Intelligent Transceiver Unit (ITU)
Technical Description

May 12, 1999

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Technical Description

1 Introduction

This document describes a device that enables: 1) Reception of control and message data using the Subsidiary Communications Authorization (SCA) of a broadcast FM radio station, 2) Geolocation determination via an embedded Global Positioning System (GPS) receiver, 3) (Optional) External sensor monitoring, and 4) Transmission of control and message data using Terion proprietary wide area wireless communication technology.

1.1 System Description

The Intelligent Transceiver Unit (ITU) is the remote component of a messaging communications system from Terion. The system provides the ability to send messages to users anywhere in the United States and for the users to acknowledge receipt of the message, send a reply and/or send their own messages. A block diagram illustrating the overall system is shown in **Error! Not a valid link.**. There are five major components: 1) Outbound Network, 2) Inbound Network, 3) Network Hub , 4) Network Access Terminals and 5) Mobile Data Terminals.

The Network Hub provides the overall system message routing and control. A subscriber utilizes a Network Access Terminal to input messages to the Network Hub using either the public phone network or the Internet. The message is sent to the Mobile (or Fixed Remote) Subscriber using the Outbound Network. First data is routed to a VSAT (Very Small Aperture Terminal) up-link site for distribution to FM radio stations around the country. A VSAT receiver at the FM station receives the message and resends it out using the Radio Broadcast Data System (RBDS) protocol. The RBDS allows the message data to be sent out as modulation on the SCA subcarrier. The Intelligent Transceiver Unit (ITU) (also known as the Mobile Subscriber Terminal) provides the RBDS receiver, controller and the HF transmitter for the remote user. A Drivers Terminal (DT) is used to 1) read messages from the HUB Station and 2) compose and edit messages to be sent to the HUB Station. There are a number of different configurations to meet several market applications. The HF transmitter is used as part of the Inbound Network for messages from the remote users. Multiple HF receive sites are provided to process the messages coming from remote users and route them to the hub site using landlines.

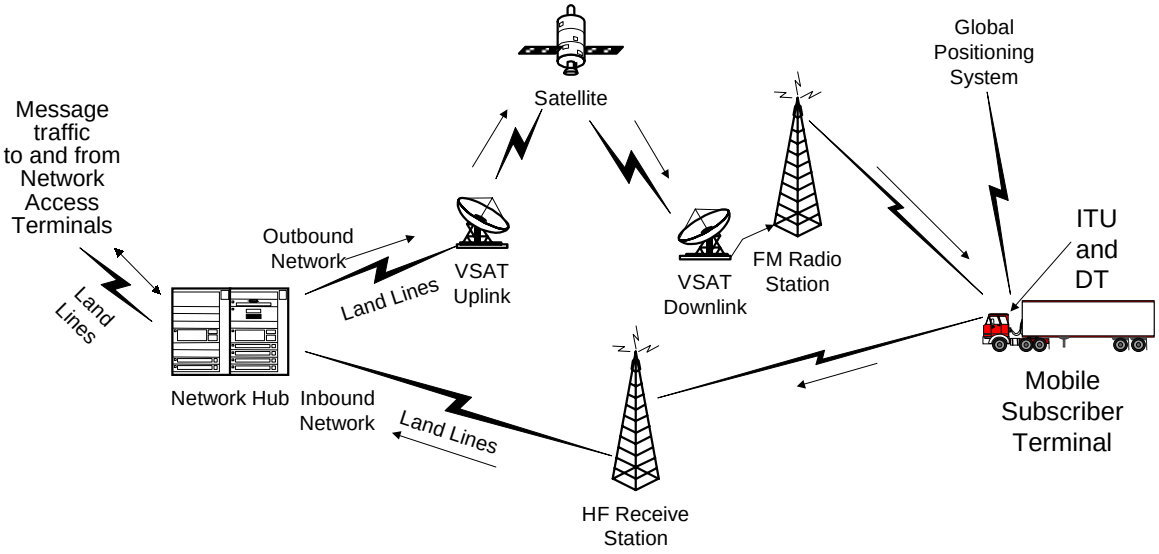

Figure 1-1 Terion Messaging System

1.2 ITU Description

A high-level functional block diagram for the ITU is shown in **Error! Not a valid link.**. The Intelligent Transceiver Unit (ITU) includes the following functional modules: 1) FM/RBDS Receiver and Demodulator, 2) HF Modulator and Transmitter (including an Automatic Antenna Tuner), 3) Global Positioning System (GPS) receiver, 4) Power Supply, and 5) Controller & External Interfaces for the Driver Terminal (rugged computer terminal) and a future optional "SAE J1708 interface" to the SAE standard Heavy-Duty Vehicle data bus.

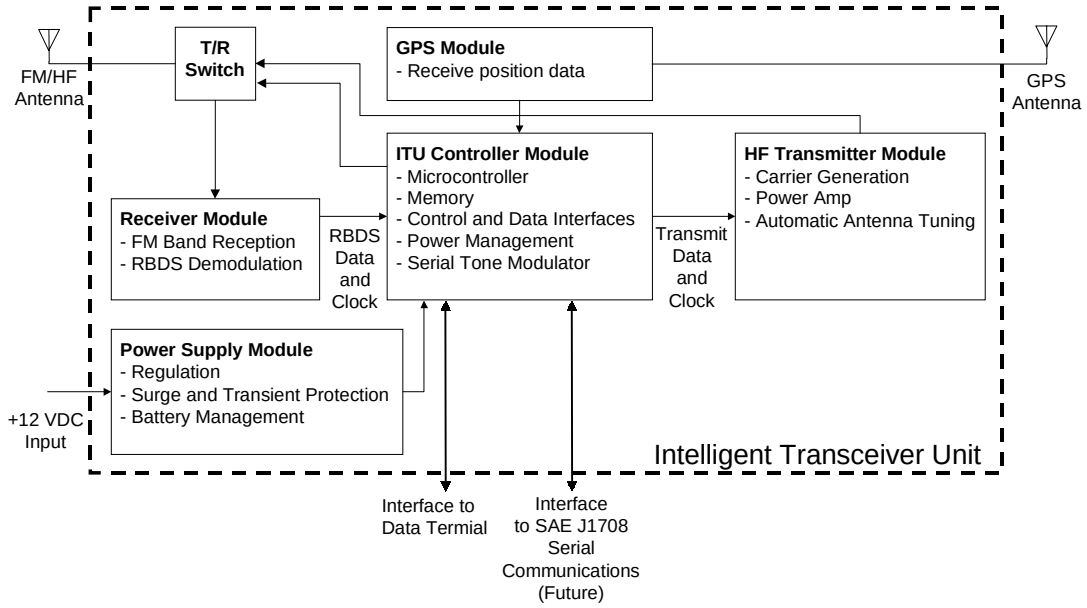

Figure 1-2 Intelligent Transceiver Unit Functional Block Diagram

Error! Not a valid link. shows the ITU with the top cover removed. There are two printed wiring boards inside 1) Digital/ Power supply board containing a piggyback mounted GPS receiver and 2) RF board containing the FM demodulator and HF modulator/transmitter. The RF board assembly is shown in **Error! Not a valid link.** and the digital/power supply/GPS board assembly is shown in **Error! Not a valid link.**.

