"**
25	**0x37**	**ASCII measurement software P/N, 4th, always "7"**
26	**0x31**	**ASCII measurement software revision level, MSB, "1"**
27	**0x34**	**ASCII measurement software revision level, MSB-1 "4"**
28	**0x35**	**ASCII measurement software revision level, LSB "5"**

Table 3 Device Information Message

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Byte	Value	Definition
29	**0x2A**	**ASCII delimiter between P/N's always ***
30	**0x31**	**ASCII fuel sensor communications software P/N, 1st digit, always "1"**
31	**0x33**	**ASCII communications software P/N, 2nd digit, always "3"**
32	**0x31**	**ASCII communications software P/N, 3rd digit, always "1"**
33	**0x36**	**ASCII communications software P/N, 4th digit, always "6"**
34	**0x30**	**ASCII communications software rev level, MSB, "0"**
35	**0x37**	**ASCII communications software rev level, MSB-1, "7"**
36	**0x32**	**ASCII communications software rev level, LSB, "2"**
37	0xE6	
38	0xB4	
39	0XF1	
40	**0x1E**	**Message CRC high byte, Always 1E**
41	**0xE6**	**Message CRC low byte, Always E6**

Table 3 Device Information Message (Cont.)

Device Information Message bytes 4 through 36 (bold font) comprise the *Acu-Trac*®™ *Sensor Identification String* which is unique for each sensor and will be extracted and embedded into the *Fuel Optimization Command* later on in this chapter:

Acu-Trac™ Sensor Identification String - Sample

```
464C533132013008303230333130303110 8F313331373134352A313331363037 32
```

This information, Acu-Trac™ Sensor Identification String, must be retained as it is an integral part of the free-form binary command structure set up by Qualcomm for linking J1708 data through the Qualcomm communications network.

Important Note: Even though the Qualcomm MCT has its own unique Make Model and ID included in each transmission the sensor's identification (Make Model, and Serial) also must be included in the free form messages to the MCT in order for the data transfer to occur correctly.

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3.1.2 Issuing a Fuel Data Request Command

The fuel data request command is a binary text message that contains the Fuel Command Header in addition to the Acu-Trac™ fuel sensor specific identification. (*Note - the Acu-Trac™ fuel sensor specific identification detail was embedded in the Qualcomm MCT's Device Information response as described previously.)* The fuel command is used to interrogate Acu-Trac™ fuel sensor and cause it to provide a return message containing the fuel data.

Important note:
The binary text string embedded within the Fuel Data Request Command is unique for every Acu-Trac® fuel sensor and vehicle MCT combination. Meaning that a separate Fuel Data Request Command Message will need to be retained for each Acu-Trac® fuel sensor installation.

The process begins by creating the *Fuel Data Request Command* and then posting the command through QTRACS® in the same manner as the Initialization Command. Upon receipt of the Fuel Data Request Command the Qualcomm MCT responds by interrogating the Acu-Trac™ fuel sensor over the J1708 data link and then transfers the fuel information back over the Qualcomm network in the form of a free form binary message.

The *Fuel Data Request Command* is unique for every Acu-Trac™ sensor MCT combination due to the method employed by Qualcomm for communicating to other devices over the J1708 data link. The binary text section for the Fu*el Data Request Command* is defined as follows:

Bytes 1-3	Bytes 4 through 36 – extracted from Device Information Message	Bytes 37-39 Fuel Data Request	Bytes 40-41 CRC
13008F	**Acu-Trac® Sensor Identification String**	**008FCD**	**CFDB**

Using the device information from the example above gives the following binary text string:

13008F464C533132013008303230333130303110 8F313331373134352A31333136303732008FCDCFDB

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The definitions and identifications contained within the binary text string are coded as follows (hexadecimal):

Byte	Value	Definition
1	0x13	Device MID Message
2	0x00	Device Addressed FOTA Message.
3	0x8F	Device MID(0x8F = 143 Fuel Level Sensor)
4	**0x46**	**ASCII Sensor Make always "F", 0x46**
5	**0x4C**	**ASCII Make always "L", 0x4C**
6	**0x53**	**ASCII Make always "S", 0x53**
7	**0x31**	**ASCII Make always "1", 0x31**
8	**0x32**	**ASCII Make always "2", 0x32**
9	**0x01**	**Number of Make revision level characters, 1**
10	**0x30**	**ASCII Make revision level, "0"**
11	**0x08**	**Number of Serial # bytes to follow**
12	**0x30**	**ASCII Sensor S/N 1st Character Year "0"**
13	**0x32**	**ASCCII S/N 2nd Character Year "2"**
14	**0x30**	**ASCII S/N 1st Character Day "0"**
15	**0x33**	**ASCII S/N 1st Character Day "3"**
16	**0x31**	**ASCII S/N 1st Character Day "1"**
17	**0x30**	**ASCII S/N 1st Character "0"**
18	**0x30**	**ASCII S/N 1st Character "0"**
19	**0x31**	**ASCII S/N 1st Character "1"**
20	**0x10**	**Number of Software P/N + sensor MID bytes to follow**
21	**0x8F**	**Fuel Sensor MID**
22	**0x31**	**ASCII fuel sensor measurement software P/N, 1st digit, always "1"**
23	**0x33**	**ASCII fuel sensor measurement software P/N, 2nd digit, always "3"**
24	**0x31**	**ASCII measurement software P/N, 3rd, always "1"**
25	**0x37**	**ASCII measurement software P/N, 4th, always "7"**
26	**0x31**	**ASCII measurement software revision level, MSB, "1"**
27	**0x34**	**ASCII measurement software revision level, MSB-1 "4"**
28	**0x35**	**ASCII measurement software revision level, LSB "5"**

