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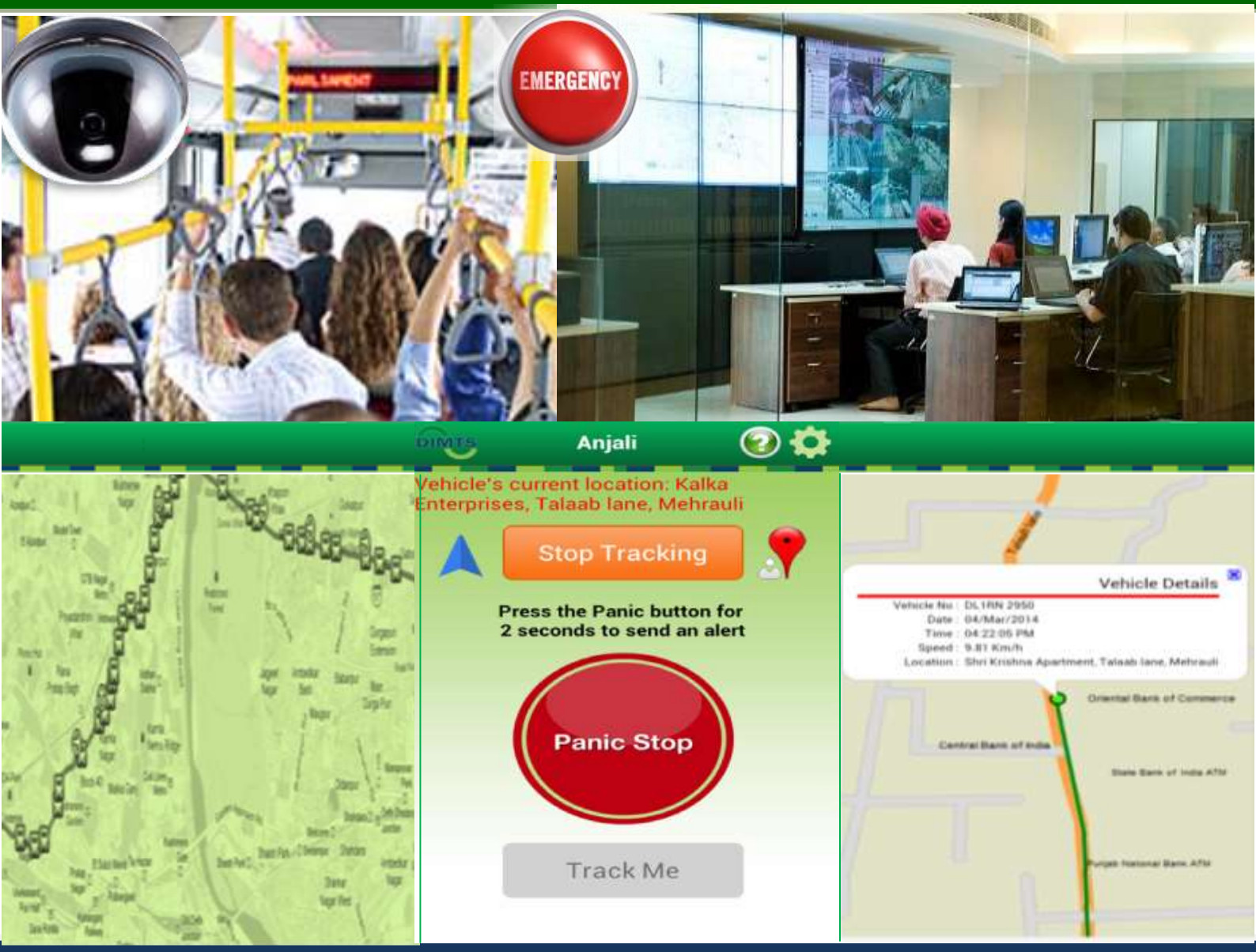
MINISTRY OF ROAD TRANSPORT AND HIGHWAYS
GOVERNMENT OF INDIA

Detailed Specification Document For Vehicle Tracking Devices (GPS)



NATIONAL LEVEL VEHICLE SECURITY AND TRACKING SYSTEM

March 2015

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Detailed Specification Document for Vehicle Tracking Devices (GPS)

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Prepared by

Delhi Integrated Multi-Modal Transit System Limited

1st Floor, Maharana Pratap ISBT Building,
Kashmere Gate, Delhi 110 006
Tel: + 91 11 43090100, Direct: +91 11 43090207, Fax: +91 11 23860966

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Abbreviations

Acronym	Definition/Description
ASCII	American Standard Code for Information Interchange
BMTC	Bangalore Metropolitan Transport Corporation
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access
CEP	Circular Error Probability
DOP	Dilution of Precision
DTC	Delhi Transport Corporation
DRMS	Distance Root Mean Square
GIS	Geographical Information System
GGSN	GPRS Gateway Service Node
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GoI	Government of India
GSM	Global System for Mobile
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
HRTC	Himachal Road Transport Corporation
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
I/O	Input / Output
IP	Ingress Protection
IRNSS	Indian Regional Navigation Satellite System
KSRTC	Karnataka State Road Transport Corporation
LAC	Location Area Code
LCD	Liquid Crystal Display
LNA	Low Noise Amplifier
MoF	Ministry of Finance, GoI
MoRTH	Ministry of Road Transport and Highways, GoI
NMR	Network Measurement Report
PDOP	Positional Dilution of Precision
PIN	Personal Identification Number
PSV	Public Service Vehicle
PUK	Personal Unblocking Code
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
SEP	Spherical Error Probability
SI	System Integrator

Acronym	Definition/Description
SIM	Subscriber Identification Module
SV	Satellite Vehicle
TAR	Technology Analysis Report
TTFF	Time To First Fix
VTD	Vehicle Tracking Device

1.0 INTRODUCTION

1.1 Project Background

The Ministry of Finance (MoF), Government of India (GoI) has set up a dedicated fund called the "Nirbhaya Fund" for implementation of initiatives aimed at enhancing the safety and security for women in the country. The proposals formulated by various Ministries/Departments aimed at enhancing the safety and security of women in the country are proposed to be funded through the Nirbhaya Fund.

The Ministry of Road Transport and Highways (MoRTH), Government of India has proposed to implement a scheme for Security for Women in Public Road Transport in the Country which is envisaged to be funded from the Nirbhaya Fund. The said MoRTH proposal has received in-principle approval from the Ministry of Finance (MoF), Government of India (GoI). The scheme to set up the National Level Vehicle Security and Tracking System has the following components proposed:

- A National Backend Data Centre
- City Command and Control Centre in 32 cities in India having population of more than one million. The architecture can be up-scaled to include more towns.
- Installation of Vehicle Tracking Device (VTD)/CCTV/Emergency buttons in notified public transport vehicles (On-Board Devices) in the above cities.

1.2 Report Context

MoRTH has engaged Delhi Integrated Multi Modal Transit System Limited (DIMTS) to support MoRTH in formulating and implementing the scheme “Security for Women in Public Road Transport in the Country”. As a part of this engagement, this detailed specification document for Vehicle Tracking Device, which would be required to be installed in vehicles under this scheme, has been prepared for MoRTH.

1.3 Report Structure

Chapter 1.0 provides an Introduction to the project, report context and structure.

Chapter 2.0 covers the detailed specifications of the vehicle tracking devices along with tracking device specifications used in different organizations.

Chapter 3.0 covers the Communication Protocol recommended for the vehicle tracking devices to interface with the backend.

Chapter 4.0 covers the recommended Test Parameters for the vehicle tracking devices.

Chapter 5.0 covers the listing of references used in preparing this report.

2.0 VEHICLE TRACKING DEVICE

2.1 Overview

Vehicle Tracking Device uses the Global Navigation Satellite System (GNSS) to determine and record the precise location of a vehicle at regular intervals. The location data so determined can be stored within the device, and/or can be transmitted to the backend using a wireless communication modem built in the device. As discussed in Technology Analysis Report (TAR) for the scheme, the Table 2-1 shows the types of on-board devices that would need to be installed in the vehicles covered under scheme.

Table 2-1: On-board Device Types

Device Type	Device Description	Applicable for Vehicles
Type 1	CCTV system with in-built tracking system and emergency button system	23 passengers and above (excl. driver)
Type 2	CCTV system with in-built emergency button system	23 passengers and above (excl. driver)
Type 3	Vehicle tracking device with in-built emergency button system	Can be used in all vehicles
Type 4	Vehicle tracking device with in-built emergency button system and fare meter	Auto rickshaws and Taxis

The vehicle tracking devices will be installed in all categories of vehicles covered under the scheme. The Type 1 devices are integrated devices with CCTV system, in-built vehicle tracking system and emergency button system. The detailed specifications for Type 1 and Type 2 devices have been covered in a separate document prepared for these devices. This document provides detailed technical specifications for Type 3 and Type 4 tracking devices. Separate specifications have been provided for these devices in respect of the parameters and elements where there is difference in requirements. For the remaining parameters and elements, a common set of specifications are applicable for both Types 3 and Type 4 vehicle tracking devices.

The vehicle tracking device primarily consists of the following elements:

- Locating Module: To determine the location of a vehicle
- Communication Module: To transfer location and other data from the device to the backend
- Storage, Other Systems and Interfaces

The above components have been described in the sections that follow.

2.2 Locating Module

Locating Module, also known as Global Navigation Satellite System (GNSS) receiver, is the main component of vehicle tracking device that determines its location on the surface of earth typically using satellite based positioning system called GNSS.

