RAYTHEON TI SYSTEMS

CELL-TRAC™ II
FCC Type Acceptance
FCC ID NMF-CT2-001

Enclosed please find Raytheon TI's submittal for FCC certification for the CELL-TRAC™ II cellular transceiver. This application mentions type acceptance throughout, but was compiled prior to the October 5, 1998, effective date changing the Commission's equipment authorization process from type acceptance to certification. The enclosed application is made up of 11 exhibits, with individual exhibits containing more than a single file in many cases. The layout of the application is as follows:

Exhibit 0 - this file (exhibit0.doc) that describes the product and measurements performed to show compliance with the Commission's rules

Exhibit 1 - contains six files: exhibit1.doc that describes the files that make up this exhibit, 4 picture files that show the construction and layout of the product (pic_1.jpg, pic_2.jpg, pic_3.jpg, pic_4.jpg) and a file showing the circuit layout of the product (exh_1.wp).

Exhibit 2 - made up of a single file (exhibit2.doc) that shows the FCC label format and label locations.

Exhibit 3 - consists of two files, exhibit3.doc which provides a detailed block diagram and theory of operation and ACE9040.pdf which is the manufacturer specification sheet for a particular chip used in the transceiver.

Exhibit 4 - contains two files, exhibit4.doc and exhibit_4.pdf that provide circuit diagrams for the transceiver.

Exhibit 5 - contains four files, exhibit5.doc, exh_5_a.doc, exh_5_b.doc, exh_5_c.doc that provide the testing and tune up procedures for the product.

Exhibit 6 - contains a single file, exhibit6.doc, that describes ESN protection methods.

Exhibit 7 - contains a single file, exhibit7.doc, that contains MPE data.

Exhibit 8 - contains a single file, exhibit8.doc, the user manual.

Exhibit 9 - contains two files, exhibit9.doc and Its.pdf, the test report.

Confidentiality Request - is contained in file confid.doc.

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Section I Introduction

This Type Acceptance application describes a mobile radiotelephone (AMPS) model CELL-TRAC™ II for use in the Remote Asset Visibility (RAV) Network. The Network monitors the location of any vehicle, trailer, mobile construction equipment that carries the CELL-TRAC™ II. The CELL-TRAC™ II contains a cellular telephone that calls into the Raytheon TI Systems Data Center (Data Center) on a predetermined schedule and, using the data from the Global Positioning Satellite (GPS) receiver, contained in the CELL-TRAC™ II, reports the longitude and latitude of its current location. The location of the asset, as reported to the Data Center, is then available to the customer via the internet. The Data Center can also initiate calls to the CELL-TRAC™ II and send commands back to the CELL-TRAC™ II which can change the schedule of the calls or update the software in the CELL-TRAC™ II with the most current revision of the software.

The CELL-TRAC™ II also monitors selected vehicle information. For instance ignition on, oil pressure, asset battery voltage, CELL-TRAC™ II battery voltage, CELL-TRAC™ II temperature, and other sensor data. may be sent to the Data Center.

Figure 1 is a picture of the CELL-TRAC™ II with available antennas (AMPS and GPS) and Figure 2 is a photo of a typical installation.

Section II Summary of Application

This application is specific to the Cellular Radiotelephone Service and is organized in accordance with CFR 47 Part 2, Part 22 and Part 15 as applicable. Applicable Part 2, Part 22, and Part 15 paragraphs are used as headings in this document to simplify traceability to the originating requirement.

Technical information such as construction, layout, photographs, circuit schematics and test data required for Type Acceptance is provided in the Exhibits.

Section III Data

2.981 Type Acceptance

The following data is submitted for Type Acceptance of a CELL-TRAC™ II for Raytheon TI Systems in accordance with the CFR 47, Part 2, (subpart J, Type Acceptance), Part 22 (subpart C, Operational and Technical Requirements, and subpart H, Cellular Radiotelephone Service), and Part 15 (subpart B, Unintentional Radiators).

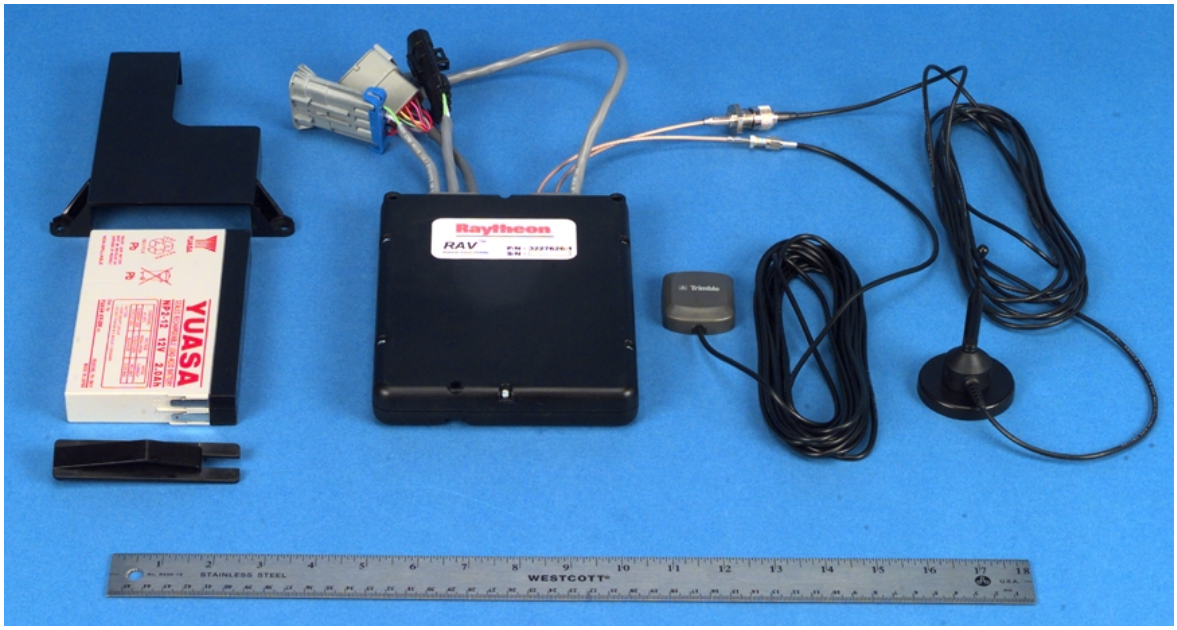

Figure 1 CELL-TRAC™ II With Antennas

Figure 2 CELL-TRAC™ II Typical Installation

2.983 Application for Type Acceptance – Form 731

A complete FCC 731 form is attached to this type acceptance report.