Table 4 Fuel Data Request Command

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Byte	Value	Definition
29	**0x2A**	**ASCII delimiter between P/N's always ***
30	**0x31**	**ASCII fuel sensor communications software P/N, 1st digit, always "1"**
31	**0x33**	**ASCII communications software P/N, 2nd digit, always "3"**
32	**0x31**	**ASCII communications software P/N, 3rd digit, always "1"**
33	**0x36**	**ASCII communications software P/N, 4th digit, always "6"**
34	**0x30**	**ASCII communications software rev level, MSB, "0"**
35	**0x37**	**ASCII communications software rev level, MSB-1, "7"**
36	**0x32**	**ASCII communications software rev level, LSB, "2"**
37	0x00	Fuel Data Request Command Byte 1
38	0x8F	Fuel Data Request Command Byte 2
39	0XCD	Fuel Data Request Command Byte 3
40	**0xCF**	**Message CRC high byte, Always CF**
41	**0xDB**	**Message CRC low byte, Always DB**

Table 4 Fuel Data Request Command (Cont.)

Bytes 4 through 36 (bold font) comprise the *Acu-Trac™ Sensor Identification String* which is unique for each sensor and was extracted from the Device Information Message earlier this chapter:

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3.2 Fuel Data Message

The Acu-Trac™ Fuel Sensor generates a *Fuel Data Message* in response to the *Fuel Data Request Command* or upon a fuel event.

Once the fuel related data transfer between Acu-Trac™ fuel sensor and the vehicle's MCT has been completed the vehicle's MCT will forward the message through the Qualcomm network and into your QTRACS® application. The QTRACS® External Application's Link will provide the data to your application program.

The definitions and identifications contained within the binary text string, are coded as shown below, (All Values are in Hexadecimal)

Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00 for a Fuel Data Response
4	0x00	Reserve byte always 0x00
5	**0x02**	**MSB of the fuel quantity in 1/8 gallon increments**
6	**0xED**	**LSB of the fuel quantity in 1/8 gallon increments**
7	**0x00**	**MSB of the fuel tank capacity in 1 gallon increments**
8	**0x64**	**LSB of the fuel tank capacity in 1 gallon increments**
9	**0x05**	**MSB of the fuel economy in 1/256 MPG increments**
10	**0xDD**	**LSB of the fuel economy in 1/256 MPG increments**
11	**0x00**	**MSB of the idle fuel in 1/8 gallon increments.**
12	**0xB8**	**LSB of the idle fuel in 1/8 gallon increments.**
13	**0x00**	**MSB of the PTO fuel in 1/8 gallon increments.**
14	**0x4B**	**LSB of the PTO fuel in 1/8 gallon increments.**
15	**0x07**	**MSB of the Tamper fuel in 1/8 gallon increments.**
16	**0x2B**	**LSB of the Tamper fuel in 1/8 gallon increments.**
17	**0x01**	**MSB of the Lost fuel in 1/8 gallon increments.**
18	**0x48**	**LSB of the Lost fuel in 1/8 gallon increments.**

Table 5 Fuel Data Message

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Byte	Value	Definition
19	**0x01**	**MSB of the Added fuel in 1/8 gallon increments.**
20	**0x2B**	**LSB of the Added fuel in 1/8 gallon increments.**
21	**0xC0**	**Transmit Reason – See definition below.**
22	**0x15**	**Fuel Temperature**
23	**0x01**	**D3 (MSB) of Life to Date Total Fuel**
24	**0x33**	**D2 of Life to Date Total Fuel**
25	**0x1D**	**D1 of Life to Date Total Fuel**
26	**0xCA**	**D0 (LSB) of Life to Date Total Fuel**
27	**0x02**	**D3 (MSB) of Life to Date Total Distance**
28	**0x41**	**D2 of Life to Date Total Distance**
29	**0xD9**	**D1 of Life to Date Total Distance**
30	**0xF2**	**D0 (LSB) of Life to Date Total Distance.**
31	**0x00**	**Spare**
32	0x44	CRC high byte
33	0xC8	CRC low byte

Table 5 Fuel Data Message (Cont.)

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Decoding the Fuel Data Message

The illustration below details the structure of the binary text component of the *Fuel Data Message* as depicted in the previous example.