The GNSS comprises a set of dedicated satellites which continuously transmit signals that are received by the locating module. Locating module in the Vehicle tracking device typically uses one or more of the GNSS. The locating module, through a process of trilateration on the basis of signals received from minimum 3 satellites, identifies its geographic location coordinates which is then used to identify the location of the vehicle on which the vehicle tracking device is installed. For a 2-dimension fix of location, a minimum of 3 satellites are required and for a 3-dimension fix, a minimum of 4 satellites would be required.

As detailed in the Technology Analysis Report (TAR) for the scheme, it is recommended that locating module *must* use any one or more of the operational GNSS (GPS, GLONASS). It is further recommended that location module to support Indian Regional Navigation Satellite System/GAGAN. Also it is recommended that locating module *may* use any one or more of the other operational augmentation systems.

The important locating module parameters have been detailed in the sub-sections that follow:

2.2.1 Channels

The number of channels in a locating module denotes the parallel channels available for the module to search for and connect to GNSS signals. The more the number of channels, the faster is the time to fix and better is the accuracy even when one satellite moves out of range. Refer Table 2-2 for the number of channels used for vehicle tracking devices in different organizations.

Table 2-2: Number of Channels

Sl.No.	Name of Organization	Year	Number of Channels
1	Bangalore Metropolitan Transport Corporation (BMTC)	Mar. 2012	Parallel GPS Receiver – Minimum 20 channels
2	Delhi (Delhi Transport Corporation (DTC)+ Cluster Buses)	Sep. 2009	The minimum specification for Parallel GPS Receiver: 20 channels or more. The supplied device supports 50 channels.
3	Himachal Road Transport Corporation (HRTC)	Dec. 2013	Parallel GPS Receiver, Minimum 16 channels
4	Karnataka State Road Transport Corporation (KSRTC)	Nov. 2013	Parallel GPS Receiver, Minimum 16 channels
5	Municipal Corporation of Greater Mumbai	2014	42 channels

Recommendation: It is recommended to use GPS or GLONASS or both receiver module with a minimum of 32 acquisition channels and minimum of 18 tracking channels. It should support GAGAN introduced in India by ISRO. The devices should also support Indian Regional Navigation Satellite System (IRNSS).

2.2.2 Sensitivity

Sensitivity refers to the minimum signal strength level at which locating module can successfully perform a location fix. A GNSS locating module has two different sensitivity levels – acquisition sensitivity and tracking sensitivity.

A. Acquisition Sensitivity

Acquisition Sensitivity refers to the minimum signal level at which the receiver is able to successfully perform a Cold Start. During the signal acquisition process the signal level must be higher than that during the tracking process because the time synchronization is not known to the locating module.

B. Tracking Sensitivity

Tracking Sensitivity refers to the minimum signal level at which the locating module receiver is able to maintain a location fix. This is generally a much lower signal level than the acquisition sensitivity level.

Table 2-3 contains the Locating Module sensitivity values used for vehicle tracking devices in different organizations.

Table 2-3: Sensitivity Values used for Tracking Devices

Sl. No.	Name of Organization	Year	Sensitivity
1	BMTC	Mar. 2012	• Acquisition sensitivity (-)160 dBm • Tracking Sensitivity (-)160 dBm
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	• Acquisition sensitivity: better than (-)148 dBm • Tracking Sensitivity better than (-)155 dBm
3	HRTC	Dec. 2013	• Minimum (-)158 dBm Acquisition without external assistance
4	KSRTC	Nov. 2013	• Minimum (-)158 dBm Acquisition without external assistance
5	Municipal Corporation of Greater Mumbai	2014	• Tracking Sensitivity (-)160 dBm

Recommendation: It is recommended that the tracking sensitivity be -165 dBm or better and acquisition sensitivity better than -160 dBm.

2.2.3 Accuracy

The accuracy of a locating module refers to the degree of closeness the location readings are to the actual position of the receiver on the ground. Typically the accuracy is expressed as Circular Error Probability (CEP) or Spherical Error Probability (SEP) or Distance Root Mean Square (DRMS).

The following are the common parameters based on which the tracking device accuracy can be specified:

A. Circular Error Probable (CEP)

Device accuracy specified as CEP relates only to the horizontal plane. CEP is defined as the radius of a circle centered on the true value that contains 50% of the actual GPS measurements. A locating module with 10 meter CEP accuracy will be within 10 meters of the true position 50% of the time.

B. Spherical Error Probability (SEP)

Tracking device accuracies specified as SEP refer to both horizontal and vertical planes. A locating module with 8 metre SEP accuracy would be within 8 metres of its actual position 50% of the time.

C. DRMS (Distance Root Mean Square also called RMS, 1Sigma)

This is computed as square root of the average of the squared horizontal position errors with 65% probability. The position expressed has the probability of being within a circle with radius with 65% probability. A locating module with 6 metre DRMS accuracy would be within 6 metres of its actual position 65% of the time.

D. 2DRMS

This is computed as square root of the average of the squared horizontal position errors with 95% probability. The position expressed has the probability of being within a circle with radius with 95% probability. A locating module with 8 metre 2DRMS accuracy would be within 8 metres of its actual position 95% of the time.

Table 2-4 provides details regarding the locating module accuracy specifications used for tracking devices by different organizations.

Table 2-4: Tracking Device: Accuracy Values

Sl. No.	Name of Organization	Year	Accuracy
1	BMTC	Mar. 2012	5 M CEP Positional Accuracy
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	Less than 10 m Positional Accuracy, (2dRMS confidence level higher than 95%) or 3m CEP
3	HRTC	Dec. 2013	Accuracy Horizontal <6 meters (50%)

Sl. No.	Name of Organization	Year	Accuracy
4	KSRTC	Nov. 2013	Accuracy Horizontal <6 meters (50%)
5	Municipal Corporation of Greater Mumbai	2014	Horizontal Position Accuracy 2.5 meter

Recommendation: It is recommended that accuracy of vehicle tracking device should be better than 6 m 2DRMS (on ground) or 2.5 m CEP (on ground).

2.2.4 Dilution of Precision

Precision is the degree of proximity of the location data to their mean value. The relative position of satellites affects the accuracy of location calculation by the locating module. Location coordinates computed when the satellites are clustered together suffer from dilution of precision (DOP), a factor that multiplies the associated errors. The DOP for an ideal satellites constellation arrangement equals close to 1, which does not magnify the underlying errors.

Locating modules provide several measures of DOP viz. Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP). The combination of these two components of the three-dimensional position is called PDOP - Position Dilution of Precision. Table 2-5 defines the meaning of various DOP values.

Table 2-5: DOP Values and Description

DOP Value	Rating	Description
1	Ideal	This is the highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
2-5	Good	Represents a level that marks the minimum appropriate for making business decisions. Positional measurements could be used to make reliable in-route navigation suggestions to the user.
5-10	Moderate	Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.
10-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.
>20	Poor	At this level, measurements are inaccurate by as much as 300 meters with a 6 meter accurate device (50 DOP × 6 meters) and should be discarded.

Source: http://www.radio-electronics.com/info/satellite/gps/accuracy-errors-precision.php

Recommendation: It is recommended that the locating module send the DOP values to the backend which is provided for in Chapter 3.0 containing communication protocol.

2.2.5 Time to First Fix - TTFF (Hot Start / Warm Start / Cold Start)

Time to First Fix (TTFF) describes the time required for a tracking device to acquire adequate satellite signals and related data (almanac and ephemeris data) to compute location.

For tracking device to determine its location, two types of data are needed by the device: almanac and the ephemeris. These data are continuously transmitted by the GNSS satellites and the locating module of the tracking device collects and stores these data. The almanac data contains satellite status and orbit information and allows the locating module to determine which satellites are visible. Ephemeris data is collected from each satellite that contains precision corrections to the almanac data and is required to compute accurate position of the satellite. It is typically updated every 2 hours and is valid for about 3-6 hours.

TTFF depends on the mode of start of the device: Hot Start, Warm Start or Cold Start with cold start having the longest TTFF. These have been described below:

Cold Start Mode: If the tracking device has not been used for a long time or has moved a few hundred kilometres, usually it takes time to get the first location fix. This is termed as cold start as the device does not have current almanac, ephemeris, initial position or time.

Table 2-6 provides the details regarding TTFF specifications in Cold Start Mode used by different organizations.

Table 2-6: TTFF in Cold Start Mode

Sl. No.	Name of Organization	Year	Cold Start Mode
1	BMTC	Mar. 2012	< 60s
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	< 60s
3	HRTC	Dec. 2013	Not specified
4	KSRTC	Nov. 2013	Not specified
5	Municipal Corporation of Greater Mumbai	2014	30 Sec, Open Sky

Warm Start Mode: Under this mode, the device has current almanac, initial position, and time which are valid. However, ephemeris data is either invalid or only partially valid.

Table 2-7 provides the details regarding TTFF in Warm Start Mode used by different organizations.

Table 2-7: TTFF in Warm Start Mode

Sl. No.	Name of Organization	Year	Warm Start Mode
1	BMTC	Mar. 2012	< 50s

Sl. No.	Name of Organization	Year	Warm Start Mode
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	< 40s
3	HRTC	Dec. 2013	Not specified
4	KSRTC	Nov. 2013	Not specified
5	Municipal Corporation of Greater Mumbai	2014	Not specified

Hot Start Mode: Under this mode, the device acquires the location fix faster as it has current almanac, initial position, time and ephemeris data which are all valid.

Table 2-8 provides the details regarding TTFF specifications in Hot Start Mode used by different organizations.