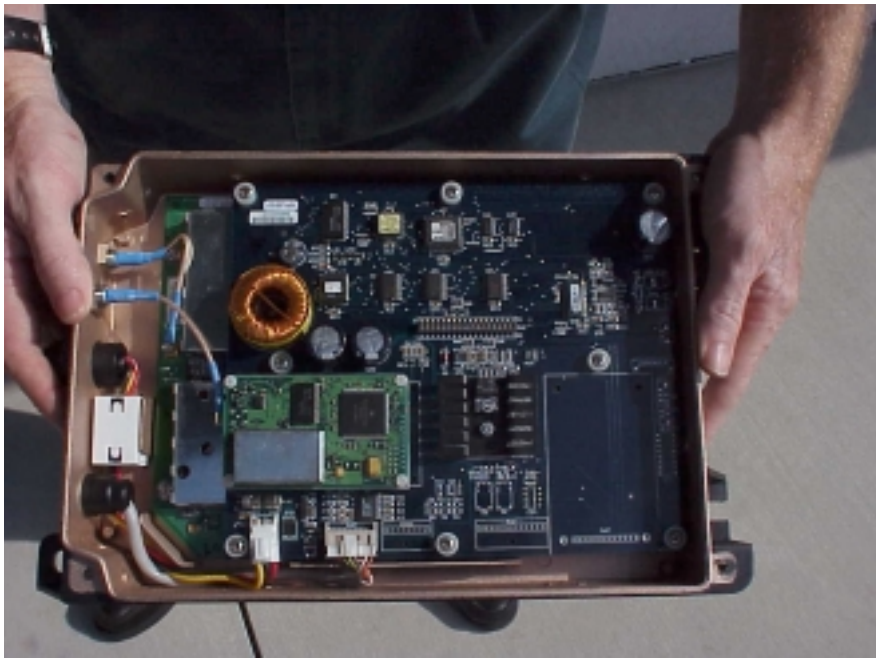

Figure 1-3 ITU with Top Cover Removed

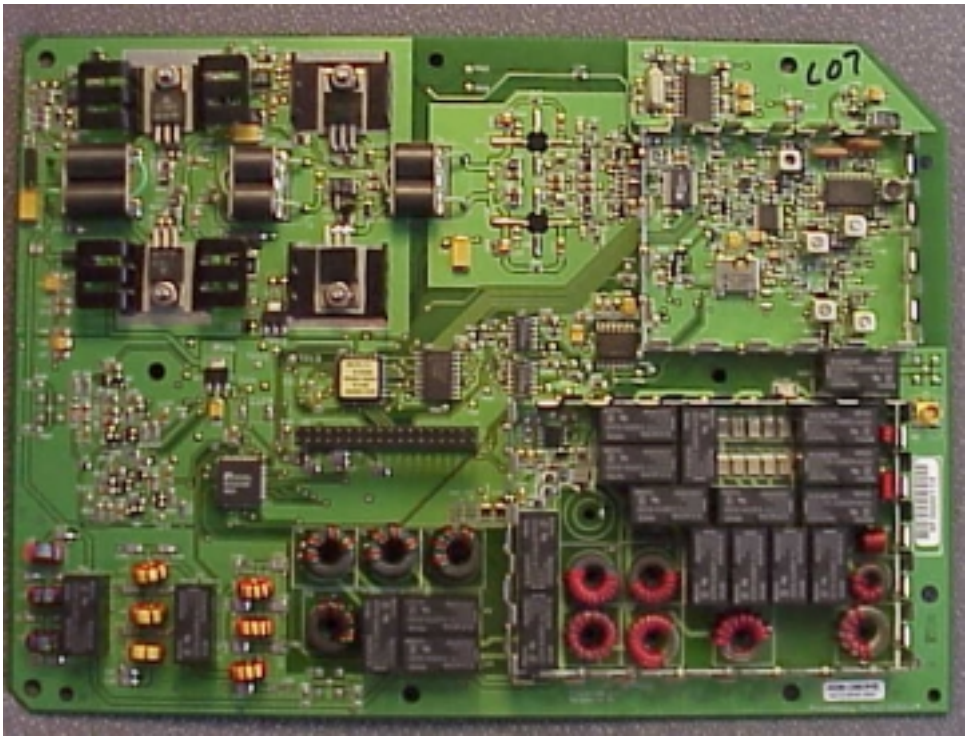

Figure 1-4 RF Printed Circuit Board Assembly

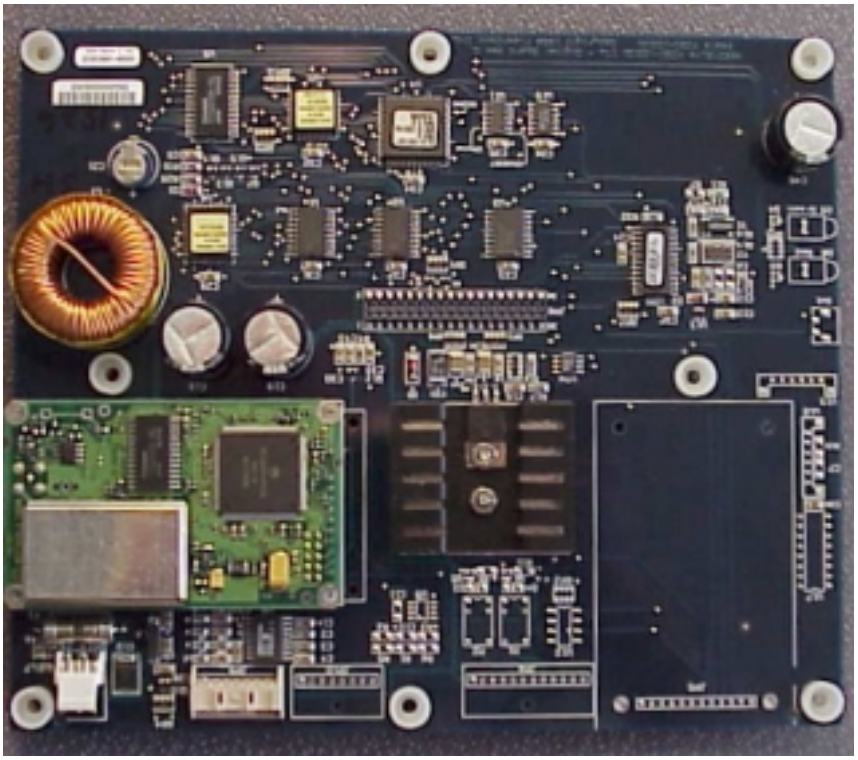

Figure 1-5 GPS, Digital and Power Supply Printed Circuit Board Assembly

1.3 ITU Operational Configuration

Error! Not a valid link. shows the ITU in a typical operational configuration. The ITU can be used in a number of applications and section 1.4 describes each of the different models. The five basic functions of the ITU are: 1) Scan the FM band and receive RBDS data when detected, 2) Transmit messages using the HF band, 3) Communicate with the Drivers Terminal (DT), 4) Interface with external sensors, and 5) determine the ITU's geolocation using GPS.

