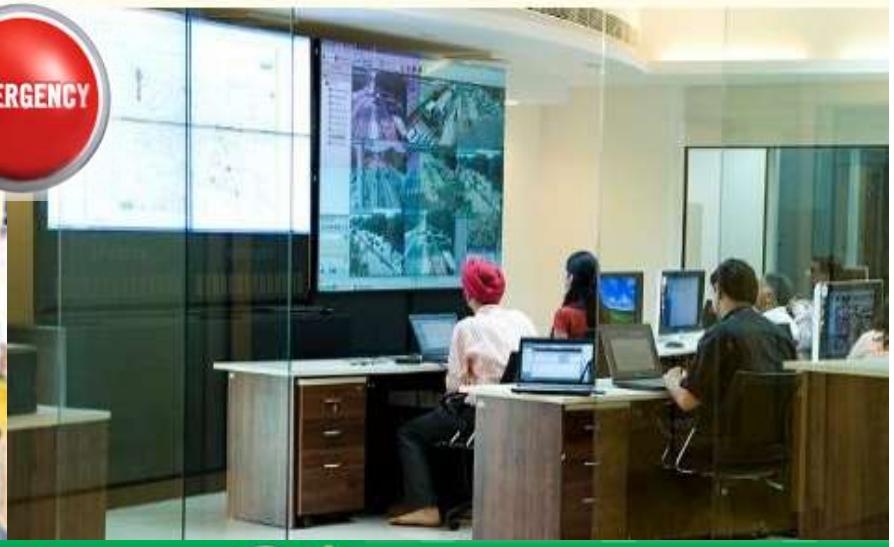
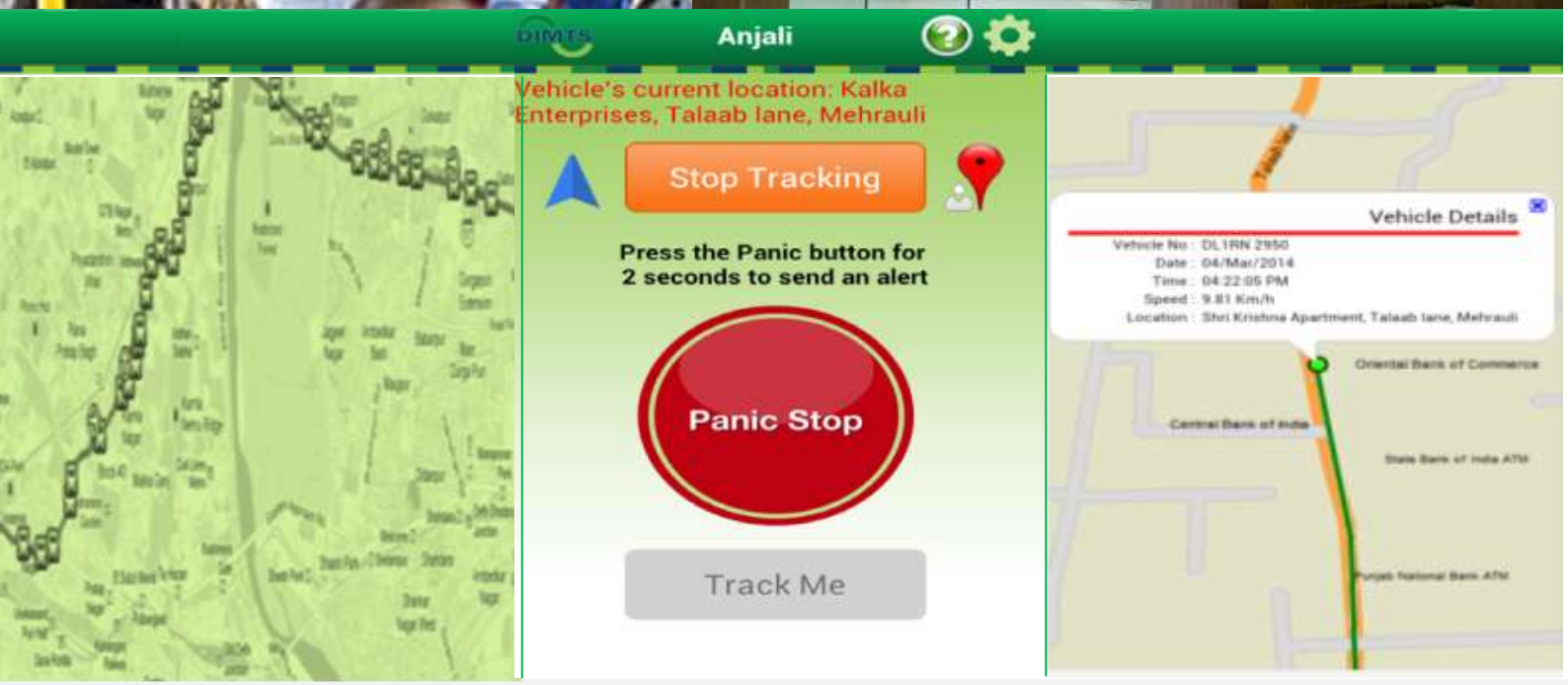
MINISTRY OF ROAD TRANSPORT AND HIGHWAYS
GOVERNMENT OF INDIA

Detailed Specifications Document For CCTV Devices





NATIONAL LEVEL VEHICLE SECURITY AND TRACKING SYSTEM

March 2015

NATIONAL LEVEL VEHICLE SECURITY AND TRACKING SYSTEM

DETAILED SPECIFICATIONS DOCUMENT FOR CCTV DEVICES

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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
AGC	Auto Gain Control
AGPS	Assisted Global Positioning System
AIS	Automotive Industry Standards
APN	Access Point Name
ASCII	American Standard Code for Information Interchange
ATW	Auto Tracking White Balance
BLC	Back Light Compensation
BMTC	Bangalore Metropolitan Transport Corporation
C	Celsius
CCD	Charge Coupled Device
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access
CEP	Circular Error Probability
CIF	Common Intermediate Format
CMOS	Complementary Metal Oxide Semi-conductor
DIMTS	Delhi Integrated Multi-Modal Transit System Limited
DRMS	Distance Root Mean Square
DTC	Delhi Transport Corporation
DVR	Digital Video Recorder
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FPS	Frames Per Second
GB	Giga Byte
GoI	Government of India
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HDD	Hard Disk Drive
HTTP	Hypertext Transfer Protocol
Hz	Hertz
IMEI	International Mobile Equipment Identity
IP	Internet Protocol
IP	Ingress Protection
IR	Infrared
LAC	Location Area Code

Acronym	Definition/Description
LAN	Local Area Network
LED	Light Emitting Diode
mDVR	Mobile Digital Video Recorder
M-JPEG	Motion - Joint Photographic Experts Group
mNVR	Mobile Network Video Recorder
MoF	Ministry of Finance, GoI
MoRTH	Ministry of Road Transport and Highways, GoI
MoUD	Ministry of Urban Development, GoI
MPEG	Moving Picture Experts Group
NC	Normally Close
NMR	Network Management Report
NO	Normally Open
NTSC	National Television System Committee
NVR	Network Video Recorder
ONVIF	Open Network Video Interface Forum
OSD	On Screen Display
PAL	Phase Alternating Line
PMPML	Pune Mahanagar Parivahan Mandal Ltd.
PoE	Power-over-Ethernet
RH	Relative Humidity
RSSI	Received Signal Strength Indicator
RTC	Real Time Clock
SATA	Serial Advanced Technology Attachment
SIM	Subscriber identity module
SMS	Short Message Service
SSD	Solid State Drive
TB	Terra Byte
TCP	Transmission Control Protocol
TTFF	Time To First Fix
TVL	Television Lines
URL	Universal Resource Locator
USB	Universal Serial Bus
WDR	Wide Dynamic Range

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, being administered by Ministry of Finance.

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 been approved by the Government of India. 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 GPS, Emergency buttons and CCTV (in buses only) in specified public transport vehicles 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 CCTV On-Board Devices, 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 the project background, report context and structure.

Chapter 2.0 outlines the types of various CCTV Devices, categorization of CCTV Devices based on technology and vehicle size and various components of CCTV devices.

Chapter 3.0 covers the details regarding the Analog CCTV Devices including Analog CCTV Cameras, Mobile Digital Video Recorders and Emergency Buttons.

Chapter 4.0 covers the details regarding the IP CCTV Devices including IP CCTV Cameras, Mobile Network Video Recorders and Emergency Buttons.

Chapter 5.0 provides details of recommended communication protocol between CCTV On-board Devices and backend server including data from CCTV Devices to the backend and data from backend to CCTV Devices.

Chapter 6.0 covers the details of testing recommended for various CCTV On-board Devices.

Chapter 7.0 provides a listing of references used in preparing this report.

2.0 CCTV ON-BOARD DEVICES – TYPES AND COMPONENTS

2.1 Overview

The National Level Vehicle Security and Tracking System envisages installation of vehicle tracking device, CCTV system and emergency buttons in passenger road transport vehicles, as per the details provided in Table 2-1.

Table 2-1: On-board Devices 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

As per the above details, vehicle tracking device and emergency buttons will be installed in all passenger road transport vehicles whereas CCTV system will be installed in vehicles having seating capacity for 23 or above passengers (excluding driver).

The detailed specifications and other related aspects for Type 1 and Type 2 devices are covered in this document. The specifications and other related aspects for Type 3 and Type 4 devices have been dealt in a separate document titled 'Detailed Specifications Document for Vehicle Tracking Device' prepared for the Scheme.

In case of Type 1 CCTV System device, which has in-built vehicle tracking system, the vehicle tracking requirements will be governed by the specifications as mentioned in the aforesaid document.

In cases where Type 2 CCTV System device is opted, a separate Vehicle Tracking Device will be required to be fitted in the vehicle to meet the tracking related requirements of the Scheme. In this case, the emergency buttons in the vehicle will be part of the CCTV System devices but they will integrate with Vehicle Tracking Device also, in order to provide input to the Vehicle Tracking Device in case of pressing of any of the emergency button to enable the Vehicle Tracking Device to send the alert information to the backend. Other than the above, the CCTV System devices (cameras or DVR/NVR) will not be integrated with the Vehicle Tracking Device in the vehicle. The feeds from vehicle Tracking Device related to vehicle location and emergency alert will be integrated with the feeds from the CCTV System related to images and health status of CCTV System devices in the backend, based on vehicle registration number.

There will be a number of options for CCTV On-board devices depending upon the technology and size of vehicle. Different configurations of the CCTV System devices and categorisation of devices based on technology and size of the vehicle are explained in the following sections.

2.2 Categorisation of CCTV On-Board Devices Based on Technology

There are following two types of CCTV Systems based on underlying technology of transfer of images from camera to external recorder:

- Analog CCTV System
- IP CCTV System

In the Analog CCTV System, the images are transferred from analog cameras to a video recorder in analog form, whereas in IP CCTV System, the images are transferred from IP cameras to a video recorder in digital form. This report covers both Analog as well as IP CCTV Systems, so that both options are available.

2.3 Categorisation of CCTV On-Board Devices Based on Vehicle Size

The number of CCTV cameras in different types of buses will depend upon the following factors:

- Number of doors
- Length of the bus
- Seating layout and interior design of the bus

The guiding principles for the number of cameras and their layout in buses will be as follows:

- All the passenger doors of the bus should be adequately covered by CCTV cameras in a way that image of each passenger boarding the bus is captured.
- The overall length of the bus is suitably covered by CCTV cameras in a way that any incident happening in the bus is adequately covered.

Based on the above guiding principles, the number of CCTV cameras in buses up to 12 meter length (midi buses and standard buses) will be up to 4, whereas in larger capacity buses (double-decker buses and articulated buses), the number of cameras in a bus will be more than 4.

Based on the number of cameras viz. up to four cameras or more than four cameras, there will be following two types of video recorders in the buses:

- Video recorders with 4 video channels
- Video recorders with 8 video channels

The detailed specifications for both types of video recorders are detailed in the later chapters. 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 type of video recorders.