2.983(a) Name of Applicant

Applicant (Corporate Location):	Raytheon TI Systems 13532 N. Central Expwy Dallas, Texas 75243
Applicant (Corporate Mailing):	Raytheon TI Systems Attention: Bruce Anderson M.S. 64 13532 N. Central Expwy Dallas, Texas 75243
Manufacturer / Location:	Ionics 1909 Milmont Drive Milpitas, California 95035

2.983(b) Identification of the Equipment

Name of Applicant:	Raytheon TI Systems
Equipment Model Numbers:	CELL-TRAC™ II
Trade Name:	CELL-TRAC™
FCC ID Number:	NMF-CT2-001

2.983 (c) Production is Planned

Production of the equipment model number described in this submittal is planned at the location noted in paragraph 2.983(a) Name of Applicant.

2.983 (d) Technical Description

Introduction:

The Raytheon TI Systems CELL-TRAC™ II is a mobile communication and tracking unit that is a product for vehicle and mobile asset management. The CELL-TRAC™ II integrates cellular (3-watt AMPS or IS-136) voice and data communications (circuit-switched and control channel), global positioning, and an intelligent power management system into a compact CELL-TRAC™ II product

The cellular phone is a class I, 3 Watt, cellular transceiver board which operates according to AMPS cellular standards EIA/TIA 553 and IS19B.

The CELL-TRAC™ II has a rugged switching power supply for harsh vehicle environments, an on-board battery charger and two optically isolated inputs to provide solid protection from vehicle power source noise and spikes. The CELL-TRAC™ II also has up to 512 Kbytes of non-volatile Flash EPROM memory for data logging, over-the-air programming for new software updates and a robust over-the-air data protocol for highly reliable message delivery.

The Global Positioning Satellite (GPS) receiver is a L1 frequency, C/A code (SPS), 8 channel, continuous tracking receiver.

A functional block diagram of the CELL-TRAC™ II is shown in Figure 3, a detailed block diagram is provided in Exhibit 3 Detailed Block Diagram and Theory of Operation.

Functional Block Description

General

The CELL-TRAC™ II is constructed with two circuit card assembles. The first circuit card assembly consists of a Cellular Transceiver, a Function Control Processor (FCP) which controls the operation of all function in the CELL-TRAC™ II, a Power Management circuit which provides the control of and the regulation of the voltages used throughout the CELL-TRAC™ II, and interface circuits which interface with external equipment such as test equipment, handset, headphone, and etc. The second circuit card assembly is a Global Position Satellite (GPS) receiver board.

Cellular Transceiver

The cellular transceiver is a class I, 3 Watt, cellular transceiver which operates in accordance with AMPS cellular standards, Telecommunications Industry Association, EIA/TIA 553 and IS19B.

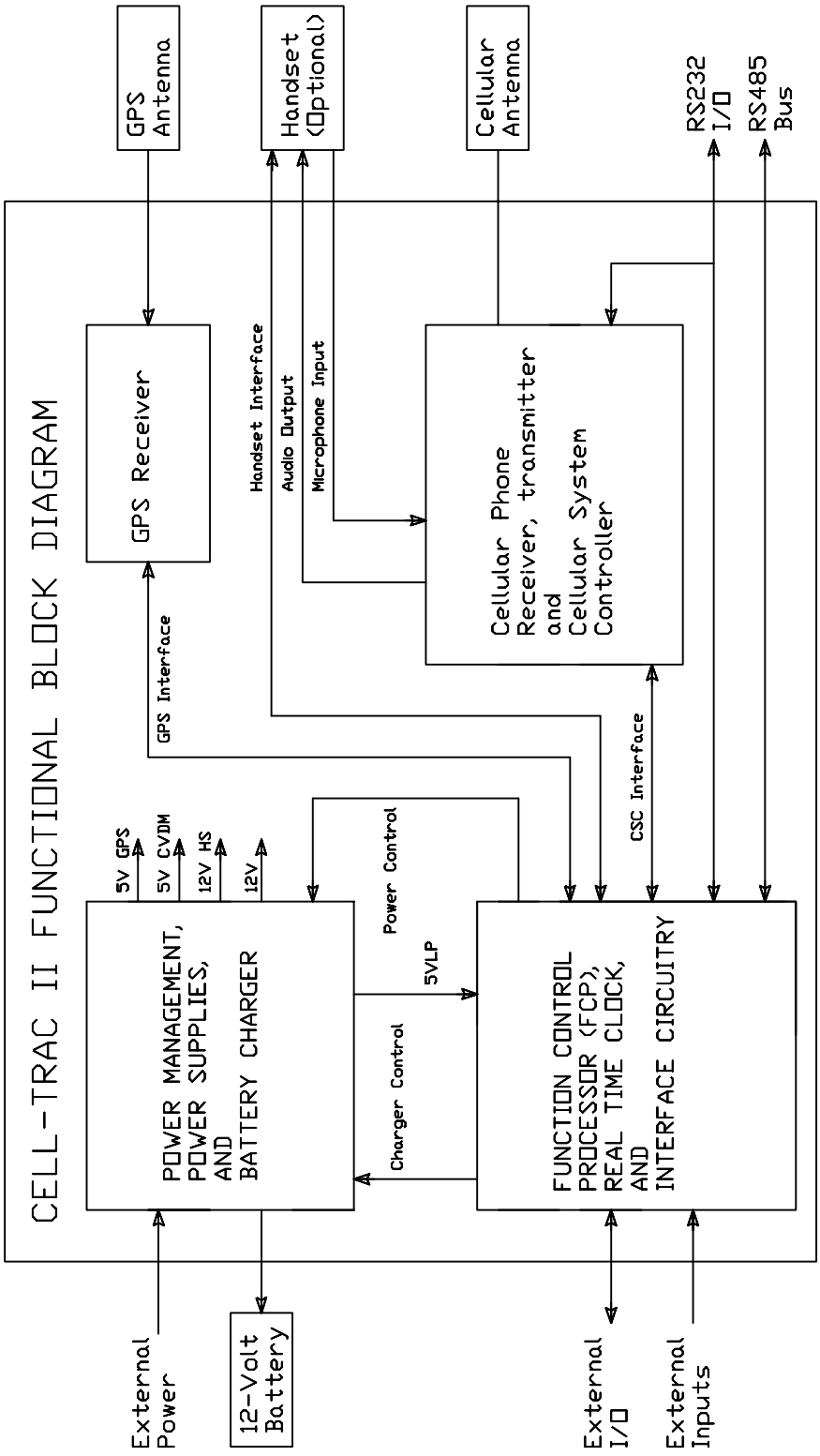

Figure 3 CELL-TRAC™ II Functional Block Diagram

Cellular Receiver

The cellular receiver consists of a dual conversion superheterodyne receiver. The receiver circuitry includes an antenna, duplexer, radio frequency (RF) amplifier, surface acoustic wave (SAW) filter, second RF amplifier, L-band 914 MHz voltage controlled oscillator (VCO), L-band mixer which converts the received signal (≈869 MHz) to 45 MHz, the first intermediate frequency (IF) frequency, a 45 MHz band pass crystal filter, VHF mixer which converts the 45 MHz signal to 450 kHz, the second IF frequency, a 450 kHz IF amplifier and ceramic filter, limiter, FM discriminator, audio filter, expander, audio amplifier and optional handset speaker. The audio signal is also input to the 2400 Baud Rockwell Compatible Modem.

