Cello-IQ
Product Overview

Cellocator Division
Pointer Telocation Ltd.

Proprietary and Confidential

Version 2.7

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POINTER

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1 Introduction

1.1 Document Purpose and Scope

The purpose of this document is to provide high-level information required by service providers who are considering the integration and operation of Cello-IQ devices with their fleet management applications.

This document describes the Cello-IQ content and deliverables. It also briefly describes the features and capabilities of driver behavior monitoring, eco-driving, and the driver safety system, as implemented in the Cello-IQ.

1.2 Definitions, Acronyms and Abbreviations

Abbreviation	Description
DBM	Driver behavior Monitoring
Cello-IQ	Cellocator Safety, DBM and Eco-driving monitoring device
CC	Communication Center
COP	Cellocator Open Platform
CSA	Cellocator Safety Application
CM	CSA Manager
CDB	Cellocator Driver Behavior
DFD	Driver Feedback Device
EDR	Emergency Data Recording
KML	Keyhole Markup Language
TIP	Traffic Injection Product

Table 1: Acronyms and Abbreviations

1.3 References

#	Reference	Description
1	Cellocator Evaluation Suite Manual	Refer to page **Error! Bookmark not defined.** for more information.
2	Cello Family Hardware Installation Guide	Refer to page 37 for more information.
3	Cello-IQ Integration Manual	Refer to page 37 for more information.
4	Programming Manual for Cellocator Cello	Refer to page 37 for more information.

#	Reference	Description
5	CSA Programming Manual	Refer to page 38 for more information.
6	Cellocator Wireless Communication Protocol	Refer to page 38 for more information.
7	Serial Interface Specifications	Refer to page 38 for more information.
8	Cellocator Integration Package Manual	Refer to page **Error! Bookmark not defined.** for more information.
9	DFD Customization	Refer to page **Error! Bookmark not defined.** for more information.

Table 2: References

1.4 Revision History

Version	Date	Description
1.0	22/02/2012	Initial version
2.0	19/07/2012	After technical writer editing
2.1	23/10/2012	Update for controlled release
2.2	14/11/2012	Update Maneuver UI table
2.3	04/02/2013	Add Cello-IQ 40 and harnesses. Add languages supported by the DFD Add DFD Customization. Replace Full Package with Evaluation Suite. Add programmable parameters for DFD maneuvers UI.
2.4	04/03/2013	Update languages supported
2.5	19/08/2013	Update Cello-IQ Variants table. Update languages supported.
2.6	30/10/2013	Add CFE-DFD Cable Add notify body number to the specifications table
2.7	20/01/2014	Add DFD specifications Update Cello-IQ announcements

Table 3: Revision history

2 Cello-IQ at a Glance

2.1 Overview

The Cello-IQ device is a driver safety and eco driving application, aligned with Telematics market evolution trends and TSP requirements to improve fleet safety and reduce fleet operation costs.

The Cello-IQ device, which is based on the legacy Cello family of products, is one of very few systems on the market that provides a fleet safety and ECO driving solution, while being simultaneously ready for integration with any TSP's SW platform with minimal integration and development effort.

Cello-IQ was developed by Cellocator based on theoretical research and extensive field tests, with references to common knowledge in the industry. The Cello-IQ processes and interprets vehicle dynamics and vehicle operation patterns into safety and ECO scores for a driver, reflecting the driver's relative level of risk, fuel consumption and emission footprint.

2.2 Cello-IQ Main Functions

The Cello-IQ system fulfills the following main objectives:

- **Driving behavior** - Detects, processes, logs and reports a wide set of events and/or raw data concerned with hazardous or aggressive driving behavior ("Safety" features).
- **E-Call & EDR** - Detects, logs, reports and uploads accident events and accident raw data for later reconstruction on the server side.
- **ECO driving** - Detects and reports events which feature uneconomic and environment-unfriendly driving in terms of fuel consumption, emission and accelerated wear and tear (brakes, axles, engine, etc. – "ECO" features).
- **On-Board trip scoring** - Provides trip statistics information, which includes Eco scoring and Safety scoring based on the information gathered and processed on-board during a trip.
- **Driver coaching** - Provides continuous real time, visual and audible feedback to the driver, via a dedicated "Driver Feedback Display", regarding the risk level of the driver's driving and hazardous / uneconomic events identification.

2.3 Cello-IQ Applications and Market Segments

The Cello-IQ system is targeted at a number of important market segments, including the following:

- **Car Insurers**
  - ✓ PAYD, PHYD → differential premium payment
  - ✓ Crash notification and EDR → life saving, efficient insurance claim management
- **Fleet Operators**
  - ✓ Fleet safety, ECO driving → improves fleet safety, reduces operational costs (up to 15% reduction in fuel consumption) and vehicle's down time
  - ✓ Join the green trend and reduce environmental footprint

- **Public Transportation**
  - ✓ Fleet safety, ECO driving → reduces operational costs (up to 15% reduction in fuel consumption) and down time, and improves passenger safety
  - ✓ EDR - align with safety regulations
- **Vehicle Owners (consumers)**
  - ✓ Teenager monitoring → improved safety and lower premium costs
- **Leased / Rental car companies**
  - ✓ Usage profiling → differential usage fees

3 Cello-IQ Description

3.1 Cello-IQ Main functions

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- Detects, logs, reports and uploads accident events and accident raw data for later reconstruction on the server side.
- Detects and reports events which feature uneconomic and environment-unfriendly driving in terms of fuel consumption, emission and accelerated wear and tear (brakes, axles, engine, etc. – "ECO" features).
- Provides trip statistics information which includes Eco scoring and Safety scoring based on the information gathered and processed on-board during a trip.
- Provides continuous real time, visual and audible feedback to the driver, via dedicated "Driver Feedback Display", regarding the risk level of his driving and hazardous / uneconomic events identification.
- Detects and reports vehicle and engine state (engine off/Engine on, Idling / Movement) for ignition switch connection-less installations.

3.2 System Operation Basics

The Cello-IQ gets as input real time GPS data (1Hz), 3D-accelerometer (100Hz) data, driver information, and optionally engine RPM data.

This information is used by the CSA for the on-board processing and delivery of the above mentioned functionalities, events and states.

The system is installed inside the vehicle and is immediately set in a calibration phase which identifies and compensates accurately the elevation and rotation angles of the installed device with respect to the vehicle's direction. Please refer to section 5.3 for further details about the calibration process.

As well as sending OTA events and raw data of a detected maneuver to the server side, the Cello-IQ can also provide online feedback to the driver through audible and visual indications. Such feedback enables the driver to improve his/her driving behavior immediately and driving skills over time.

The system monitors, analyses and delivers information about the following driving maneuvers and scenarios, as shown in the following table.