2.4 Components of CCTV System

The on-board CCTV System will comprise various devices such as video recorder with or without in-built vehicle tracking module, CCTV cameras and emergency buttons. The specifications of these devices will vary depending upon the type of CCTV System device and technology of CCTV System. Different devices which will become part of the CCTV System are listed in Table 2-2.

Table 2-2: Components of CCTV System

Device Type	Analog CCTV System	IP CCTV System
Type 1	• Mobile Digital Video Recorder (mDVR) with in-built Vehicle Tracking Module • Analog CCTV Cameras • Emergency Buttons	• Mobile Network Video Recorder (mNVR) with in-built Vehicle Tracking Module • IP CCTV Cameras • Emergency Buttons
Type 2	• Mobile Digital Video Recorder (mDVR) • Analog CCTV Cameras • Emergency Buttons	• Mobile Network Video Recorder (mNVR) • IP CCTV Cameras • Emergency Buttons

The detailed specifications and features of the above devices are explained in the subsequent chapters of the document.

3.0 ANALOG CCTV ON-BOARD DEVICES

3.1 Overview

The Analog CCTV system will comprise the following devices:

- Analog CCTV Cameras
- Mobile Digital Video Recorder (mDVR)
- Emergency Buttons

The detailed specifications of the above devices are provided in subsequent sections in this chapter.

3.2 Analog CCTV Cameras

3.2.1 Focal Length

The focal length of the lens of the CCTV camera is one of the most important parameters to determine the field of view of the camera. Focal length of lens of the CCTV camera directly impacts the angle of view of the CCTV camera. Focal length of the lens of the camera is measured in mm. Short focal length cameras have wide angles of view and long focal lengths cameras have narrow angles of view.

The focal length of the CCTV camera can be fixed or variable. In case of variable focal length cameras, the focal length can be varied manually in case of Vari-focal CCTV cameras or it can be varied electrically in case of Zoom cameras. The variable focal length cameras are used mostly in case of PTZ (pan, tilt, zoom) cameras, where large area is required to be monitored through a single camera, often in real-time.

The focal length for fixed CCTV cameras generally varies from 2.8 mm to 100 mm. The common focal lengths for fixed CCTV cameras are 2.8 mm, 3.6 mm, 6 mm, 10 mm, 16 mm etc. For a typical 1/3” CCD, a CCTV camera with lens of 3.6 mm focal length will have about 72 degree horizontal field of view, whereas a CCTV camera with lens of 16 mm focal length will have only about 15 degree horizontal field of view. It is important to use an optimum focal length of the lens for CCTV camera to meet the desired objectives.

The focal length of CCTV camera lens specified by various organizations for surveillance projects in their buses are given in Table 3-1.

Table 3-1: Lens Focal Length Specifications by Different Organizations

Sl. No.	Name of Organization	Year	Lens
1	Haryana Roadways (Gurgaon and Faridabad)	Oct 2014	Fixed Lens 3.6 mm
2	Delhi Transport Corporation	Jan 2014	3.6 mm

Sl. No.	Name of Organization	Year	Lens
	(DTC)		
3	Urban Bus Specifications - II, (JnNURM), Ministry of Urban Development (MoUD)	May 2013	Fixed Lens 3.6 mm
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	3.6 mm (2.8 mm, 6 mm optional)
5	Bangalore Municipal Transport Corporation (BMTC), Bangalore	Mar 2013	Fixed Lens 3.6 mm

Analog CCTV cameras with fixed lens with focal length of 3.6 mm are recommended for the current project.

3.2.2 Resolution

In case of Analog cameras, the image resolution is measured in terms of TV Lines or TVL, which denotes the horizontal resolution of the image. The resolution of Analog cameras mostly varies between 420 and 700 TV Lines. TVL is defined as the maximum number of alternating light and dark lines that can be resolved. A resolution of 400 TVL means that 200 distinct dark lines and 200 distinct white lines can be counted over a horizontal span equal to the height of the picture. The higher the number of TV Lines, more is the resolution of the camera image.

The CCTV camera resolutions specified by various organizations for surveillance projects in their buses are given in Table 3-2.

Table 3-2: CCTV Camera Resolution Specifications by Different Organizations

Sl. No.	Name of Organization	Year	CCTV Camera Resolution
1	Haryana Roadways	Oct 2014	520 TVL
2	Delhi Transport Corporation	Jan 2014	600 TVL
3	Urban Bus Specifications - II, MoUD	May 2013	420 TVL
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	420 TVL
5	BMTC, Bangalore	Mar 2013	420 TVL

CCTV cameras with resolution of 600 TV Lines are recommended for the current project.

3.2.3 Video Format

There are mainly two video format standards used in the Analog CCTV cameras namely PAL and NTSC. There is another standard named SECAM which is used in

very few countries in the world. NTSC stands for National Television Standards Committee and is the colour video signal television standard comprising 525 lines, 60Hz. PAL stands for Phase Alternate Line which is the colour video signal television standard working on 625 lines, 50Hz. The difference between the two standards is mainly due to different electrical power systems in use in different countries. NTSC is used In the United States where 60 Hz electric power is used, most of the South American countries and a few other countries whereas PAL is used in most of other countries, including India, where 50 Hz electric power is used.

Most of the Analog CCTV cameras and DVRs support both NTSC and PAL standards. The video standard specified by various organizations for surveillance projects in their buses are given in Table 3-3.

Table 3-3: Video Standards Specifications by Different Organizations

Sl. No.	Name of Organization	Year	CCTV System Video Standard
1	Haryana Roadways	Oct 2014	PAL
2	Delhi Transport Corporation	Jan 2014	PAL/NTSC
3	Urban Bus Specifications - II, MoUD	May 2013	PAL
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	PAL/NTSC
5	BMTC, Bangalore	Mar 2013	PAL

CCTV cameras supporting PAL video format are recommended for the current project.

3.2.4 Image Sensor

Image sensors are placed after the lens of the camera. The light passes through the lens and falls on the image sensor. The picture elements (pixel) on the sensor collect the light and convert it into analog voltage, which is further converted into digital signal through a separate analog to digital convertor. There are two types of image sensors namely CMOS (Complementary Metal Oxide Semi-conductor) and CCD (Charge Coupled Device). CCD sensors give good quality images in a wide range of light conditions, whereas CMOS sensors are not able to perform well in low light conditions. The analog cameras typically use CCD sensors. The CCD sensors come in different sizes such as $^{2}/_{3}$", ½", $^{1}/_{3}$", ¼", etc. The size of the CCD sensors along with focal length has an impact on the field of view of the camera. The CCTV cameras with smaller CCDs have narrower field of view whereas those with bigger CCDs have wider field of view.

The image sensor specified by various organizations for surveillance projects in their buses are given in Table 3-4.

Table 3-4: Image Sensor Specifications by Different Organizations

Sl. No.	Name of Organization	Year	Image Sensor Specifications
1	Haryana Roadways	Oct 2014	1/3" CCD
2	Delhi Transport Corporation	Jan 2014	1/3" CCD
3	Urban Bus Specifications - II, MoUD	May 2013	1/3" CCD
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	1/3" CCD
5	BMTC, Bangalore	Mar 2013	1/3" CCD

CCTV cameras with 1/3" CCD image sensor are recommended for the current project.

3.2.5 Minimum Illumination

Minimum illumination is a parameter to measure the sensitivity of a camera to be able to capture useable images in low light conditions.

The minimum illumination specified by various organizations for surveillance projects in their buses are given in Table 3-5.

Table 3-5: Minimum Illumination Specifications by Different Organizations

Sl. No.	Name of Organization	Year	Minimum Illumination Specifications
1	Haryana Roadways	Oct 2014	Not specified
2	Delhi Transport Corporation	Jan 2014	0.01 lux
3	Urban Bus Specifications - II, MoUD	May 2013	Not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	0.1 lux at F1.2
5	BMTC, Bangalore	Mar 2013	0.0 lux at F1.2

CCTV cameras with minimum illumination of 0.01 lux at F1.2 are recommended for the current project.

3.2.6 Colour/Monochrome

CCTV Cameras are available in colour, monochrome or cameras that have the ability to switch between colour and monochrome. The CCTV cameras that switch between colour and monochrome are also called day/night CCTV cameras and are intended for environments of low lighting at various times. At zero or very low ambient light, the cameras can switch to monochrome to be able to capture images, with the help of built-in Infrared light.

It is thus recommended to have a Day/Night colour camera which can switch between colour and monochrome as per the intensity of light like day time or night time.

3.2.7 Infrared Capability

The CCTV cameras which are required to work in day as well as night including conditions with zero ambient light have lenses that are capable of viewing in Infrared (IR) light in addition to the ambient light. Since the buses shall be plying at the day time as well as during the night time, the camera should be capable of effectively capturing images in bright light as well as low light intensities. A CCTV camera can have Infrared LEDs mounted on its housing to provide Infrared light to be able to capture images. The range of Infrared LEDs or IR Distance is the distance of the illumination made by the Infrared LEDs to enable the camera to capture images.

The infrared capability of CCTV cameras specified by various organizations for surveillance projects in their buses are given in Table 3-6.

Table 3-6: Infrared Capability Specifications by Different Organizations

Sl. No.	Name of Organization	Year	Infrared Capability Specifications
1	Haryana Roadways	Oct 2014	Yes, IR Distance of 10 meters
2	Delhi Transport Corporation	Jan 2014	Yes, IR Distance of 10 meters
3	Urban Bus Specifications - II, MoUD	May 2013	Yes, IR Distance of 10 meters
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	Yes, Approx 10 to 20 meters
5	BMTC, Bangalore	Mar 2013	Yes, IR Distance of 10 meters

CCTV cameras with built-in Infrared LEDs with a range of minimum 10 meters are recommended for the current project.

3.2.8 CCTV Camera Ruggedness

The CCTV cameras will be installed in buses and will be subject to vibrations and shocks. Also, the CCTV cameras will be prone to vandalism and tampering attempts. Accordingly, the CCTV camera should be suitably protected against vibration, shocks and vandalism.

The features for protection against vibration, shocks and vandalism for CCTV cameras specified by various organizations for surveillance projects in their buses are given in Table 3-6.

Table 3-7: CCTV Camera Ruggedness Specifications by Different Organizations

Sl. No.	Name of Organization	Year	CCTV Camera Ruggedness Specifications
1	Haryana Roadways	Oct 2014	Vandal Proof
2	Delhi Transport Corporation	Jan 2014	Vandal Proof
3	Urban Bus Specifications - II, MoUD	May 2013	Not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	Impact Protection – IEC60068-2-75 test, Eh, 50J; EN50102, up to IK10
5	BMTC, Bangalore	Mar 2013	Rugged

CCTV cameras with rugged, vandal proof housing are recommended for the current project.

3.2.9 IP Rating

An Ingress Protection (IP) rating is used to specify the environmental protection of enclosures of equipment. The IP rating number is composed of two digits, the first digit refers to the protection against solid objects and the second digit signifies protection against water. The higher is the number, the better is the protection offered by the equipment against ingress of solid objects/ water. Different IP ratings and the corresponding protection levels, as prescribed in IS/IEC 60529 standards are given in Table 3-8.

Table 3-8: IP Rating Numbers and Corresponding Protection Levels

First Digit	Protection Level	Second Digit	Protection Level
0	No protection	0	No protection
1	Protected against solid objects of 50 mm diameter and greater	1	Protection against vertically falling drops of water
2	Protected against solid objects of 12.5 mm diameter and greater	2	Protection against vertically falling drops of water when enclosure is tilted up to 15 degree
3	Protected against solid objects of 2.5 mm diameter and greater	3	Protection against water spray at any angle up to 60 degree from the vertical
4	Protected against solid objects of 1 mm diameter and greater	4	Protection against water splashing from any direction
5	Protected against dust, limited ingress (no harmful	5	Protected against low pressure jets of water from all directions

First Digit	Protection Level	Second Digit	Protection Level
	deposit)		
6	Totally protected against dust	6	Protected against high pressure jets of water
		7	Protected against the effect of temporary immersion up to 1m
		8	Protected against long periods of immersion beyond 1m

The ingress protection rating specified by various organizations for CCTV cameras for surveillance projects in their buses are given in Table 3-9.