Cellular Transmitter

The cellular transmitter consists of a audio amplifier and filter, deviation limiter, 90 MHz VCO which is frequency modulated by the audio signal from the deviation limiter, mixer which uses the 90 MHz VCO and the receiver L-band 914 MHz VCO to produce the carrier frequency (≈824 MHz), SAW filter, RF amplifier, 3W RF Power Amplifier, duplexer, and antenna

Cellular System Controller

The Cellular System Controller (CSC) receives cellular control commands from the Function Control Processor such as listen for incoming calls, make a call to a specific phone number, place a call to the Data Center and transfer stored GPS and status data, store GPS data, and etc. The CSC interfaces to the cellular transmitter, cellular receiver, audio amplifiers, 2400 Baud Modem, Function Control Processor, Flash EPROM, and a RS232 interface. The CSC controls the operating frequency of the cellular transceiver, output power of the 3W RF Power Amplifier, data transfer thru the modem, data storage, and all functions relating to the cellular transceiver in accordance with AMPS cellular standards EIA/TIA 553 and IS19B.

Function Control Processor

The Function Control Processor (FCP) is a microcontroller IC that controls all operations of the CELL-TRAC™ II unit. The FCP interfaces to CSC circuitry, GPS receiver board, optional external Handset, RS485 interface, RS232 interface, external I/O, opto isolator, and Power Management circuitry. The FCP monitors the status of the various circuits and sends commands that control the operation of the circuits. Also the FCP has a Real time clock to determine when the CELL-TRAC™ II should be in sleep mode, listening for an incoming call, placing a call to transfer stored data, and waking up for collecting GPS data.

Power Management Circuit
The Power Management Circuit consist of a 12V Battery Charger circuit that is a pulse width modulated switching power supply which is synched to a 611 kHz clock supplied by the FCP, a +5 VDC Main regulator that is a constant off time pulse width modulated switching power supply with a free running switching frequency from 93 kHz to 141 kHz, and semiconductor switches that are controlled by the FCP to turn on and off the power applied to the GPS receiver and cellular transceiver.

GPS Receiver Board
The Global Position Satellite (GPS) receiver board is an eight channel continuous tracking GPS receiver that provides position, velocity, and status updates once a second using Trimble Standard Interface Protocol (TSIP) or National Marine Electronics Association (NMEA) 0183 v2.1 protocol. The GPS receiver also supports differential operation using Radio Technical Commission for Maritime Services (RTCM) SC-104 communication protocol.

For more detail see the detailed block diagram, detailed theory of operation, and Schematics, in Exhibit 3 Detailed Block Diagram and Theory of Operation, and Exhibit 4 Circuit Diagrams.

2.983 (d) -1 Types of Emission

The CELL-TRAC™ II operates according to AMPS cellular standards EIA/TIA 553 and IS19B. All frequency channels have a maximum bandwidth of 40 kHz in accordance with CFR 47 Part 22 Section 22.905. Modulation type is Frequency Modulation (F), with a single channel containing digital information (1) and/or a single channels containing analogue information (3), with the type of information being data transmission (D) and/or a combination of data transmission and telephony (W). Therefor the emission designators are 40K0F3W and 40K0F1D. Exhibit 9 Intertek Testing Services NA Inc. Test Report section 6,7, and 8 contains test data taken on a CELL-TRAC™ II demonstrating that the cellular transmitter does meet the Emission limits as required by CFR 47 Part 2 Section 2.989, Section 2.993, Part 15 Section 15.109, and Part 22 Section 22.917 .

2.983 (d) -2 Frequency Range

The CELL-TRAC™ II operates in accordance with CFR 47 Part 22 Section 22.905, Channels for Cellular Service. The operation frequency range of the CELL-TRAC™ II is:
Channel Blocks A and B, and Control Channels
Transmit frequency: 824-849 MHz
Receive frequency: 869-894 Mhz

2.983 (d) -3 Range of Operating Power

The CELL-TRAC™ II has a RF power amplifier that can be programmed to change it's output power level from 0 watts to 3 watts (35 dBm ± 0.5 dB), as required to maintain good communication with the cellular base station. Exhibit 9 Intertek Testing Services NA Inc. Test Report section 2 contains test data taken on a CELL-TRAC™ II transmitter connected to a 50 Ohm coaxial attenuator demonstrating that the transmitter's RF Power Output is 35 dBm ± 0.5 dB.

2.983 (d) -4 Maximum Transmit Power level (22.913(a) 7 W ERP)

The Effective Radiated Power (ERP) of mobile transmitters and auxiliary test transmitters must not exceed 7 watts in accordance with CFR 47 Part 22 Section 22.913(a). Exhibit 9 Intertek Testing Services NA Inc. Test Report section 3 contains test data taken on a CELL-TRAC™ II transmitter. The radiated emission testing was done at a distance of 3 meters, and the ERP for the CELL-TRAC™ II was determined to be 4.47 watts (36.5dBm) which is less then 7 watts.

2.983 (d) -5 DC Voltages and Current

The prime power supplied to the CELL-TRAC™ II is 9 to 36 VDC @ 1.5 amperes maximum. Switching DC-DC converters with filtering and linear regulations are used internally to generate the required voltages to operate the active circuits. Voltages generated internal to the CELL-TRAC™ II include; 5.0 VDC and 12 VDC.

2.983 (d) -6 Functions of each active circuit

The CELL-TRAC™ II contains four active circuits. Three of the active circuits are fabricated on a single circuit card assembly and the fourth on another circuit card assembly. The four actives circuits are: the power management circuit, GPS receiver, Cellular Voice/Data Transceiver, and Function Control Processor(FCP).

The function of the power management circuit is to provide a 12 VDC battery charging circuitry, multiple 5 VDC regulator circuitry, and 5 VDC and 12 VDC power switch circuitry that controls the application of power to the other active circuits.