#	Maneuver Type	Attributes
1	Acceleration	Based on analysis of 3D accelerometer data and GPS samples. The maneuver analysis takes into account speed and acceleration averages and extreme values, as well as maneuver duration. This results in a maneuver score (0-99), severity encoding (Green, Yellow, Red) and statistics (duration, strength, averages etc.) that are used
2	Brake	
3	Harsh Lane Crossing (Slalom)	
4	Turn	

#	Maneuver Type	Attributes
5	Turn & Acceleration	later by the CSA in the Eco/Safety trip-scoring algorithms.
6	Turn & Brake	
7	Off-Road	Enter / exit off road events based on Z –axis accelerometer data and GPS data. No score attached. Events and statistics only.
8	Speeding	GPS / VSS based (according to configuration). Results in maneuver score, severity and statistics. Can also be sent as raw speeding profile for server side analysis through cross reference with GIS.
9	Crash Event	2-level (light and heavy crash) identification based on 100Hz 3D accelerometer data. Results in Event generation/E-call/recording according to configuration settings.
10	Wrong Gear	Based on RPM frequency line. Detects coasting or excessive RPM events. Results in event generation and statistics to be used in ECO trip scoring mechanism.
11	Idling	Based on GPS or accelerometer data. Results in start / stop events generation and statistics to be used in ECO trip scoring.

Table 4: CSA Processed Maneuvers

For more detailed information about the processing principles for driving maneuvers utilized by the CSA, please refer to section 5.1.

Upon an accident event, the system logs high resolution 3D acceleration and location data and uploads it, in response to a corresponding request or as a function of predefined logic to the server side for further analysis (for example, for insurance purposes).

On the server side the information gathered can be used in a number of ways, including: to report risky events and to reconstruct the evolution of events, to score driver behavior parameters (risk, ECO) over time, to build a driver profile (DNA), to compare driver skills and behavior with other drivers in the fleet, to evaluate a driver's risk level, and as a consequence, be able to take measures in order to improve their driving skills and monitor improvement over time.

3.3 Cello-IQ Main Features

The main features of the Cello-IQ system include the following:

- **Driver Behavior and ECO Driving Management** - the detection, onboard processing, logging, scoring and reporting of a wide set of maneuvers representing hazardous and/or wasteful driving:
  - In-vehicle maneuvers analysis across multiple parameters such as length, max and average accelerations and speeds, speed delta, etc.

- On-board classification of a detected maneuver into 3 configurable risk levels: **Green** (standard and safe maneuver), **Yellow** (Moderate maneuver featuring wrong driving behavior) and **Red** (significantly risky maneuver indicating harsh behavior and/or bad driving skills).
- On board Trip Safety - scoring taking into account a weighted influence of all the detected maneuvers on the trip.
- On board trip Eco-driving - scoring utilizing sophisticated algorithms involving parameters which highly affect fuel consumption, emission and wear and tear factors.
- Real time driver feedback, including visual (LEDs, icons) and audible (buzzer or recorded voice) options for coaching and mentoring purposes.
- Flexible and configurable maneuver and trip scoring logic (severity levels, relative contribution of various maneuver types, switchable detection, logging, raw data aggregation and transmission of each maneuver type independently).
- On-board scoring calculation - reduces to a minimum the amount of backend processes, in conjunction with optional raw data upload for server side interrogation, event replay or further processing.
- Presets for various vehicle types (LCV, MCV, Bus, HCV).
- Compliance with ongoing fine tuning of thresholds and dynamic ranges of the scoring algorithms over time, as the amount of statistical data increases, to achieve better resolution, accuracy and reliability in driver evaluation accuracy.

◆ **Crash Detection** - emergency data recording and reconstruction, including:

- Configurable length of pre and post accident buffers.
- Up to 100Hz 3D Acceleration sampling rate (±8g) + 1PPS GPS stamp.
- Proven survivability in up to 50g impact conditions.

◆ **Proprietary e-Call** - with In-band compliance (infrastructure).

◆ **Self automatic calibration** - resulting in an easy installation.

◆ **Add-on** - to Cellocator's legacy Fleet management application.

◆ **Extended memory capacity** - enables more than 2 weeks of operation outside coverage.

◆ **Independent communication socket for the CSA -** allowing modular design of the backend.

◆ **Modular CSA protocol** - for best message-structure definition flexibility and easy integration.

3.4 Cello-IQ Competitive Advantages

Unlike many entry level Telematics devices that deliver driver behavior management capabilities by simply detecting and reporting G-sensor threshold-crossing or over speeding events, the maneuver scoring algorithms and techniques utilized by the CSA feature several significant advantages and benefits for the TSP and the end user:

◆ All maneuvers are detected and processed online, during their occurrence, extracting the most valuable information relevant to the attributes of the maneuver and in turn, reducing the bandwidth required to deliver the raw data itself.

- The real time processing results in a clear maneuver safety score and attributes, eliminating the need for backend processing to extract maneuver severity.
- The real time and on-going processing and severity scoring allows immediate feedback to the driver; initially as a warning, and if not responded to, as a notification about a registered violation.
- Real time processing takes into account multiple parameters influencing the safety score, such as the length of the maneuver, the max and average G recorded on the relevant axis, the max and average speed recorded during the maneuver, the delta between the start and end speed along the maneuver, and so on. Such multi-dimensional processing delivers a coherent and reliable assessment of the driver's risk level.
- Thresholds and dynamic ranges of the various influencing parameters are defined uniquely for each vehicle category, based on statistics aggregation from hundreds of driving hours on each category, across many different drivers. This ensures the reliability and quality of a maneuver scoring, and score distribution among a given drivers group.
- All thresholds, ranges, severity levels, weighting factors, etc, are fully configurable in order to comply with the needs of a specific operation or application.
- Every maneuver can be reported to the backend not only as an event, but also along with an extensive event statistics log, and/or raw data, as a function of the maneuver type and its severity level, for replaying and further processing purposes.
- On-board processing inside the device allows delivery of **valuable information**, rather than **data**, to the server side, making the effort required by the integrator to launch real DBM operations that much easier and quicker.

3.5 System Architecture

The Cello-IQ is based on the Cello-F HW, utilizing more powerful processor, larger memory and more accurate accelerometer. This enables the unit to provide the required driver behavior and crash detection and reconstruction information.

The Cello-IQ FW is based on the Cello-F FW version 31 and provides all the Cello-F features (Cellocator Fleet Application in the diagram below), drivers and capabilities. A new FW module – called Cellocator Safety Application (CSA) – is responsible for all the tasks needed for providing the driver behavior management eco-driving and crash information. The CSA communicates with two separate servers (regardless of the FM server):

- **CSA Event Comm. Server** (see diagram below) – to which Cello-IQ delivers all the real time events and statistical information as defined in the CSA protocol.
- **CSA File Comm. Server** (see diagram below) – to which the Cello-IQ sends raw data using the FTP/TFTP protocol (maneuver raw data for server side processing / interrogation).