Table 3-9: CCTV Camera IP Rating Specifications by Different Organizations

Sl. No.	Name of Organization	Year	CCTV Camera IP Rating Specifications
1	Haryana Roadways	Oct 2014	IP66
2	Delhi Transport Corporation	Jan 2014	IP65/IP66
3	Urban Bus Specifications - II, MoUD	May 2013	IP66
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	IP66
5	BMTC, Bangalore	Mar 2013	IP66

CCTV cameras with IP Rating of IP66 are recommended for the current project.

3.2.10 Operating Temperature

The CCTV cameras are required to work in varying temperature conditions. So, the CCTV cameras should be able to perform in a wide range of temperature.

The operating temperature range for CCTV cameras specified by various organizations for surveillance projects in their buses are given in Table 3-10.

Table 3-10: Operating Temperature Specifications by Different Organizations

Sl. No.	Name of Organization	Year	CCTV Camera Operating Temperature Specifications
1	Haryana Roadways	Oct 2014	0 to 65 degree C
2	Delhi Transport Corporation	Jan 2014	-10 to 60 degree C
3	Urban Bus Specifications - II, MoUD	May 2013	Not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML),	Apr 2013	-10 to 60 degree C

Sl. No.	Name of Organization	Year	CCTV Camera Operating Temperature Specifications
	Pune		
5	BMTC, Bangalore	Mar 2013	0 to 45 degree C

CCTV cameras with operating temperature range of -10 to 60 degree C are recommended for the current project.

3.2.11 Humidity

Humidity is a highly varying parameter in India and the CCTV cameras need to function in a wide range of humidity levels. The humidity levels for CCTV cameras specified by various organizations for surveillance projects in their buses are given in Table 3-11.

Table 3-11: CCTV Camera Humidity Specifications by Different Organizations

Sl. No.	Name of Organization	Year	CCTV Camera Humidity Specifications
1	Haryana Roadways	Oct 2014	Upto 90% RH
2	Delhi Transport Corporation	Jan 2014	0% to 95% RH
3	Urban Bus Specifications - II, MoUD	May 2013	Not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	90% or less (non-condensing)
5	BMTC, Bangalore	Mar 2013	Not specified

CCTV cameras with humidity levels of 0% to 95% are recommended for the current project.

3.2.12 Audio

CCTV Cameras can have the option for recording of audio in addition to the images. The feature to capture audio with the images in the CCTV cameras can be of great help in investigating any incident and also can serve as important piece of evidence against the culprits.

Though, the organizations as mentioned above have not specified audio capture as part of their CCTV systems, it is recommended to have CCTV cameras to capture audio along with the images, for the current project. The CCTV cameras can have built-in microphones or there can be a separate microphone installed in proximity to CCTV camera to capture audio.

3.2.13 Input Power

The CCTV cameras in a vehicle can draw electric power from the DVR to which they are connected. It is recommended that the CCTV cameras in the vehicle draw power

from the DVR and in view of this, there shall not be any separate direct power provisioning for the cameras.

3.2.14 Image Enhancement Features

CCTV cameras have to work in different light conditions, which include low light, bright light and different combinations of white and colour lights. CCTV cameras can have automatic controls to manage such varying conditions to enhance the image quality. These features are explained below:

White Balance

In order to represent white and different colours in the image properly, the CCTV cameras use a feature called white balance. The CCTV cameras with Automatic White Balance automatically adjusts the colour temperature of the camera image with reference to the best-match white colour available in the image, so that white and other colours appear as natural as possible. Some cameras use an advance technique called Auto-tracking White Balance (ATW) in which, the camera maintains a fixed reference of white balance built into its settings, so that the camera will be able to display the correct colours even if there is no white in the scene.

Gain Control

In case of low light conditions, the camera images can become practically useless due to grains and noise in the image. To tackle this problem, cameras can have a feature called Automatic Gain Control (AGC). The AGC function provides clear image in low light condition with the help of an amplifier which is used to boost the video signal in low light to increase the camera's sensitivity.

Backlight Compensation

In case, bright light falls on the camera from some source such as through window, CCTV camera reduces the exposure which causes a dark image of the object of interest. In such cases, due to large amount of background light, it becomes practically impossible to see any details of the objects. In order to resolve this issue, the CCTV cameras use a mechanism called Back Light Compensation (BLC), which improves the exposure of the objects that are in front of the bright light source. The image with BLC is much clearer than that without BLC. However, the BLC has a limitation of making the background also brighter. Another mechanism called Wide Dynamic Range (WDR) which, instead of brightening the entire image, brightens the dark parts and darkens the bright parts of the image. WDR is able to give better image quality than BLC.

Various image quality enhancement features specified by various organizations for surveillance projects in their buses are given in Table 3-12.

Table 3-12: CCTV Camera Image Quality Features by Different Organizations

Sl. No.	Name of Organization	Year	CCTV Camera Image Quality Features
1	Haryana Roadways	Oct 2014	Automatic Backlight Compensation
2	Delhi Transport Corporation	Jan 2014	Auto Backlight Compensation Auto White Balance Auto Gain Control
3	Urban Bus Specifications - II, MoUD	May 2013	Automatic Backlight Compensation
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	Backlight Compensation
5	BMTC, Bangalore	Mar 2013	Automatic Backlight Compensation Auto White Balance Auto Gain Control

CCTV cameras with the following features are recommended for the current project:

- Wide Dynamic Range (WDR) & Auto Backlight Compensation (BLC)
- Auto-tracking White Balance (ATW)
- Automatic Gain Control (AGC)

3.2.15 Motion Detection

Motion Detection is an electronic method of detecting a change in the field of view of a camera. It is achieved by storing one frame of the image and then comparing the next frame with the stored frame to find out, if there has been a change. Motion detection can be used to initiate some action such as starting recording of images in case there is some change in the camera's field of view.

It is recommended that the CCTV cameras for the project should support Motion Detection, so that during night time, the recording can be restricted to the times when there is some happening in the vehicle, as per the specified configuration.

3.2.16 Analog Camera Specifications

A summary of recommended specifications for Analog CCTV Camera including those suggested in the above sub-sections as well as other parameters is given in Table 3-13 below:

Table 3-13: Recommended Specifications of Analog CCTV Camera

Sl. No.	Parameter	Recommended Minimum Specification
1	Type	Analog, Colour camera

Sl. No.	Parameter	Recommended Minimum Specification
2	Video Format	PAL
3	Lens	Fixed, 3.6 mm
4	Camera Resolution	600 TV Lines, 752 (H) x 582 (V)
5	Image Sensor	1/3" CCD
6	Minimum Illumination	0.01 Lux at F1.2 with IR Off 0.0 Lux with IR On
7	Shutter Time	1/50 sec to 1/100,000 sec
8	Infrared Capability	Built-in Infrared LEDs with range of minimum 10 meters Auto Day/Night
9	Camera Ruggedness	Rugged, vibration, shock and tamper proof housing Vibration resistance as per EN 60068 or equivalent Shock resistance as per EN 60068 or equivalent
10	IP Rating	IP66
11	Operating Temperature	-10 to 60 degree Celsius
12	Operating Humidity	0% to 95% RH
13	Audio	Built-in Microphone or separate microphone
14	Image Enhancement	• Auto-tracking White Balance (ATW) • Automatic Gain Control • Wide Dynamic Range (WDR) and Automatic Backlight Compensation (BLC)
15	Input Power	Power from mDVR
16	Motion Detection	Automatic Motion Detection

3.3 Mobile Digital Video Recorder

3.3.1 Video Input Channels

Video input channel is the number of camera inputs the recorder is capable of handling. A recorder with 4 video channels input can handle simultaneous connectivity with 4 CCTV cameras.

The numbers of video input channels specified by various organizations for surveillance projects in their buses are given in Table 3-14.

Table 3-14: Video Input Channels Specifications by Different Organizations

Sl. No.	Name of Organization	Year	Number of Video Input Channels
1	Haryana Roadways	Oct 2014	4 Channels

Sl. No.	Name of Organization	Year	Number of Video Input Channels
2	Delhi Transport Corporation	Jan 2014	4 Channels
3	Urban Bus Specifications - II, MoUD	May 2013	4 Channels
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	4 Channels
5	BMTC, Bangalore	Mar 2013	4 Channels

The mobile DVR with minimum 4 video input channels is recommended for midi and standard buses for the current project. In case of articulated or double-decker buses with more than 4 CCTV cameras, the mobile DVR with 8 video input channels is recommended.

3.3.2 Video Compression

A video compression standard (codec) is designed to compress and uncompress digital video in order to reduce the amount of bandwidth required to transmit the video over a wireless link and to store the video on a storage medium.

The common codecs used in video compression are Motion JPEG or M-JPEG (Joint Photographic Experts Group), MPEG-4 (Moving Picture Experts Group) and H.264. In addition to the above codecs, H.265 (also known as High Efficiency Video Coding or HEVC) is a new standard for video compression that can deliver better performance than previously available standards including H.264. However, most of the currently available mDVRs do not support H.265 standard. The H.264 codec is most efficient of the standards currently supported by mDVRs and records high quality videos while reducing storage space of the Hard Disk Drive (HDD) by a considerable extent. Most mDVRs on the market provide H.264 codec to compress videos.

The support for various video compression standards specified by various organizations for surveillance projects in their buses are given in Table 3-15.

Table 3-15: Video Compression Standards Specified by Different Organizations

Sl. No.	Name of Organization	Year	Video Compression Standards Supported
1	Haryana Roadways	Oct 2014	H.264
2	Delhi Transport Corporation	Jan 2014	MPEG-4, H.264
3	Urban Bus Specifications - II, MoUD	May 2013	H.264
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	H.264, MPEG-4, MJPEG
5	BMTC, Bangalore	Mar 2013	Not specified

For the current project, the mobile DVR with support for H.264, MPEG-4 and M-JPEG is recommended. Once the H.265 video compression standard becomes commonly available, the future mDVRs will also be required to support the same.

3.3.3 Frame Rate

Frame Rate or Frames per Second (FPS) represents the number of pictures that can be captured into the video stream for all the video inputs received from CCTV cameras connected to the mDVR. Certain DVRs are capable of streaming the video at dual rate i.e. one video stream at higher frame rate for local storage and second video stream at a lower frame rate for transmission to remote server.

The video frame rates specified by various organizations for surveillance projects in their buses are given in Table 3-16.

Table 3-16: Video Frame Rate Specified by Different Organizations

Sl. No.	Name of Organization	Year	Video Frame Rate
1	Haryana Roadways	Oct 2014	2CIF (352x288) 25 fps each for four channels D1 (704x576) 25 fps for one channel D1 (704x576) 12 fps each for four channels
2	Delhi Transport Corporation	Jan 2014	25 fps
3	Urban Bus Specifications - II, MoUD	May 2013	CIF (352x288) 25 fps each for four channels D1 (704x576) 25 fps for one channel D1 (704x576) 12 fps each for four channels
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	100/120 fps at D1 Dual stream, configurable
5	BMTC, Bangalore	Mar 2013	CIF (352x288) 25 fps each for four channels D1 (704x576) 12 fps each for four channels

For the current project for midi and standard buses, the mobile DVR with support for 25 fps at 4CIF (704x576) resolution for all channels i.e. cumulative 100 fps at 4CIF (704x576) resolution is recommended. For articulated or double-decker buses with more than 4 CCTV cameras, the mobile DVR with support for 25 fps at 4CIF (704x576) resolution for all channels i.e. cumulative 200 fps at 4CIF (704x576) resolution is recommended. In both the cases, the mDVR should support dual streaming, each video stream configurable at different frame rates and resolution.

3.3.4 Audio

The mobile DVR can have one or more audio input channels to record audio captured by microphones either built-in the CCTV camera or separately installed. Availability of audio can greatly help in resolving security incidences in buses by providing vital clues/evidences.