Table 2-8: TTFF in Hot Start Mode

Sl. No.	Name of Organization	Year	Hot Start Mode
1	BMTC	Mar. 2012	< 5s
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	< 10s
3	HRTC	Dec. 2013	Not specified
4	KSRTC	Nov. 2013	Not specified
5	Municipal Corporation of Greater Mumbai	2014	Hot Start: 1 sec, Open Sky

Recommendation: It is recommended that acquisition time be as follows:

Cold Start	Warm Start	Hot Start
Less than 40 sec, Open Sky	Less than 20 sec, Open sky	Less than 5 sec, Open Sky

2.2.6 Antennae

Tracking devices require an antenna to capture the satellite signals and transmit to the device. Antenna could be external or be embedded within the device. The external antenna is used generally in a situation where the location of tracking device is such that it does not have sufficient view of the sky or the device has metal enclosure. High sensitivity vehicle tracking devices with internal antenna are able to work with limited view of the sky as well. Table 2-9 provides details regarding the tracking device antennae used by different organizations.

Table 2-9: Tracking Device Antennae

Sl.No.	Name of Organization	Year	Antennae
1	BMTC	Mar. 2012	Built In Active antenna
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	Built In Active antenna
3	HRTC	Dec. 2013	Built In Active antenna
4	KSRTC	Nov. 2013	Suitable Antenna for

Sl.No.	Name of Organization	Year	Antennae
			efficient operation with provisions for stable mounting
5	Municipal Corporation of Greater Mumbai	2014	Active GPS Antenna

Recommendation: It is suggested that the device with built-in active antenna should be used in the Type 3 and Type 4 vehicle tracking devices.

2.3 Communication Module

The vehicle tracking device would have a communication module to connect to the backend system and send the captured location data as per the configured protocol. The communication module would rely upon and use cellular wireless communication network that is available in the geographic area to transmit the data to the backend.

Key Recommendations: The following are recommended:

- In view of the project requirements and the quantum of data transfer anticipated, 2G services would be adequate for the tracking devices under the project.
- 2G communication module would be adequate for tracking device on a standalone basis.

The detailed specifications for the communication module are covered in sub-sections below.

2.3.1 Wireless Network

General Packet Radio Service (GPRS) is widely used for transmitting data over Global System for Mobile (GSM) (2G) network. Table 2-10 provides details regarding the supported wireless network and related specifications used by different organizations.

Table 2-10: GPRS/GSM Specifications

Sl. No.	Name of Organization	Year	GPRS/GSM
1	BMTC	Mar. 2012	• Multi Slot GPRS • GPRS class 10 , EDGE (e-GPRS) Multi-slot class 10 • Supports all modes – SMS, Voice, Data, GPRS, TCP/IP
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	• Multi Slot GPRS • GPRS class 10 or Above • Should support SMS, Voice, Data, GPRS, TCP/IP
3	HRTC	Dec. 2013	• GSM: Normal MS-SMS data • GPRS: Type B class 10
4	KSRTC	Nov. 2013	• GSM: Normal MS-SMS data

Sl. No.	Name of Organization	Year	GPRS/GSM
			• GPRS Type B class 10
5	Municipal Corporation of Greater Mumbai	2014	• GSM/GPRS or Higher Modem – Transmitting power Class 4 (2W) at GSM 850 and EGSM 900 Class 1 (1W) at DCS 1800 and PCS 1900 with IMEI

Recommendation: It is recommended that Multi Slot GPRS class 10 (or above) communication module be used in the tracking devices under the project. The module should support SMS, Voice and Data.

2.3.2 Frequency Band

A multi-band communication module (such as dual-band, tri-band, quad-band and penta-band module) supports communication over multiple radio frequency bands.

A quad-band module typically supports four frequency bands: 850 and 1900 MHz, mostly used in the Americas (ITU region 2), and the 900 and 1800 MHz bands used elsewhere (also in India).

Table 2-11 provides details regarding for Frequency Band related specifications used by different organizations.

Table 2-11: Frequency Band Used by Different Organizations

Sl. No.	Name of Organization	Year	Frequency Band
1	BMTC	Mar. 2012	In- Built GPRS module / Modem (Dual Band)
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	In- Built Triband GPRS module / Modem
3	HRTC	Dec. 2013	Frequency: 900/1800/1900 (dual band) Class 4 (2W) at 900 MHz (EGSM) Class 1 (1W) at 1800 MHz
4	KSRTC	Nov. 2013	Frequency as per allowed bandwidth and frequency for operations in India
5	Municipal Corporation of Greater Mumbai	2014	Quad-band GSM/GPRS Modem or higher, Downlink max. Speed 85.6 kbps and Uplink max. speed 42.8 kbps Transmitting power Class 4 (2W) at GSM 850 and EGSM 900 Class 1 (1W) at DCS 1800 and PCS 1900 with IMEI

Recommendation: It is recommended to have Quad-band GSM/GPRS Modem supporting all 2G and 3G frequency bands in India.

2.3.3 Subscriber Identity Module (SIM)

Currently in India, the SIM cards used in mobile phones are generally utilized in the tracking devices. However SIM cards specially designed for the M2M (Machine to Machine) applications and automotive environment are also available in the Indian market.

The features required for automotive environment which are critical to this application are as follows:

- Survive the automotive operational requirement such as vibration, temperature, and humidity
- Long life span

Table 2-12 shows the SIM types for M2M applications and their typical features.

Table 2-12: SIM Types and Features

Sl. No.	Parameter	SIM M2M Plastic 	SIM M2M Robust Plastic 	M2M Industrial SIM 
1	Operating Conditions	• Standard Environmental Conditions • Standard Electrical Conditions	• Standard Environmental Conditions • Extreme Electrical Conditions – Longer Usage life-Span – Intensive Use	• Extreme Environmental Conditions – Temperature – Shock – Humidity – Corrosion • Extreme Electrical Conditions – Longer Usage Life Span – Intensive Use
2	Temperature Range	-25^0 C to 85^0 C	-25^0 C to 85^0 C	-40^0 C to 85^0 C
3	Erase and Write Cycles	500k E/W cycles	• High stress memory supports > 2M E/W cycles per file • Outside of HSM 500k E/W cycles	• High stress memory supports > 2M E/W cycles per file • Outside of HSM 500k E/W cycles
4	Data Retention	>2 Years	>10 Years	>10 Years
5	Designed Lifetime	2 Years +	10 Years + for electrical	10 Years + at -40^0 C to 85^0 C

Recommendation: It is recommended to use SIM M2M Plastic or M2M Standard Industrial SIM or Robust Plastic SIM and the device should support this requirement.

2.3.4 Network Measurement Report (NMR)

The GPRS / GSM module of the device should be capable of capturing and sending serving Cell ID as well as the neighbouring Cell IDs, where the device is located. The Cell ID should come along with the LAC (Location Area Code) and RSSI (Received Signal Strength Indicator) field to indicate the GSM network parameter. This data would help in providing a limited tracking even if the location fix is lost.

Recommendation: It is recommended that the devices send to backend the serving Cell ID and neighbouring Cell IDs along with LAC and the RSSI value as per the protocol set out in Chapter 3.0 of this report.

2.3.5 Connection Type

The device should communicate with the backend in TCP/IP connection mode. Device may also have application level acknowledgement from the backend to check against any error.

At the device end, priority would always be given for the live packet. In case any history packets are to be sent, then device would send the history packets during the intervening period between 2 live packets.

The SMS mode of data transmission as backup would be followed, in case of emergency state (if the device is in emergency state) wherein the device would send data to the backend as per the protocol set out in Chapter 3.0 of this report.

2.4 Storage, Other Systems and Interfaces

2.4.1 Storage

The vehicle tracking devices need to have sufficient memory to operate in offline mode with no loss of data. Typically the tracking devices have memory to store data for about 5,000-20,000 logs. Table 2-13 contains the details regarding tracking device storage capacity used by different organizations.

Table 2-13: Device Storage

Sl. No.	Name of Organization	Year	Storage
1	BMTC	Mar. 2012	20,000 logs
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	20,000 logs (Location data)
3	HRTC	Dec. 2013	Not specified
4	KSRTC	Nov. 2013	5000 way points
5	Municipal Corporation of Greater Mumbai	2014	Not specified

Recommendation: It is suggested that the device should have capability to store a minimum of 40,000 location data.

2.4.2 Geofencing

Geofencing is a tool that supports creation of virtual perimeter or barrier around a physical geographical area. This together with the location tracking application supports monitoring of vehicles having tracking devices enter or exit an established geo-fenced area and provides administrators with alerts when there's a change in status.

Table 2-14 contains details regarding the Geofencing related provisions used for tracking devices by different organizations.

Table 2-14: Geofencing Parameters

Sl. No.	Name of Organization	Year	Geofencing
1	BMTC	Mar. 2012	20,000 logs
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	150 route Geofences
3	HRTC	Dec. 2013	Not specified
4	KSRTC	Nov. 2013	Not specified
5	Municipal Corporation of Greater Mumbai	2014	Not specified

Recommendation: It is recommended that Type 3 and Type 4 devices should have facility to store minimum 3,000 geofence points and should also have the facility to update route Geo-fence master in the device over the air. Geofence can be a circular area or polygon area. Device should also support creation of minimum 200 routes (a route consists of a sequence of geofence points). One route in general can be of 150 distinct geofence points. Device should have enough memory to store 3,000 geofence points. However device will compare a maximum of 150 geofences at a time as these 3,000 geofence points will be stored as route wise.

Device Geofence Downloading Mechanism (As an example)

- Server will send a command to indicate the start of route downloading process with start character, device IMEI, total number of routes, route numbers to be downloaded, and end character.
- Device will send an acknowledgement and ask server to send route definitions having route number, number of geofence points of route, geofence latitude, longitude, radius and geofence ID. Maximum 5 routes definition would be sent at a time.
- Device should save these routes on its flash memory and be able to select the particular route when receiving command from server. Device would search only geofence points of the selected route/area.