The CSA also controls the driver feedback via communication with the Driver Feedback Device (DFD).

The Cello-IQ PL is based on the Cello FW version 31 PL, with the addition of a library for the CSA parameters. The PL can be updated and downloaded to the unit using the Programmer / Communication Center. A default PL featuring a specific operational scenario is provided.

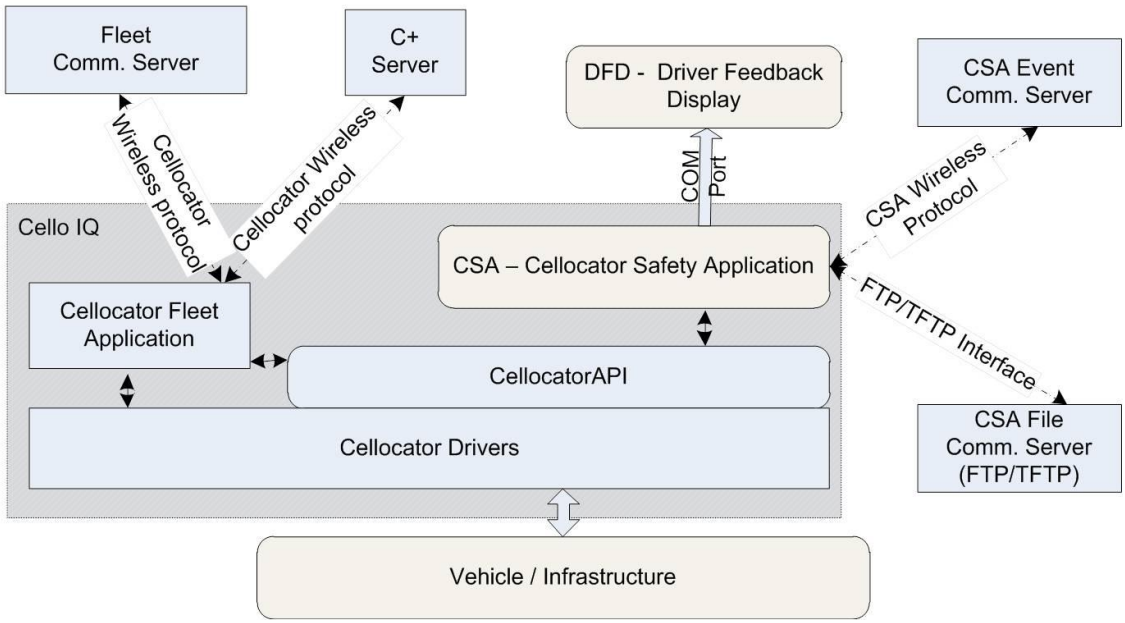

Figure 1: Cello-IQ Architecture

3.6 Cello-IQ Variants

Two variants of Cello-IQ are available in order to address different types of applications and market needs. The Cello-IQ 50 is targeted for the high end solutions while the Cello-IQ 40 serves as the entry level product. The following table lists the differences between these two Cello-IQ variants.

Feature	Sub Feature	Cello-IQ	
		Cello-IQ 40	Cello-IQ 50
Accelerometer based Ignition sense		√	√
Crash Notification		√	√
Maneuvers	Speeding	√	√
	Harsh Acceleration		√
	Harsh Brake		√
	Harsh Turn		√
	Turn & Acceleration	–	√
	Turn & Brake	–	√
	Off road	–	√

Feature	Sub Feature	Cello-IQ	
		Cello-IQ 40	Cello-IQ 50
	Excessive RPM	Events only	√
	Slalom	–	√
	Crash	√	√
E-Call		√	√
EDR		–	√

Table 5: Cello-IQ Variants

3.7 Cello-IQ Hardware Components

The Cello-IQ Hardware components are listed in the table below.

Name/Part Number	Description	Picture
Cellocator Cello-IQ 50 unit **PN:** CT7700225-000	The unit is based on the Cello Family platform with hardware improvements and dedicated PL and Firmware tailored for the specific requirements of the DBM and ECO services.	
Cellocator Cello-IQ 40 unit **PN:** CT7700226-000	The unit is based on the Cello Family platform with hardware improvements and dedicated PL and Firmware tailored for the reduced requirements of the DBM and ECO services.	
Cello-IQ Harness **PN**: 711-00281	Full harness which provides power and serial communication to the DFD via the appropriate connector.	

Name/Part Number	Description	Picture
DFD Unit **PN** 715-50000	Driver Feedback Display provides visual and audible notifications intended for friendly Eco-driving coaching and real-time assistance to help improve the driver's safety level.	
CFE – DFD harness **PN** 711-00323	A harness which connects the DFD to the CFE harness	
Cello-IQ Evaluation kit **PN**: K073-005	The Cello-IQ Evaluation Kit includes all the components required for the evaluation of the Cello-IQ.	

Table 6: Cello-IQ Components

4 Driver Feedback Display (DFD)

4.1 Overview

Cellocator's DFD is a **Driver Feedback Display**, available as an accessory connecting to the Cello-IQ product. The DFD provides visual and audible notifications intended for friendly Eco-driving coaching and real-time assistance to help improve the driver's safety level. The DFD also supports the following functionalities:

- Driver identification reminder
- In-vehicle installed tracking device reminder (for non-identified drivers)
- System operation / health status indication

The real-time notifications to the driver are generated based on the Cello-IQ embedded 3D accelerometer, GPS/VSS speed data, the vehicle's RPM signal (optional), and executed maneuver detection algorithms running on the CSA.

The DFD is designed to support and coach fleet drivers rather than to punish or preach to them. It is meant to be used as the driver's mentor for safety and eco driving, and continuous improvement.

Figure 2: DFD

4.2 HW Interface

The DFD is connected to the main device through an RS232 serial connection. The DFD is a slave device, controlled solely by the Cello-IQ. Only the initial boot and self test operations are triggered by the DFD itself.

The DFD is powered from the main device harness and does not require a separate VCC/GND connection. The DFD is powered only during the 'ignition on' state of the vehicle.

4.3 MMI – Man Machine interface

4.3.1 *Overview*

The DFD was designed to provide a clear and intuitive user interface. It comprises bright colourful LEDs and icons, visible even in a daylight environment. Icons and graphics are used rather than text labels in order to achieve immediate recognition by the driver. The audible interface is a combination of human voice and tones (fully configurable) for maximum flexibility. It offers a selection of programmable languages and can support additional languages, dialects or a male/female voice upon request.