The audio channels specified by various organizations for surveillance projects in their buses are given in Table 3-17.

Table 3-17: Audio Channels Specified by Different Organizations

Sl. No.	Name of Organization	Year	Audio Channels in mDVR
1	Haryana Roadways	Oct 2014	Not specified
2	Delhi Transport Corporation	Jan 2014	1 Channel
3	Urban Bus Specifications - II, MoUD	May 2013	Number of Channels not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	4 Channels G.711
5	BMTC, Bangalore	Mar 2013	Not specified

For the current project, it has been recommended to have audio recording with one microphone each built in the camera or placed along with cameras inside the bus. The mDVR shall, therefore, have a feature to support four channels of audio. The mDVR shall support G.711 and G.726 audio compression standards. For bigger buses (articulated and double-decker buses) with more than 4 CCTV cameras, the mobile DVRs with 8 audio channels are recommended.

3.3.5 Storage

The storage media supported by mobile DVR is very important from the point of view of capacity, security and safety of video storage in the mDVR. Currently the available modes of video recording media inside the recorder are Secure Digital (SD) Cards, Solid State Disks (SSD) and Serial Advanced Technology Attachment (SATA) Hard Disk Drives (HDD). Secure Digital (SD) Cards and Solid State Disks do not have moving parts but the SATA Hard Disks have moving parts. The mDVR would be mounted on the buses and shall be subject to vibrations and shocks, making the storage media susceptible to damage or corruption of data. Thus, the mDVR should have adequate measures to protect the storage media from damage or corruption due to vibrations and shocks.

In addition to the type of storage, capacity is another important parameter of storage in mDVR. The mDVR should have adequate storage capacity to be able to store the data for the desired period. In case of recording by 4 cameras for a continuous period of 20 hours per day with video compression on H.264 on 4CIF quality at the rate of

25 frames per second and a video retention period of 7 days, the mDVR shall require a storage capacity of about 452 GB including 7 days audio storage.

The type of storage and its capacity specified by various organizations for mDVRs for surveillance projects in their buses are given in Table 3-18.

Table 3-18: Storage Type/Capacity Specified by Different Organizations

Sl. No.	Name of Organization	Year	Storage Type and Capacity in mDVR
1	Haryana Roadways	Oct 2014	Type: Not specified Capacity: 30 days for total 2 channels in 2CIF mode, 20 hours per day
2	Delhi Transport Corporation	Jan 2014	Type: Not specified Capacity: 7 days (24x7 recording)
3	Urban Bus Specifications - II, MoUD	May 2013	Type: Hard Disk / SD Card Capacity: 48 hours (for total 4 channels) recording of images and voice in CIF mode
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	Type: Not specified Capacity: 7 days video
5	BMTC, Bangalore	Mar 2013	Type: Compact Flash (CF) Card Capacity: 48 hours recording in CIF

The mDVRs with Solid State Disk or SATA Hard Disk Drive (with special mounting arrangements for vibration and shock prevention, such as anti-vibration pads) with a storage capacity of 500 GB are recommended for midi and standard buses for the current project. For articulated or double-decker buses with more than 4 CCTV cameras, the mobile DVRs with 1 TB capacity Solid State Disk or SATA Hard Disk Drive (with special mounting arrangements for vibration and shock prevention, such as anti-vibration pads) are recommended.

3.3.6 Network Interfaces

The mobile digital video recorder needs to have network/communication interfaces to enable data transfer with external devices. The stored video and health check updates will be required to be transferred from the mDVR to external system, whereas the firmware and configuration parameters will be required to be transferred to the mDVR. The mDVR can have various network interfaces such as Ethernet (RJ45), Wireless LAN (Wi-Fi) and 2G/3G.

Various network/communication interfaces specified by various organizations for mDVRs for surveillance projects in their buses are given in Table 3-19.

Table 3-19: Network Interfaces Specified by Different Organizations

Sl. No.	Name of Organization	Year	Network Interfaces in mDVR
1	Haryana Roadways	Oct 2014	Not Specified
2	Delhi Transport Corporation	Jan 2014	LAN, 2G/3G/CDMA/GSM enabled, Wi-Fi
3	Urban Bus Specifications - II, MoUD	May 2013	Wireless LAN with backhaul
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	LAN
5	BMTC, Bangalore	Mar 2013	Not Specified

The currently used 2G and 3G telecom frequency bands in India are given in Table 3-20.

Table 3-20: Telecom Frequency Bands in India

Sl. No.	Telecom Network	Frequency Bands
1	2G Telecom Network	900 MHz, 1800 MHz
2	3G Telecom Network	2100 MHz

It is recommended that the mDVRs for the current project should have Ethernet (RJ45) and Wireless LAN (Wi-Fi) interfaces. In addition, the mDVR also should have inbuilt 3G communication module capable of working on 2G connectivity, supporting 900 MHz, 1800 MHz and 2100 MHz frequency bands.

3.3.7 Subscriber Identity Module (SIM)

Based on the environment of usage, the subscriber identity module (SIM) can be of different types such as general purpose plastic SIM or Machine to Machine (M2M) SIM. The M2M SIMs are further categorised as M2M Plastic SIM, M2M Robust Plastic SIM and M2M Industrial SIM, depending upon their environmental robustness, data retention capability and life span. The key features of different types of M2M SIMs are described in Table 3-21.

Table 3-21: M2M 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	• Extreme Environmental Conditions ○ Temperature ○ Shock ○ Humidity ○ Corrosion

Sl. No.	Parameter	SIM M2M Plastic	SIM M2M Robust Plastic	M2M Industrial SIM
			life-Span ○ Intensive Use	• 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

It is recommended to use M2M Plastic or M2M Robust Plastic or M2M Industrial SIM in the mDVR and the mDVR should support the use of all of these types of SIMs.

3.3.8 Input Power

The mDVR in the bus shall draw power from the vehicle battery. As there are different types of models and manufacturers of buses, the battery inputs to the recorder could be different. Moreover, the bus power shall be subject to spikes at the time of starting the ignition of the bus. The mDVR should be able to work on a wide range of input power and also be capable of withstanding spikes in power.

The input power specified by various organizations for mDVRs for surveillance projects in their buses are given in Table 3-22.

Table 3-22: mDVR Input Power Specified by Different Organizations

Sl. No.	Name of Organization	Year	Input Power to mDVR
1	Haryana Roadways	Oct 2014	Will work on bus battery, 24 Volts
2	Delhi Transport Corporation	Jan 2014	8 to 36 Volts
3	Urban Bus Specifications - II, MoUD	May 2013	Not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	12 Volt
5	BMTC, Bangalore	Mar 2013	Not specified

It is recommended that the mDVRs for the current project should work on input power of 8 to 32 volts.

3.3.9 Environmental Conditions

The mDVR should be able to operate in the wide range of environmental conditions i.e. temperature and humidity levels likely to be experienced in buses in various cities in India.

The environmental parameters specified by various organizations for mDVRs for surveillance projects in their buses are given in Table 3-23.

Table 3-23: Environmental Parameters Specified by Different Organizations

Sl. No.	Name of Organization	Year	Environmental Parameters for mDVR
1	Haryana Roadways	Oct 2014	Temp: 0 to 55 degree C Humidity: Not specified
2	Delhi Transport Corporation	Jan 2014	Temp: -10 to 60 degree C Humidity: 0% to 95%
3	Urban Bus Specifications - II, MoUD	May 2013	Temp: Not specified Humidity: Not specified
4	Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), Pune	Apr 2013	Temp: -20 to 60 degree C Humidity: Up to 85% RH, non-condensing
5	BMTC, Bangalore	Mar 2013	Temp: -21 to 56 degree C Humidity: Not specified

It is recommended that the mDVRs for the current project should work on a temperature range of -10 to 60 degree Celsius and humidity levels of 0% to 95% RH, non-condensing.

3.3.10 mDVR Specifications

A summary of recommended specifications of mDVR including those suggested in above sub-sections as well as other parameters is given in Table 3-24.

Table 3-24: Recommended Specifications of mDVR

Sl. No.	Parameter	Recommended Minimum Specification	
		mDVR for Midi and Standard Buses having up to 4 CCTV cameras	mDVR for bigger Buses having up to 8 CCTV cameras
1	Video Format	PAL	
2	Number of Video Inputs	4 channels	8 channels
3	Number of Video Outputs	1	
4	Number of Audio Inputs	4 channels	8 channels

Sl. No.	Parameter	Recommended Minimum Specification	
		mDVR for Midi and Standard Buses having up to 4 CCTV cameras	mDVR for bigger Buses having up to 8 CCTV cameras
5	Number of Audio Outputs	1	
6	Video Compression Standards Supported	H.264, MPEG-4 and M-JPEG	
7	Audio Compression Standards Supported	G.711 and G.726	
8	Number of streams	Dual streams, both streams independently configurable for each camera resolution and frame rate	
9	Recording Resolutions	4CIF/2CIF/CIF/QCIF (can be set independently for each channel, for both streams)	
10	Video Frame Recording Rate	1 to 25 fps for all channels at 4CIF (total 100 fps at 4CIF) – resolution and frame rate can be set independently for each camera, for both streams	1 to 25 fps for all channels at 4CIF (total 200 fps at 4CIF) – resolution and frame rate can be set independently for each camera, for both streams
11	Alarm Sensors	Minimum 4 inputs (NO/NC, configurable) 2 outputs	
12	Storage	500 GB, 2.5” SATA Hard Disk Drive or Solid State Drive with suitable anti-vibration mechanism Desirable: Solid State Drive Hard Disk to be pluggable and easily removable, secure and protected by lock	1 TB, 2.5” SATA Hard Disk Drive or Solid State Drive with suitable anti-vibration mechanism Desirable: Solid State Drive Hard Disk to be pluggable and easily removable, secure and protected by lock
13	Recording Modes	Normal, Schedule based, Alarm triggered, Motion detection	
14	Event Based Recording and Tagging	Pre-recording – 1 to 15 minutes Post-recording – 1 to 60 minutes	
15	Shut Down Delay	Configurable shut down delay after ignition off – 5 min to 4 hours	
16	Power Input	8 to 32 volts, spike/surge protection	
17	Power output	Regulated power to CCTV cameras and microphones	
18	Working Temperature	-10 to 60 degree Celsius	
19	Working Humidity	0% to 95% relative humidity non-condensing	
20	Network/Communication	LAN – 1 RJ45 interface	

Sl. No.	Parameter	Recommended Minimum Specification	
		mDVR for Midi and Standard Buses having up to 4 CCTV cameras	mDVR for bigger Buses having up to 8 CCTV cameras
	Interfaces	Wi-Fi – 802.11/b/g/n Built-in 3G module, supporting both 2G and 3G (at least 900, 1800 and 2100 MHz frequency bands), Support for SMS, Voice, Data, GPRS, TCP/IP	
21	External Interfaces	1 RS232 1 USB 2.0 1 SIM slot (Capable of using M2M Plastic, M2M Robust Plastic SIM and M2M Industrial SIM)	
22	Image quality	1 to 5 (configurable)	
23	Watermark	Tamper-proof Watermark	
24	Configurable Video Overwriting	Video over-writing to be configurable to support: • Cyclic overwriting (oldest recording to be overwritten) • Event tagged recording not to be overwritten for a longer period (7 to 30 days, configurable)	
25	Connections	All input and output connections to be vibration/shock resistant and locking Desirable: Aviation Connectors	
26	LED Indicators	Power, Recording, 3G/ GPRS Network	Power, Recording, 3G/ GPRS Network, GPS
27	Vibration resistance	EN 60068 or equivalent	
28	Shock resistance	EN 60068 or equivalent	
29	Health Parameters over 2G/ 3G/ SMS	Capable of sending health parameters (cameras not-functioning, cameras tamper, HDD/SSD error, HDD/SSD full) at specified frequency to the server Capable of detecting failure, error or tamper of cameras or any component and sending alert to server	
30	Over-the-air Update/ Upgrade	Over-the-air update of configuration parameters of mDVR and cameras, as specified in protocol document Over-the-air upgrade of firmware	
31	Motion Detection	Configurable sensitivity levels Motion Detection zones to be configurable independently for each camera	
32	RTC	Built-in RTC, drift not more than 10 seconds at any time	
33	Data Download	mDVR should provide video and audio download facility for the desired date/time and duration. It should be possible to connect a laptop to mDVR through network cable on RJ45 port and open	

Sl. No.	Parameter	Recommended Minimum Specification	
		mDVR for Midi and Standard Buses having up to 4 CCTV cameras	mDVR for bigger Buses having up to 8 CCTV cameras
		mDVR's user interface in a standard browser using a standard URL such as http://dvr (or any other text specified by MoRTH) without having to configure the laptop's network settings. After entering user-id and password (specified by MoRTH), it will be possible to search, view, select and download video clips of desired duration and date/time in standard formats such as .avi or .mpg. It will not be possible to delete any video or change configuration settings using this set of user-id and password.	
34	Data Transfer on 3G and 2G	In case the vehicle moves to an area where 3G coverage is not present, the mDVR will automatically shift to GPRS (2G) connectivity to send the health status data. Also, in such case, on press of an emergency button, the mDVR will automatically shift to a lower frame rate and resolution (both configurable) and send the video from cameras to the backend server over GPRS (2G).	