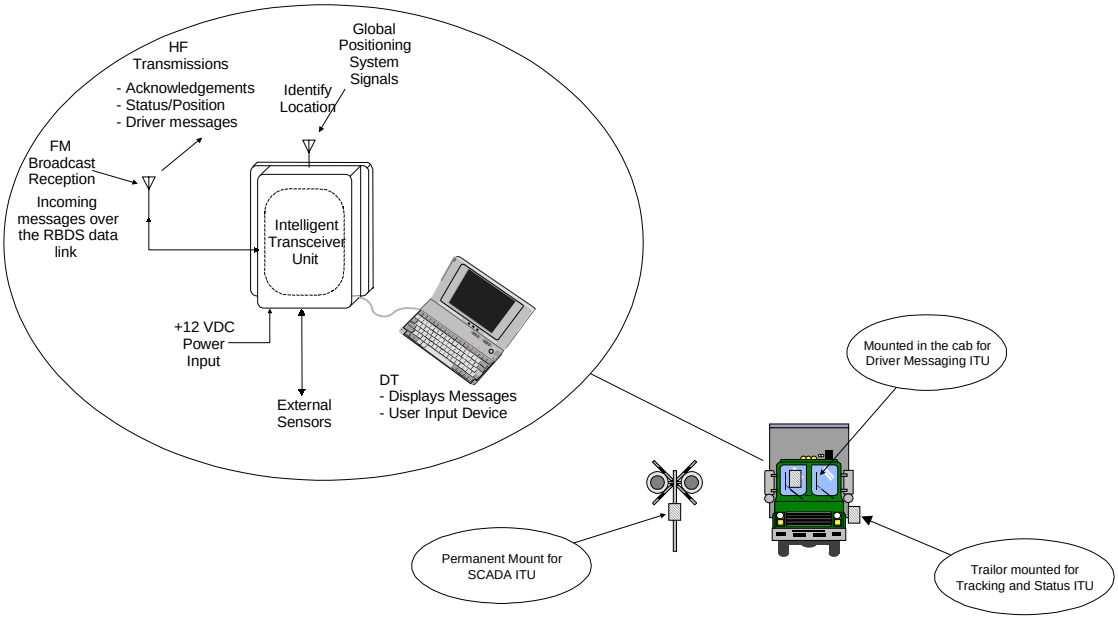

Figure 1-6 ITU Operational Configuration

The ITU interfaces to an external FM antenna and scans the FM band from 88.0 to 108.0 MHz. As it scans the band it searches for RBDS signals and upon detecting such a carrier it processes the data to determine if the message is intended for this remote user. The ITU controller performs all protocol processing for the RBDS messages including the standard RBDS protocol and the specific Terion protocol that is encapsulated by the standard protocol. Once a valid message is received and decoded, the controller interprets the command and determines the proper response. The ITU normally acknowledges (ACK) the receipt of the message automatically using the HF transmitter (there are some messages types where no ACK is requested). In driver messaging applications, the message is buffered in memory and is transmitted to the DT for display to the user. In SCADA (Supervisory Control and Data Acquisition) or Tracking and Status applications, the ITU automatically collects the requested data and transmits it with the message acknowledgment. The data can be GPS location and/or sensor measurements. The Terion message protocol includes a field that specifies the HF frequency to be used for the acknowledgment message. The ITU controller, in accordance with the Terion protocol for the HF link, formats the outbound message. The HF transmitter is tuned to the specified frequency and the serial bit stream modulates the carrier in accordance with the physical link layer specifications for the Terion HF link protocol. One of the key timing requirements is that the transmission be completed within four (4) seconds in order to meet FCC requirements. Messages to be transmitted over the HF link can also be manually originated by the remote user. The messages are input using the DT and transmitted via the serial port to the ITU. In order to ensure compliance with FCC requirements, the ITU must receive a clear channel frequency assignment from the Network Hub. If no valid frequency information is received over the FM subcarrier network by the ITU, then an ITU does not transmit on any HF frequency.

The ITU also has the capability to monitor external sensors on the remote user's vehicle. The results of polling these sensors are included in the HF message as specified in the protocol for status reporting. For example, the second optional serial interface may be configured to communicate with third party external data acquisition modules to gather engine performance information using SAE J1708/J1939 protocols.

The ITU includes an internal GPS (Global Positioning System) for position-location. The GPS receiver provides ITU location information to a accuracy of within 100 meters.

1.4 ITU Application Environment

The design of the ITU provides the baseline unit which serves several different applications. Three different applications are described below : 1) Driver Messaging, 2) Tracking and Status and 3) SCADA. **Error! Not a valid link.** summarizes the specific features for each version. The core electronics design is essentially the same for the different models and the RF specifications are identical. The model designs will vary in: 1) Power source and associated quiescent power dissipation, 2) Mounting provisions, 3) Level of weather protection provided by the enclosure, 4) Electrical interfaces , and 5) Software.

Table 1-1 ITU Features for Different Models

Parameter	Driver Messaging	Tracking and Status	SCADA
Environment	Inside the cab	Outdoors, mounted on the trailer	Outdoors, fixed location mounting
Shock and Vibration	Typical surface vehicle (SAE J1455).	Typical surface vehicle (SAE J1455)	Minimal shock and vibration
User Interface	DOS based DT, full keyboard and display	DT supported	DT supported
Other External Interface	J1708	J1939 or other TBD proprietary sensor/monitor	TBD proprietary sensor/monitor/controller
Mounting	Inside the cab	Trailer mount (under carriage)	Outdoor, pole mount
Power	Vehicle provided (nominal 12VDC)	Battery, charged by vehicle power when available	Nominal +12VDC prime (external AC/DC converter for AC prime power applications)

1.4.1 Driver Messaging ITU

The “driver messaging” model of the ITU is used with a DT to provide messages to, and collect messages from, the remote user. In a typical application, a cross-country truck driver will use the DT/ITU to send and receive messages from the dispatcher. The ITU is mounted in the cab of the truck with a wired RS232 interface to the DT. External antennas are used for the FM receiver, GPS receiver and HF transmitter (HF and FM use a single dual-band whip antenna). Since the Driver Messaging ITU is mounted inside the cab, its enclosure does not need to provide protection from the elements. However, it is subjected to the normal spray wash, shock and vibration that occurs within a heavy-duty vehicle. Power is provided from the vehicle, and therefore battery operation is not required. In this configuration the ITU will: 1) Receive messages using the FM/SCA RBDS, 2) Automatically acknowledge the receipt of messages using the HF link, 3) Download the message to the DT for display to the driver, 4) Accept messages from the DT for transmission using the HF link, 5) Interface to sensors (if installed), and 6) Transmit information requested by the Network Hub (or Dispatcher Terminal).