The function of the GPS receiver is to determine location of the CELL-TRAC™ II.

The function of the Cellular Voice/Data Transceiver is to provide cellular radio communication using class I, 3 Watt cellular transceiver circuit which operates according to AMPS cellular standards EIA/TIA 553 and IS19B.

The function of the FCP is to interface to the other circuits, supply an external RS485 serial communication bus, TTL external I/O, monitors system usage and shuts down unnecessary circuits to reduce current being used by the battery, and control the enabling of the Cellular Voice/Data Transceiver. The circuit also determines which power source to use based on the voltage levels of the two power sources.

2.983 (d) -7 Circuit Diagrams

Figure 3 CELL-TRAC™ II Functional Block Diagram provides circuit block diagrams for each of the active circuits noted above. For more detail see Exhibit 3 Detailed Block Diagram and Theory of Operation and Exhibit 4 Circuit Diagrams.

2.983 (d) -8 Users /Instruction Book

Exhibit 8 Users Manual describes the use of and setup of the CELL-TRAC™ II.

2.983 (d) – 9 Tune – up Procedure

The CELL-TRAC™ II is calibrated at the assembly line before being installed in the enclosure. The CELL-TRAC™ II is checked again after final assembly to ensure the RF power output of the CELL-TRAC™ II is set to the specified 35dBm ± 0.5dB.

Manufacturing:

1. Each CELL-TRAC™ II is adjusted on the production test bench during manufacturing Board Level Test for a maximum output power of 35 dBm ± 0.5dB.
2. Following the installation of the CELL-TRAC™ II CCA's into the enclosure, the RF output power is measured during manufacturing Final Level Test to verify nominal power out of 35dBm ± 0.5dB.

See Manual Board Level Test, Automated Board Level Test, and Final Level Test procedures in Exhibit 5 Tune-Up Procedure.

2.983 (d) - 10 Frequency Stability

The Frequency Stability of the mobile transmitter must not exceed ±2.5ppm in accordance with CFR 47 Part 2 Section 2.995(a), 2.995(d)(2), and 22.355. Exhibit 9 Intertek Testing Services NA Inc. Test Report section 10 and 11 contains test data taken on a CELL-TRAC™ II transmitter. The Frequency Stability was tested over temperature and tested over voltage, and the Frequency Stability for the CELL-TRAC™ II was determined to be better than 2.5ppm.

For more detail see Exhibit 3 Detailed Block Diagram and Theory of Operation and Exhibit 4 Circuit Diagrams.

2.983 (d) – 11 Circuits for Suppression of Spurs, Limiting Modulation, or Power Limits

The Cellular transmitter contains circuitry and devices for suppression of spurious radiation, for limiting modulation, and for limiting power.

Note: In the following paragraphs reference designators and signal names will be followed by a sheet number(s) in parentheses, for example U11 (sheet 11) or PCNTL_V (sheet 9,14). The sheet number(s) corresponds to the sheet number of the schematic diagram in Exhibit 4 Circuit Diagrams where the part or signal can be found.

Suppression of spurious radiation from the cellular transmitter is accomplished by using a duplexer, FL1 (sheet 6), to connect the output of the cellular transmitter to the cellular antenna. The duplexer, FL1, is a ceramic band pass filter that has a pass band of 824 - 849 MHz, 10 dB minimum attenuation 779-804 MHz, and 45 dB minimum attenuation 869-894 MHz. Also the rejection of spurious radiation at higher frequencies is increased by the low pass filter created by the etch run from the RF Power Amplifier, U6, thru the 20 dB coupler PA1 to the duplexer FL1, and also by the absorption effect of the pwb material at higher frequencies.

The Audio Processor IC, U12 (sheet 12), has a built in hard limiter to ensure compliance with the peak deviation specification for cellular telephone systems. The hard limiter follows the pre-emphasis filter to remove any transient level changes that have passed through the soft limiter. An 8dB attenuator follows the hard limiter to prevent any further clipping of the signal in the following transmit low pass filter stage. For more detail see page 22 of the data sheet for U12 included in Exhibit 3 Detailed Block Diagram and Theory of Operation.

The transmitter output power can be varied from 0 to 3 Watts as required to maintain good communication with the cellular base station. The Cellular System Controller IC, U14 (sheet 13), and the Radio Interface and Twin Synthesiser IC, U18 (sheet 14), work together to determine the needed transmitter output power. U18 outputs the reference analog voltage PCNTL_V (sheet 9,14) that corresponds to the required transmitter power level. The transmitter output power is sensed using a 20 dB coupler, PA1 (sheet 9), a diode detector, U4 (sheet 9), and a differential amplifier, U7A (sheet 9). The output of the differential amplifier, U7A, is input to an error amplifier, U7B (sheet 9), along with the reference signal PCNTL_V to produce the control signal VPC (sheet 9). Signal VPC is connected to the RF Power Amplifier, U6 (sheet 9), control input thus regulating the transmitter output power to the desired level.

2.983 (d) - 12 Digital Modulation

The CELL-TRAC™ II uses a 2400 Baud Modem, U23 (sheet 13), located in the Cellular Voice/Data Transceiver circuitry to receive and transmit audio digital data. The modem outputs audio digital data in accordance with CCITTV.22bis (2400bps), CCITTV.22 (1200bps), Bell 212A (1200bps), or Bell 103 (300bps). The audio digital data is filtered and deviation limited by the Audio Processor IC U12 (sheet 12). For more detail see Exhibit 3 Detailed Block Diagram and Theory of Operation page 4 and Exhibit 4 Circuit Diagrams sheet 12 and 13. Also see test results in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 4 Modulation Deviation Limiting CFR 47 Part 2 Section 2.987 and part 22 Section 22.915(c), and section 5 Audio Filter Characteristics CFR 47 Part 22 Section 22.915(d)(1)

2.983 (e) Data

Test data required by paragraphs 2.985 to 2.997 in accordance with paragraph 2.999 is shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 2 thru 11, also see Table 1 - Test Summary.

2.983 (f) ID Plate

Exhibit 2 FCC Label Format and Label Location provides a drawing of the CELL-TRAC™ II label.

2.983 (g) Equipment Construction & Layout

Exhibit 1 Construction and Layout provides photographs and assembly drawings which show detailed views of the equipment layout and construction.

2.985 -2.997 Measurements Required

Introduction:
A CELL-TRAC™ II was subjected to the measurements as specified in this section. Table 1 is a summary of the tests performed. Measured data, block diagrams, and test equipment information is included in Exhibit 9 Intertek Testing Services NA Inc. Test Report.