The above specifications for mDVR will be applicable for both Type 1 and Type 2 devices. However, the mDVR which are part of Type 1 device will also have to meet vehicle tracking related specifications as listed in sub-section 3.3.11.

3.3.11 Additional Specifications for Type 1 mDVR

The mDVRs which will be part of Type 1 device (CCTV system with in-built tracking system and emergency button system) will have a built-in locating module which will provide vehicle tracking related functionalities. Various parameters that are important for vehicle tracking device have been examined in another document titled 'Detailed Specifications Document for Vehicle Tracking Device' prepared as part of the project documentation. As such these parameters are not being explained in this document and only a summary of recommended specifications of mDVR related to vehicle tracking functionalities is provided in Table 3-25.

Table 3-25: Additional Specifications for Type 1 mDVR

Sl.No.	Paramter	Recommended Minimum Specification
1	Location Module	Parallel GPS or GLONASS or both receiver module with 32 (minimum) acquisition channels & 18 minimum tracking channel. The devices should also support Indian Regional Navigation Satellite System (IRNSS). The device should also support GAGAN, the Indian SBAS (Satellite Based

Sl.No.	Paramter	Recommended Minimum Specification
		Augmentation System). Location, speed, heading, timestamp data polling and sending frequency capability of less than or equal to 10 sec
2	Location on demand	On 3G/GPRS/SMS Configurable backup SMS facility in case of 3G/ GPRS failure
3	Memory	Memory to store minimum 40,000 positional logs
4	Acquisition sensitivity	Better than (-)160 dBm
5	Tracking sensitivity	Better than (-)165 dBm
6	Accuracy	Less than 6 meter Positional Accuracy 2DRMS (on ground) or 2.5 meter CEP (on ground)
7	Hot start	< 5 sec
8	Warm start	< 20 sec
9	Cold start	< 40 sec
10	Outputs	As per NMEA 0183
11	WGS-84 compliant	Yes
12	A-GPS	Yes
13	Geo-fence capability	Device should store minimum 3000 geo-fence points. One route in general can be of 150 distinct geo-fence points.
14	Cell ID and Network Measurement Report	Capability to send serving and adjacent cell ID as well as network measurement report (NMR)
15	Over the Air Capability	Download of firmware as well as configuration parameters Remote administration and firmware update over the air Facility to update route Geo-fence master in the device over the air Device should be capable of sending a packet to 2 different IP's simultaneously

The following specifications which have been recommended for Type 3 Device (Vehicle tracking device with in-built emergency button system) and Type 4 Device (Vehicle tracking device with in-built emergency button system and fare meter) are not being recommended for Type 1 mDVR as the same are not technically feasible and prevalent in the available mDVRs:

- Internal battery backup of minimum 4 hours
- Internal GPS antenna
- Internal GPRS antenna

3.4 Emergency Buttons

3.4.1 Overview of Emergency Buttons

Several Emergency Buttons will be required to be installed in the bus within easy reach of the passengers. One Emergency Button will be installed within reach of the driver also, so that the driver can also raise alert in case of an emergency situation in the bus. On pressing of any Emergency Button in the bus, the mDVR and Vehicle Tracking Device (if a separate unit) will get the signal. On receipt of the signal from the Emergency Button, the mDVR and Vehicle tracking device will initiate the following actions:

- Send the emergency alert to the backend system, as part of the bus location data.
- Start sending the images from the cameras to the backend at a specified frequency. The mDVR will continue sending the images to the backend for a specified duration.
- Tag the video recording of cameras for a specified duration before and after the press of Emergency Button with emergency event. The video recording tagged with emergency event will not get overwritten and deleted for a specified number of days.

Figure 3-1: Emergency Button on a Bus

3.4.2 Recommendations

The recommendations in respect of Emergency Buttons are given below:

- The number of Emergency Buttons and their positioning in different types of buses will be decided based on the length, seating and interior layout of the buses. One Emergency Button will be installed within easy reach of the driver. Other Emergency Buttons will be installed on both sides of the bus in such a way that the distance between two buttons is not more than 3 meters.
- The Emergency Buttons will be connected to both, the mDVR and the Vehicle Tracking Device (if a separate device) in a manner such that in case of press of any Emergency Button, both mDVR and the Vehicle Tracking Device get the alert signal.

- The Emergency Buttons will be ‘Normally Closed’ (NC) type. The form factor of Emergency Buttons will be such that the button is easy to press in the case of an emergency, and simultaneously also minimizes the possibility of accidental or unintended press thereby causing a false alert.

4.0 IP CCTV ON-BOARD DEVICES

4.1 Overview

The IP CCTV On-Board Devices will comprise the following devices:

- IP CCTV Cameras
- Mobile Network Video Recorder (mNVR)
- Emergency Buttons

Certain specifications of IP CCTV On-Board Devices which have been listed in section 4.2.9 will be same as that of Analog CCTV On-Board Devices analysed in previous chapter. The specifications of IP CCTV On-Board Devices, which are different than Analog CCTV On-Board Devices, are analysed in the following sections.

4.2 IP CCTV Cameras

4.2.1 Image Sensor

Unlike analog CCTV Cameras which use CCD sensors only, the IP Cameras can use both CCD as well as CMOS sensors. The CCD sensors are better at capturing images in low light conditions, but CMOS sensors have better speed of processing and lower costs.

It is recommended to use $^1/_3$" Progressive Scan CMOS sensors or $^1/_3$" CCD sensors for the IP cameras.

4.2.2 Resolution

In case of Analog CCTV cameras, the resolution is limited to about 0.4 megapixels, whereas IP cameras can have higher resolutions of several megapixels. The higher resolution camera offer more details in the image captured, but the size of image increases manifold, thus impacting storage and bandwidth requirements.

It is recommended that the IP cameras should have minimum 0.4 megapixel resolution, as in the case of Analog cameras.

4.2.3 Interface

The IP cameras can have an Ethernet interface for connection to the mNVR. Thus it is recommended that the IP CCTV cameras in the bus shall have 1 RJ45, 10/100 M Ethernet interface for connection to the mNVR.

4.2.4 Input Power

The CCTV cameras in the bus shall draw power from the mNVR and there shall not be any separate power provisioning for the cameras. As the IP Cameras have RJ-45 Ports to connect to the network, the Power-over-Ethernet (PoE) can be used to

supply power to CCTV cameras from mNVR, eliminating the need for extra power cable.

Thus, it is recommended that the IP cameras shall draw power from mNVR through Power-over-Ethernet.

4.2.5 Video Compression

In case of IP cameras, the camera itself processes and encodes the video. For the current project, the IP cameras with support for H.264, MPEG-4 and M-JPEG video compression are recommended. Once the H.265 video compression standard becomes commonly available, the future IP cameras will also be required to support the same.

4.2.6 Frame Rate

Frame Rate or Frames per Second (FPS) indicates the number of pictures that can be captured into the video stream. The IP cameras should be able to support frame rate of up to 25 frame per seconds for all resolutions.

4.2.7 ONVIF Compliance

ONVIF (Open Network Video Interface Forum) is a global open standard for interface of IP surveillance products. ONVIF helps in standardization of communication between IP based video devices and achieving inter-operability between them. It is recommended that the IP cameras should be ONVIF Profile S compliant.

4.2.8 Audio Compression

In case of IP cameras, the audio is compressed by the IP camera, before sending it to the mNVR. The IP cameras should support G.711 and G.726 audio compression standards.

4.2.9 IP Camera Specifications

A summary of recommended specifications of IP CCTV cameras including those which are same as that of Analog cameras as well as those suggested in above sub-sections is given in Table 4-1.

Table 4-1: Recommended Specifications of IP CCTV Camera

Sl. No.	Parameter	Recommended Minimum Specification
1	Type	IP, Colour camera
2	Lens	Fixed, 3.6 mm
3	Camera Resolution	Minimum 0.4 megapixels, 800 x 600 pixels
4	Image Sensor	1/3" CCD or 1/3" progressive scan CMOS
5	Video Compression	H.264, MPEG-4, M-JPEG
6	Audio Compression	G.711, G.726
7	Frame Rate	1 to 25 fps for different resolution

Sl. No.	Parameter	Recommended Minimum Specification
8	Minimum Illumination	0.01 Lux at F1.2 with IR Off 0.0 Lux with IR On
9	Shutter Time	1/50 sec to 1/100,000 sec
10	Infrared Capability	Built-in Infrared LEDs with range of minimum 10 meters Auto Day/Night
11	Camera Ruggedness	Rugged, Vibration and shock proof housing Vibration resistance as per EN 60068 or equivalent Shock resistance as per EN 60068 or equivalent
12	IP Rating	IP66
13	Operating Temperature	-10 to 60 degree Celsius
14	Operating Humidity	0% to 95% RH
15	Audio	Built-in Microphone or separate microphone
16	Image Enhancement	• Auto-tracking White Balance (ATW) • Automatic Gain Control • Wide Dynamic Range (WDR) and Automatic Backlight Compensation (BLC)
17	Input Power	Power from mNVR through Power-over-Ethernet (PoE)
18	Motion Detection	Automatic Motion Detection
19	Interface	RJ45 10/100 M Ethernet
20	ONVIF compliance	ONVIF Profile S compliant

4.3 Mobile Network Video Recorder

4.3.1 Power-over-Ethernet (PoE)

Mobile Network Video Recorders are capable of supporting Power-over-Ethernet (PoE) which means providing power to IP cameras through the Ethernet cable along with communication of data. It is recommended that the mobile NVR for midi and standard buses with up to 4 CCTV cameras should have integrated PoE switch that meets the peak power requirement for 4 CCTV cameras with infrared ON. In case of articulated or double-decker buses with more than 4 CCTV cameras, the mobile NVR should have integrated PoE switch that meets the peak power requirement for 8 CCTV cameras with infrared ON.

4.3.2 mNVR Specifications

A summary of recommended specifications of Mobile Network Video Recorder including those which are same as that of mDVR as well as those suggested in above sub-section is given in Table 4-2.