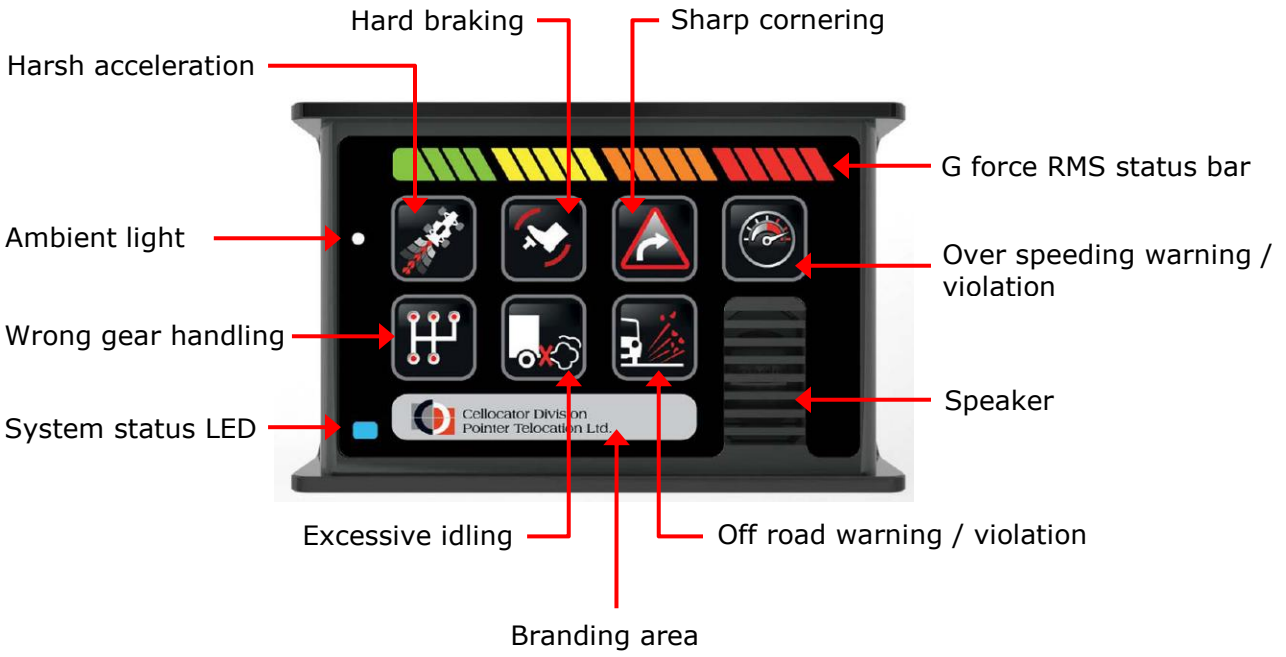

Figure 3: DFD UI

4.3.2 *System status indications*

The DFD provides the following system indications:

- Self test: while performing a self test, a short alarm beep is played and all LEDS are turned on sequentially in order to verify their functionality. For the rest of the time, as long as the self test is taking place, all LEDs are turned off.
- System Ready: indicated when the blue LED is ON.
- System Error: the System Error announcement is played and the blue LED blinks in 1Hz as long as the system is in error state.
- Communication Error: the Communication Error announcement is played and the blue LED blinks in 0.5Hz as long as the system is in error state.

4.3.3 *Driver status indications*

The DFD provide the following system indications:

- Monitored Vehicle: upon System Ready and only when driver identification is not required, the system announces that the vehicle is monitored by a tracking system.
- Driver ID Received: upon successful driver identification, the welcome announcement is played.
- Unidentified driver reminder: if the vehicle ignition is switched on and no driver identification is provided within the expected time, the Unidentified Driver Reminder announcement is played.

4.3.4 *Maneuver Events Indications*

The DFD provides 3 types of indications per event: beep, announcement and display. Each one of these indication is programmable per event.

UI Event	Trigger	Audible Indication	Visual Indication	Remarks
Acceleration Alert	Acceleration maneuver is terminated.	0.5 second beep is played followed by the Acceleration Alert announcement.	Acceleration icon is turned on and the status bar displays the corresponding severity for programmed Time period.	-
Braking Alert	Braking maneuver is terminated.	0.5 second beep is played followed by the Braking Alert announcement.	Braking icon is turned on and the status bar displays the corresponding severity for programmed Time period.	-
Cornering Alert	Cornering maneuver is terminated.	0.5 second beep is played followed by the Cornering Alert	Cornering icon is turned on and the status bar	-

UI Event	Trigger	Audible Indication	Visual Indication	Remarks
		announcement.	displays the corresponding severity for programmed Time period.	
Turn&Brake Alert	Turn&Brake maneuver is terminated.	0.5 second beep is played, followed by the Turn&Brake alert announcement.	Cornering and Braking icons are turned on and the status bar presents the corresponding severity for programmed Time period.	-
Turn&Accel Alert	Turn&Accel maneuver is terminated.	0.5 second beep is played, followed by the Turn&Accel alert announcement.	Cornering and Acceleration icons are turned on and the status bar presents the corresponding severity for programmed Time period.	-
Lane Departure Alert	Lane Departure maneuver is terminated.	0.5 second beep is played, followed by the Lane Departure alert announcement.	Cornering icon is turned on and the status bar presents the corresponding severity for programmed Time period.	-
Off-Road Warning	Off-Road maneuver is detected for programmable time period.	Off-Road Warning announcement is played followed by short repeating beeps.	Off-Road icon blinking in 1Hz frequency.	Ends upon Off-Road Alert provisioning or end of Off-Road session.
Off-Road Alert	Off-Road maneuver continues for programmable time period after provisioning of the Off-Road Warning.	0.5 second beep is played followed by the Off-Road Alert announcement.	Off-Road icon is turned on till the end of the maneuver.	-