1.4.2 Tracking and Status ITU (Not Currently Available)

This version of the ITU is used in an unattended mode. An ITU mounted underneath a trailer is powered on at regular intervals and reports its location using the internal GPS data. This is so that the dispatcher can determine the location of the cargo at regular intervals. In the ITU sleep mode, there is no FM reception possible. The ITU can also transmit status information if it is available using the external sensor port. This information could include cargo temperature, door ajar, trailer occupancy, etc. The operator interface is much simpler than for the driver messaging application. The Network Hub stores information such as the cargo type and when cargo is loaded or unloaded. The DT interface is used to load and retrieve this type of data.

This ITU operates while mounted on the outside of the vehicle. It operates in rain, sleet, or snow conditions while the vehicle is running. Environmentally, this unit can tolerate moisture, temperature extremes, shock and vibration. In most installations, the ITU obtains power from the trailer when it is attached to a tractor. However, since trailers can be left for long periods of time without power, the ITU can operate on battery power. The controller software has the ability to provide power management including a power down mode that only maintains the ability to wake up and scan for messages. This mode maximizes the battery life while maintaining regular status updates.

1.4.3 SCADA ITU (Not Currently Available)

The SCADA ITU is similar in concept to the Tracking and Status ITU. Most of its operations occur while unattended. A typical application is to monitor railroad-crossing equipment. The ITU periodically sends the status of the monitored equipment. Another mode provides for automatic message transmission whenever a fault is detected. Many sites cannot supply power to the ITU so it utilizes all of the power conservation methods described above (for the Tracking and Status ITU) to operate over a designated time period without maintenance.

2 External Interface and Protocol Description

This section presents the external interfaces and protocols.

2.1 Serial Port #1

The electrical interface is compatible with RS-232C electrical requirements. The communications protocol is compatible with the Terion Driver Terminal Interface Protocol. An example is Wescor RDT700 & RDT800, PC laptops, PDAs, or other custom devices that may be used as Human Interface Units (HIU's).

2.2 Serial Port #2 (Not Currently Available)

The ITU interfaces to external sensors using the second serial interface. Levels shall be compatible with J1708 standards. The actual communications protocol are set at time of manufacture, and are typically selected from the following list:
SAE J1708/J1587 (for monitoring "in-cab" functions)
SAE J1939 /11/21/31/71 & /73 (for monitoring "trailer" functions)
Other Custom Protocols as necessary (e.g., to support proprietary asset monitors, vehicle sensors, rail-crossing monitors, etc.)

2.3 ITU to GPS Antenna

The interface to the GPS antenna is according to the requirements as specified by the OEM GPS manufacturer.

2.4 ITU to FM/HF Antenna Interface

The ITU provides an internal Transmit/Receive switch to support a single antenna connection to the FM/SCA receiver and the HF Transmitter. The switch isolation is sufficient so that the maximum HF transmit power does not damage the FM/SCA receiver input. The antenna port is a nominal 12.5 ohms.

2.5 FM Broadcast Station to ITU Interface Protocol

The ITU controller software is capable of processing the data received from the RBDS decoder output. The controller processes the RBDS protocol to extract the data within the group that contains the Terion message data. It then processes the Terion Data in accordance with the protocol defined in Terion Protocol Requirements Document (number FC951-041). The ITU then performs the functions and routing as designated within the message.

2.6 ITU to HF Receive Site Interface Protocol

When the ITU transmits a message using the HF link, the data protocol is in accordance with Terion Protocol Requirements Document (number FC951-041). Data transmissions are initiated in response to receive messages or based upon a predetermined time interval. All HF transmissions are made at the frequency as commanded by the system hub.

2.7 External Interface Connector Description

The Intelligent Transceiver Unit (ITU) has provisions for the following external electrical interfaces:
1) One serial port with connector type circular DIN, 2) One external power connector type with circular 3-pin Amphenol C091A, 3) One external VHF/HF antenna connector (TNC), and 4) One external GPS antenna connector (SMA).

3 ITU Description

The following sections present the electrical, mechanical and environmental information for the ITU.

3.1 Electrical Description

The following sections present a detailed electrical description of the ITU.

3.1.1 ITU Top Level Electrical Description

Error! Not a valid link. shows a top-level block diagram of the ITU. There are four major sections: 1) an FM receiver, 2) an HF transmitter, 3) Frequency generation and control, and 4) antenna switch and antenna.