Note: All the commands and their definitions for route downloading mechanism would need to be provided for each tracking device.

2.4.3 Encryption and Error Checking

Encryption technology can be used for data security and validity. Although GPRS is a secure licensed channel however encryption is needed in data network when packet leaves the GPRS Gateway Service Node (GGSN). Encryption can be undertaken using an 8 bit Ex-OR or CRC-16, but the details must be available so that location update (LU) data received at backend can be decrypted and compared to determine, if the LU got tempered or not while in transmission.

The encryption and error checking is a desired feature in the tracking device to protect against error in data during transmission. Appropriate encryption mechanism is required from the device.

2.4.4 Firmware Updates/ Configuration Over the Air (OTA)

The device should support firmware updates/upgrades and configuration of the device parameters over the air. The configuration should be possible over both GPRS as well as over SMS through secure mechanism. The details of device parameters that are to be configured are detailed in Chapter 3.0 containing communication protocol.

Table 2-15 contains firmware update and device parameter configuration related provisions used by different organizations.

Table 2-15: Firmware Update / Device Configuration Specification

Sl. No.	Name of Organization	Year	Firmware Update
1	BMTC	Mar. 2012	Software upgradeable / configurable over the air.
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	Facility to update route geofence master in the device over the air. Remote administration and firmware update over the air.
3	HRTC	Dec. 2013	Over the Air Download of firmware as well as configuration parameters
4	KSRTC	Nov. 2013	Over the Air Download of firmware as well as configuration parameters
5	Municipal Corporation of Greater Mumbai	2014	Not specified

Recommendation: It is recommended that the device should support both firmware updates/upgrades as well as device parameter configuration over the air. The configuration of parameters should be possible both over GPRS as well as over SMS channel through secure mechanism.

2.4.5 Tracking Device Health Monitoring Parameters

The device should send status of health parameters at configured interval and this should also be configurable over the air. It should be possible for the health parameters to be fetched on demand via command as set out in protocol in Chapter 3.0.

2.4.6 Ports and Sensors

Vehicle tracking devices are required to be connected to external devices for data exchange and to enable this, they need to be provided with suitable interfaces.

A. Rx/Tx: Typically referred as a serial port.

- Rx: Receive Line
- Tx: Transport Line

B. Digital / Analog Input

These port will be used for interfacing the sensor / equipment such as emergency button, sensors etc.

C. Debugging Port

This port will be used for connecting external device for updating firmware, downloading logs etc.

Table 2-16 provides details related to Ports and Sensors specifications used by different organizations for the vehicle tracking devices.

Table 2-16: Ports and Sensors Specification

Sl. No.	Name of Organization	Year	Ports and Sensors
1	BMTC	Mar. 2012	Either USB or RS232. 8 or more digital Inputs, 4 or more digital outputs
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	Two number RS232 ports, with 8 or more digital Inputs, 4 or more digital outputs (For Relays, sirens etc.), 1 or more analog inputs (For analog inputs like fuel, temperature etc.
3	HRTC	Dec. 2013	RS232
4	KSRTC	Nov. 2013	Not specified
5	Municipal Corporation of Greater Mumbai	2014	RS232

Recommendation: Table 2-17 shows the details of recommended ports in the vehicle tracking devices.

Table 2-17: Recommended Ports for Tracking Devices

External I/O	Device Type 3	Device Type 4
Transmit Line, Receive Line	2 TX, 2 RX	1 TX, 1 RX
Input / Output (I/O)	4 Digital Input, 2 Analog Input	2 Digital Input, 1 Analog Input
Debugging Port	1	1

The above TX and RX lines can be used as USB, Mini USB or RS232 etc.

2.4.7 Emergency Button

The emergency button will be used to raise an alert in case of any emergency in the vehicle. Commuters can press emergency button installed in the public transport vehicle to alert the authorities. Table 2-18 contains provisions related to emergency button used by different organizations.

Table 2-18: Emergency Button Specifications

Sl. No.	Name of Organization	Year	Emergency Button
1	BMTC	Mar. 2012	Not specified
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	Not specified
3	HRTC	Dec. 2013	Emergency messages from the vehicles by generating alarms
4	KSRTC	Nov. 2013	Emergency button provided in the Vehicle Tracking and Monitoring System (VTMS) Unit
5	Municipal Corporation of Greater Mumbai	2014	Buttons for emergency alerts and SOS messages

Recommendation: Table 2-19 shows the recommended number and location of emergency buttons for Type 3 and Type 4 devices.

Table 2-19: Emergency Button Requirement

Device Type	In-built in the device	External
Type 3	1	Up to 7
Type 4	1	1

2.4.8 Vibration Parameters

The vehicle tracking devices will be subjected to high degree of vibration during vehicle operation. As vibration leads to mechanical failure, the tracking devices will need to be designed and tested to work in such environment. Refer Table 2-20 for vibration related specifications used by different organizations.

Table 2-20: Vibration Related Specifications

Sl. No.	Name of Organization	Year	Vibration Specifications
1	BMTC	Mar. 2012	Vibration to meet SAE standards
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	Dust, temperature, vibration and Water Splash resistant
3	HRTC	Dec. 2013	Vibration to meet SAE standards
4	KSRTC	Nov. 2013	Vibration to meet SAE standards
5	Municipal Corporation of Greater Mumbai	2014	Not specified

Recommendation: It is recommended that device should conform to and meet the testing requirements outlined in Chapter 4.0.

2.4.9 Environmental Variables

Table 2-21 contains the specifications used by different organizations for various environmental parameters.

Table 2-21: Environmental Parameters Specifications

Sl. No.	Name of Organization	Year	Environmental Parameters Specifications
1	BMTC	Mar. 2012	• Temperature range; -10° C to 60 °C • Humidity Level: 5% to 95% non-condensing
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	• Temperature range ; -10° C to 85 °C • Humidity Level: 5% to 95% non-condensing
3	HRTC	Dec. 2013	• Temperature Operating -20°C to +70°C • Humidity 5% to 95% RH non-condensing at +40°C
4	KSRTC	Nov. 2013	• Temperature Operating -20°C to +70°C • Humidity 5% to 95% RH non-condensing at +40°C
5	Municipal Corporation of Greater Mumbai	2014	• Operating Temperature : -25 to 80 degree Celsius (without LCD), -20 to 70 degree Celsius (with LCD)

Recommendation: It is recommended that the device be able to operate in temperature range from -20° C to 85° C (Type 3) and -20° C to 70° C (Type 4). It is further recommended that the device be able to operate under Humidity ranges from 5% to 95% RH non-condensing.

2.4.10 Ingress Protection (IP)

The vehicle tracking devices must be able to work in dusty environment that are typically encountered by the public transport vehicles where these would be installed. IP rating (IS/IEG 60529) is used for specifying the environmental protection characteristics of the tracking device. The IP rating is composed of two digits, the first referring to the protection against solid objects and the second against liquids. The higher the number, the better would be the protection offered.

A. First Digit

0	No protection (Sometimes X)
1	Protected against solid objects up to 50 mm^3
2	Protected against solid objects up to 12 mm^3
3	Protected against solid objects up to 2.5 mm^3
4	Protected against solid objects up to 1 mm^3
5	Protected against dust, limited ingress (no harmful deposit)
6	**Totally protected against dust**

B. Second Digit

0	No protection (Sometimes X)
1	Protection against vertically falling drops of water (e.g. condensation)
2	Protection against direct sprays of water up to 15 degrees from vertical
3	Protection against direct sprays of water up to 60 degrees from vertical
4	Protection against water sprayed from all directions - limited ingress permitted
5	**Protected against low pressure jets of water from all directions - limited ingress permitted**
6	Protected against low pressure jets of water, limited ingress permitted (e.g. ship deck)
7	Protected against the effect of immersion between 15cm and 1m
8	Protected against long periods of immersion under pressure

Table 2-22 contains details of the IP ratings used by different organizations for the tracking devices.

Table 2-22: IP Rating of Tracking Devices

Sl. No.	Name of Organization	Year	Ingress Protection
1	BMTC	Mar. 2012	• Dust, temperature, vibration and Water Splash resistant • IP 65 rated or equivalent
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	• Dust, temperature, vibration and Water Splash resistant

Sl. No.	Name of Organization	Year	Ingress Protection
			• IP 65 rated or equivalent
3	HRTC	Dec. 2013	• IP 65 or equivalent
4	KSRTC	Nov. 2013	• Vibration and shock resistant, heat resistant, dust resistant and water / rain splash resistant and shall be tamper proof • IP 65 or equivalent
5	Municipal Corporation of Greater Mumbai	2014	• Heat, dust proof, UV resistant and sea water resistant. • IP 65

Recommendation: It is recommended that the tracking device be at least IP 65 rated.

2.4.11 Power Supply

The tracking devices will be installed on the vehicles where power supply voltage from vehicle battery widely varies (12V, 24V etc.) and also the power supply is not as stable as that in case of fixed locations, especially during engine start-up and braking when the voltage can fall to 9V or less. Typically electronic devices are very sensitive to power surges and spikes, and equipment may fail if they do not receive stable power supply. The devices will need to have a resilient power supply unit that can withstand such fluctuations and the devices also need to have power backup so that they continue to function for some duration when the vehicle battery is not functional or is disconnected from the devices. Refer Table 2-23 for power supply related specifications used by different organizations for tracking devices.