UI Event	Trigger	Audible Indication	Visual Indication	Remarks
Speeding Warning	Speeding maneuver is detected for programmable time period.	Speeding Warning announcement is played followed by short repeating beeps.	Speeding icon blinks in 1Hz frequency.	Ends upon Speeding Alert provisioning or end of Speeding session.
Speeding Alert	Speeding maneuver continues for programmable time period after provisioning of the Speeding Warning.	0.5 second beep is played followed by one of the Speeding Alert announcements (green, yellow or red according to the severity of the maneuver).	Speeding icon is turned on till the end of the maneuver.	-
Wrong Gear Warning	Wrong Gear maneuver is detected for programmable time period.	Wrong Gear Warning announcement is played followed by short repeating beeps.	Wrong Gear icon blinks in 1Hz frequency.	Ends upon Wrong Gear Alert provisioning or end of Wrong Gear session.
Wrong Gear Alert	Wrong Gear maneuver continues for programmable time period after provisioning of the Wrong Gear Warning.	0.5 second beep is played followed by the Wrong Gear Alert announcement.	The Wrong Gear icon is turned on till the end of Wrong Gear maneuver.	-
Idling Warning	Idling maneuver is detected for programmable time period.	Idling Warning announcement is played followed by short repeating beeps.	Idling icon blinks in 1Hz frequency.	Ends upon Idling Alert provisioning or end of Idling session.
Idling Alert	Idling maneuver continues for programmable time period after provisioning of the Idling Warning.	0.5 second beep is played, followed by the Idling Alert announcement.	Idling icon is turned on till the end of Idling maneuver.	-

Table 7: DFD UI Events

4.3.5 *Cello-IQ Announcements and Languages Support*

The following table describes the default phrases announced to the driver as required. These phrases can be modified upon request in order to comply with the operational needs of the DBM service provider.

Type	Announcement
System Error	Sorry, System error detected. Please contact your service provider.
Communication Error	Sorry, Communication error detected. Please contact your service provider
Monitored Vehicle	Welcome, This vehicle is fitted with a wireless tracking system. Please drive carefully.
Identified Driver	Welcome, please drive carefully.
Unidentified Driver	Hello, please input your driver ID.
Harsh Acceleration	Harsh acceleration recorded. Please accelerate with caution.
Hard Braking	Hard braking recorded. Please anticipate a safe stopping distance.
Sharp Cornering	Sharp cornering detected. Please Slow down.
Turn&Brake	Risky turn recorded. Please slow before turning.
Turn&Accel	Harsh cornering recorded. Maintain speed thru turn.
Lane Departure	Unsafe lane change recorded. Please pass carefully when road conditions allow.
Off Road Warning	You may be off-road. If so, please return to the main road.
Off Road Alert	Off-road driving recorded. Return to the main road.
Over Speed Warning	You may be speeding. Please slow down and observe the speed limit.
Over Speed Green Alert	Minor Speed limit violation recorded. Slow down.
Over Speed Yellow Alert	Moderate Speed limit violation recorded. Slow down.
Over Speed Red Alert	Extreme Speed limit violation recorded. Slow down.
Wrong Gear Warning	You are in the wrong gear. Please shift to the correct gear.
Wrong Gear Alert	Wrong gear recorded. Shift to the correct gear.
Idling Warning	Please start driving or turn off the engine.
Idling Alert	Excessive idling recorded. Start driving or turn off the engine.

Table 8: Cello-IQ Announcements

The DFD supports the following languages:

- English
- Spanish
- French
- Russian
- Hebrew
- Morocco Arabic
- Swedish
- Polish

4.4 Mechanical Attributes

The DFD is a compact and aesthetical device with approximate dimensions of 75mm x 45mm x 20mm (2.95’ x 1.77’ x 0.8’). It can be installed using screws or double-sided adhesive on any vertical or horizontal surface on the dashboard.

The DFD is made of automotive standard materials and should be able to sustain the same vehicular and environmental conditions applicable for the tracking device itself including vibration, temperature, exposure to direct sunlight, etc.

Figure 4: DFD Mechanical View

4.5 DFD Functions

- The DFD performs a self test upon powering up and provides a visual indication of this ongoing process to the driver.
- The DFD provides indication for system readiness and proper connectivity to the main device (Cello-IQ).
- Lack of connectivity or an identified error is clearly signaled on the system LED of the DFD.
- The DFD optionally provides a verbal indication to the driver that their driving is being monitored.

- The relative amplitude of the G forces sensed by the system is presented at any time on the color LED bar, with a minimum refresh rate of 5Hz.
- Detected aggressive driving, speeding, idling or other supported maneuvers is indicated by a visual and/or verbal alert (configurable).
- A registered event is designated by all or a subset of the following indications:
  - Typical tone followed by
  - Verbal message announcing the type of violation
  - Turning on the applicable maneuver icon concurrently with
  - Turning on the applicable severity level (Green / Yellow / Red) on the LED array for two seconds
- Whenever possible, a warning will be first delivered in order to allow the driver to correct their unsafe / wasteful behavior. Only if a correction does not happen within the granted grace period, a violation will be registered by the system.

4.6 Configuration

Every function mentioned in this document can be controlled by the Cello-IQ itself, including but not limited to:

- General operation on/off – whether the display is enabled or disabled
- Voice level and/or mute
- Tone / verbal messages on/off
- LED array visual indications on/off
- Icon array visual indications on/off
- Driver identification feedback enable/disable
- Applicable maneuver severity level to warn / report

4.7 Customization

The DFD Branding label and announcements can be customized to fit the specific operational requirements of the service provider. The customization process is defined in the *DFD Customization* document.

4.8 DFD Specifications

Interfaces	
COM1 Port (RS232)	True RS232 Levels 8 bit; 1 Stop Bit; No Parity, 115200 BPS. Proprietary Serial Protocol
Connectors	4 pin connector: GND, Power Supply, RS232 TX, RS232 RX

Power	
Input Voltage	7-32VDC
Power consumption	Hibernation: 760uA at 12 V Operational : up to 5.4 W assuming all LEDs are illuminating
Display	
Led Array	12 white LEDs
Audio	
Recorded messages	128Mbytes SDCARD holding voice recordings.
Loudspeaker	1W
Recording Format	Sampling rate: 16Khz Encoding: Signed 16 Bit PCM RAW data file format.
Environment	
Temp, operating	-15°C to +65°C full performance
Temp, storage	-20°C to +85°C
Humidity	95% non condensing
Protection	IP40
Certifications	
FCC	Part 15 Subpart B, part 22/24 compliant
CE	CE EMC & R&TTE according to 89/336/EEC or 1999/5/EC CE Safety EN60950-1:2001+A11:2004 Automotive Directive 2004/104/EC (E-Mark)
IC	Industrial Canada
Mechanical Attributes	
Dimensions	~ 73 x 47x 18.6 mm
Weight	~ 62 grams
Stand	Manually adjustable view angle with Screw.
Mounting	Double-sided adhesive tape or screws

Cable	4 wires, 28 Gauge, 30 cm long.
Connector	4 Pins, 2.54 mm Pitch, Single row

5 Cello-IQ Operation

5.1 Maneuvers

5.1.1 *Maneuver scoring basics*

Every driving maneuver processed by the CSA is scored in a range of 0-99, where 0 means the most risky maneuver and 99 means safe driving, in a level which requires almost no processing at all.