Table 1 - Test Summary

FCC Rule	Description of Test	Test Report Section	Result
2.985(a)	RF Power Output	2	Pass
22.913	Effective Radiated Power	3	Pass
2.987 22.915(c)	Modulating Deviation Limiting Deviation Limitation Circuitry	4	Pass
22.915(d)(1)	Audio Filter Characteristics	5	Pass
2.989(c)(1) 22.917(b)(d)	Occupied Bandwidth Emission Limitations for Cellular	6	Pass
22.917(e) 22.917(f)	Out of Band Emissions at Antenna Terminals Mobile Emissions in Base Frequency Range	7	Pass
2.993 22.917(e) 15.109(a)	Field Strength of Spurious Radiation Out of Band Emissions Radiated Emission Limits	8	Pass
15.107(a)	AC Line Conducted Emission	9	N/A
2.995(a) 22.355	Frequency Stability vs. Temperature Frequency Tolerence	10	Pass
2.995(d)(2) 22.355	Frequency Stability vs. Voltage Frequency Tolerence	11	Pass

2.985(a) Measurements Required: RF Power Output

Requirements: CFR 47 Part 2 Section 2.985(a)

The Antenna was removed and a TNC type connector was connected to the transmitter output. The transmitter output was connected to a 20 dB calibrated coaxial attenuator (50 ohm), the other end of which was connected to a spectrum analyzer. Transmitter output was read off the spectrum analyzer in dBm. The power output at the transmitter was determined by adding the value of the attenuator to the spectrum analyzer reading. This was accomplished by programming an offset of 20.7 dB (20 dB attenuator plus 0.7 dB cable loss) into the spectrum analyzer. Thus the marker reading corresponded to the transmitter output. A power meter was connected to the transmitter output and its reading was compared to the spectrum analyzer data. At low channel the power meter read 35.0 dBm and the spectrum analyzer read 35.3 dBm. The power meter reading was 0.3 dB less than the spectrum analyzer reading.

The test was performed at three frequencies (low, middle, and high channels) and on all power levels which can be setup on the transmitters.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 2. Test data is shown in section 2 plots 2.3.a (low channel), plot 2.3.b (middle channel), plot 2.3.c (high channel), and the data is

recorded in the data sheet on page 4 of section 2. The requirements of CFR 47 Part 2 Section 2.985(a) were met.

22.913 Measurements Required: Effective Radiated Power

Requirements: CFR 47 Part 22 Section 22.913

The Effective Radiated Power (ERP) of mobile transmitters and auxiliary test transmitters must not exceed 7 watts.

The equipment under test (EUT) was positioned on a non-conductive turntable, 0.8m above the ground plane on an open test site.

The radiated emissions at the fundamental frequency was measured at 3 meters distance with a test antenna and spectrum analyzer. During the measurement, the resolution and video bandwidths of the spectrum analyzer were set to 100 kHz. Worst case emissions was recorded with the rotation of the turntable and the raising and lowering of the test antenna. The spectrum analyzer reading was recorded.

The ERP was calculated as follows:

ERP(dBm) = E(dBuV/m) + 20 log D - 10 log 30 - 10 log G - 90

Where E = Field Intensity Measurement + Antenna Factor +Cable Loss, dBuV/m
D = Distance from EUT, 3 meters
G = 1.64 is the gain of half-wave dipole

The maximum ERP was found to be 36.5 dBm, 4.467 watts, at the low channel test. The test was performed at three frequencies (low, middle, and high channels).

In addition, the Equivalent Isotropic Radiated Power (EIRP) in dBpW was calculated as follows:

EIRP(dBpW) = ERP(dBm) + 90 + 10 log 1.64

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 3. The requirements of CFR 47 Part 22 Section 22.913 were met.

2.987 Measurements Required: RF Modulation

Requirements: CFR 47 Part 2 Section 2.987

Modulation Characteristics per CFR 47 Part 2 Section 2.987 requires data showing modulation input voltage versus modulation.

The RF output of the transceiver was connected to the input of an FM deviation meter through sufficient attenuation so as not to overload the meter or distort the readings. An audio signal generator with a variable attenuator on the output was connected to pins 2 and 1 of the headphone connector pads.

At three different modulating frequencies, the output level of the audio generator was varied and the FM deviation level was recorded. See Exhibit 9 Intertek Testing Services NA Inc. Test Report, page 7, Table 4.1a, Modulation Limiting.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 4. The requirements of CFR 47 Part 2 Section 2.987 were met.

22.915(a) Non-Voice Modulation signals

Requirement: CFR 47 Part 22 Section 22.915(a)

Modulation signals other than voice signals, such as data signals, may be transmitted, provided the resulting modulated emission Exhibits spectral characteristics not exceeding those resulting from voice modulation.

The CELL-TRAC™ II uses voice signals and audio digital data as described in 2.983 (d) - 12 Digital Modulation. The audio digital data is processed thru the audio processor IC, U12. The wideband emission created by the audio digital data was tested (see paragraph 2.989(c)(1) Measurements Required: Occupied Bandwidth, and 22.917(b)(d) Emission Limitations for Cellular) and the test results are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 6, plots 6.3.b and 6.3.c.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 6. The requirements of CFR 47 Part 22 Section 2.915(a) were met.

22.915(b) Modulating signals.

Requirements: CFR 47 Part 22 Section 22.915(b)

Per CFR 47 Part 22 Section 22.915(b), the levels of the modulating signals must be set to the values specified in this paragraph, and must be maintained within ± 10% of those values.

1. The instantaneous frequency deviation resulting from the main modulating signal must be ± 12 kHz.
2. The instantaneous frequency deviation resulting from the supervisory audio tone must be ± 2 kHz.
3. The instantaneous frequency deviation resulting from the signaling tone must be ± 8 kHz.
4. The instantaneous frequency deviation resulting from wideband data signals must be ± 8 kHz.

The audio processor IC, U12 (sheet 12), working in conjunction with the Cellular System Controller IC, U14 (sheet 13), were design to meet the requirements. In Exhibit 5 Tune-Up Procedure and the Manual Board Level Test Procedure the deviation levels are tested and set. The audio deviation is tested and set to 11 kHz ± 0.3 kHz, see page 11 paragraph 4.3.54. The supervisory audio tone (SAT) deviation is tested and set to 2.0 kHz ± 0.1 kHz, see page 10 paragraph 4.3.38, and the signaling tone (ST) deviation is tested and set to 8 kHz ± 0.4 kHz. Other Transmitter tests and adjustments are done in the Test Procedure to insure the transmitter meets the requirements.