Table 2-23: Power Supply Specifications of Tracking Devices

Sl. No.	Name of Organization	Year	Power Supply
1	BMTC	Mar. 2012	• Input voltage range 8-30 Volts • Active mode Peak <= 1.0 A • Active mode Avg <= 200 mA; Intelligent power management system 4 hours or more of Battery Back Up • Sleep Mode <= 25 mA
2	Delhi (DTC+ Cluster Buses)	Sep. 2009	• Primary Power: Vehicle Battery 12/24 volts • Battery Life: 8 hours normal life
3	HRTC	Dec. 2013	• Primary Power: Vehicle Battery 12/24 volts • Battery Life: Mandatory 8 hours normal operation
4	KSRTC	Nov. 2013	• Operating Voltage: 8V – 32V • Operating current: @24V , Ideal

Sl. No.	Name of Organization	Year	Power Supply
			Mode: 80m, GPRS or higher trans/rec: - 160 mA • Battery Reverse: Integrated Protection
5	Municipal Corporation of Greater Mumbai	2014	• Input voltage range 8-30 Volts • Active mode Peak < 1.0 A • Active mode Avg < 200 mA • Sleep Mode < 25 mA • Battery Backup: 4 hours or more in active mode

Recommendation: Table 2-24 shows the details of the recommended power supply related specification.

Table 2-24: Recommended Power Supply Related Specifications

Input Voltage Range	Active Mode Peak	Active Mode Avg.	Sleep Mode	Battery Backup
8-32 Volts	< 1.0 A	Avg. < 120 mA	< 25 mA	Minimum of 4 hours or more in active mode.

There must be a protection mechanism to protect device from sudden surges in voltage and current.

2.5 Recommended Technical Specifications for Vehicle Tracking Devices

Table 2-25 presents the detailed specifications of Type 3 and Type 4 devices. As has been explained earlier, Type 3 devices are vehicle tracking devices with in-built emergency button system. Type 4 devices are vehicle tracking devices with in-built emergency button system and fare meter.

Table 2-25: Minimum Specifications for Type 3 and Type 4 Vehicle Tracking Devices

Sl. No.	Specification	Type 3	Type 4
General Features			
1.	GPS or GLONASS or both (Location, speed, heading, time stamp) data polling and sending frequency capability of less than or equal to 10 sec. The devices should also support Indian Regional Navigation Satellite System (IRNSS)	✓	✓
2.	Vehicle tracking device to support GAGAN, the Indian SBAS (Satellite Based Augmentation System)	✓	✓
3.	Location on demand on GPRS/SMS	✓	✓

Sl. No.	Specification	Type 3	Type 4
4.	Memory to store min 40,000 positional log	✓	✓
5.	Configurable backup SMS facility in case of GPRS failure	✓	✓
6.	Capability to send serving and adjacent cell ID as well as network measurement report (NMR)	✓	✓
GPS Module Specification			
1.	Parallel GPS or GLONASS or both receiver module with 32 (minimum) acquisition channels and 18 minimum tracking channel. The devices should also support Indian Regional Navigation Satellite System (IRNSS)	✓	✓
2.	Vehicle tracking device to support GAGAN, the Indian SBAS (Satellite Based Augmentation System)	✓	✓
3.	Acquisition sensitivity: better than (-)160 dBm	✓	✓
4.	Tracking sensitivity better than (-)165 dBm	✓	✓
5.	Accuracy of Less than 6m Positional Accuracy 2DRMS (on ground) or 2.5 m CEP (on ground)	✓	✓
6.	Hot start: <5s	✓	✓
7.	Warm start: < 20s	✓	✓
8.	Cold start: <40s	✓	✓
9.	Outputs as per NMEA 0183	✓	✓
10.	WGS-84 compliant	✓	✓
11.	A-GPS	✓	✓
GPRS			
1.	In - Built Quad-band GPRS module/Modem	✓	✓
2.	Multi Slot GPRS	✓	✓
3.	GPRS class 10 or above	✓	✓
4.	Should support all – SMS, Voice, Data, GPRS, TCP/IP	✓	✓
Power Characteristics			
1.	Input voltage range 8 – 32 volts	✓	✓
2.	Active mode peak current < 1.0 A	✓	×
3.	Active mode Avg < 120 mA	✓	×
4.	Sleep mode < 25 mA	✓	×
5.	Battery backup of minimum of 4 hours in active mode	✓	✓
Environmental Variables			
1.	Temperature range ; -20° C to 85° C (Type 3), -20° C to 70° C (Type 4)	✓	✓
2.	Humidity Level: 5% to 95% non-condensing	✓	✓

Sl. No.	Specification	Type 3	Type 4
3.	Dust, temperature, vibration and water splash resistant	✓	✓
4.	IP 65 rated or better. Tamper proof	✓	×
5.	Automotive grade unit with components and manufacturing process as required for automotive use.	✓	×
Antennae			
1.	Should have internal GPRS antenna	✓	✓
2.	Should have internal GPS antenna	✓	✓
Port/Sensors (External I/O)			
1.	Transmit Line, Receive Line	✓	✓
a.	2 TX, 2 RX	✓	×
b.	1 TX, 1 RX	×	✓
2.	I/O	✓	✓
a.	4 Digital Input, 2 Analog Input	✓	×
b.	2 Digital Input, 1 Analog Input	×	✓
3.	Emergency Button I/o	✓	✓
4.	Debugging Port (1)	✓	✓
Geofencing			
1.	Device should store minimum 3000 geofence points. One route in general can be of 150 distinct geofence points.	✓	✓
2.	Facility to update route Geo-fence master in the device over the air	✓	✓
Other Features			
1.	Emergency button	✓	✓
2.	Processor: 32 bit, 400MHz or above	✓	✓
3.	Device should be capable of sending a packet to 2 different IPs simultaneously.	✓	✓
4.	Status LED's to indicate Power, GPS, emergency function, and GPRS status.	✓	✓
5.	Over the Air Download of firmware as well as configuration of parameters.	✓	✓
6.	Remote administration and firmware update over the air.	✓	✓
7.	Integration with Fare Meter for Cab as well as Auto Rickshaw	×	✓
8.	Printer (i) Font : 12 x 24 (ii) Print Width : 2 Inch minimum (iii) Print Speed : 60mm/sec (iv) Print : English , Alphanumeric characters (v) Resolution : 8 dots/mm (vi) Print receipt should have the following	×	✓

Sl. No.	Specification	Type 3	Type 4
	fields: a) Vehicle Number b) Start Time c) End Time d) Trip details e) Trip Distance f) Waiting Time g) Night Time flag / Charge		
9.	LCD Display (Minimum 4 lines x 20 character per line, backlit)	×	✓
10.	Switches/Buttons Mechanism (i) Trip Start (Mandatory and integrated with the meter start) (ii) Trip End (Mandatory and integrated with the end of meter) (iii) Waiting (Visual Display) (iv) Emergency button to trigger the alert message. (v) Print button to get the bill printed.	×	✓

3.0 COMMUNICATION PROTOCOL

3.1 Frame Format – Type 3 Devices (GPS Standalone)

Table 3-1 contains the listing of fields that the Type 3 vehicle tracking devices would be required to send to the backend. Such devices will be installed in the non-metered vehicles such as buses, grameen sewa etc. The first 3 fields (Start character, Header for SI and Vendor ID, who had supplied the device) must be fixed in position as well as format (Header part of frame). Rest all other fields are required to be present in the location data sent by the devices to the backend, but can be in any sequence or with any separator between fields. The data value can be either in American Standard Code for Information Interchange (ASCII) or in HEX format.

Device must transmit the Login message whenever it establishes its connectivity with Server with the specified fields. Login Message will carry below following information:

- $DeviceName –Vehicle number where the device was installed
- $IMEI –15 Digit IMEI number
- $Firmware – Version of the firmware used in the hardware
- $Protocol -Version of the frame format protocol.
- $LastValidLocation – Last location info saved at the device.

Example:

- $Msg.Server.Login
- $DeviceName=DL3CBM9821
- $IMEI=123456789012345
- $Firmware=1.0.0
- $Protocol =1.0.1
- $LastValidLocation=$1,220714,050656,28.758963,N,77.6277844,E,25*

Table 3-1: Data Frame Format for Type 3 Devices

Field	Description	Sample Data
Start Character	$	$
Header	The header of the packet/ identifier	
Vendor ID	Vendor identification header	
Firmware Version	Version details of the Firmware used in EX.1.0.0	1.0.0
Packet Type	Specify the packet type – NR = Normal EA = Emergency Alert TA = Tamper Alert HP = Health Packet	Depending upon the context, every frame from tracking device must carry a qualification code. This helps to determine the state in which vehicle is at that time.