The Cello-IQ scoring mechanism is relative rather than absolute. This does not mean that a driver with a low score of 30 will surely be involved in road accident within a specific period of time. It does mean that according to certain research, this driver is more likely to be involved in a road accident over time than a driver with an average score of 90.

The maneuver scoring mechanism in the CSA involves the linear manipulation of input parameters such as start, stop, average and max speed during a maneuver, average and max acceleration on relevant axes, length of the maneuver, and so on. Dynamic ranges of processed parameters, thresholds and weights, were selected to provide the best representation of relative driving behavior scoring. However, these parameters can also be changed by the Telematics service provider whenever required.

Each detected maneuver is also classified with one of the severity levels defined in the PL:

- **Green level** – represents maneuvers within normal driving safety margins
- **Yellow level** – represents moderately risky or unsafe maneuvers
- **Red level** – represents harsh and dangerous driving, increasing risk to the driver or other road users.

The default thresholds representing maneuver severity were set according to extensive and statistical field tests, as well as deterministic definition of the risk reflected by certain G force levels and speed values measured during the maneuver. These thresholds can be changed according to the service provider or fleet manager's needs or definitions.

A discrete severity classification is used for convenience and ease of use. However, note that the maneuver score is continuous and even if a green maneuver can be assigned any score between 51 and 99, it is clear that a score in the range of 50-60 should be given much more attention and coaching than scores in the range of 80-90, regardless of the identical discrete severity level.

5.1.2 *Harsh accelerations*

Harsh accelerations indicate aggressive and wasteful driving which are highly correlated with the probability a driver could be involved in a road accident. The Cello-IQ incorporates algorithms and logic to identify, log, score, and report upon occurrence of harsh acceleration events.

5.1.3 *Hard braking*

Hard braking indicates inappropriate awareness / anticipation, distance keeping or aggressive driving. It imposes danger to the vehicle on the rear, and accelerated damage to the vehicle's breaking system and tires. The Cello-IQ incorporates algorithms and logic processes to identify, log, score, and report upon occurrence of hard braking events.

5.1.4 *Sharp turns / Cornering*

Sharp turns indicate driving performance which is not aligned with road conditions, putting in risk not only the driven vehicle but also nearby vehicles. Different cornering maneuvers can be detected by the Cello-IQ, with or without combinations of braking and accelerating, such as:

- Turn & Acceleration (accelerating into or after driving out from a curve)
- Turn & Brake (braking into or during the cornering event)

The Cello-IQ operates algorithms and logic processes to identify, log, score, and report upon occurrence of sharp turn events.

5.1.5 *Over Speeding*

The effect of Speeding on safety parameters depends on road type (urban, highway etc) and road conditions (such as ice or rain).

In common applications, speeding events are processed on the server side in order to cross reference the speed data with geo-spatial information.

- In order to allow backend processing of speeding events, the CSA application can store (configurable) valid GPS profile information (Time, X, Y, speed, heading) at all times during a trip if the speed received from the main application is higher than X km/h (configurable). The profile enables the calculation of a speeding event score on the server side.
- In order to allow onboard processing of speeding events, the application can also continuously monitor the speed of the vehicle and compare it to predefined thresholds which represent generic speed limits in 3 different levels:
  - Standard allowed speed – above which speed is considered a minor violation
  - Speed level B – above which speed is considered a moderate violation.
  - Speed level C – above which speed is considered a serious violation.

The CSA can generate events upon the breaching of the above mentioned thresholds, and keep maneuver raw data (GPS profile) and statistics in order to be used later on by the trip safety scoring mechanism (Eco trip scoring uses speed in a different way).

Events are generated upon the breaching of the abovementioned thresholds only once per unique speeding event and only once per zone. A distinct speeding event is defined by the time between breaching above or below the lowest threshold.

FUTURE ENHANCEMENT: The allowed speed on the current road in which a vehicle is driving will be known to the device through direct communication with a geographic database on the server side or accessing local mapping data set in NVM. In this case, speeding events can be generated by the device itself in real-time. The event should not trigger accelerometer raw data accumulation but only GPS 1Hz information.

5.1.6 *Sharp lane departure (or slalom)*

Sharp and frequent lane crossing indicates aggressive driving highlighted by short distance keeping from vehicles in front, navigating between heavy traffic, etc. Sometimes such maneuvers are combined with harsh acceleration.

Only sharp and fast lane departures are detected by the system. Standard by-passing maneuvers are not expected to be detected as risky lane crossing (but it could be indicated as harsh acceleration). Also entering a roundabout is not considered as sharp lane crossing but as a sharp turn.

5.1.7 *Off road driving*

A continuous increase in a vehicle's vibration level may indicate wrong / forbidden use of the vehicle for inappropriate purposes or on forbidden roads. The system can identify a sudden but long-term (at least several seconds – configurable) change in the values obtained from the accelerometer. This type of event does not trigger raw data accumulation but only events generation and maneuver statistics.

5.1.8 *Basic accident detection*

If the EDR function is disabled, the CSA can detect and report under similar conditions to other maneuvers (in terms of raw data, maneuver attributes and statistics, pre/post maneuver logging, etc), accident events based on extreme values received from the accelerometer.

Basic accident detection is the only maneuver type expected to operate while the vehicle is parked (Ignition off). It is therefore possible to generate an event upon significant impact detection as a probable accident occurrence through a third party vehicle. The generated event identifies clearly the engine state upon impact detection.

It is also possible to trigger E-call functionality as if the unit was connected to an external impact sensor (equivalent to FW V31 or earlier versions). This capability is meant to replace the use of external impact sensors. Basic information such as Max G (RMS) should be provided.

5.1.9 *Wrong gear*

Driving in the wrong gear is wasteful driving behavior which dramatically impacts vehicle fuel consumption. When driving at a steady speed, you cannot choose any operating point for the engine since there is a specific amount of power needed to maintain the chosen speed. Too low a gear will move the engine into a high-rpm, low-torque region in which the efficiency drops off rapidly, and fuel consumption increases. Thus best efficiency is achieved nearer the higher gear.

On the other hand, when coasting with the engine running and manual transmission in neutral, or clutch depressed, there is still some fuel consumption due to the engine needing to maintain idle engine speed. While coasting with the engine running and the transmission in gear, most car engine control units with fuel injection will cut off fuel supply, and the engine will continue running, being driven by the wheels. Compared to coasting in neutral, this has an increased drag, but has the added safety benefit of enabling the driver to react to any sudden change in a potentially dangerous traffic situation, and being in the right gear when acceleration is required.

The Cello-IQ operates RPM sensing logic whenever enabled to identify, log, score, and report upon occurrence of wrong gear engagements for a time longer than a predefined parameter.

Wrong gear events are also used by the CSA for the trip ECO scoring calculations.