Table 4-2: Recommended Specifications of mNVR

Sl. No.	Parameter	Recommended Minimum Specifications	
		mNVR for Midi and Standard Buses having up to 4 CCTV cameras	mNVR for bigger Buses having up to 8 CCTV cameras
1	Number of Video Inputs	4 channels	8 channels
2	Number of Video Outputs	1	
3	Number of Audio Inputs	4 channels	8 channels
4	Number of Audio Outputs	1	
5	Video Compression Standards Supported	H.264, MPEG-4 and M-JPEG	
6	Audio Compression Standards Supported	G.711 and G.726	
7	Number of streams	Dual streams, both streams independently configurable for each camera resolution and frame rate	
8	Recording Resolutions	Equivalent to 4CIF/2CIF/CIF/QCIF (can be set independently for each channel, for both streams)	
9	Video Frame Recording Rate	1 to 25 fps for all channels at 4CIF equivalent (total 100 fps at 4CIF equivalent) – resolution and frame rate can be set independently for each camera, for both streams	1 to 25 fps for all channels at 4CIF equivalent (total 200 fps at 4CIF equivalent) – resolution and frame rate can be set independently for each camera, for both streams
10	Alarm Sensors	Minimum 4 inputs (NO/NC) 2 outputs	
11	Storage	500 GB, 2.5” SATA Hard Disk Drive or Solid State Drive with suitable anti-vibration mechanism Desirable: Solid State Drive Hard Disk to be pluggable and easily removable, secure and protected by lock	1 TB, 2.5” SATA Hard Disk Drive or Solid State Drive with suitable anti-vibration mechanism Desirable: Solid State Drive Hard Disk to be pluggable and easily removable, secure and protected by lock
12	Recording Modes	Normal, Schedule based, Alarm triggered, Motion detection	
13	Event Based Recording and Tagging	Pre-recording – 1 to 15 minutes Post-recording – 1 to 60 minutes	
14	Shut Down Delay	Configurable shut down delay after ignition off – 5 min to 4 hours	
15	Power Input	8 to 32 volts, spike/surge protection	

Sl. No.	Parameter	Recommended Minimum Specifications	
		mNVR for Midi and Standard Buses having up to 4 CCTV cameras	mNVR for bigger Buses having up to 8 CCTV cameras
16	Power-on-Ethernet	Integrated PoE switch supporting peak power requirement for 4 CCTV cameras with infrared on	Integrated PoE switch supporting peak power requirement for 8 CCTV cameras with infrared on
17	Working Temperature	-10 to 60 degree Celsius	
18	Working Humidity	0% to 95% relative humidity non-condensing	
19	Network/Communication Interfaces	LAN – 1 RJ45 interface (in addition to the camera ports) Wi-Fi – 802.11/b/g/n Built-in 3G module, supporting both 2G and 3G (at least 900, 1800 and 2100 MHz frequency bands), Support for SMS, Voice, Data, GPRS, TCP/IP	
20	ONVIF compliance	ONVIF Profile S compliant	
21	External Interfaces	1 RS232 1 USB 2.0 1 SIM slot (Capable of using M2M Plastic or M2M Robust Plastic SIM and M2M Industrial SIM)	
22	Image quality	1 to 5 (configurable)	
23	Watermark	Tamper-proof Watermark	
24	Configurable Video Overwriting	Video over-writing to be configurable to support: • Cyclic overwriting (oldest recording to be overwritten) • Alarm linked recording not overwritten	
25	Connections	All input and output connections to be vibration/shock resistant and locking Desirable: Aviation Connectors	
26	LED Indicators	Power, Recording, Network	
27	Vibration resistance	EN 60068 or equivalent	
28	Shock resistance	EN 60068 or equivalent	
29	Health Parameters over 3G/ 2G/ SMS	Capable of sending health parameters (cameras not-functioning, cameras tamper, HDD/SSD error, HDD/SSD full) at specified frequency to the server Capable of detecting failure, error or tamper of cameras or any component and sending alert to server	
30	Over-the-air Update/ Upgrade	Over-the-air update of configuration parameters of mNVR and cameras Over-the-air upgrade of firmware	
31	Motion Detection	Configurable sensitivity levels Motion Detection zones to be configurable	

Sl. No.	Parameter	Recommended Minimum Specifications	
		mNVR for Midi and Standard Buses having up to 4 CCTV cameras	mNVR for bigger Buses having up to 8 CCTV cameras
		independently for each camera	
32	RTC	Built-in RTC, drift not more than 10 seconds	
33	Data Download	mNVR should provide video and audio download facility for the desired date/time and duration. It should be possible to connect a laptop to mNVR through network cable on RJ45 port and open mNVR's user interface in a standard browser using a standard URL such as http://dvr (or any other text specified by MoRTH) without having to configure the laptop's network settings. After entering user-id and password (specified by MoRTH), it will be possible to search, view, select and download video clips of desired duration and date/time in standard formats such as .avi or .mpg. It will not be possible to delete any video or change configuration settings using this set of user-id and password.	
34	Data Transfer on 3G and 2G	In case the vehicle moves to an area where 3G coverage is not present, the mNVR will automatically shift to GPRS (2G) connectivity to send the health status data. Also, in such case, on press of an emergency button, the mNVR will automatically shift to a lower frame rate and resolution (both configurable) and send the video from cameras to the backend server over GPRS (2G).	

The above specifications for mNVR will be applicable for both Type 1 and Type 2 devices. However, the mNVR which are part of Type 1 device will also have to meet vehicle tracking related specifications as listed in sub-section 4.3.3.

4.3.3 Additional Specifications for Type 1 mNVR

The mNVRs which will be part of Type 1 device (CCTV system with in-built tracking system and emergency button system) will have a built-in locating module which will provide vehicle tracking related functionalities. Various parameters that are important for vehicle tracking device have been examined in another document titled 'Detailed Specifications Document for Vehicle Tracking Device' prepared as part of the project documentation. As such these parameters are not being explained in this document and only a summary of recommended specifications of mNVR related to vehicle tracking functionalities is provided in Table 4-3.

Table 4-3: Additional Specifications for Type 1 mNVR

Sl.No.	Paramter	Recommended Minimum Specification
1	Location Module	Parallel GPS or GLONASS or both receiver module with 32 (minimum) acquisition

Sl.No.	Paramter	Recommended Minimum Specification
		channels & 18 minimum tracking channel The devices should also support Indian Regional Navigation Satellite System (IRNSS). The device should also support GAGAN, the Indian SBAS (Satellite Based Augmentation System). Location, speed, heading, timestamp data polling and sending frequency capability of less than or equal to 10 sec
2	Location on demand	On 3G/GPRS/SMS Configurable backup SMS facility in case of 3G/ GPRS failure
3	Memory	Memory to store minimum 40000 positional logs
4	Acquisition sensitivity	Better than (-)160 dBm
5	Tracking sensitivity	Better than (-)165 dBm
6	Accuracy	Better than 6 meter Positional Accuracy 2DRMS (on ground) or 2.5 meter CEP (on ground)
7	Hot start	< 5 sec
8	Warm start	< 20 sec
9	Cold start	< 40 sec
10	Outputs	As per NMEA 0183
11	WGS-84 compliant	Yes
12	A-GPS	Yes
13	Geo-fence capability	Device should store minimum 3000 geo-fence points. One route in general can be of 150 distinct geo-fence points.
14	Cell ID and Network Measurement Report	Capability to send serving and adjacent cell ID as well as network measurement report (NMR)
15	Over the Air Capability	Download of firmware as well as configuration parameters Remote administration and firmware update over the air Facility to update route Geo-fence master in the device over the air Device should be capable of sending a packet to 2 different IPs simultaneously

The following specifications which have been recommended for Type 3 Device (Vehicle tracking device with in-built emergency button system) and Type 4 Device (Vehicle tracking device with in-built emergency button system and fare meter) are

not being recommended for Type 1 mNVR as the same are not technically feasible and prevalent in available mNVRs:

- Internal battery backup of minimum 4 hours
- Internal GPS antenna
- Internal GPRS antenna

4.4 Emergency Buttons

The requirements and recommendations for the Emergency Buttons for IP CCTV Camera system will be same as listed in previous chapter in section 3.4.

5.0 COMMUNICATION PROTOCOL

5.1 Overview

The CCTV devices will communicate with the backend server for sending data to the backend server as well as to receive data from the backend server. The data that will be sent by the two types of the CCTV Devices (Type 1 – CCTV system with in-built tracking system and Emergency buttons and Type 2 - CCTV system with Emergency buttons) is listed in Table 5-1.

Table 5-1: Data Sent to Server by Different Types of CCTV Devices

Sl. No.	Data	Type 1 Device	Type 2 Device	Remarks
1	Image data	✓	✓	Only in case of press of Emergency Button
2	Tracking data	✓		
3	Health status data	✓	✓	
4	Emergency Alert data	✓	✓	

In addition to the data that will be sent by the On-board CCTV Devices to the backend, the latter will also be required to send certain data to the On-board CCTV Devices. This data will not be required to be sent on a pre-specified frequency, but will be sent on need-basis.

In order to prevent unauthorised access to the On-board CCTV Devices, they will communicate over-the-air with pre-defined IP addresses (configurable) only.

The data to be sent by the backend to the On-board Devices will comprise:

- Configuration Parameters Update
- Firmware Upgrade

The data communication related requirements are analysed in the following sections.

5.2 Data from CCTV Devices to Backend Server

5.2.1 Image Data in case of Emergency

In case of press of any Emergency Button, the video recorder (mDVR or mNVR) will get the input regarding the Emergency Alert. The video recorder will start sending the images to the backend at a specified frequency and resolution (both configurable parameters). The video recorder will keep on sending the images to the backend for a specified duration (configurable parameter).

The following metadata will also be sent with the images:

- Vehicle Registration Number (Can be configured as video recorder's identifier)
- Camera Identifier
- Date and Time
- Location coordinates (In case of Type 1 device)

5.2.2 Data on Request

It will be possible to poll a video recorder (mDVR or mNVR) from the backend and download live or recorded video and/or audio data from the video recorder. It will be possible to search and select the video and/or audio clip to be downloaded, based on date and time.

5.2.3 Tracking Data (applicable only for Type 1 device)

The tracking data will be sent by Type 1 device only. In case a vehicle is fitted with Type 2 device, the tracking data will be sent separately by the tracking device.

The tracking data will be sent at specified frequency (configurable parameter). The frequency can be different for different situations, such as ignition on/off, normal situation or Emergency situation etc.

In case of an Emergency event triggered by press of Emergency button, the tracking data will have higher priority than image data and health status data.

The first 3 fields of the tracking data (Start character, Header for the device manufacturer 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 tracking data sent by the device to the backend, which 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) format or in HEX format.

Device must transmit the login message whenever it establishes its connectivity with backend server, as per the fields provided in Table 5-2.

Table 5-2: Login Message Format for Tracking Data for Type 1 Device

Sl. No.	Field	Description	Sample Data
1	$Msg.Server.Login	Stat of Message	
2	$DeviceName	Vehicle number where the device was installed	DL3CBM9821
3	$IMEI	15 Digit IMEI number	123456789012345
4	$Firmware	Version of the firmware used in the hardware	1.0.0
5	$Protocol	Version of the frame format protocol	1.0.1
6	$LastValidLocation	Last location info saved at the device	$1,220714,050656,28.758963,N,77.6277844,E,25

The tracking data message will carry information in the format as provided in Table 5-3.