Field	Description	Sample Data
	IN = Ignition On IF = Ignition Off BD = Battery Disconnect BR = Battery Reconnect BL = Battery Low GE = Geofence Entry / Bus Stop entry GX = Geofence Exit / Bus Stop Exit DI = Depot/Parking In shed DO = Depot/Parking Out shed	
Packet Status	L=Live or H= History	L
IMEI	Identified of the sending unit. 15 digit standard unique IMEI no.	123456789012345
Vehicle Reg. No	Mapped vehicle registration number	DL1PC9821
GPS Fix	1 = GPS fix OR 0 = GPS invalid	1
Date	Date value as per GPS date time per GPS date time (ddmmyy)	220714
Time	Time value as per GPS date time in UTC format (hhmmss)	050656
Latitude	Latitude value in decimal degrees (up to not less than 6 places)	28.758963
Latitude Dir	Latitude Direction. Example N=North, S= South	N
Longitude	Longitude value in decimal degrees (up to not less than 6 places).	77.6277844
Longitude Dir	Longitude Direction. Example E=East, W= West	W
Speed	Speed in km/hr (Upto One Decimal Value)	25.1
Heading	Course over ground in degrees	310.56
No of Satellites	Number of satellites used for fix (minimum 5 satellites in vision, to have the fix)	8
Altitude	Altitude of the device in meters	183.5
PDOP	Positional dilution of precision	
HDOP	Horizontal dilution of precision	
Distance	Distance Travelled in Meters (Between Current and the Previous packet)	100
ODO	Total Distance Travelled in Km (from activation of unit to till last packet) Upto One Decimal	25.8
Min Speed	Minimum Speed travelled by vehicle between last and the current packet in Km/h (Upto One decimal value)	2.0
Avg. Speed	Average Speed between last and the current packet in Km/h (Upto One decimal value)	5.0
Max Speed	Maximum Speed travelled by vehicle	10.5

Field	Description	Sample Data
	between last and the current packet in Km/h (Upto One decimal value)	
Network Operator Name	Name of Network Operator	INA Airtel
Ignition	1= Ignition On , 0 = Ignition Off	1
Main Power Status	0 = Vehicle Battery Disconnected 1= Vehicle Battery Reconnected	1
Main Input Voltage	Indicator showing source voltage in Volts.(Upto One Decimal Value)	12.5
Internal Battery Voltage	Indicator for Level of battery charge remaining. (Upto One Decimal Value)	4.2
Emergency Status	1= On , 0 = Off	0
Tamper Alert	C = Cover Closed, O = Cover Open	C
GSM Signal Strength	Value Ranging from 0 – 31	25
MCC	Mobile Country Code	404
MNC	Mobile Network Code	10
LAC	Location Area Code	00D6
Cell ID	GSM Cell ID	CFBD
NMR (neighboring Cell ID)	Neighbouring 4 cell ID along with their LAC	
Digital Input Status	4 external digital input status (Status of Input 1 to Input 3 (0=Off; 1=On))	000
Digital Output Status	2 external digital output status (0=Off; 1=On)	01
Geofence Stop ID	Identify the particular stop, Default = 0	U001
Frame Number	Sequence Number of the messages (000001 to 999999)	000005
Checksum	Insures No error in transmission (optimal)	16
End Character	Indicated End of the frame	*

Recommendation: It is recommended that the tracking device support minimum fields as mentioned above. Individual devices can give more fields than the ones listed above.

The tracking device should be able to support different frequency of sending the data frames, in following states:

- Ignition OFF
- Emergency (Emergency state would supersede every other state)
- Ignition ON

3.2 Frame Format – Type 4 Devices (Tracking Device with EFM)

Table 3-2 contains the listing of fields that the Type 4 vehicle tracking devices (with electronic fare meter) would be required to send to the backend. Such devices will be installed in the vehicles that charge fare as computed by the fare meter such as Auto rickshaws or Taxis. Such devices would be required to send certain additional data to the backend as compared to the Type 3 vehicle tracking device (without fare meter) covered in the earlier section.

It is the first 3 fields (Start character, Header for SI and Vendor ID, who had supplied the device) which must be fixed in position as well as format (Header part of frame). Rest all other fields are required to be present in the location data sent by the devices to the backend, but can be in any sequence or with any separator between fields. The data value can be either in American Standard Code for Information Interchange (ASCII) or in HEX format.

Table 3-2: Data Frame Format for Type 4 Devices

Field	Description	Sample Data
Start Character	$	$
Header	The header of the packet/ identifier	
Vendor ID	Vendor identification header	
Firmware Version	Version details of the Firmware used in EX.1.0.0	1.0.0
Packet Type	Specify the packet type – NR = Normal EA = Emergency Alert TA = Tamper Alert HP = Health Packet IN = Ignition On IF = Ignition Off BD = Battery Disconnect BR = Battery Reconnect BL = Battery Low GE = Geofence Entry / Bus Stop entry GX = Geofence Exit / Bus Stop Exit DI = Depot/Parking In shed DO = Depot/Parking Out shed TS = Trip Start TE = Trip End	NR
Packet Status	L=Live or H= History	L
IMEI	Identified of the sending unit. 15 digit standard unique IMEI no.	123456789012345
Vehicle Reg. No	Mapped vehicle registration number	DL1PC9821
GPS Fix	1 = GPS fix OR 0 = GPS invalid	1
Date	Date value as per GPS date time (ddmmyy)	220714

Field	Description	Sample Data
Time	Time value as per GPS date time in UTC format (hhmmss)	050656
Latitude	Latitude value in decimal degrees (with minimum 6 decimal places)	28.758963
Latitude Dir.	Latitude Direction. Example N=North, S= South	N
Longitude	Longitude value in decimal degrees (with minimum 6 decimal places)	77.6277844
Longitude Dir.	Longitude Direction. Example E=East, W= West	W
Speed	Speed in km/hr. (Upto One Decimal Value)	25.1
Heading	Course over ground in degrees	310.56
No of Satellites	Number of satellites used for fix	8
Altitude	Altitude of the device in meters	183.5
PDOP	Positional dilution of precision (Upto 2 digit)	2
HDOP	Horizontal dilution of precision (Upto 2 digit)	3
Distance	Distance Travelled in Meters (Between Current and the Previous packet)	100
ODO	Total Distance Travelled in Km (from activation of unit to till last packet) .(Upto One Decimal Value)	25.8
Min Speed	Minimum Speed travelled by vehicle between last and the current packet in Km/h (Upto One decimal value)	2.0
Avg Speed	Average Speed between last and the current packet in Km/h (Upto One decimal value)	5.0
Max Speed	Maximum Speed travelled by vehicle between last and the current packet in Km/h (Upto One decimal value)	10.5
Network Operator Name	Name of Network Operator	INA Airtel
Ignition	1= Ignition On , 0 = Ignition Off	1
Main Power Status	0 = Vehicle Battery Disconnected 1= Vehicle Battery Reconnected	1
Main Input Voltage	Indicator showing source voltage in Volts .(Upto One Decimal Value)	12.5
Internal Battery Voltage	Indicator for Level of battery charge remaining. (Upto One Decimal Value)	4.2
Emergency Status	1= On , 0 = Off	0
Tamper Alert	C = Cover Closed , O = Cover Open	C

Field	Description	Sample Data
GSM Signal Strength	Value Ranging from 0 – 31	25
MCC	Mobile Country Code	404
MNC	Mobile Network Code	10
LAC	Location Area Code	00D6
Cell ID	GSM Cell ID	CFBD
NMR (neighboring Cell ID)	Neighbouring 4 cell ID along with their LAC	
Digital Input Status	4 external digital input status (Status of Input 1 to Input 3 (0=Off; 1=On)	000
Digital Output Status	2 external digital output status (0=Off; 1=On)	01
Vehicle Status	H = Hired , A = Available , R = Retired / Off Duty	H
Trip Start	Trip start time integrated with meter switch	050620
Trip End	Trip End time integrated with meter switch	053020
Trip ID	Unique ID for each trip	06
Trip Duration	Duration of the Trip in minutes	30
Trip Distance	Km's covered during the Trip in Km .(Upto One Decimal Value)	18.5
Trip Fare	Total amount payable for the trip .(Upto One Decimal Value)	56.0
Geofence Stop ID	Identify the particular stop, Default = 0	U001
Frame Number	Sequence Number of the messages (000001 to 999999)	000005
Checksum	Insures No error in transmission (optional)	16
End Character	Indicated End of the frame	*

Recommendation: It is recommended that the Type 4 tracking devices support minimum fields as mentioned above. Individual devices can send more data fields than the ones listed above.

The Type 4 device should be able to support different frequency of sending the data frames, in the following states:

- Ignition OFF
- Emergency (Emergency state would supersede every other state)
- Ignition ON
- Trip ON state

3.3 Alerts from Devices

Table 3-3 contains the listing of alerts that need to come from the tracking devices. These alerts are applicable for both live packets as well as the history packets.

Table 3-3: Alerts Supported for the Devices for Vehicle Tracking

Sl. No.	Message	Type 3	Type 4	Remarks
1	Location Update	✓	✓	Default message coming from each device
2	Location Update (history)	✓	✓	Would be sent, if GPRS is not available at the time of sending the message
3	Alert – Disconnect from main battery	✓	✓	If device is disconnected from vehicle battery and running on its internal battery
4	Alert – Low battery	✓	✓	If device internal battery had fallen below a defined threshold, indicating that device need to get a recharge
5	Alert – Low battery removed	✓	✓	Indicate that vehicle internal battery is charged again
6	Alert – Connect back to main battery	✓	✓	Indicate that vehicle is connected back to main battery
7	Alert – Ignition ON	✓	✓	Indicates that Vehicle has started (ignition ON)
8	Alert – Ignition OFF	✓	✓	Indicates that Vehicle has stopped (ignition OFF)
9	Alert – SIM removed or tampered	✓	✓	Message would be generated indicating SIM is removed or tampered
10	Alert – SIM inserted or tampered	✓	✓	Message would be generated indicating SIM is inserted or tampered
11	Alert – GPS box opened	✓	✓	Message would be generated indicating GPS box opened
12	Alert – Emergency state ON	✓	✓	When any of the emergency button is pressed by any passenger. System should also provide location of emergency button which is pressed.
13	Alert – emergency State OFF	✓	✓	When emergency state of vehicle is removed

Sl. No.	Message	Type 3	Type 4	Remarks
14	Trip Start	X	✓	Only for hired mode vehicle, when Fare meter is 'Down'
15	Trip End	X	✓	Only for hired vehicle, when fare meter is 'Up'
16	Alert – Geofence Entry	✓	✓	Triggered when geofence entry happened
17	Alert – Geofence exit	✓	✓	Triggered when geofence exit happened.
18	Over the air parameter change	✓	✓	Should support the change of configuration parameters from backend by sending a command
19	Over the air change of tariff fare	X	✓	Changing of fare parameters, night time rates, waiting period rate, minimum fixed rate.