5.1.10 *Excessive Idling*

Idle speed is the rotational speed the engine runs on when the engine is uncoupled to the drive train and the throttle pedal is not depressed (generally measured in revolutions per minute, or rpm, of the crankshaft). At idle speed, the engine generates enough power to run reasonably smoothly and operate its ancillaries (water pump, alternator, and, if equipped, other accessories such as power steering), but usually not enough to perform useful work, such as moving an automobile. For a passenger-car engine, idle speed is customarily between 600 rpm and 1,000 rpm.

If the engine operates a large number of accessories, particularly air conditioning, the idle speed must be raised to ensure that the engine generates enough power to run smoothly and operate the accessories.

In fleet operations, avoiding long periods of idle speed is an efficient measure to save fuel costs dramatically.

The Cello-IQ operates idle speed sensing logic (speed data source may be either GPS or VSS if available) whenever enabled to identify, log, score, and report upon occurrence long idle speed events while aiming to ignore short idling events cause by heavy traffic or traffic lights.

5.2 Trip and Driver Scoring Principles

5.2.1 *Safety score*

The Trip Safety score is calculated based on the following events and parameters detected during the trip:

- Acceleration events
- Braking events
- Cornering events
- Sharp lane departure
- Combined events (accelerations + turn, brake + turn)
- Over Speeding events (time, max and average speed)

The safety score is weighted by a factor (configurable) representing the relative risk featured by each of the affecting maneuvers for a certain operation. In addition, another factor represents the unbalanced appearance probability (as a function of distance / time) and relative effect of the green / yellow / red maneuvers on the total trip score (RED maneuvers may be weighted for example as 10 times more influencing than green events and will draw the trip score downwards accordingly).

IMPORTANT: The Cello-IQ does not weight the safety score according to the performed trip distance or length as it does not hold enough statistical reference for the average or typical rate of maneuvers performance as a function of distance or time unit. It is therefore the server side's role to accumulate information from all drivers and vehicles in the system and to scale each trip's score before calculating the driver's total score or comparing the driver's skills with other driver groups.

5.2.2 *Eco Scoring*

The variables which influence vehicle energy consumption and emission rates are:

- Travel related – distance of a trip
- Weather related – temperature, humidity and wind effects
- Vehicle related – engine size and efficiency, weight, etc
- Roadway related – roadway grade and surface roughness
- Traffic related – vehicle to vehicle interaction
- Driver related – driver behavior and aggressiveness

The Cello-IQ deals with driver related and traffic related factors while the server side will add the travel related factor on top of the estimations provided in the unit. The rest of the variables are outside the scope of Cello-IQ monitored variables.

The parameters with the most impact on fuel consumption and emission, in terms of driver behavior, are:

- Vehicle speed
- Acceleration profiles
- RPM and gear handling
- Idling sessions

In general, decelerations will not impact the ECO score since it was proven by research that deceleration has a small impact on fuel consumption and emission. Accelerations which are usually complementary to decelerations have a much greater effect on the ECO score of the trip.

The CSA collects and processes the available Eco-driving affecting variables during consecutive short time slots along a given trip, and generates an ECO score for each time slot. Each time slot is then associated with a different driving category in order to determine the proper calculation method which fits that specific time slot. There are three types of "driving categories":

- Idling (stationary, 'engine on')
- Urban driving – between 10Km/h and 80km/h
- Freeway / highway driving – above 80km/h

At the end of the trip, a weighted average of all accumulated time slots is performed in order to obtain the final ECO score of the trip. A configurable (PL) weight is given to each driving condition.

5.3 Automatic Calibration Process

One of the important and beneficial features of the Cello-IQ is its self-calibration process, which facilitates dramatically the device installation process and eliminates nearly all limitations or restrictions concerning its installation, or any server side processing expected to be implemented by the TSP.

Unlike other devices on the market, the on-board automatic calibration provides the freedom to install the device without aligning it with the vehicle movement direction or ground level. The only guideline which should be kept is a tilt of less than 60^0 and

orientation shift with respect to the sky in order to maintain an adequate GPS signal reception and calibration algorithms convergence.

Cello-IQ calibration will start autonomously immediately upon the first trip after installation, and will normally last 2-5 hours (95% of installation) depending on the actual driving scenario (for example, urban driving leads to a faster calibration than highway driving). The calibration status is reported in every CSA status message during the calibration process and calibration failures are also reported if convergence was not achieved within the predefined time.

The calibration process results in the acquisition of a rotation matrix, with which every sample from the 3D accelerometer is multiplied in order to get its "gravity-free" value.

For further information regarding the calibration process control and monitoring, please refer to the *Cello-IQ Programming Manual*.

6 Cello-IQ Technical Specifications

Communication	
GSM Modes	GPRS class 10, PDU SMS
Bands	Quad band: 850, 900, 1800, 1900MHz
Power Output	2W, 1W
SIM	Internal, replaceable, remote PIN code management
Antenna	Internal, quad band GSM antenna
Packet Data	TCP/IP, UDP/IP
SMS	PDU, text SMS for data forwarding
GPS	
Technology	Chipset: SiRFIII GSC3F/LP single chipset
Sensitivity (tracking)	-159dBm
Acquisition (normal)	Cold <42Sec, Warm<35Sec, Hot<1Sec
Antenna	On board, internal patch antenna Optional external Active antenna (2.85V ± 0.5%), automatic switching, standard SMA connector
Inputs and Outputs	
Inputs	1 internally pulled down input dedicated for ignition switch 3 internally pulled up Discrete Dry inputs with assignable functionality and configurable threshold for logical high and low states. 2 configurable inputs capable to serve as: **Frequency counters - Configurable resolution;** Up to 5kHz input signal; Signal level (3V < Vin ≤ 30V) Accuracy ±2% **Analog inputs with variable resolution** - 8bit, adapted to 0-2.5V signal, resolution 20mV, accuracy ±20mV; 8bits, adapted to 0-30V signal, resolution 100mV, accuracy ±100mV **Discrete Dry** – configurable threshold for logical high and low states. **Discrete wet** - configurable threshold for logical high and low states.
Outputs	5 general purpose open drain outputs (250mA max) with assignable functionality