- Fuel Quantity on Remaining (bytes 5 & 6)
  - Fuel Quantity = 0x02ED
  - Convert to Decimal = 749
  - Convert to gallons (divide by 8) = 749/8 = 93.6 gallons
- Fuel Tank Capacity (bytes 7 & 8)
  - Tank Capacity = 0x0064
  - Convert to Decimal = 100 gallons
- Fuel Economy in MPG (bytes 9 & 10)
  - Fuel Economy = 0x05DD
  - Convert to Decimal = 1501
  - Convert to MPG (divide by 256) = 1570/256 = 5.86 mpg
- Idle Fuel (bytes 11 & 12)
  - Idle Fuel = 0x00B8
  - Convert to Decimal = 184
  - Convert to gallons (divide by 8) = 184/8 = 23 gallons
- PTO Fuel (bytes 13 & 14)
  - PTO Fuel = 0x004B
  - Convert to Decimal = 75
  - Convert to gallons (divide by 8) = 75/8 = 9.38 gallons
- Tamper Fuel (bytes 15 & 16)
  - Tamper Fuel = 0x072B
  - Convert to Decimal = 1835
  - Convert to gallons (divide by 8) = 1835/8 = 229.38 gallons

Important Note:
The Average MPG is based on a running average covering the last 16 hours of vehicle operation. In performing the calculation, the sensor excludes idling at rest, stops, and out of range data such as traveling in excess of 100 miles or less than 20 miles in one hour.
A valid average MPG value will not be available until the vehicle has been operating for at least 16 hours on the road with the Acu-Trac™ fuel sensor installed.

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- Lost Fuel (bytes 17 & 18)
  - Lost Fuel = 0x0148
  - Convert to Decimal = 328
  - Convert to gallons (divide by 8) = 328/8 = 41 gallons
- Added Fuel (bytes 19 & 20)
  - Added Fuel = 0x012B
  - Convert to Decimal = 299
  - Convert to gallons (divide by 8) = 299/8 = 37.38 gallons
- Transmit Reason (byte 21)
  - Transmit Reason =0xC0
- Fuel Temperature (byte 22)
  - Fuel Temperature =0x15
  - Convert to Decimal =21 degrees C.
- Life to Date Total Fuel (byte 23-26)
  - Life to Date Total Fuel =0x01331DCA
  - Convert to Decimal = 20127178
  - Convert to gallons (divide by 8) = 2515897.25 gallons.
- Life to Date Total Distance (byte 23-26)
  - Life to Date Total Distance =0x0241D9F2
  - Convert to Decimal = 37870066
  - Convert to miles (divide by 10) = 3787006.6 miles

Bits 7 and 6 are set. See Table Below for Transmit Reason definition. The data was received due to being requested and an ECM Exchange.

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Host Request	Low Fuel	Fuel Lost	PTO Fuel		
				1	Idle Fuel Consumed during the stop was in excess of the Idle Fuel Notification Parameter.
			1		PTO Fuel Consumed during the stop was in excess of the PTO Fuel Notification Parameter.
		1			The sensor and/or data link was disabled for a period of time during which the fuel consumed was in excess of the Tamper Fuel Notification Parameter.
		1			Fuel Removed from the Tank was in excess of the Fuel Lost Notification Parameter.
	1				Fuel Added to the Tank was in excess of the Fuel Added Notification Parameter.
	1				The current Fuel Quantity in the Tank is less than the Low Fuel Notification Parameter.
1					The Sensor/ECM has been exchanged during the stop.
1					The Host Software requested the fuel data.

Table 6 Transmit Reason Bit Definitions.

3.3 Event Based Messages

As previously mentioned, the Acu-Trac™ Fuel Level Sensor supports fuel event based messaging. The fuel level sensor supports two modes of operation based on the Minimized Messages bit in the Satellite Communications Parameters previously defined. If the Minimized Message bit is disabled the fuel level sensor will send out the Fuel Data Message on each event. Reference the Fuel Data Message Section for the definition of this message. If the Minimized Message bit is enabled, the fuel level sensor will send the minimized event based messages defined below.

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3.3.1 Minimized Fuel Add Return Message

If the Minimized Message bit and the Fuel Added Transmit bit are enabled in the Satellite Communications Parameter, the Acu-Trac™ fuel level sensor will send a Minimized Fuel Add Return Message each time the fuel added to the tank exceeds the Fuel Added Configuration Level defined in the Satellite Communications Parameter. The binary text for the Minimized Fuel Add Return Message is defined in the table below:

Minimized Fuel Add Return Message		
Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x85	Header for fuel add 133
7	0x3D	8 bit % capacity @ 0.5% per bit
8	0x6E	8 bit mpg @ 1/16 mpg per bit
9	0x02	MSB of the fuel add quantity in 1/8 gallon increments
10	0x12	LSB of the fuel add quantity in 1/8 gallon increments
11	0x02	Byte 3 of the odometer reading at the time of the add @ 0.1 miles per bit
12	0x4B	Byte 2 of the odometer reading at the time of the add @ 0.1 miles per bit
13	0xD1	Byte 1 of the odometer reading at the time of the add @ 0.1 miles per bit
14	0x7C	Byte 0 of the odometer reading at the time of the add @ 0.1 miles per bit
15	0x??	CRC high byte
16	0x??	CRC low byte

Table 7 Minimized Fuel Add Message

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The illustration below details the structure of the binary text component of the *Minimized Fuel Add Return Message* as depicted in the previous example.