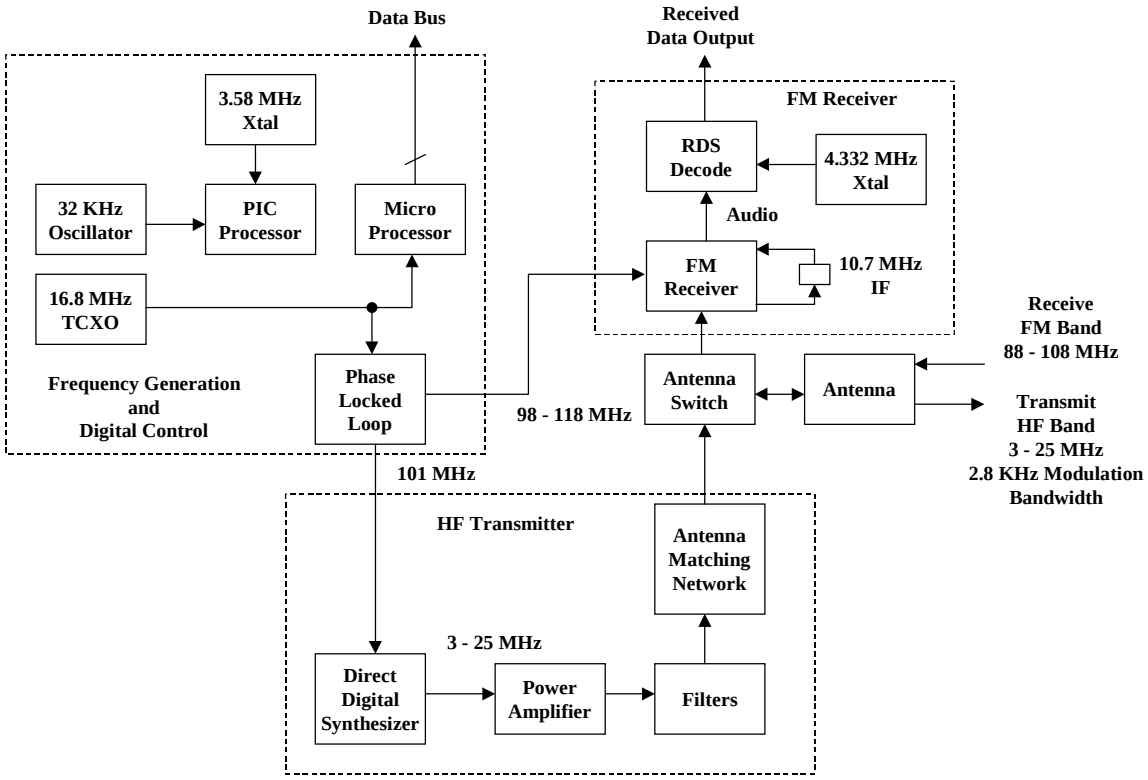

Figure 3-1 ITU Top-Level Block Diagram

3.1.1.1 ITU Electrical Description

Error! Not a valid link. shows the top-level electrical specifications for the ITU.

Table 3-1 ITU Electrical Specifications

Parameter	Specification
Power Consumption	
Peak	40 Watts during transmit
Average	8 mW
Transmit duty cycle for battery operation	less than 35 x 10^{-6} in a typical scenario
FM Receive Input	
Frequency Range	88 to 108.0 MHz
Tuning Step Size	200 kHz
Sensitivity	–100 dBm

Parameter	Specification
GPS Receiver Geolocation Determination	
Accuracy, without Selective Availability	better than 25 meters
Accuracy, with Selective Availability	100 meters (90% CEP)
Acquisition Time, cold start	45 seconds (with current almanac, position, time and ephemeris)
Acquisition Time, warm start	20 seconds (with current almanac, position and time)
Reacquisition Time	2.5 seconds
HF Transmission	
Regulatory Compliance	Per FCC DA 97-1451
Frequency	3.170 to 25.037 MHz
Tuning Step Size	< 1 Hz
Output Power	+40 dBm into 12.5 Ω, < 1 watt average EIRP from antenna.
External Interfaces	
Serial #1	Flash Comm Driver Terminal Interface Protocol
Serial #2	Set at time of Manufacture (J1708, J1939) (Not Currently Implemented)
Power Inputs	Nominal +12 VDC input from vehicle
Antennas	Active GPS Combination FM receive and HF transmit

3.1.1.2 EMI/RFI

The Intelligent Transceiver Unit is designed to comply with the specifications referenced in section 4. The ITU is also designed to reduce self-interference to acceptable levels to insure proper operation of the various subsystems. For example, the Controller does not cause interference with the FM receiver. Internal shielding and filtering are used to prevent such interference within the ITU. The frequency plans and reference frequencies for the receiver and transmitter are selected to minimize the possibility of self-interference.

3.1.1.3 Module Descriptions

The following sections describe each of the modules within the ITU.

3.1.1.4 FM Receiver Module Electrical Description

The FM/SCA subsystem includes the circuitry starting at the antenna input and going to the recovered digital output. Also included is the frequency synthesizer which selects the frequency corresponding to the desired FM station frequency. **Error! Not a valid link.** is a detailed block diagram of the FM Receiver Module and **Error! Not a valid link.** contains the electrical specifications.

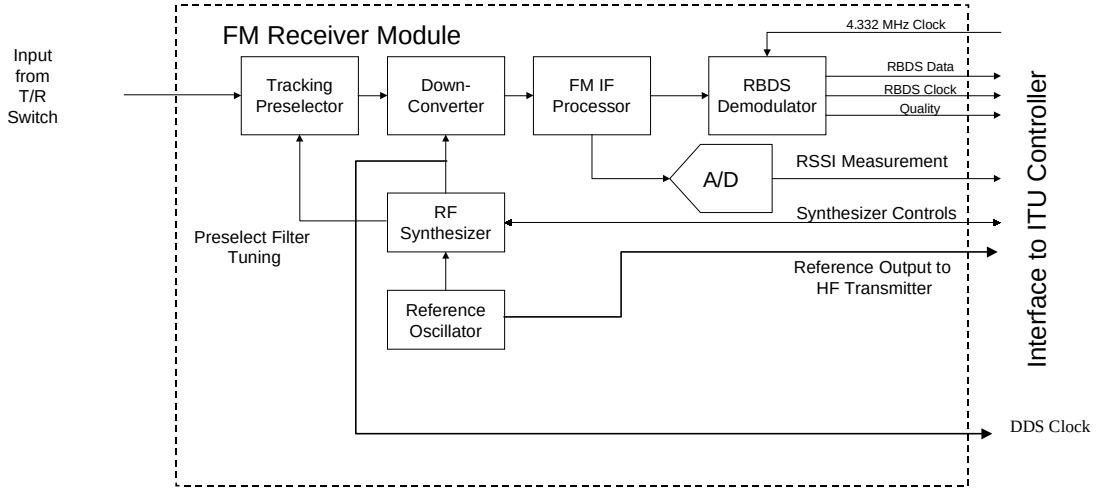

Figure 3-2 ITU FM Receiver Module Block Diagram

Table 3-2 FM Receiver Module Electrical Specifications

Parameter	Specification
Frequency Range	88 - 108.0 MHz
Frequency Channel Step Size	100 kHz (max)
RF Input	
Operational RF Input Signal Range	2 µV to 10 mV rms
RF Input Impedance VSWR	50 ohms nominal into preselector 1.5:1 Maximum
Conversion Scheme	High Side Conversion, $F_{LO} = F_o + 10.7$ MHz
Adjacent Channel Rejection	40 dB min @ F_o +/- 200 kHz 65 dB min @ F_o +/- 400 kHz
Desense	70 dB min for all frequencies greater than 400 kHz from F_o image
Image Rejection	30 dB min (10.7 MHz IF)
Noise Figure	15 dB max
Sensitivity	-100 dBm into 50 ohms
Spurs	80 dB min, may include preselector filtering
Dynamic Range	80 dB (0 - Vcc)
Accuracy	+/- 3 dB
Bandwidth	> 10 kHz
Operational Voltage Range	+5 VDC
Active Current Consumption	<25 mA
Synthesizer Lock	<5 mSec after tune command is issued by µP
RDS Clock Lock	<100 mSec after receipt of first valid RDS bit

3.1.1.5 Modulator/Transmitter Module Electrical Description

This section describes the modulator/transmitter subsystem of the Intelligent Transceiver Unit. The HF Modulator/Transmitter goes from the data output of the Controller to the antenna output, and includes the frequency

synthesizer function to select the transmit channel. The relationship of the modulator and transmitter modules to the other ITU components is shown in **Error! Not a valid link.**. The detailed block diagram for the HF transmitter is shown in **Error! Not a valid link.** and the HF Transmitter Specifications are given in **Error! Not a valid link.**.