Interfaces	
Voice Interface	Cellocator HF compliant Full duplex Echo cancelation Noise suppression Spy listening option Auto-answer option Volume control by single button or two buttons Distress voice call and plain call generation
COM (RS232) port	Selectable baud rate (9600 or 115000bps) True RS232 levels 8 bit; 1 Stop Bit; No Parity MDT Interface Garmin™ Interface PSP™ (Car Alarm) Interface Cellocator Serial Protocol Transparent data mode Configuration upgrade Firmware upgrade
Debug port (RS232 out)	External Monitoring of Modem-CPU dialog 115000bps True RS232 levels 8 bit, 1 Stop Bit, No Parity
1-Wire™ (Dallas port)	DS1990A compliant Driver management Car Alarm Authorization
Accelerometer	3D, 2g/8g range, 12 Bit representation, 1mg resolution, I2C interface
Connectors	20pin Molex, Automotive SMA switch for optional external GPS Antenna
Power	
Input Voltage	7-32VDC
Average Current consumption	**Normal:** 40mA **Economic:** 23mA **Hibernation:** <2mA **Shipment (Off):** <20uA (Internal Battery)

Internal Battery	Li-Ion Polymer, 3.7V, 900mAh, rechargeable Embedded NTC for temperature controlled charging Operating Temperature: -20 (65% charge) to 60°C
Internal Battery	**Battery Monitoring:** Temperature (NTC) & voltage **Autonomy:** Up to 200 Tx @ 1Msg/min @ 25°C **Protections:** over current, overcharge and over discharge
Vehicle environment immunity	
Immunity	Compliant with ISO 7637 test level #4 (in accordance with e-mark directive)
Environment	
Temp, operating	-30°C to +70°C full performance -40°C to +85°C – degraded communication
Temp, storage	-40°C to +85°C
Humidity	95% non condensing
Protection	IP40
Vibration, Impact	ISO 16750
Mounting	Tie-wraps and/or two sided adhesive
Certifications	
FCC	Part 15 Subpart B, part 22/24 compliant
CE	CE EMC & R&TTE according to 89/336/EEC or 1999/5/EC CE Safety EN60950-1:2001+A11:2004 Automotive Directive 2004/104/EC (E-Mark)
IC	Industrial Canada
PTCRB	TRP, TIS, Spurious and harmonics emission
Notify Body Number	**CE 1177,0889**
Dimensions & Weight	
Dimensions	91x73x23mm
Weight	110gr

7 Cello-IQ release package

The release package of the Cello-IQ includes, in addition to the hardware components mentioned in the Cello-IQ Hardware Components section, SW tools and documents as described in this section.

7.1 Evaluation Suite

The Evaluation Suite is the SW application, which contains all the SW components necessary for the evaluation of any Cellocator unit. The special SW components required for the Cello-IQ evaluation are described below.

7.1.1 *CSA Communication Manager Server*

The CSA Communication Manager Server (CM) – has been added to the Communication Center in order to support the CSA protocol as well as the regular Cellocator protocol. With this addition, the CC now supports the following capabilities:

- Present and parse the CSA communication messages.
- Generate commands and send them to the CSA.
- Program the CSA parameters in the PL.

For more details about the new CSA Communication Manager Server capabilities and use during the integration process, please refer to the *Cellocator Evaluation Suite Manual* document.

7.1.2 *Communication Center*

The Communication Center also supports the KML generator. The **Keyhole Markup Language** (**KML**) is an XML notation for expressing geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers, such as **Google Earth, Google Maps,** and **Google Maps for mobile.**

The Communication Center enables you to select Cello-IQ trip reports and converts them to KML format files, adding to each event a dedicated icon. The KML files can then be loaded to the Earth browsers as temporary places, presenting the trip track with all the appropriate icons and information. This capability provides a visual presentation of the trip report and compares it to the integrated application information.

For more details about the new Communication Center capabilities and use during the integration process, please refer to the *Cellocator Evaluation Suite Manual* document.

7.1.3 *Cellocator Programmer*

The Cellocator Programmer supports the manipulation of the CSA parameters in the PL and downloading the PL to the Cello-IQ unit.

7.1.4 *CSA Unit Simulator*

The CSA Unit Simulator enables the creation and transmission of custom CSA events to the Cello-IQ.

7.2 FTP/TFTP Server

A TFTP server is required for receiving the raw data sent by the Cello-IQ. Cellocator does not provide a TFTP Server and the integrator must purchase an off-the-shelf product (such as FileZilla, http://filezilla-project.org/).

7.3 Integration Package (Cellocator GW)

The Cellocator Gateway is a set of SW components offered to Cellocator customers wishing to integrate the Cellocator OTA protocol into their production environment. Customers using Cellocator Gateway benefit from a quicker and easier integration process, and are also entitled to software upgrades, technical support and more.

Cellocator Gateway is built utilizing the latest MS-based technologies, and provides high availability and load balancing options, as well as enabling clients the opportunity to integrate and start working with Cellocator units without investing a large amount of time and resources.

The new version of Cellocator GW delivers new components aimed at addressing bidirectional CSA protocol parsing and command building.

7.4 Cello Family Hardware Installation Guide

This document provides all the necessary information for a technician involved in the installation of a Cello-IQ unit. It describes how to install and verify the proper functioning of the installation kit elements, as well as installation of the DFD.

7.5 Cello-IQ Integration Manual

This document provides the SW integrator with information and hints on how to integrate an application with the Cello-IQ. The document provides information such as CSA code samples for parsing the CSA messages, Trip messages examples, and Crash messages examples.

7.6 Cellocator Evaluation Suite Manual

The Cellocator Evaluation Suite Manual is a comprehensive guide that provides information required to run an initial appraisal and testing process of the Cellocator Cello-IQ unit, without requiring connection to an actual vehicle during testing. In addition to the regular Cello family information, it describes the CSA Server and Communication Center changes as a result of the special capabilities of the Cello-IQ. The document also includes the CSA Simulator Guide.

7.7 DFD Customization

This document describes how to customize the DFD branding label and the DFD announcements to fit to the specific requirements of the service provider.

7.8 Cellocator Cello Programming Manual

This document describes the features supported by the Cellocator unit and provides details about the configuration parameters.

7.9 Cellocator CSA Programming Manual

The CSA Programming Manual is an additional document to the Cellocator Programming Manual and describes all the new CSA capabilities and related parameters.

7.10 Cellocator Wireless Communication Protocol

This document explains the unit's wireless communication structure. It describes every byte of the incoming/outgoing packets, which can be sent or received by the unit over-the-air. The document also describes the CSA protocol and the CSA File Structure.

7.10.1 *CSA Wireless Protocol*

This section defines the CSA protocol, including events generated by the CSA, commands to the CSA, and OTA programming. It does not cover file upload sessions, since this is performed using FTP or TFTP standard protocols.

7.10.2 *CSA File Structure*

The section describes the format of a file type generated by the CSA, which is delivered through the FTP/TFTP connection, as well as file name conventions.

7.11 Cellocator Serial Communication Protocol

This document explains the unit's serial communication structure. It describes every byte of the incoming/outgoing packets, which can be sent or received by the unit via the serial interface.