- 8 bit Percent Fuel Quantity Remaining (byte 7)
  - Fuel Quantity = 0x3D
  - Convert to Decimal = 61
  - Convert to percent (multiply by 0.5) = 30.5 percent.
  - Multiply by Tank Capacity =0.305*190 = 57.9 gal
- 8 bit Fuel Economy in MPG (byte 8)
  - Fuel Economy = 0x6E
  - Convert to Decimal = 110
  - Convert to MPG (divide by 16) = 110/16 = 6.87 mpg
- Fuel Added Quantity (bytes 9 & 10)
  - Fuel Added = 0x0212
  - Convert to Decimal = 530
  - Convert to gallons (divide by 8) = 530/8 = 66.25 gal
- Fuel Added Odometer (bytes 11-14)
  - Fuel Added Odometer = 0x024BD17C
  - Convert to Decimal = 38523260
  - Convert to miles (divide by 10) = 38523260/10 = 3852326.0 miles

Important Note: The Percent Fuel Quantity and Fuel Added Odometer are captured at the time of the fuel add. They are captured at the time of the fuel add to allow a Tank MPG calculation. They do not reflect the Fuel Quantity or Odometer at the time the message is received.

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3.3.2 Minimized Fuel Loss Return Message

If the Minimized Message bit and the Fuel Loss Transmit bit are enabled in the Satellite Communications Parameter, the Acu-Trac™ fuel level sensor will send a Minimized Fuel Loss Return Message each time the fuel lost from the tank exceeds the Fuel Loss Configuration Level defined in the Satellite Communications Parameter. The binary text for the Minimized Fuel Loss Return Message is defined in the table below:

Minimized Fuel Loss Return Message		
Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x86	Header for fuel loss 134
7	0x01	MSB of the fuel loss quantity in 1/8 gallon increments
8	0x9E	LSB of the fuel loss quantity in 1/8 gallon increments
9	0x??	CRC high byte
10	0x??	CRC low byte

Table 8 Minimized Fuel Loss Message

The illustration below details the structure of the binary text component of the *Minimized Fuel Loss Return Message* as depicted in the previous example.

- Fuel Loss Quantity (bytes 7 & 8)

  Fuel Loss = 0x019E

  Convert to Decimal = 414

  Convert to gallons (divide by 8) = 414/8 = 51.75 gallons

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3.3.3 Minimized Idle Tamper Return Message

If the Minimized Message bit and the Idle Fuel Transmit bit are enabled in the Satellite Communications Parameter, the Acu-Trac™ fuel level sensor will send a Minimized Idle Tamper Return Message each time the Idle fuel exceeds the Idle Fuel Configuration Level defined in the Satellite Communications Parameter. If the Minimized Message bit and the Tamper Transmit bit are enabled in the Satellite Communications Parameter, the Acu-Trac™ fuel level sensor will send a Minimized Idle Tamper Return Message each time the Tamper fuel exceeds the Tamper Fuel Configuration Level defined in the Satellite Communications Parameter. The binary text for the Minimized Idle Tamper Return Message is defined in the table below:

Minimized Idle Tamper Return Message		
Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x87	Header for Idle/Tamper 135
7	0x00	MSB Cumm Idle Fuel Consumed @ 1/8 gallon/bit
8	0x45	LSB Cumm Idle Fuel Consumed @ 1/8 gallon/bit
9	0x00	MSB Cumm Tamper Fuel Consumed @ 1/8 gal/bit
10	0x12	LSB Cumm Tamper Fuel Consumed @ 1/8 gal/bit
11	0x??	CRC high byte
12	0x??	CRC low byte

Table 9 Minimized Idle/Tamper Message

The illustration below details the structure of the binary text component of the *Minimized Idle Tamper Return Message* as depicted in the previous example.

- Idle Fuel Quantity (bytes 7 & 8)
  - Idle Fuel = 0x0045
  - Convert to Decimal = 69
  - Convert to gallons (divide by 8) = 69/8 = 8.62 gallons
- Tamper Fuel Quantity (bytes 9 & 10)
  - Tamper Fuel = 0x0012
  - Convert to Decimal = 18
  - Convert to gallons (divide by 8) = 18/8 = 2.25 gallons

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3.3.4 Minimized Sensor/ECM Exchange Return Message

If the Minimized Message bit and the Tamper Transmit bit are enabled in the Satellite Communications Parameter, the Acu-Trac™ fuel level sensor will send a Minimized Sensor/ECM Exchange Return Message each time the sensor detects that the Component ID of the ECM has changed. This methodology was implemented to prevent drivers from switching the sensor to a different truck. Note that if this message is enabled at the time it is installed on the truck, the message will be sent.