3.4 Configuration of Device Parameters Over the Air (OTA)

The device parameters as shown in Table 3-4 should be configurable over the air (through SMS or GPRS) for the Type 3 and Type 4 devices.

Configurable commands must involve the following features:

- SET: For setting the parameters.
- GET: For enquiring regarding the parameters such as mobile number, gsm strength, vehicle number and other important parameters.
- CLR: For clearing certain commands, alarms, alerts etc.

Table 3-4: Configurable Parameters for Type 3 and Type 4 Devices

Sl. No.	Parameter Description	Type 3	Type 4
1	Change of the APN	Y	Y
2	Change of IP and port number	Y	Y
3	Setting of the Primary or Secondary IP	Y	Y
4	Configuring the Vehicle registration number	Y	Y
5	Configuring the frequency of data transmission in Ignition ON / OFF, Emergency state	Y	Y
6	Configuring the time duration for Emergency state	Y	Y
7	Configuring the frequency of data update in Trip ON		Y
8	Capability to reset the device	Y	Y

Sl. No.	Parameter Description	Type 3	Type 4
9	Capability to create a geo fence, or increasing the number of geo fences which can be configured	Y	Y
10	Command to get the IMEI of the device	Y	Y

3.5 SMS Fall back

The SMS mode of data transmission as backup would be followed, in case of emergency state (if the device is in emergency state) since SMS has the limitation of sending only 160 characters, so LU (location update) message, to be send in SMS, would have following fields: IMEI, Lat, Direction, Long, Direction, GPS fix, speed, Cell ID, LAC, Date, Time.

3.6 Tracking Device Health Monitoring Parameters

The device should send status of health parameters at configurable interval and this threshold value should also be configurable over the air. It should be possible for health parameters to be fetched on demand via command as set out in Table 3-5.

Table 3-5: Health Packet Frame Format

Sl. No.	Field	Description	Type 3	Type 4
1	Start Character	$	✓	✓
2	Header	The header of the packet/ identifier	✓	✓
3	Vendor ID	Vendor identification header	✓	✓
4	Firmware Version	Version details of the Firmware used in EX.1.0.0	✓	✓
5	IMEI	Identified of the sending unit. 15 digit standard unique IMEI no.	✓	✓
6	Battery percentage	Indicates the internal battery percentage	✓	✓
7	Low battery threshold value	Indicates value on which low battery alert generated	✓	✓
8	Memory percentage	Indicates flash memory used	✓	✓
9	Data update rate when ignition ON	Indicates Packet frequency on ignition ON	✓	✓
10	Data update rate when ignition OFF	Indicates Packet frequency on ignition OFF	✓	✓
11	Digital I/o status	Inputs connected to the	✓	✓

Sl. No.	Field	Description	Type 3	Type 4
		device.		
12	Analog I/o status	Analog input status	✓	✓
	EFM LED working	LED health status	X	✓
	Printer Working	Printer status	X	✓
	Printer paper present or not	Optional, to be made available if possible	X	✓
13	End character	*	✓	✓

4.0 TRACKING DEVICE TESTING

4.1 Introduction

The vehicle tracking devices are expected to work in a challenging automotive environment of dust, vibration, heat etc. The following sections provide the details of recommended key tests that the device models need to be subjected to in order to get assurance on their performance characteristics. The final set of tests and related details would be provided as part of the device empanelment document.

4.2 Functional Testing

Functional testing will be carried out to assess the performance of the tracking device on important functional aspects as below:

A. Location Accuracy Test

Location accuracy signifies the ability of tracking device to accomplish a location data relative to the true position. The various types of location accuracy tests to be performed on the device are as follows:

i. ***Relative Location Accuracy test*** compares the variation between multiple location data obtained by the device under the cold/warm/hot start mode while the device remains at the same location.

Acceptance Criteria: 2.5 m CEP or 6 m 2DRMS

ii. ***Absolute Location Accuracy test*** compares the location data obtained by the device under cold/warm/hot mode while the device remains at the same location with known true position.

Acceptance Criteria: 2.5 m CEP or 6 m 2DRMS

iii. ***Moving or Dynamic Location Accuracy test*** compares the variation between the location data obtained by the device with the true positions at multiple locations along a test path.

Acceptance Criteria: 2.5 m CEP or 6 m 2DRMS

B. Cold-Start Time to First Fix (TTFF) Test

This test is used to determine the time taken for first fix during a cold start of the device. The device in this test is placed into a cold start state. The time it takes for the device to determine its first good location fix is recorded. The cold start test is performed several times and the results are averaged.

Acceptance Criteria: Should be less than 40 seconds

C. Warm-Start Time to First Fix Test

This test is used to determine the time taken for first fix during a warm start of the device. In this test the device is started in warm start mode and time taken by

device to determine the first valid location fix is recorded. This is done several times and results are averaged.

Acceptance Criteria: The warm start TTFF should be less than 20 seconds.

D. Hot-Start Time to First Fix Test

This test is used to determine the time taken for first fix during a hot start of the device. In this test the device is started in Hot start mode and time taken by device to determine the first valid location fix is recorded. This test is performed several times and results are averaged.

Acceptance Criteria: The hot start TTFF should be less than 5 seconds.

E. Acquisition Sensitivity Test

Acquisition sensitivity refers to the minimum signal level at which the device is able to successfully perform a cold start TTFF. The acquisition sensitivity test is a simulated signal test. A device cold start is performed, and the time to acquisition is measured. Signal levels are then progressively decreased until the device can no longer acquire the location. This signal strength is recorded.

Acceptance Criteria: The acquisition sensitivity should be better than (-)160 dBm.

F. Tracking Sensitivity Test

Tracking sensitivity refers to the minimum signal level at which the device is able to successfully maintain the location fix. The acquisition sensitivity test is a simulated signal test.

The device under this test is locked on to the simulator's output frequency and the simulator power output is lowered until the lock is lost. Multiple repetition of the test with different satellite geometries ensures that an accurate average measure is recorded.

Acceptance Criteria: The tracking sensitivity should be better than (-)165 dBm.

G. Interference Testing

Interference is a common problem affecting GNSS based devices. Interference can come from various sources such as intentional jamming/spoofing etc.

Interference testing is a type of test, in which Cold Start/Hot Start test are performed with device exposed to interfering signals and the performance os recorded.

Acceptance Criteria: The Interference should not result in any degradation of the Cold Start/Hot Start TTFF times. In addition, it should not result in any degradation of the absolute location accuracy required and the same should be 2.5 m CEP or 6 m 2DRMS.

H. Multipath Testing

This test is a simulated frequency test conducted to determine the effect of multipath signals. The signal from a single satellite is simulated to arrive at the device via two or more paths. One path is typically a direct path, and other paths are typically a reflection of the same signal from building or structure.

Acceptance Criteria: The multipath should not result in any degradation of the Cold Start/Hot Start TTFF times. In addition, it should not result in any degradation of the absolute location accuracy required and the same should be 2.5 m CEP or 6 m 2DRMS.

4.3 Performance and Durability Testing

The devices will need to be tested for performance in the challenging vehicle environments of vibration, dust, fluctuating power supply etc.

4.3.1 Vibration Test

The devices in vehicles are subjected to a harsh environment in terms of vibrations and that too for extended period of time. Two tests are recommended based on the nature of application environment.

Shock: Shock test is performed to provide a degree of confidence that the device can physically and functionally withstand the relatively infrequent, non-repetitive shocks encountered in transportation environments. This test provides an assessment of the effect of the shocks on the performance of the device. The test shall be performed as per MIL-STD-810 F Method 516.5 or equivalent.

Acceptance Criteria: Device after the shock test shall meet the the requirements of functional tests.

Vibration: This test is performed to check that the device the device can physically and functionally withstand the vibration exposures in the life cycle typically encountered in a vehicular environment. The test shall be performed as per MIL-STD-810F Method 514.5 or equivalent.

Acceptance Criteria: Device after the vibration test shall meet the the requirements of functional tests.

4.3.2 Ingress Protection (IP)

The vehicle tracking devices must be able to work in dusty environment that are typically encountered by the public transport vehicles where these would be installed. IP rating (IS/IEG 60529) is used for specifying the environmental protection characteristics of the tracking device. The device will be tested for dust and water ingress according to IP 65 test specification.

- ***Acceptance Criteria***: The device should be IP 65 compliant or better.

4.3.3 EMI /EMC

The Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) tests are performed to assess whether the device performs its intended functions in the electromagnetic environment to which it would be exposed. Further, the device should not generate electromagnetic disturbances that may influence other equipment in the vicinity.

Note: In case the device is 'e' marked as per The Automotive Electromagnetic Compatibility Directive (AEMCD) and a detailed test report is submitted (which includes above tests), no fresh testing would be required.

Acceptance Criteria: The device should meet the EMI/EMC requirements as per AIS 004 (Part 3) or equivalent.

4.3.4 Power Rating and Parameters Testing

Table 4-1 shows the power rating and applicable parameters:

Table 4-1: Power Rating and Its Parameters

Rated Power	Type 3 Device	Type 4 Device
Idle Current Consumption	<120 mA	<300 mA

4.3.5 Battery Backup Test

Battery backup is the amount of time that the device battery can support sending the data without being connected to the power source.

This test will be performed by disconnecting the input charging voltage to the device. On disconnecting the external supply, battery would use its charge capacity to send data through GPRS. Time duration between external power disconnect to the last data packet time denotes the battery backup time.