The requirements of CFR 47 Part 22 Section 2.915(b) are met by design and production testing.

22.915(c) Deviation Limitation Circuitry

Requirements: CFR 47 Part 22 Section 22.915(c)

Per CFR 47 Part 22 Section 22.915(c), cellular transmitters must be equipped with circuitry that automatically prevents modulation levels for voice transmission from exceeding the limits of CFR 47 Part 22 Section 22.915(b)(1), which is that the instantaneous frequency deviation resulting from the main modulating signal must be ± 12 kHz ± 10 %.

The RF output of the transceiver was connected to the input of an FM deviation meter through sufficient attenuation so as not to overload the meter or distort the readings. An audio signal generator with a variable attenuator on the output was connected to pins 2 and 1 of the headphone connector pads.

The audio input was adjusted for 8 kHz deviation at 1 kHz tone with the 2:1 compressor enabled and the SAT disabled. The audio input was increased by 20 dB in one step. Both the initial and the subsequent steady state values of the peak frequency deviation, at and following the time of the 20 dB increase, were measured and recorded in the frequency range 300 Hz - 3 kHz. See Exhibit 9 Intertek Testing Services NA Inc. Test Report, page 8, Table 4.1b, Peak Frequency Deviation.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 4. The requirements of CFR 47 Part 22 Section 22.915(c) were met.

22.915(d)(1) Measurements Required: Audio Filter Characteristics

Requirements: CFR 47 Part 22 Section 22.915(d)(1)

For mobile stations, these signals must be attenuated (per CFR 47 Part 22 Section 22.915(d)(1)), relative to the level at 1 kHz, as follows:
(i) In the frequency range of 3.0 to 5.9 kHz and 6.1 to 15.0 kHz, signals must be attenuated by at least 40 log (f/3) dB, where f is the frequency of the signal in kHz.
(ii) In the frequency range of 5.9 to 6.1 kHz, signals must be attenuated at least 35 dB.
(iii) In the frequency range above 15 kHz, signals must be attenuated at least 28 dB.

The Audio Filter is located in the Audio Processor IC, U12. The Frequency response relative to 1040 Hz is listed in the data sheet for U12, included in Exhibit 3 Detailed Block Diagram and Theory of Operation, on page 5 under "TX Audio Bandpass Filter TXBPF, IPS TO TBPO"and lists the following:

Frequency in Hz	Gain Max. in dB
3010	-1.5
3500	-13.0
4120	-38.0
5590	-38.0
9900	-38.0
11870	-35.0

The frequency response is also plotted, in the data sheet, on page 13 Figure 4.

The RF output of the transceiver was connected to the input of an FM deviation meter through sufficient attenuation so as not to overload the meter or distort the reading. The measurements were performed using the test setup shown in Figure 4 Audio Filter Test Setup Block Diagram.

The audio signal at the transceiver audio input was adjusted to obtain 9 kHz deviation at the modulation frequency of maximum response (approximately 2.6 kHz).

As shown in Figure 4, a spectrum analyzer having a tracing generator, and the Radio Communication Test Set having an output of a demodulator, are used.

After the calibration was made (the -20 dBm reading of the spectrum analyzer corresponds to the 9 kHz deviation) the spectrum analyzer was set to scan the frequency from 300 Hz to 30 kHz, with the same audio input level as described above. The audio filter response was plotted directly from the spectrum analyzer. The relative level was obtained from the plots and the attenuation was calculated with reference to the level at 1 kHz. See Exhibit 9 Intertek Testing Services NA Inc. Test Report, section 5, Table 5.1 and plots 5.1.a thru 5.1.c.
(i) In the frequency range of 3.0 to 5.9 kHz, the attenuation was 39.6 dB at 4.5 kHz which is better then the 7.04 dB (40log(4.5/3) dB) requirement. In the frequency range of 6.1 to 15 kHz, the attenuation was 50.5 dB at 15 kHz which is better then the 27.96 dB (40log(15/3) dB) requirement.
(ii) In the frequency range of 5.9 kHz to 6.1 kHz, the minimum attenuation was 38.9 dB at 6.0 kHz which is better then the 35 dB requirement.
(iii) In the frequency range above 15 kHz the attenuation was 61.0 dB at 20 kHz which is better then the 28 dB requirement.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 5. The requirements of CFR 47 Part 22 Section 22.915(d)(1) were met.

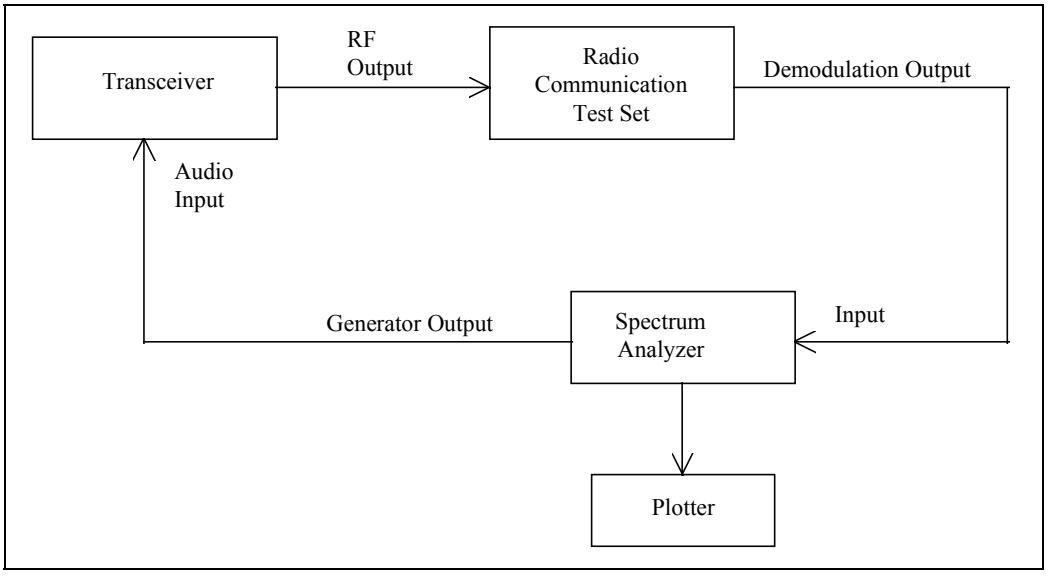

Figure 4 Audio Filter Test Setup Block Diagram

2.989(c)(1) Measurements Required: Occupied Bandwidth, and 22.917(b)(d) Emission Limitations for Cellular

Requirements: CFR 47 Part 2 Section 2.989(c)(1), Part 22 Section 22.917(b)(d)

22.917(b) Emission Limitations, F3E/F3D Emission Mask

F3E/F3D emission mask for use with audio filter per CFR 47 Part 22 Section 22.917(b). The mean power of emissions must be attenuated below the mean power of the unmodulated carrier wave (P) as follows:

(1) On any frequency removed from the carrier frequency by more than 20 kHz but not more than 45 kHz: at least 26 dB;

(2) On any frequency removed from the carrier frequency by more than 45 kHz, up to the first multiple of the carrier frequency: at least 60 dB or 43+log(P) dB, whichever is the lesser attenuation.