Minimized Sensor/ECM Exchange Return Message		
Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x8A	Header for Sensor/ECM Exchange 138
7	0x??	CRC high byte
8	0x??	CRC low byte

Table 10 Minimized Sensor/ECM Exchange Message

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3.3.5 Minimized Low Fuel Return Message

If the Minimized Message bit and the Low Fuel Transmit bit are enabled in the Satellite Communications Parameter, the Acu-Trac™ fuel level sensor will send a Minimized Low Fuel Return Message at the time the fuel level falls below the Low Fuel Configuration Level defined in the Satellite Communications Parameter. The binary text for the Minimized Low Fuel Return Message is defined in the table below:

Minimized Low Fuel Return Message		
Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x88	Header for Low Fuel 136
7	0x3D	8 bit % capacity @ 0.5% per bit
8	0x6E	8 bit mpg @ 1/16 mpg per bit
9	0x02	Byte 3 of the current odometer reading @ 0.1 miles per bit
10	0x4B	Byte 2 of the current odometer reading @ 0.1 miles per bit
11	0xD1	Byte 1 of the current odometer reading @ 0.1 miles per bit
12	0x7C	Byte 0 of the current odometer reading @ 0.1 miles per bit
13	0x??	CRC high byte
14	0x??	CRC low byte

Table 11 Minimized Low Fuel Message

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The illustration below details the structure of the binary text component of the *Minimized Low Fuel Return Message* as depicted in the previous example.

- 8 bit Percent Fuel Quantity Remaining (byte 7)
  - Fuel Quantity = 0x3D
  - Convert to Decimal = 61
  - Convert to percent (multiply by 0.5) = 30.5 percent.
  - Multiply by Tank Capacity =0.305*190 = 57.9 gal
- 8 bit Fuel Economy in MPG (byte 8)
  - Fuel Economy = 0x6E
  - Convert to Decimal = 110
  - Convert to MPG (divide by 16) = 110/16 = 6.87 mpg
- Fuel Added Odometer (bytes 9-12)
  - Fuel Added Odometer = 0x024BD17C
  - Convert to Decimal = 38523260
  - Convert to miles (divide by 10) = 38523260/10 = 3852326.0 miles

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3.3.6 Minimized PTO Return Message

If the Minimized Message bit and the PTO Fuel Transmit bit are enabled in the Satellite Communications Parameter, the Acu-trac™ fuel level sensor will send a Minimized PTO Return Message each time the PTO fuel exceeds the PTO Fuel Configuration Level defined in the Satellite Communications Parameter. The binary text for the Minimized PTO Return Message is defined in the table below:

Minimized Idle Tamper Return Message		
Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x89	Header for PTO
7	0x00	MSB Cumm PTO Fuel Consumed @ 1/8 gallon/bit
8	0x45	LSB Cumm PTO Fuel Consumed @ 1/8 gallon/bit
9	0x??	CRC high byte
10	0x??	CRC low byte

Table 12 Minimized PTO Data Message

The illustration below details the structure of the binary text component of the *Minimized PTO Return Message* as depicted in the previous example.

- PTO Fuel Quantity (bytes 7 & 8)
  - PTO Fuel = 0x0045
  - Convert to Decimal = 69
  - Convert to gallons (divide by 8) = 69/8 = 8.62 gallons

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3.3.7 Minimized Fuel Data Message

The Minimized Fuel Data Request command is a binary text message that contains a PID 250 request to the fuel level sensor. The syntax for the request is as follows:

238FFA0000000000

The Minimized Fuel Data Request command is used to interrogate Acu-Trac™ fuel sensor and cause it to provide a return message containing the following binary text message:

Minimized Fuel Optimization Return Message		
Byte	Value	Definition
0	**0x23**	**Qualcomm Specific PID Request**
1	**0x00**	**Reserved**
2	**0x8F**	**Fuel Level Sensor MID 143**
3	**0xFA**	**Total Fuel PID 250**
4	**0x8F**	**Fuel Level Sensor MID 143**
5	**0x05**	**Total Number of Response Bytes**
6	**0x04**	**Number of Bytes in this response**
7	**0x02**	**MSB of the fuel quantity in 1/8 gallon increments**
8	**0xED**	**LSB of the fuel quantity in 1/8 gallon increments**
9	**0x05**	**MSB of the fuel economy in 1/256 MPG increments**
10	**0xDD**	**LSB of the fuel economy in 1/256 MPG increments**
11-14		Unused.

Table 13 Minimized Fuel Data Message

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The illustration below details the structure of the binary text of the *Minimized Fuel Data Message* as depicted in the previous example.

- Fuel Quantity on Remaining (bytes 7 & 8)
  - Fuel Quantity = 0x02ED
  - Convert to Decimal = 749
  - Convert to gallons (divide by 8) = 749/8 = 93.6 gallons
- Fuel Economy in MPG (bytes 9 & 10)
  - Fuel Economy = 0x05DD
  - Convert to Decimal = 1501
  - Convert to MPG (divide by 256) = 1570/256 = 5.86 mpg

Important Note:
The Average MPG is based on a running average covering the last 16 hours of vehicle operation. In performing the calculation, the sensor excludes idling at rest, stops, and out of range data such as traveling in excess of 100 miles or less than 20 miles in one hour.
A valid average MPG value will not be available until the vehicle has been operating for at least 16 hours on the road with the Acu-Trac™ fuel sensor installed.