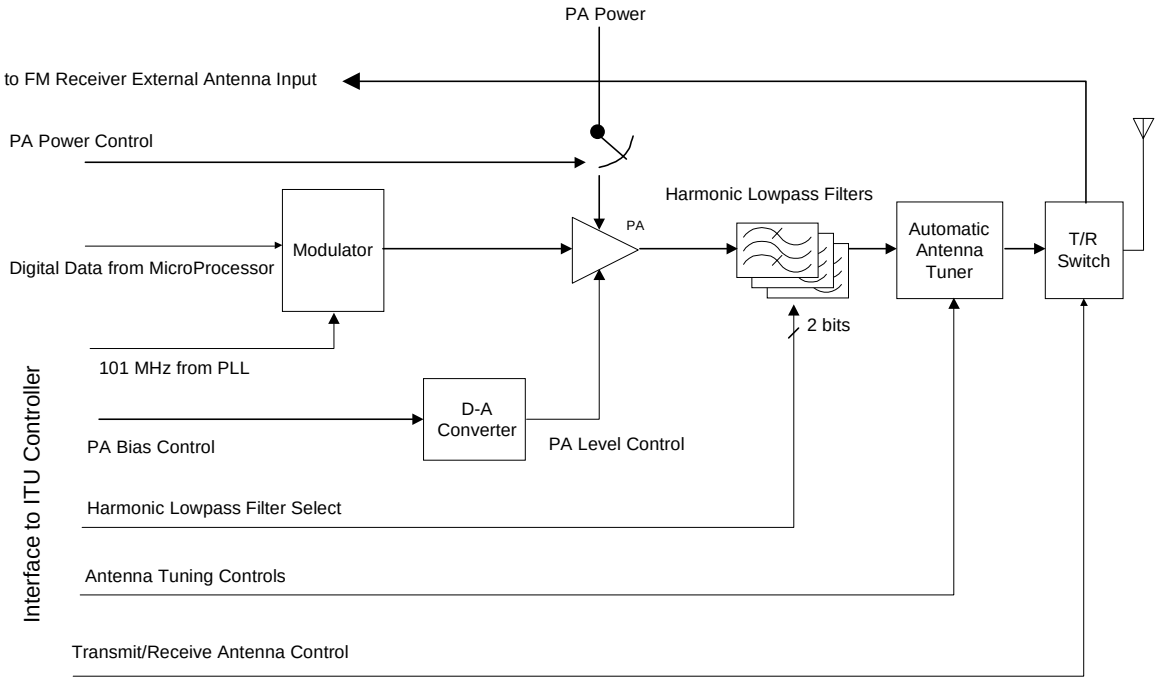

Figure 3-3 HF Transmitter Module Block Diagram

Table 3-3 HF Transmitter Specifications

Parameter	Specification
Frequency Range	3.170 to 25.037 MHz
Frequency Channel Step Size	< 1 kHz (max)
RF Levels	
PA Output Power	10 watts, nominal with ALC
PA Output Impedance	12.5 ohms nominal stable under up to 30:1 VSWR
PA Efficiency	> 40%
Modulation	8-CPSK as per Terion Protocol Requirements Document (FC951-041)
Transmit Bandwidth	3.0 kHz (-25 dBc, below unmodulated carrier)
Adjacent	-35 dBc @ ≥ 4.5 kHz (removed from the unmodulated carrier) -43 dBc @ ≥ 7.0 kHz (removed from the unmodulated carrier)
Stability	+/- 37.5 Hz over time and temperature
Transmit Spurs	< -43 dBc
Synthesizer Lock	<100 mSec after tune command is issued by uP
Automatic Antenna Tuner Settling Time to Best Match	< 1.0 sec after tune command is issued by uP

Parameter	Specification
Power Supply:	
PA Voltage Range	+12VDC, nominal +9.5VDC, min +18VDC, max sourced from vehicle power
Other Circuits	+5 VDC
Symbol Rate	2000 8-ary symbols per second

3.1.1.6 Transmit Signal Characteristics

The ITU transmitter has an FCC type designator of 2K80G1D. **Error! Not a valid link.** shows the transmission spectrum which illustrates that the spectral roll-off characteristic with frequency falls beneath the required FCC spectral mask. The FCC authorized bandwidth is 3 KHz and the approved transmit frequency band ranges from 3.17 MHz to 25.037 MHz .

The modulation is 8-ary phase-shift keyed as shown in **Error! Not a valid link.** with controlled transitions from one phase to the next that transitions around a circle thus resulting in constant envelope modulation. This 8-ary continuous phase modulation technique produces the transmit spectrum as shown in **Error! Not a valid link.**.