- ***Acceptance Criteria***: Device should be able to work in active mode for a period of 4 hours or more.

4.3.6 High voltage/ Current Test

The device shall operate under the automotive environment of fluctuating voltage and high current. The test shall be carried out as per ISO 7637 to assess the device performance under such conditions.

- ***Acceptance Criteria***: The device should be able to withstand the simulated test volt and current levels to which it will be exposed during the test without degradation in performance.

4.3.7 Reverse Polarity Protection without Fuse

The device must fulfil the functional requirements after being subjected to reverse polarity based on the input voltage rating of the device.

- ***Acceptance Criteria***: Device shall meet the requirements of functional tests, after the reverse polarity test.

4.3.8 Test for Wiring Harness

Flammability Test: The wiring harness used in the device should be tested for flammability as per IS 2465.

Electrical Properties: The wiring harness used in the device should be tested for electrical properties as per AIS 028.

4.4 Environmental Test

The following testing should be carried out as part of environmental testing:

4.4.1 High Temperature Test

The high temperature test is used to evaluate effects of high temperature conditions on safety, integrity, and performance of the device. The test shall be carried out in accordance with Indian Standard IS: 9000 (Part 3/Sec 5) or MIL-STD-810 F Method 501.4. The device shall be subjected to the high temperature test conditions as per device specification of + 85°C/ + 70°C, as applicable.

- ***Acceptance Criteria***: Device during and after the high temperature test shall meet the requirements of functional tests.

4.4.2 Cold Test

The temperature testing is used to evaluate effects of low temperature conditions during storage and operation affect device safety, integrity and performance. The test shall be carried out in accordance with Indian Standard (IS): 9000 (Part 2/Sec 4) or MIL-STD-810 F Method 502.4. The device shall be subjected to low temperature conditions as per device specification of (-)20°C.

- ***Acceptance Criteria***: Device during and after the cold test shall meet the the requirements of functional tests.

4.4.3 Damp Heat Test

The temperature and humidity conditions change based on geographical locations and time. The purpose of this test is to determine the effects of a warm, humid atmosphere on the device performance. The device should be tested according to IS 9000 (Part 5/Sec 2) or MIL-STD-810F Method 507.4 as per the device specification of 95% Humidity.

- ***Acceptance Criteria***: Device during and after the test shall meet the requirements of functional tests.

4.4.4 Temperature Shock:

Temperature shock test is carried out to determine if the device can withstand sudden changes in the temperature of the surrounding atmosphere without

experiencing physical damage or deterioration in performance. The device shall be tested as per MIL-STD-810 F Method 503.4 or equivalent.

- ***Acceptance Criteria***: Device after the test shall meet the requirements of functional tests.

4.4.5 Salt Spray Test

The salt spray test is conducted to check corrosion resistance of device. Salt spray test is an accelerated corrosion test that produces a corrosive attack on the device sample. The device shall be tested as per AIS: 012/ IS10250.

- ***Acceptance Criteria***: Device after the test shall meet the requirements of functional tests.

4.5 Protocol Testing

Protocol is a set of rules to be followed by the device while sending data to the backend. The protocol comprises data update rate, number of fields, start character, end character, alert type etc. (Table 4-2)

Protocol testing involves checking the compliance of data sets received by the backend against the protocol both with respect to the data fields as well the format. It is expected that the data coming to a central server should be exactly as required under the protocol.

Table 4-2: Protocol Testing Validation Process

Field	Description	Validation Process
Start Character	$	
Header	The header of the packet/ identifier	
Vendor ID	Vendor identification header	
Firmware Version	Version details of the Firmware used in EX.1.0.0	
Packet Type	Specify the packet type – NR = Normal EA = Emergency Alert TA = Tamper Alert HP = Health Packet IN = Ignition On IF = Ignition Off BD = Battery Disconnect BR = Battery Reconnect BL = Battery Low GE = Geofence Entry / Bus Stop entry GX = Geofence Exit / Bus Stop Exit DI = Depot In shed DO = Depot Out shed TS = Trip Start TE = Trip End	To be demonstrated by manufacturer/ supplier and to be tested.

Field	Description	Validation Process
Packet Status	L=Live or H= History	To be tested.
IMEI	Identified of the sending unit. 15 digit standard unique IMEI no.	To be tested.
Vehicle Reg. No	Mapped vehicle registration number	To be tested.
GPS Fix	1 = GPS fix OR 0 = GPS invalid	To be tested.
Date	Date value as per GPS date time (ddmmyy)	To be tested.
Time	Time value as per GPS date time in UTC format (hhmmss)	To be tested.
Latitude	Latitude value in decimal degrees (with minimum 6 decimal places)	To be tested.
Latitude Dir.	Latitude Direction. Example N=North, S= South	To be tested.
Longitude	Longitude value in decimal degrees (with minimum 6 decimal places)	To be tested.
Longitude Dir.	Longitude Direction. Example E=East, W= West	To be tested.
Speed	Speed in km/hr	To be tested.
Heading	Course over ground in degrees	To be tested.
No of Satellites	Number of satellites used for fix	To be tested.
Altitude	Altitude of the device in meters	To be tested.
PDOP	Positional dilution of precision	To be tested.
Distance	Distance Travelled in Meters (Between Current and the Previous packet)	To be tested.
ODO	Total Distance Travelled in Km (from activation of unit to till last packet)	To be demonstrated by manufacturer/ supplier and to be tested.
Min Speed	Minimum Speed travelled by vehicle between last and the current packet in Km/h (in decimal value)	To be demonstrated by manufacturer/ supplier and to be tested.
Avg. Speed	Average Speed between last and the current packet in Km/h (in decimal value)	To be demonstrated by manufacturer/ supplier and to be tested.
Max Speed	Maximum Speed travelled by vehicle between last and the current packet in Km/h (in decimal value)	To be demonstrated by manufacturer/ supplier and to be tested.
Network Operator Name	Name of Network Operator.	To be tested.
Ignition	1= Ign On , 0 = Ign Off	To be demonstrated by manufacturer/ supplier and to be tested.
Main Power Status	0 = Vehicle Battery Disconnected 1= Vehicle Battery Reconnected	To be demonstrated by manufacturer/ supplier and to be tested.
Main Input Voltage	Indicator showing source voltage in Volts.	To be demonstrated by manufacturer/ supplier and

Field	Description	Validation Process
		to be tested.
Internal Battery Voltage	Indicator for Level of battery charge remaining	To be demonstrated by manufacturer/ supplier and to be tested by SI or empanelment authority.
Emergency Status	1= On , 0 = Off	To be demonstrated by manufacturer/ supplier and to be tested.
Tamper Alert	C = Cover Closed , O = Cover Open	To be demonstrated by manufacturer/ supplier and to be tested.
GSM Signal Strength	Value Ranging from 0 – 31	To be tested.
MCC	Mobile Country Code	To be tested.
MNC	Mobile Network Code	To be tested.
LAC	Location Area Code	To be tested.
Cell ID	GSM Cell ID	To be tested.
NMR (neighboring Cell ID)	Neighbouring 4 cell ID along with their LAC	To be tested.
Digital Input Status	4 external digital input status (Status of Input 1 to Input 3 (0=Off; 1=On))	To be demonstrated by manufacturer/ supplier and to be tested.
Digital Output Status	2 external digital output status (0=Off; 1=On)	To be demonstrated by manufacturer/ supplier and to be tested.
Vehicle Status	H = Hired , A = Available , R = Retired / Off Duty	To be demonstrated by manufacturer/ supplier and to be tested.
Trip Start	Trip start time integrated with meter switch	To be demonstrated by manufacturer/ supplier and to be tested.
Trip End	Trip End time integrated with meter switch	To be demonstrated by manufacturer/ supplier and to be tested.
Trip ID	Unique ID for each trip	To be tested.
Trip Duration	Duration of the Trip in minutes	To be tested.
Trip Distance	Km's covered during the Trip in Km	To be demonstrated by manufacturer/ supplier and to be tested.
Trip Fare	Total amount payable for the trip	To be tested.
Geofence Stop ID	Identify the particular stop, Default = 0	To be tested.
Frame Number	Sequence Number of the messages (000001 to 999999)	To be tested.
Checksum	Insures No error in transmission (optional)	To be tested.

Field	Description	Validation Process
End Character	Indicated End of the frame	*

The following tests would be performed along with the protocol testing of the device:

A. Memory Storage

The device should support 40000 or more positional logs. This is a functional test and the device will be simulated to be in non –GPRS coverage area and the logs will be maintained. The capacity of logging will be checked by monitoring the logs on the device.

B. Geofencing

The device should support over 3000 geofences as per the device specification.

5.0 REFERENCES

The following is a list of documents that have been used in the preparation of this report.

- MoRTH approval note on the project
- MoRTH scheme for the project
- Concept Report for the Project
- Technology Analysis Report for the Project
- Urban Bus Specifications – II, Ministry of Urban Development, Government of India (MoUD)
- Tender documents: Delhi Transport Corporation (DTC), Bangalore Metropolitan Transport Corporation (BMTC), Himachal Road Transport Corporation (HRTC), Karnataka State Road Transport Corporation (KSRTC), Municipal Corporation of Greater Mumbai.

Delhi Integrated Multi Modal Transit System Limited (DIMTS)
(A Joint Venture of Govt. of Delhi and IDFC Foundation)

1st Floor Maharana Pratap ISBT Building, Kashmere Gate, Delhi–110006
Ph. : +91-11-43090100; Fax : +91-11-23860966
Email : info@dimts.in Web : www.dimts.in