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3.4 Fuel Level Sensor Configuration Messages

3.4.1 Satellite Communications Parameters Write Message

The Acu-Trac™ Fuel Level Sensor provides remote configuration of the following items:

1. Event based automatic messaging.
2. Idle Fuel Notification Parameter
3. PTO Fuel Notification Parameter
4. Tamper Fuel Notification Parameter
5. Fuel Lost Notification Parameter
6. Fuel Added Notification Parameter

Writing the Satellite Communications Parameters to the fuel level sensor follows the same process as the Fuel Data Request Command. Reference the Fuel Data Request Command Section for more details. An example of the binary text for the Satellite Communications Write message is shown below:

Satellite Communications Parameter Write Message.

Bytes 1-3	Bytes 4 through 36 – extracted from Device Information Message	Bytes 37-43 SatCom Parameters	Bytes 44-45 CRC
13008F	**Acu-Trac™ Sensor Identification String**	**008F7D5F211233**	**AF13**

Reference the Fuel Data Request Command Section on the definition of the first 36 bytes. Bytes 37 ➔43 constitute the Satellite Com Parameters configuration data as follows:

Byte	Value	Definition
37	0x00	Reserved Byte
38	0x8F	Fuel Sensor MID
39	0x7D	Satellite Communication Parameters identification message type
40	0x5F	Communication option parameter
41	0x21	Fill Loss Notification Parameter
42	0x12	Idle/PTO Notification Parameter
43	0x33	Tamper/Low Fuel Parameter

Table 14 Satellite Communications Parameters

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The communications options parameter is defined as follows:

Low Fuel Transmit	Added Transmit	PTO Transmit	Minimize Message	
			1	**Reset Data on successful Transmit.**
			1	**Enable Minimized Event Based ROTA Messages.**
		1		**Transmit the Fuel Data Message when the Idle Fuel Consumed during the stop is in excess of the Idle Fuel Notification Parameter.**
		1		**Transmit the Fuel Data Message when the PTO Fuel Consumed during the stop is in excess of the PTO Fuel Notification Parameter.**
	1			**Transmit the Fuel Data Message when the Fuel Removed from the Tank is in excess of the Fuel Lost Notification Parameter.**
	1			**Transmit the Fuel Data Message when the Fuel Added to the Tank is in excess of the Fuel Added Notification Parameter.**
1				**Transmit the Fuel Data Message when the sensor and/or data link was disabled for a period of time during which the fuel consumed was in excess of the Tamper Fuel Notification Parameter.**
1				**Transmit the Fuel Data Message when current Fuel Quantity in the Tank is less than the Low Fuel Notification Parameter.**

Table 15 Communication Option Parameter

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Communications Options Parameter (byte 38)

Communication Options = 0x5F

- Reset Enabled.
- Minimize Message Enabled
- Idle Transmit Enabled
- PTO Transmit Enabled
- Lost Enabled
- Adds Disabled
- Tamper Enabled
- Low Disabled

- Fill/Loss Notification Parameter (byte 39)

  Fill/Loss Parameter = 0x21

  Loss = 0x1 (Lower Nibble)

  Loss = 0x1*10 gallons per bit = 10 gallons.

  Fill = 0x2 (Upper Nibble)

  Fill = 0x2 * 10 gallons per bit = 20 gallons.

- Idle/PTO Notification Parameter (byte 40)

  Idle/PTO Parameter = 0x12

  PTO = 0x2 (Lower Nibble)

  PTO = 0x2*1 gallons per bit = 2 gallons.

  Idle = 0x1 (Upper Nibble)

  Idle = 0x1 * 1 gallons per bit = 1 gallons.

- Tamper/Low Fuel Notification Parameter (byte 41)

  Tamper/Low Fuel Parameter = 0x33

  Low Fuel = 0x3 (Lower Nibble)

  Low Fuel = 0x3*10 gallons per bit = 30 gallons.

  Tamper = 0x3 (Upper Nibble)

  Tamper = 0x3 * 1 gallons per bit = 3 gallons.

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3.4.2 Satellite Communications Parameter Read Message

Reading the Satellite Communications Parameters from the fuel level sensor follows the same process as the Fuel Data Request Command. Reference the Fuel Data Request Command Section for more details. An example of the binary text for the Satellite Communications Read message is shown below:

Satellite Communications Parameter Read Message.

Bytes 1-3	Bytes 4 through 36 – extracted from Device Information Message	Bytes 37-39 Read Command	Bytes 40-41 CRC
13008F	**Acu-Trac® Sensor Identification String**	**008F7D**	**6800**

Satellite Communications Parameter Response Message

After receiving a Satellite Communications Write Message or Read Message, the sensor will respond with the Satellite Communications Parameter Response Message. The binary text for the Satellite Communications Parameter Response Message is as follows:

Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00 for a Fuel Sensor Response
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x7D	Satellite Communications Identification message type
7	0x5F	Communication option parameter
8	0x21	Fill Loss Notification Parameter
9	0x12	Idle/PTO Notification Parameter
10	0x33	Tamper/Low Fuel Parameter
11	0xAF	MSB of CRC 16
12	0x13	LSB of CRC 16

Table 16 Satellite Communication Parameter

Reference the Satellite Communication Parameters Write Message for the definition of these bytes.