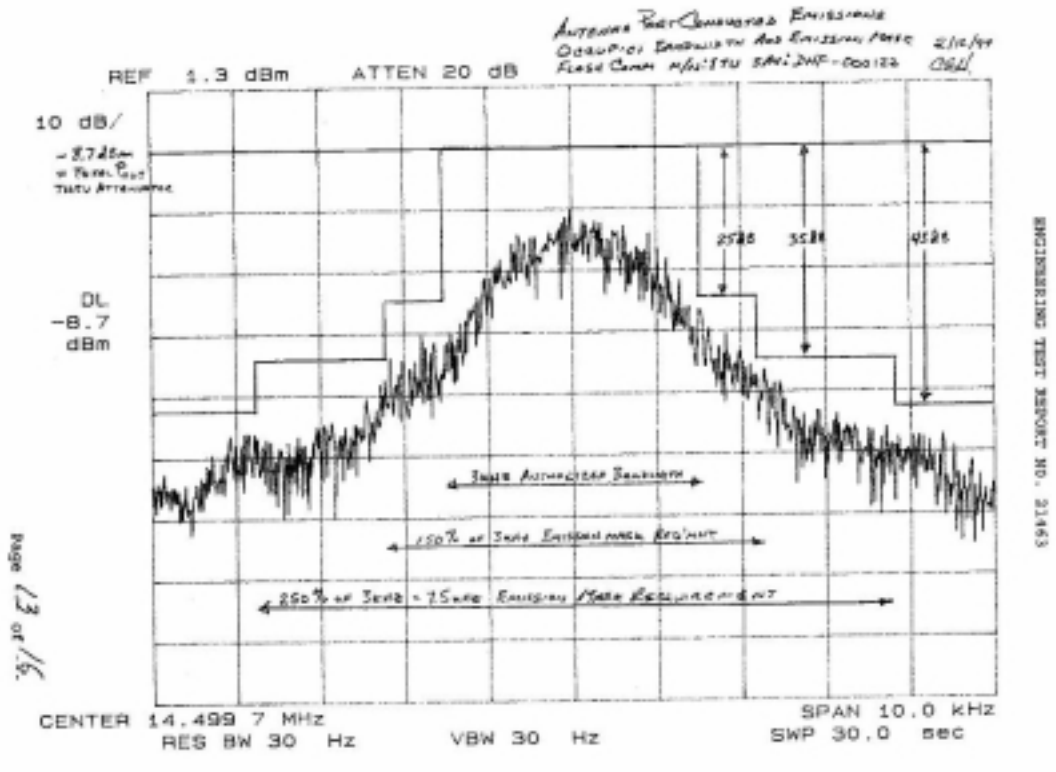

Figure 3-4 Transmit Spectrum

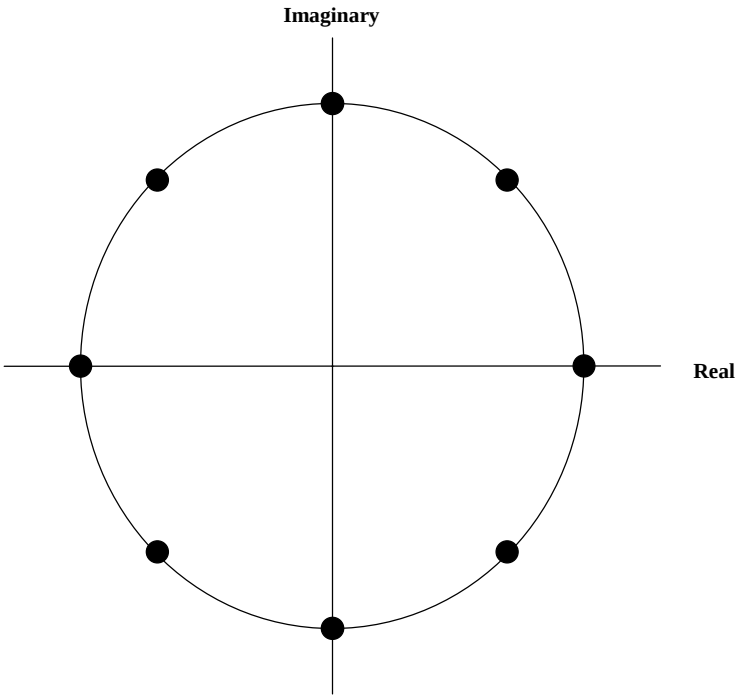

Figure 3-5 8-ary Phase Shift Key Modulation Constellation

3.1.1.7 ITU Controller Electrical Description

The interfaces of the ITU Controller are shown in the ITU functional block diagram in **Error! Not a valid link.**. **Error! Not a valid link.** provides a detailed block diagram of the Controller.

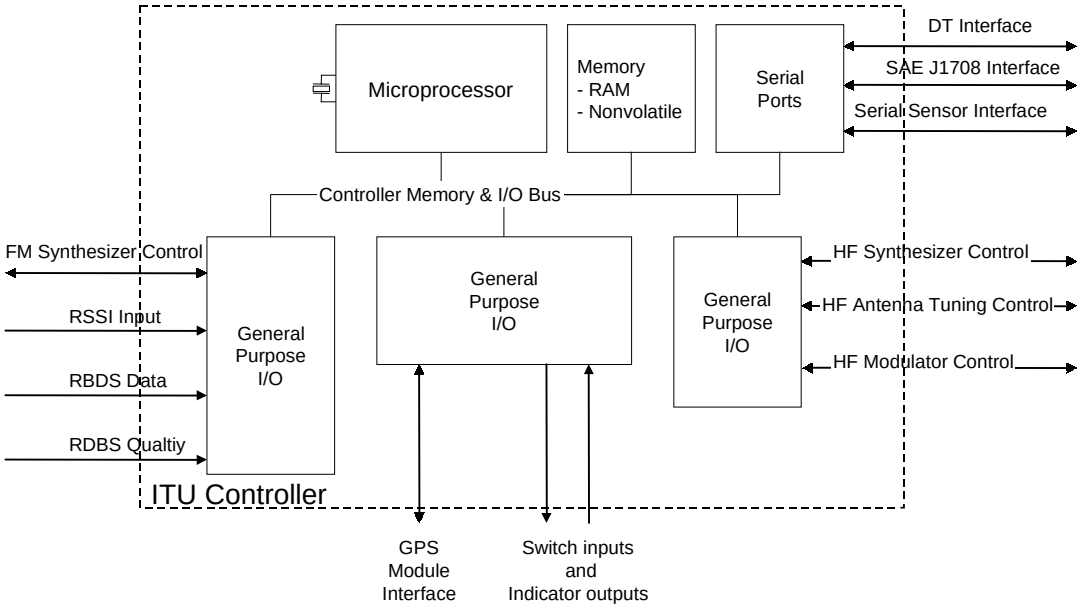

Figure 3-6 ITU Controller Module

3.1.1.7.1 Processor Description

A Dallas 82C520 (Intel 8051 family) microcontroller is used.

3.1.1.7.2 Memory

The ITU Controller design incorporates the following types of memory: 1) FLASH memory for retention of executable program plus configuration and set-up parameters, 2) Static RAM for "scratch-pad" program variables and message memory (backed up with "super-cap").

3.1.1.7.3 Digital Subsystem External I/O

In addition to the internal digital interfaces, the digital subsystem of the Intelligent Transceiver Unit also supports up to two (2) RS-232C compatible serial ports (9.6 kbps). One is used for the GPS and the other for the HIU.

3.1.1.8 Power Supply Module Electrical Description

The power supply module provides the voltages required for the other ITU modules at the specified current ratings. The various ITU models have different power source requirements. The Driver Messaging ITU operates directly from the vehicle power while the Tracking and Status and the SCADA models require battery operation. The Intelligent Transceiver Unit Power subsystems shall be designed to accommodate (tolerate without damage, but not operate at full functionality) load dump conditions as described in **Error! Not a valid link.**. Other power supply specifications are listed in **Error! Not a valid link.**.