Table 5-3: Tracking Data Format for Type 1 Device

Sl. No.	Field	Description	Sample Data
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	1.0.0
5	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	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.
6	Packet Status	L=Live or H= History	L
7	IMEI	Identified of the sending unit. 15 digit standard unique IMEI no.	123456789012345
8	Vehicle Registration No	Mapped vehicle registration number	DL1PC9821
9	Location Module Fix	1 = Location Module fix OR 0 = Location Module invalid	1
10	Date	Date value as per location module date time (ddmmyy format)	220714
11	Time	Time value as per location module date time in UTC format (hhmmss format)	050656
12	Latitude	Latitude value in decimal degrees (up to not less than 6 places)	28.758963
13	Latitude Dir	Latitude Direction (N=North, S=	N

Sl. No.	Field	Description	Sample Data
		South)	
14	Longitude	Longitude value in decimal degrees (up to not less than 6 places).	77.6277844
15	Longitude Dir	Longitude Direction (E=East, W= West)	W
16	Speed	Speed in km/hr (Upto one decimal value)	25.1
17	Heading	Course over ground in degrees	310.56
18	No of Satellites	Number of satellites used for fix (minimum 5 satellites in vision, to have the fix)	8
19	Altitude	Altitude of the device in meters	183.5
20	PDOP	Positional dilution of precision	3
21	HDOP	Horizontal dilution of precision	2
22	Distance	Distance Travelled in Meters (Between Current and the Previous packet)	100
23	ODO	Total Distance Travelled in Km (from activation of unit to till last packet) Upto one decimal value	25.8
24	Min Speed	Minimum Speed travelled by vehicle between last and the current packet in Km/h (Upto one decimal value)	2.0
25	Avg. Speed	Average Speed between last and the current packet in Km/h (Upto one decimal value)	5.0
26	Max Speed	Maximum Speed travelled by vehicle between last and the current packet in Km/h (Upto one decimal value)	10.5
27	Network Operator Name	Name of Network Operator	XYZ
28	Ignition	1= Ignition On , 0 = Ignition Off	1
29	Main Power Status	0 = Vehicle Battery Disconnected 1= Vehicle Battery Reconnected	1
30	Main Input Voltage	Indicator showing source voltage in Volts.(Upto one decimal value)	12.5
31	Emergency Status	1= On , 0 = Off	0
32	Tamper Alert	C = Cover Closed, O = Cover	C

Sl. No.	Field	Description	Sample Data
		Open	
33	GSM Signal Strength	Value Ranging from 0 – 31	25
34	MCC	Mobile Country Code	404
35	MNC	Mobile Network Code	10
36	LAC	Location Area Code	00D6
37	Cell ID	GSM Cell ID	CFBD
38	NMR (neighboring Cell ID)	Neighbouring 4 cell ID along with their LAC	
39	Digital Input Status	4 external digital input status (Status of Input 1 to Input 3 (0=Off; 1=On))	000
40	Digital Output Status	2 external digital output status (0=Off; 1=On)	01
41	Geo-fence Stop ID	Identify the particular stop, Default = 0	U001
42	Frame Number	Sequence Number of the messages (000001 to 999999)	000005
43	Checksum	Insures No error in transmission (optimal)	16
44	End Character	Indicated End of the frame	*

It is recommended that the Type 1 Device should support minimum fields as mentioned above with respect to tracking data. Different devices can provide more fields than specified above. The Type 1 Device should be able to support different frequency of sending the tracking data, in following states:

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

5.2.4 Health Status Data

The CCTV system device will send the health status data to the backend at specified frequency (configurable parameter). The health status data will comprise the data elements as listed in Table 5-4.

Table 5-4 : CCTV System Health Status Parameters

Sl. No.	Data Element	Remarks
1	mDVR ID	
2	mDVR Name	
3	Manufacturer's ID	Unique Identifier for Manufacturer
4	Date and Time of Health Status	

Sl. No.	Data Element	Remarks
5	Device Primary IP	
6	Device Secondary IP	
7	Firmware Version	
8	Protocol Version	
9	IMEI Number	IMEI number of device
10	HDD 1 Status	Whether HDD is functioning properly or has any error
11	HDD 1 Memory Status	Whether memory has exceeded the specified threshold
12	HDD 2 Status	Whether HDD is functioning properly or has any error
13	HDD 2 Memory Status	Whether memory has exceeded the specified threshold
14	Camera 1 Recording Status	
15	Camera 2 Recording Status	
16	Camera 3 Recording Status	
17	Camera 4 Recording Status	
18	Camera 5 Recording Status	
19	Camera 6 Recording Status	
20	Camera 7 Recording Status	
21	Camera 8 Recording Status	
22	Microphone 1 Recording Status	
23	Microphone 2 Recording Status	
24	Microphone 3 Recording Status	
25	Microphone 4 Recording Status	
26	Microphone 5 Recording Status	
27	Microphone 6 Recording Status	
28	Microphone 7 Recording Status	
29	Microphone 8 Recording Status	
30	Ignition Status	Whether Ignition is ON or OFF
31	Emergency Buttons Status	

It will be possible to configure the mDVR to send an image at CIF resolution from each camera on the vehicle to the backend along with the health status. The images will be accompanied with the metadata, as listed in the sub-section 5.2.1 above.

5.2.5 Alert Data

In case of press of any Emergency Button, the mDVR will get the input regarding the Emergency Alert. The mDVR will immediately send the Emergency Alert data to the backend. The Emergency Alert data will be prioritised above all other type of data scheduled to be sent by the device to the backend. In addition, the mDVR will also send alert data in case of specified events like SIM card ignition on, ignition off, SIM

card removed, etc. A list of such alerts that CCTV Device will send to the backend server is provided in Table 5-5:

Table 5-5: Alerts Supported for the CCTV Device

Sl. No.	Message	Remarks
1	Alert – Ignition ON	Indicates that Vehicle has started (ignition ON)
2	Alert – Ignition OFF	Indicates that Vehicle has stopped (ignition OFF)
3	Alert – SIM removed or tampered	Message would be generated indicating SIM is removed or tampered
4	Alert – SIM inserted or tamper removed	Message would be generated indicating SIM is inserted or tamper is removed
5	Alert – Device enclosure opened	
6	Alert – Emergency state ON	When any of the emergency buttons is pressed by any passenger. System should also provide location of emergency button which is pressed.

In addition to the above alerts, certain additional alert messages will be sent by Type 1 CCTV Device to the backend, as provided in Table 5-6:

Table 5-6: Additional Alerts Supported for the Type 1 CCTV Device

Sl. No.	Message	Remarks
1	Alert – Geo-fence Entry	Applicable for Vehicles which are authorized to run on a defined route or within a geographic area only. Triggered when vehicle enters a geo-fence
2	Alert – Geo-fence Exit	Applicable for Vehicles which are authorized to run on a defined route or within a geographic area only. Triggered when vehicle exits a geo-fence

5.3 Data to be Sent by Backend to CCTV Devices

5.3.1 Configuration Parameters Update

There may be a requirement to change the configuration parameters of various CCTV System Devices from the back-end. The list of such configuration parameters of CCTV cameras and mDVR (or mNVR) that could be changed from the backend is provided in Table 5-7.

Table 5-7 : CCTV Devices Configuration Parameters

Sl. No.	Configuration Parameter	Remarks
1	Camera Main Stream Video Resolution	Main Stream will be for local recording

Sl. No.	Configuration Parameter	Remarks
2	Camera Main Stream Image Quality	
3	Camera Main Stream Bitrate	
4	Camera Main Stream Bitrate Type	
5	Camera Main Stream Max Bitrate	
6	Camera Main Stream Frame Rate	
7	Camera Main Stream I Frame Interval	
8	Camera Sub Stream Video Resolution	Camera Sub Stream will be for transmission to backend in case of press of Emergency Button
9	Camera Sub Stream Image Quality	
10	Camera Sub Stream Bitrate	
11	Camera Sub Stream Bitrate Type	
12	Camera Sub Stream Max Bitrate	
13	Camera Sub Stream Frame Rate	
14	Camera Sub Stream I Frame Interval	
15	Camera Video Recording Enable/ Disable	
16	Camera Audio Recording Enable/ Disable	
17	Camera Name for display	
18	Camera Name Display X-coordinate	
19	Camera Name Display Y-coordinate	
20	Camera OSD Date Format	Camera On Screen Display
21	Camera OSD X-coordinate	
22	Camera OSD Y-coordinate	
23	Camera OSD Type	Transparent, Non-transparent, Flashing, Non-Flashing
24	Camera Schedule based Recording – On/Off	In case of Camera Schedule based Recording – Off, it will be All-day recording
25	Camera Record Schedule – WeekDay; Start Time; End Time	In case of Camera Schedule based Recording On only Can be different for different days of week
26	Camera Video Expired Time (Number of Days)	Time for keeping the recording in local storage. Recording will be permanent (will be overwritten on cyclic basis), in case, Camera Video Expired Time is set as 0.
27	Camera Record based on Motion Detection – On/Off	

Sl. No.	Configuration Parameter	Remarks
28	Camera Record based on Motion Detection – Sensitivity	
29	Camera Record based on Motion Detection – Area for Motion Detection	
30	Camera Pre-record Time for Event Trigger	
31	Camera Post-record Time for Event Trigger	
32	Camera Text Overlay – Text	
33	Camera Text Overlay – X-coordinate	
34	Camera Text Overlay – Y-coordinate	
35	mDVR Clock Time	To set the mDVR clock time
36	mDVR Post Ignition-Off Duration	
37	Get mDVR Firmware Version	
38	Get mDVR Protocol Version	
39	Get mDVR MAC Address	
40	Get mDVR Primary IP Address	
41	Set mDVR Primary IP Address	
42	Get mDVR Secondary IP Address	
43	Set mDVR Secondary IP Address	
44	Set Port Number	
45	Configure Vehicle Registration Number	
46	Change APN	
47	Configure time duration for Emergency state	
48	Get IMEI number of mDVR	
49	Reboot/Reset mDVR	

The above parameters will be applicable for both Analog CCTV System as well as IP CCTV System. In case of IP CCTV System, mDVR will be read as mNVR.

It will be possible to set the parameters at Sl. 1 to 34, separately for each camera, based on Camera-ID.

In addition to the configuration parameters listed in Table 5-7 above, certain additional parameters can be configured for Type 1 mDVR or mNVR, as provided in Table 5-8.

Table 5-8: Additional Configuration Parameters for Type 1 CCTV Devices

Sl. No.	Configuration Parameter	Remarks
1	Set frequency of vehicle tracking data transmission in Ignition ON state	Set or modify polling rate of vehicle tracking data when vehicle ignition is 'ON'

Sl. No.	Configuration Parameter	Remarks
2	Set frequency of vehicle tracking data transmission in Ignition OFF state	Set or modify polling rate of vehicle tracking data when vehicle ignition is 'OFF'
3	Set frequency of vehicle tracking data transmission in Emergency state	
4	Create Geo-fence	
5	Delete Geo-fence	
6	Increase the number of geo-fences	

For each Configuration update message, the mDVR (or mNVR in case of IP CCTV System) will return a success message on successful update.

5.3.2 CCTV Devices Firmware Upgrade

There may be a requirement to upgrade the firmware of the CCTV Devices (mDVR or mNVR) for enhancement of any functionality or removal of any error. It will be possible to upgrade the firmware of the CCTV Devices from the backend over-the-air. This will also include any upgrade of protocol of communication between CCTV Devices and backend. For upgrade of CCTV Device firmware, the backend will first get the current firmware version of the CCTV Device using command 'Get mDVR Firmware Version' (or Get mNVR Firmware Version). In case, the firmware version is not matching the latest firmware version and needs to be upgraded, the backend will send a message to the mDVR or mNVR, as the case may be, with the new firmware file.

For each firmware version upgrade message, the mDVR (or mNVR in case of IP CCTV System) will return a success message on successful upgrade.

5.4 SMS Fall back

In case, the mDVR or mNVR is in emergency mode (i.e. within a specified duration of pressing of Emergency Button), the device will shift to the SMS mode in case both 3G and GPRS connectivity are not available. In such case, the device will send the Alert message, health status data and tracking data (in case of Type 1 device) through SMS mode. Since SMS has the limitation of sending only 160 characters, so the tracking data to be sent in one SMS will have fields - IMEI, Latitude, Direction, Longitude, Direction, location fix, speed, Cell ID, LAC, Date and Time.

6.0 CCTV DEVICES TESTING

6.1 Introduction

The CCTV 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.

6.2 Functional Testing

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

6.2.1 Image Quality Test

Applicable for: Analog and IP Cameras

The CCTV devices in vehicles are subjected to a wide range of light condition such as bright light, low light, etc. The CCTV cameras will be tested for image quality in varying light conditions including bright light at a spot, overall bright light, low light and in no light with IR on.

Acceptance Criteria: The images captured by the camera in different light conditions should be clear without any blur or haziness.

6.2.2 Camera Resolution Test

Applicable for: Analog and IP Cameras

The CCTV cameras will be tested for meeting the camera resolution specification. The analog camera will be tested for meeting the requirement of 600 TV Lines, 752 (H) x 582 (V) resolution. The IP camera will be tested for meeting the requirement of 0.4 megapixels, 800 x 600 pixels.

Acceptance Criteria: The camera resolution meets the prescribed specification.