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3.4.3 Tank Capacity Write Message

Writing the Tank Capacity to the fuel level sensor follows the same process as the Fuel Data Request Command. Reference the Fuel Data Request Command Section for more details. An example of the binary text for the Tank Capacity Write message is shown below:

Tank Capacity Write Message.

Bytes 1-3	Bytes 4 through 36 – extracted from Device Information Message	Bytes 37-43 Tank Capacity	Bytes 44-45 CRC
13008F	**Acu-Trac™ Sensor Identification String**	**008F7B011C5150**	**3659**

Reference the Fuel Data Request Command Section on the definition of the first 36 bytes. Bytes 37 through 43 constitute the Tank Capacity configuration data as defined in the following table:

Byte	Value	Definition
37	0x00	Reserved Byte
38	0x8F	Fuel Sensor MID
39	0x7B	Tank Capacity identification message type
40	0x01	Tank Capacity MSB
41	0x1C	Tank Capacity LSB
42	0x51	Reserved
43	0x50	Reserved

Table 17 Tank Capacity Write Message

- Tank Capacity Parameter (bytes 40 and 41)
  Tank Capacity = 0x011C
  Convert to Decimal = 284 gallons

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3.4.4 Tank Capacity Read Message

Reading the Tank Capacity from the fuel level sensor follows the same process as the Fuel Data Request Command. Reference the Fuel Data Request Command Section for more details. An example of the binary text for the Tank Capacity Read message is shown below:

Tank Capacity Read Message.

Bytes 1-3	Bytes 4 through 36 – extracted from Device Information Message	Bytes 37-39 Read Command	Bytes 40-41 CRC
13008F	**Acu-Trac™ Sensor Identification String**	**008F7B**	**08C6**

3.4.5 Tank Capacity Response Message

After receiving a Tank Capacity Write Message or Read Message, the sensor will respond with the Tank Capacity Response Message. The binary text for the Tank Capacity Response Message is defined as follows:

Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00 for a Fuel Sensor Response
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x7B	Tank Capacity Identification message type
7	0x01	Tank Capacity MSB
8	0x1C	Tank Capacity LSB
9	0x51	Spare
10	0x50	Spare
11	0x??	MSB of CRC 16
12	0x??	LSB of CRC 16

Table 18 Tank Capacity Read Message

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3.4.6 Tank Parameters Write Message

Writing the Tank Parameters to the fuel level sensor follows the same process as the Fuel Data Request Command. Reference the Fuel Data Request Command Section for more details. An example of the binary text for the Tank Parameters Write message is shown below:

Tank Parameters Write Message.

Bytes 1-3	Bytes 4 through 36 Device Information	Bytes 37-43 Tank Parameters	Bytes 44-45 CRC
13008F	**Acu-Trac™ Sensor Identification String**	**008F8141F000004120000 00000000051**	**F931**

Reference the Fuel Data Request Command Section on the definition of the first 36 bytes. Bytes 37 through 43 constitute the Tank Capacity configuration data as defined in the following table:

Byte	Value	Definition
37	0x00	Reserved Byte
38	0x8F	Fuel Sensor MID
39	0x81	Tank Parameters identification message type
40	0x41	Tank Depth D3 (MSB)
41	0xF0	Tank Depth D2
42	0x00	Tank Depth D1
43	0x00	Tank Depth D0 (LSB)
44	0x41	Air Gap D3 (MSB)
45	0x20	Air Gap D2
46	0x00	Air Gap D1
47	0x00	Air Gap D0 (LSB)
48	0x00	Tank Width D3 (MSB)
49	0x00	Tank Width D2
50	0x00	Tank Width D1
51	0x00	Tank Width D0 (LSB)
52	0x51	Operations Mode

Table 19 Tank Capacity Configuration Data

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- Tank Depth Parameter (bytes 40 through 43)
  - Tank Depth in Floating Point = 0x41F00000
  - Convert to Decimal = 30.0 inches
- Air Gap Parameter (bytes 44 through 47)
  - Air Gap in Floating Point = 0x41200000
  - Convert to Decimal = 10.0 inches
- Tank Width Parameter (bytes 48 through 51)
  - Tank Width in Floating Point = 0x00000000
  - Convert to Decimal = 0.0 inches
- Decoding Operation Mode
  - Operations Mode Example = 51

Bit	Bit Definition	Bit Value	Field Definition	Field Value
0	Tank Geometry LSB	1	0 = Linear Distance 1 = Cylindrical Level 2 = Linear Level 3 = Table Lookup Level	1 = Cylindrical Level
1	Tank Geometry MSB	0		
2	Spare			
3	Spare			
4	Voltage Output Part	1	Enabled if Sensor has a Voltage Output	Voltage Output
5	Current Output Part	0	Enabled if the Sensor has a Current Output.	
6	Analog Output Mode LSB	1	1 = Linear Mode 2 = Spare 3 = Table Output	Linear Mode
7	Analog Output Mode MSB	0		

Table 20 Tank Parameters Write Message

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3.4.7 Tank Parameters Read Message

Reading the Tank Parameters from the fuel level sensor follows the same process as the Fuel Data Request Command. Reference the Fuel Data Request Command Section for more details. The binary text for the Tank Parameters Read message is shown below:

Tank Parameters Read Message.