22.917(d) Emission Limitations, F1D Emission Mask

F1D emission mask per CFR 47 Part 22 Section 22.917(d). The mean power of emissions must be attenuated below the mean power of the unmodulated carrier (P) as follows:

(1) On any frequency removed from the carrier frequency by more than 20 kHz but not more than 45 kHz: at least 26 dB;

(2) On any frequency removed from the carrier frequency by more than 45 kHz but not more than 90 kHz: at least 45 dB;

(3) On any frequency removed from the carrier frequency by more than 90 kHz, up to the first multiple of the carrier frequency: at least 60 dB or 43+log(P) dB, whichever is the lesser attenuation.

The RF output of the transceiver was connected to the input of the spectrum analyzer through sufficient attenuation so as not to overload the spectrum analyzer or distort the reading. A 20 dB calibrated coaxial attenuator (50 ohm) was used.

An audio signal generator with a variable attenuator on the output was coupled into the audio input of the transceiver. The spectrum of the RF output, with no modulation, was recorded. The audio signal at the transceiver audio input was adjusted to obtain 6 kHz deviation at the modulation frequency of maximum response (approximately 2.4 kHz) which was determined by measuring deviation versus frequency from 300 Hz to 3.5 kHz. The audio input level was increased by 16 dB and the audio frequency was then set to the frequency of 2.5 kHz as required by CFR 47 Part 2 Section 2.989(c)(1).

The resolution bandwidth of the spectrum analyzer was set to 300 Hz as required by CFR 47 Part 22 Section 22.917(h) and the spectrum of the transceiver RF output was scanned over the frequency range of carrier frequency ±50 kHz. The response was plotted directly from the spectrum analyzer. The test was repeated and results plotted for wideband emissions, SAT, ST, DTMF9, and some of the combinations of these modulating signals.

Plots 6.3.a thru 6.3.o along with the table that list the plots and their description are in Exhibit 9 Intertek Testing Services NA Inc. Test Report, section 6. The

spectrum analyzer was programmed with an offset of 20.7 dB (corresponding to the 20 dB attenuator plus 0.7 dB cable loss). Thus the spectrum analyzer marker reading corresponded to the transmitter output. As can be seen in plot 6.3.a (carrier frequency with no modulation), the spectrum analyzer reference level was adjusted to 35.8 dBm so that the top line on the plot corresponds to the mean power of the unmodulated carrier (P). This setup was maintained for all the plots 6.3.a thru 6.3.o so that the attenuation could be more easily read from the plots. For example in plot 6.3.b (Wideband emissions, scan 100 kHz) with 10 kHz per division in the x axis and 10 dB per division in the y axis, at 20.1 kHz (2.01 divisions to the right of the center line) the signal is attenuated by about 35 dB (3.5 divisions down from the top line on the plot) which is better then the 26 dB requirement. Also at 45.1 kHz (4.51 divisions to the right of the center line) the signal is attenuated by about 68 dB (6.8 divisions down from the top line on the plot) which is better then the 45 dB requirement In plot 6.3.c (Wideband emissions, scan 200 kHz) with 20 kHz per division in the x axis and 10 dB per division in the y axis, at 90.1 kHz (4.5 divisions to the right of the center line) the signal is attenuated by about 80 dB (8 divisions down from the top line on the plot) which is better then the 48.8 dB (43+10log(3.8 watts) dB) requirement.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 6. The requirements of CFR 47 Part 2 Section 2.989(c)(1) and CFR 47 Part 22 Section 22.917(b)(d) were met.

22.917(e) Measurements Required: Out of Band Emissions, and 22.917(f) Mobil Emissions in Base Frequency Range

Requirements: CFR 47 Part 22 Section 22.917(e), and Part 22 Section 22.917(f)

22.917(e) Out of Band Emissions

The mean power of emissions must be attenuated below the mean power of the unmodulated carrier (P) on any frequency twice or more than twice the fundamental frequency by at least 43+10log(P) dB per CFR 47 Part 22 Section 22.917(e). The out of band emissions must be greater then 43+10log(3.8 watts) = 48.8 dB.

The RF output of the transceiver was connected to the input of the spectrum analyzer through sufficient attenuation so as not to overload the spectrum analyzer or distort the reading. A 20 dB calibrated coaxial attenuator (50 ohm) was used.

An audio signal generator with a variable attenuator on the output was coupled into to the audio input of the transceiver. The audio signal at the transceiver audio input was adjusted to obtain 6 kHz deviation at the modulation frequency of maximum response (approximately 2.4 kHz) which was determined by measuring deviation versus frequency from 300 Hz to 3.5 kHz. The audio input level was

increased by 16 dB and the audio frequency was then set to the frequency of 2.5 kHz.

The resolution bandwidth of the spectrum analyzer was set to 30 kHz and the spectrum of the transceiver RF output was scanned over the frequency range of 1 MHz to 10 GHz with the transmitter at Low Channel, Middle Channel, and then High Channel. Sufficient scans were taken to show the outband emissions, if any, up to the 10th harmonic. The responses were plotted directly from the spectrum analyzer, and showed that the requirements of CFR 47 Part 22 Section 22.917(e) and CFR 47 Part 22 Section 22.917(f) were met.

Plots 7.3.a thru 7.3.o along with the table that list the plots and their description are in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 7. The spectrum analyzer was programmed with an offset of 20.7 dB (corresponding to the 20 dB attenuator plus 0.7 dB cable loss). Thus the spectrum analyzer marker reading corresponded to the transmitter output. The spectrum analyzer reference level was adjusted to 35.8 dBm (the unmodulated power output) so that the top line on the plot corresponds to the mean power of the unmodulated carrier (P). This setup was maintained for all the plots 7.3.a thru 7.3.l so that the attenuation could be more easily read from the plots. For example in plot 7.3.a (1 MHz - 30 Mhz (Low Channel)) at 10.14 Mhz a spike is seen that, with 10 dB per division in the y axis, is attenuated by 77.9 dB (7.79 divisions down from the top line on the plot, or equal to 35.8 dBm, reference level, minus -42.10 dBm marker reading) which is better then the 48.8 dB (43+10log(3.8 watts) dB) requirement.