6.2.3 Camera IR Test

Applicable for: Analog and IP Cameras

The Infrared capability of CCTV cameras is used to capture images in low light or no-light conditions. The cameras will be tested for their IR capability. The cameras should be able to switch on the IR and shift to monochrome image capture automatically in case of insufficient light conditions. The camera should automatically switch off the IR and shift back to colour image capture, in case light conditions improve.

With IR on, the camera should be able to capture clear image for objects up to 10 meters range.

Acceptance Criteria: The camera switches IR on and off automatically and capture clear images for objects up to the specified IR range.

6.2.4 IP Camera Video Compression Support

Applicable for: IP Cameras

The IP CCTV cameras should support H.264, MPEG-4 and M-JPEG video compression standards. The IP CCTV cameras will be tested for supporting all these compression standards. The future IP CCTV cameras which support H.265 video compression standard, will be tested for this also.

Acceptance Criteria: The IP CCTV camera should support H.264, MPEG-4 and M-JPEG video compression standards. The future IP CCTV cameras should support H.265 video compression standard also.

6.2.5 IP Camera Frame Rate

Applicable for: IP Cameras

The IP CCTV cameras should be able to capture images in varying frame rate ranging from 1 fps to 25 fps for all resolutions supported by the camera. The capability of camera to capture images at different frame rates will be tested at different resolutions (equivalent to QCIF, CIF and 4CIF).

Acceptance Criteria: The IP CCTV camera should be able to capture images at varying frame rates ranging from 1 to 25 fps at all supported resolutions.

6.2.6 IP Camera Audio Compression Support

Applicable for: IP Cameras

The IP CCTV cameras should support G.711 and G.726 audio compression standards. The IP CCTV cameras will be tested for supporting both these compression standards.

Acceptance Criteria: The IP CCTV camera should support G.711 and G.726 audio compression standards.

6.2.7 mDVR/mNVR Video Compression Support

Applicable for: mDVR and mNVR

The mDVR and mNVR should support H.264, MPEG-4 and M-JPEG video compression standards. The video recorder will be tested for supporting all these compression standards. The future mDVR and mNVR which support H.265 video compression standard, will be tested for this also.

Acceptance Criteria: The video recorder should support H.264, MPEG-4 and M-JPEG video compression standards. The future video recorders should support H.265 standard also.

6.2.8 mDVR/mNVR Audio Compression Support

Applicable for: mDVR and mNVR

The mDVR and mNVR should support G.711 and G.726 audio compression standards. The video recorder will be tested for supporting all these compression standards.

Acceptance Criteria: The video recorder should support G.711 and G.726 audio compression standards.

6.2.9 mDVR/mNVR Recording Resolution

Applicable for: mDVR and mNVR

The mDVR and mNVR should be capable of recording video at different resolutions which would be configurable individually for each channel. The video recorder will be tested for recording of video at different resolutions individually for each channel.

Acceptance Criteria: The video recorder should be capable of recording video at 4CIF, 2CIF, CIF and QCIF resolutions (equivalent for mNVR) set individually for different channels.

6.2.10 mDVR/mNVR Dual Stream Capability Testing

Applicable for: mDVR and mNVR

The mDVR and mNVR should be capable of capturing video in dual stream mode in which both streams can be configured separately for each camera resolution and frame rate. The video stream at high resolution and frame rate is used for recording in local storage whereas the other stream at lower resolution and frame rate can be transmitted to backend server over-the-air, if required. The video recorder will be tested for recording of video in dual stream at different camera resolutions and frame rates set individually for each stream.

Acceptance Criteria: The video recorder should be capable of recording video in dual stream, each stream at different camera resolution and frame rate.

6.2.11 mDVR/mNVR Recording Modes Testing

Applicable for: mDVR and mNVR

The mDVR and mNVR should be capable of initiating and stopping recording in the following modes:

- Normal mode – the video recorder records continuously.
- Schedule based – the video recorder records as per the specified schedule. The schedule can be configured for different time spans for different week days.
- Alarm triggered – the recorder starts recording in case an alarm is triggered and continues the same for a pre-specified duration.
- Motion detection – the recorder starts recording on detection of motion in the pre-specified detection zone and continues the same for a pre-specified duration.
- Event based pre and post recording – in case of an event or alarm, the recorder tags the recording for a specified duration preceding and post event. The durations for tagging of recording pre and post event can be configured separately in the range of 1 to 15 minutes and 1 to 60 minutes respectively, both

in the steps of 1 minute.

- Shut down delay after ignition off – the recorder shuts down after a specified duration after the vehicle ignition is switched off. The shut-down delay duration can be configured in the range of 5 minutes to 4 hours.

The video recorder will be tested for each of the above configurations for different values of the parameters in the steps of 5 minutes, covering the entire range specified for the parameter.

Acceptance Criteria: The video recorder should be capable of recording in each of the above modes for the entire range of values specified for different modes.

6.2.12 mDVR/mNVR Video Overwriting Testing

Applicable for: mDVR and mNVR

The mDVR and mNVR will have limited storage capacity to store the video. So, the video recorder should be capable of overwriting the old video on FIFO (first in first out) basis. Also, the event tagged video recording should not be overwritten for a configurable period. The video recorder will be tested for capability of overwriting old video on FIFO basis and to retain the event tagged video for a period configurable between 7 to 30 days.

Acceptance Criteria: The video recorder should be capable of overwriting the old video when the storage capacity is about to exhaust. The video recorder should be able to retain the event tagged video for a configurable period in the range of 7 to 30 days.

6.2.13 mDVR/mNVR Data Download Testing

Applicable for: mDVR and mNVR

The mDVR and mNVR should support downloading of data (video and audio files) from its local storage to an external device such as a laptop. It should be possible to connect the external device to the video recorder through network cable on RJ45 port and open its user interface in a standard browser using a standard URL such as http://dvr (or any other text specified by MoRTH) without having to configure the laptop's network settings.

After entering user-id and password (specified by MoRTH), it will be possible to search, view, select and download video clips of desired duration and date/time in standard formats such as .avi or .mpg. It will not be possible to delete any video or change configuration settings using this set of user-id and password. There will be a separate set of user-id and password for setting/modifying configuration parameters of the mDVR and mNVR.

The video recorder will be tested for download of video and audio data from its local memory, as per the above process. Also, it will not be possible for the user to delete any video or change any configuration settings.

Acceptance Criteria: The video recorder should support the capability of downloading video and audio data as per the above process.

6.2.14 mDVR/mNVR Data Communication Testing

Applicable for: mDVR and mNVR

The mDVR and mNVR should support data transfer to backend server on both 3G as well as 2G connectivity. In case the vehicle moves to an area where 3G coverage is not present, the video recorder should automatically shift to GPRS (2G) connectivity to send the health status data. Also, in such case, on press of an emergency button, the video recorder should automatically shift to a lower frame rate and resolution (both configurable) and send the video from cameras to the backend server over GPRS (2G).

The video recorder will be tested for data transfer on both 3G and 2G and automatically shift from one connectivity to the other. The video recorder will also be tested for the capability to shift to a lower frame rate and resolution (configurable) and send the video from cameras to the backend server over GPRS (2G).

Acceptance Criteria: The video recorder should support data transfer on both 3G and GPRS (2G) and automatically shift to lower frame rate and resolution when 3G is not available for video transfer to backend.

6.2.15 mNVR Power-over-Ethernet (PoE) Test

Applicable for: mNVR

mNVRs will be required to provide power to cameras over Ethernet. The mNVR will be tested for its capability to provide power to all the cameras connected to it through PoE, in varying power requirement conditions such as camera IRs switched on or switched off.

Acceptance Criteria: The mNVR should be able to provide power to all the cameras connected to it over PoE for all the power requirement conditions of the cameras.

6.2.16 IP Camera and mNVR ONVIF Compliance Testing

Applicable for: IP Cameras and mNVR

The IP CCTV cameras and mNVR should be ONVIF Profile S compliant to ensure integration of IP CCTV equipment from different suppliers. The IP CCTV cameras and mNVR will be tested for compliance to ONVIF Profile S standards.

Acceptance Criteria: The IP CCTV camera and mNVR should be compliant to ONVIF Profile S standards.

6.3 Performance and Durability Testing

The CCTV devices (cameras and video recorders) will need to be tested for performance in the challenging vehicle environments of vibration, dust, fluctuating power supply etc.

6.3.1 Shock and Vibration Test

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

The CCTV devices (cameras and video recorders) in vehicles are subjected to a harsh environment in terms of shocks and 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 relevant parts of EN 60068 standard 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 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 relevant parts of EN 60068 standard or equivalent.

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

6.3.2 Ingress Protection (IP)

Applicable for: Analog and IP cameras

The CCTV cameras 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/IEC 60529) is used for specifying the environmental protection characteristics of the CCTV cameras. The cameras will be tested for dust and water ingress according to IP 66 test specification.

Acceptance Criteria: The camera should be IP66 compliant or better.

6.3.3 EMI /EMC

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

The Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) tests are performed to assess whether a CCTV device (camera or video recorder) 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.

6.3.4 High voltage/ Current Test

Applicable for: mDVR and mNVR

The video recorder 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.

6.3.5 Reverse Polarity Protection without Fuse

Applicable for: mDVR and mNVR

The video recorder 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.

6.3.6 Test for Wiring Harness

Applicable for: All wiring for Analog cameras, IP cameras, mDVR and mNVR

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.

6.4 Environmental Test

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

6.4.1 High Temperature Test

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

The high temperature test is used to evaluate effects of high temperature conditions on safety, integrity, and performance of the CCTV devices (cameras and video recorders). The test shall be carried out in accordance with Indian Standard IS: 9000 (Part 3/Sec 5) or EN60068 or MIL-STD-810 F Method 501.4 or equivalent. The device shall be subjected to the high temperature test conditions as per device specification.

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

6.4.2 Cold Test

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

The temperature testing is used to evaluate effects of low temperature conditions during storage and operation affect safety, integrity and performance on the CCTV devices (cameras and video recorders). The test shall be carried out in accordance with Indian Standard (IS): 9000 (Part 2/Sec 4) or EN60068 or MIL-STD-810 F

Method 502.4 or equivalent. The device shall be subjected to low temperature conditions as per device specification.

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

6.4.3 Damp Heat Test

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

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 CCTV devices (cameras and video recorders) 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.

6.4.4 Temperature Shock

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

Temperature shock test is carried out to determine if the CCTV devices (cameras and video recorders) can withstand sudden changes in the temperature of the surrounding environment without experiencing physical damage or deterioration in performance. The device shall be tested as per relevant parts of EN 60068 standard or equivalent.

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

6.4.5 Salt Spray Test

Applicable for: Analog cameras, IP cameras, mDVR and mNVR

The salt spray test is conducted to check corrosion resistance of CCTV devices (cameras and video recorders). 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.

6.5 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. as detailed in chapter 5.0.

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.

The following testing will be performed as part of the protocol testing:

- The capability of the video recorder to send various types of data messages to the server in the protocol specified for the corresponding message.
- The capability of the video recorder to receive and correctly interpret messages from the server with respect to configuration update.
- The capability of the video recorder to upgrade its firmware over-the-air on receipt of the same from server.

6.6 Additional Testing for Type 1 mDVR and mNVR

The following additional testing will be carried out for Type 1 mDVR and mNVR with respect to vehicle tracking related features.

- Location Accuracy Test
- Cold Start Time to First Fix (TTFF) Test
- Warm Start Time to First Fix Test
- Hot Start Time to First Fix Test
- Acquisition Sensitivity Test
- Tracking Sensitivity Test
- Interference Testing
- Multipath Testing
- Protocol Testing with respect to tracking data
- Memory Storage Test
- Geofencing Test

The details and acceptance criteria for the above tests is provided in the document titled ‘Detailed Specifications Document for Vehicle Tracking Device’ prepared as part of the scheme.

7.0 REFERENCES

The following is a list of documents that have been referred to 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)
- CCTV Related Tender Documents: Delhi Transport Corporation (DTC), Bangalore Metropolitan Transport Corporation (BMTC), Haryana Roadways (HR), Pune Mahanagar Parivahan Mahamandal Ltd. (PMPML)

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