Bytes 1-3	Bytes 4 through 36 – extracted from Device Information Message	Bytes 37-39 Read Command	Bytes 40-41 CRC
13008F	**Acu-Trac® Sensor Identification String**	**008F81**	**4693**

3.4.8 Tank Parameters Response Message

After receiving a Tank Parameters Write Message or Read Message, the sensor will respond with the Tank Parameters Response Message. The binary text for the Tank Parameters Response Message is defined as follows:

Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x00	Always 0x00 for a Fuel Sensor Response
4	0x00	Reserve byte always 0x00
5	0x8F	Fuel Sensor MID
6	0x81	Tank Parameters Identification message type
7	0x41	Tank Depth D3 (MSB)
8	0xF0	Tank Depth D2
9	0x00	Tank Depth D1
10	0x00	Tank Depth D0 (LSB)
11	0x41	Air Gap D3 (MSB)

Table 21 Tank Parameters Response Message

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Byte	Value	Definition
12	0x20	Air Gap D2
13	0x00	Air Gap D1
14	0x00	Air Gap D0 (LSB)
15	0x00	Tank Width D3 (MSB)
16	0x00	Tank Width D2
17	0x00	Tank Width D1
18	0x00	Tank Width D0 (LSB)
19	0x51	Operations Mode
20	0xF9	MSB of CRC 16
21	0x31	LSB of CRC 16

Table 21 Tank Parameters Response Message (Cont.)

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3.4.9 CRC Generation

Configuration Messages require the generation of a CRC as shown in the proceeding sections.

The CRC used is the standard 16-bit CCIT CRC calculated from the following polynomial:

$P(x) = x^{16} + x^{12} + x^5 + x$

Generation of the CRC starts with the data bytes for the message (Byte 37 in the above examples).

The following C++ function implements the 16-bit CCIT CRC polynomial. Only the configuration data bytes (starting with 37) are CRC'ed.

```
#define POLY16 0x1021

    short CFuelFiles::CRC_16 (unsigned char *data, int Num_Bytes)
    {
        int i, j;
        short crc = (short) 0xffff;
        for (i=0; i<Num_Bytes; i++)
        {
            for (j = 0; j<8; j++)
            {
                if (((short) (data[i] << (j+8)) ^crc) & 0x8000)
                    crc = (crc<<1) ^ POLY16;
                else crc <<= 1;
            }
        }
        return crc;
}
```

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3.5 Connection Error Notification Message

This message reports errors pertaining to the J1708 data link connection between the Qualcomm MCT and fuel level sensor. The binary text for the Connection Error Notification Message is defined as follows:

Byte	Value	Definition
1	0x13	Qualcomm MCT
2	0x8F	Fuel Sensor MID
3	0x01	Connection Error.
4	0x00	Reserve byte always 0x00
5	0x??	Error Flags

Table 22 Connection Error Notification Message

The Error Flags byte is defined as follows:

Bit	Description
0	Reserved
1	Device not enabled for FOTA messaging
2	J1708 bus transmission of FOTA message failed.
3	Device Information mismatch
4	FOTA CRC failure
5	Reserved
6	ROTA CRC failure
7	Invalid device information requested.
8-15	Reserved.

Table 23 Error Flags Definition

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3.6 Parsing Acu-Trac™ ROTA Messages

The following table provides a list of the Binary Messages returned through Channel 6 and suggestions on parsing them.

Binary Message	Prefix	Bytes	ID	Parsing/Comments
Minimized ECM Exchange Message.	138F00	16	8A	Parse on Prefix, Length, and ID
Minimized Fuel Loss Message	138F00	20	86	Parse on Prefix, Length, and ID
Minimized PTO Message	138F00	20	89	Parse on Prefix, Length, and ID
Tank Capacity Response Message	138F00	24	7B	Parse on Prefix, Length, and ID
Satellite Communications Response Message	138F00	24	7D	Parse on Prefix, Length, and ID
Minimized Idle/Tamper Message	138F00	24	87	Parse on Prefix, Length, and ID
Minimized Low Fuel Message	138F00	28	88	Parse on Prefix, Length, and ID
Minimized Fuel Optimization Message	23008F	30	FA	Parse on Prefix, Length, and ID
Minimized Fuel Add Message	138F00	32	85	Parse on Prefix, Length, and ID
Tank Parameters Response Message	138F00	42	81	Parse on Prefix, Length, and ID
Fuel Data Response Message	138F00	66	NA	Parse on Prefix, Length
Error Information	138F01	10	NA	Parse on Prefix, Length
Device Information	138F02	82	NA	Parse on Prefix, Length
Busy Signal Message	138F03	6	NA	Parse on Prefix, Length. MCT is busy and unable to process received message.

Table 24 ROTA Binary Messages

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