22.917(f) Mobile Emissions in Base Frequency Range

The mean power of any emissions appearing in the base station frequency range from cellular mobile transmitters operated must be attenuated to a level not to exceed -80 dBm at the transmit antenna connector per CFR 47 Part 22 Section 22.917(f).

For plots 7.3.m thru 7.3.o the resolution bandwidth of the spectrum analyzer was set to 30 kHz and the video bandwidth was set to 10 kHz to increase the noise floor to about 86 dB so that the emissions in base frequency range could be tested. In plot 7.3.m the marker was set to the highest spike at 891.3 Mhz and it's attenuation is -81.7 dBm (marker reading) which is better then the -80 dBm requirement.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 7.

2.993 Measurements Required: Field Strength of Spurious Radiation, 15.109(a) Radiated Emission Limits, and 22.917(e) Out of Band Emissions

Requirements: CFR 47 Part 2 Section 2.993, CFR 47 Part 15 Section 15.109(a), CFR 47 Part 22 Section 22.917(e)

15.109(a) Radiated Emission Limits
The field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency of Emission MHz	Field Strength microvolts/meter	Field Strength dB(uV/m)
30-88	100	40.0
8-216	150	43.5
216-960	200	46.0
Above 960	500	54.0

22.917(e) Out of Band Emissions
The mean power of emissions must be attenuated below the mean power of the unmodulated carrier (P) on any frequency twice or more than twice the fundamental frequency by at least 43+10log(P) dB.

Channel Frequency MHz	Attenuation Limit dB
824.04 (low)	46.9
836.52 (middle)	48.2
848.97 (high)	48.1

The measurement antenna was placed at a distance of 3 meters from the equipment under test (EUT). During the tests, the antenna height and polarization as well as the EUT azimuth were varied in order to identify the maximum level of emissions from the EUT.

The frequency range up to the tenth harmonic of each of the three fundamental frequency's (low, middle, and high channel) was investigated.

The spurious emissions attenuation was calculated as the difference between field strength in dBuV/m at the fundamental frequency and at the spurious emissions frequency.

Section 8 of Exhibit 9 Intertek Testing Services NA Inc. Test Report contains five data sheets. The first three data sheets correspond to the test results FCC Part 22 Radiated Emissions at low, middle, and high channel. The first FCC Part 22 data sheet, low channel, shows that at 1648.1 Mhz the spurious attenuation was 55.5 dB versus a requirement of 46.9 dB (43+10log(P) dB) and the margin column shows -8.6 dB which means the unit passed the test with a margin of -8.6 dB.
The last two data sheets correspond to the test results FCC 15 Class B Radiated Emissions. The first FCC 15 data sheet, mid channel, shows that at 2779.5 Mhz

the corrected reading was 47.4 dB(uV/m) versus a requirement of 54.0 dB(uV/m) and the margin column shows -6.6 dB which means the unit passed the test with a margin of -6.6 dB.

The requirements of CFR 47 Part 2 Section 2.993 and CFR 47 Part 15 Section 15.109(a) were met.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 8.

15.107(a) Measurements Required: AC Line Conducted Emission

Requirements: CFR 47 Part 15 Section 15.107(a)

The CELL-TRAC™ II does not connect to the public utility (AC) power lime. Therefore this paragraph is not applicable.

2.995(a) Measurements Required: Frequency Stability versus Temperature, and 22.355 Frequency Tolerance

Requirements: CFR 47 Part 2 Section 2.995(a), CFR 47 Part 22 Section 22.355
Frequency Tolerance: ±2.5ppm

The EUT was connected to an external DC power supply and the RF output was connected to a calibrated coaxial attenuator, the other end of which was connected to a frequency counter. The EUT was placed inside the temperature chamber. The DC leads, RF output cable, and external computer control cable exited the chamber through an opening made for that purpose.

After the temperature stabilized for approximately 20 minutes, the external computer activated the transmitter, and the frequency output was recorded from the counter.

Section 10 of Exhibit 9 Intertek Testing Services NA Inc. Test Report contains the data sheet Frequency Stability versus Temperature. The data sheet shows that at -20°C the frequency difference was 1610 Hz versus a requirement of 2088 Hz which means the unit passed the test at -20°C.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 10. The requirements of CFR 47 Part 2 Section 2.995(a) and CFR 47 Part 22 Section 22.355 were met.

2.995(d)(2) Measurements Required: Frequency Stability versus Voltage, and 22.355 Frequency Tolerance

Requirements: CFR 47 Part 2 Section 2.995(d)(2), CFR 47 Part 22 Section 22.355
Frequency Tolerance: ±2.5ppm

An external variable DC power supply was connected to the battery terminals of the EUT. The RF output was connected to a calibrated coaxial attenuator, the other end of which was connected to a frequency counter. The voltage was set to 115 % (14.2 VDC) of the nominal value and was then decreased until the transmitter light no longer illuminates; i.e., the point where the control circuit inhibits transmission, about 10 VDC. The output frequency was recorded for each battery voltage.

Section 11 of Exhibit 9 Intertek Testing Services NA Inc. Test Report contains the data sheet Frequency Stability versus Voltage (note: the data sheet has a typo in its title. It says Temperature instead of Voltage). The data sheet shows that at 85% (10.5 VDC) the frequency difference was -30 Hz versus a requirement of 2088 Hz which means the unit passed the test at 85%.

Test methodology and data are shown in Exhibit 9 Intertek Testing Services NA Inc. Test Report section 11. The requirements of CFR 47 Part 2 Section 2.995(d)(2) and CFR 47 Part 22 Section 22.355 were met.

2.1091 Radio frequency Radiation Exposure Evaluation: Mobile

The CELL-TRAC™ II is a mobile device that operates in the cellular radiotelephone service with effective radiated power (ERP) of 1.5 watts or more that uses a vehicle-mounted antenna that meets the 20 centimeter separation requirement. The ERP was measured, see Exhibit 9 Intertek Testing Services NA Inc. Test Report, and the average power density was calculated, using equations 2 and 5 from OET Bulletin 65 Edition 97-01 dated August 1997, and compared to the maximum permissible exposure (MPE) Limits for General Population/ Uncontrolled Exposure (Appendix A, Table 1B of OET Bulletin 65, Evaluation Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields).

Exhibit 7 MPE Data, contains the calculations showing that the CELL-TRAC™ II complies with the limits for MPE.

Section IV Exhibits