Table 3-4 Load Dump Specification

Surface Vehicle Recommended Practice - Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)	SAE J1455	Issued 1988-01 Revised 1994-08

Table 3-5 Other Power Supply Specifications

Parameter	Value
Efficiency	>80%
Noise and ripple on outputs	10 mV peak to peak
PA Voltages Other Electronics Voltages	+12VDC, nominal +9.5VDC, min +18.0VDC, max sourced from vehicle power or internal batteries +5 (or 3.0) VDC, nominal
Maximum output current +5 V PA	 < 0.8 A continuous 4 A peak for a maximum of 4 seconds with a duty cycle of 0.01

3.2 Mechanical Description

3.2.1 ITU Top Level Mechanical Description

Illustrations of the ITU box and external connectors are shown in **Error! Not a valid link.** and **Error! Not a valid link.**, respectively. **Error! Not a valid link.** shows the Drivers Terminal (DT) which is used to 1) read messages from the HUB Station and 2) compose and edit messages to be sent to the HUB Station. **Error! Not a valid link.** and **Error! Not a valid link.** shows the Mirror Mount Whip Antenna and Rear Cab Mount Whip Antenna, respectively.

Figure 3-7 ITU Box

Figure 3-8 ITU Connectors

Figure 3-9 Driver Terminal

Figure 3-10 Mirror Mount Whip Antenna

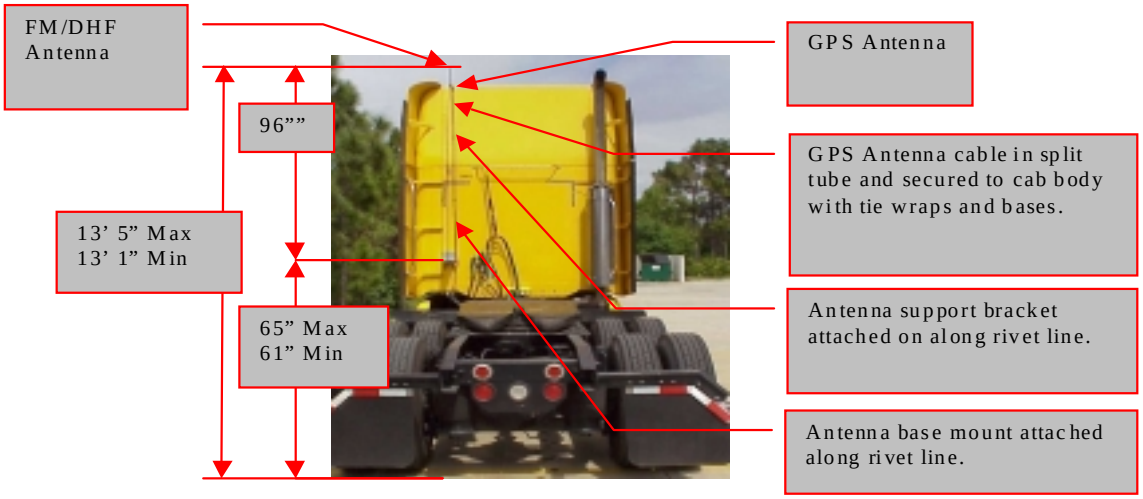

Figure 3-11 Rear Cab Mount Whip Antenna

3.3 Environmental

The environmental requirements for the Intelligent Transceiver Unit depend upon the primary target market application, e.g. whether it is used outside and/or mounted to a heavy-duty vehicle. The environmental conditions within heavy-duty vehicles has been characterized by the Society of Automotive Engineers (SAE), and recommendations are provided in; "Surface Vehicle Recommended Practice - Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)", SAE J1455, Issued 1988-01, Revised 1994-08.

Environmental performance level specifications are shown in **Error! Not a valid link.**.

Table 3-6 Environmental Level Specifications

Performance Level	Definition
Fully Operational	All ITU subsystems operate at full electrical/mechanical performance levels
Storage	Intelligent Transceiver Unit not powered (i.e., off), not functional

3.3.1 Temperature

In accordance with the recommendations given by SAE J1455, the Intelligent Transceiver Unit meets the following temperature requirements:

Fully Operational: -25°C to +75°C
Storage: -40°C to + 85°C

Temperature testing is in accordance with MIL-STD-810E (14 July 1989), Method procedures are according to:

High Temperature - Basic Hot Conditions (Table 501.3-III)
Storage: 501.3 Procedure I
Operation: 501.3 Procedure II
Low Temperature - Basic Cold Conditions (Table 502.3-I)
Storage: 502.3 Procedure I

Operation: 502.3 Procedure II

3.3.2 Water Resistance

The Intelligent Transceiver Unit survives (be fully operational after event) exposure to rain and/or water. Water resistance of the Intelligent Transceiver Unit is in compliance with MIL-STD-810E (14 July 1989), section 506.3 Procedure I - Blowing Rain.

3.3.3 Humidity

The Intelligent Transceiver Unit is compliant with MIL-STD-810E (14 July 1989), section 507.3 Procedure III - Aggravated.

3.3.4 Shock

The intent of the Intelligent Transceiver Unit shock requirement is to insure usability of the unit after repeated abuses by customers. The Intelligent Transceiver Unit survives (that is, be fully operational, with minor surface "nicks" and/or "scratches") after drops onto concrete from 1 meter height -- all sides and all corners.

3.3.5 Vibration

The Intelligent Transceiver Unit is in conformance with SAE 1455 vibration requirements for cab mounted components.

4 Regulatory Compliance

The ITU is verified per CFR47 part 15 for FM broadcast receivers (class B) and digital devices (class A). Additionally, the ITU transmitter is certified per CFR 47 part 90, including the requirements set forth in DA 97-145. Other standards and specifications listed herein are typically voluntary standards and/or recommended practices and thus, are not strict regulatory compliance requirements (i.e., compliance requirements that must be tested by a certified test facility before units may be marketed or sold to the public). However, certain recommended practices and standards are used by Terion to insure compatibility of the Intelligent Transceiver Unit in its intended application. The list of voluntary standards and recommended practices are given in **Error! Not a valid link.**.

Table 4-1 Voluntary Standards and Recommended Practices Imposed by Terion

Document Title	Document Number or Identifier	Last Release or Revision Date
United States RBDS Standard (EIA & NAB)	RBDS	April 9, 1998
Military Standard - Environmental Test Methods and Engineering Guidelines	MIL-STD-810E	14 July 1989
Surface Vehicle Recommended Practice - Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)	SAE J1455	Issued 1988-01 Revised 1994-08
Highway Vehicle Practice - Electromagnetic Susceptibility Measurement Procedures for Vehicle Components (Except Aircraft)	SAE J1113	Issued Apr 1975 Revised Aug 1987
Surface Vehicle Recommended Practice - Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications	SAE J1708	Issued 1986-01 Revised 1993-10
Surface Vehicle Recommended Practice – Joint SAE/TMC Electronic Data Interchange Microcomputer Systems in Heavy-Duty Vehicle Applications	SAE J1587	Issued 1988-01 Revised 1996-03
Surface Vehicle Recommended Practice - Serial Data Communications Between Tractors and Trailers in Heavy-Duty Vehicle Applications	SAE J1939 Doc's /11/21/31/71 & /73	
IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz	ANSI/IEEE C95.1-1992	1991