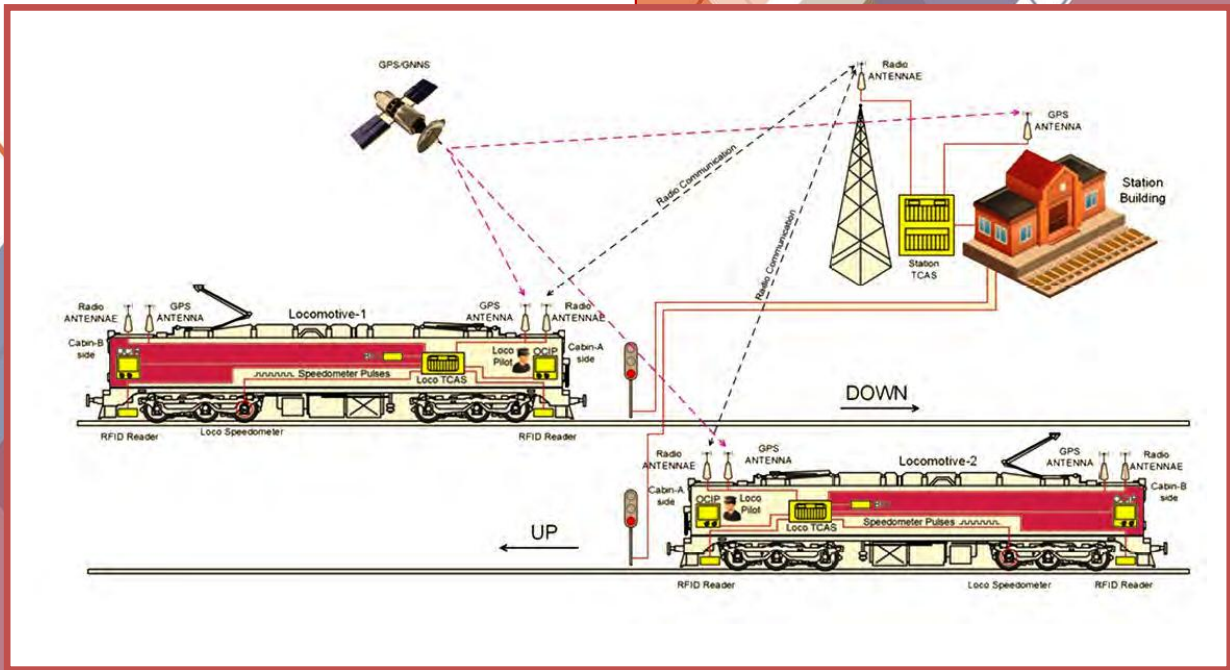




GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS

# Handbook on Train Collision Avoidance System (TCAS) - An Indigenous ATP System



End Users: Signal & Telecom. Engineers of Indian Railways

CAMTECH/S/PROJ/2020-21/SP10/1.0  
April 2021



INDIAN RAILWAYS  
Centre for Advanced Maintenance Technology  
Maharajpur, Gwalior (M.P.) Pin Code – 474 005

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**Handbook on  
Train Collision Avoidance System (TCAS)  
- An Indigenous ATP System**

**CAMTECH/S/PROJ/2020-21/SP10/1.0  
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# Foreword

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The focus of the Indian Railways is to increase capacity utilization of existing assets including rolling stock, track infrastructure, traction power and signalling & telecommunications. By running more high speed trains on the existing infrastructure, passengers and freight carrying capacity as well as revenue and profitability can be increased. In order to ensure safety over high speed and high density rail networks of Indian Railways it is the need of the hour to implement Automatic Train Protection (ATP) system such as Train Collision Avoidance System (TCAS). Indian Railways have taken up indigenous development of Train Collision Avoidance System (TCAS) through Research Designs & Standards Organization (RDSO) to prevent dangerous train collisions caused due to human errors or limitations and equipment failures by providing additional layer of enhanced safety in the operations.

CAMTECH has issued this introductory handbook on the subject for Signal & Telecommunication engineers to help them in enhancing their knowledge about TCAS. As this is a new technology, the information given in this handbook may be subsequently revised after gaining further experience.

I hope that this handbook will be helpful to S&T engineers of Indian Railways in understanding the concept of ATP and TCAS. I wish them all the success.

**CAMTECH Gwalior**

**Jitendra Singh**  
**Principal Executive Director**

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# Preface

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Safety attains the top most priority in train running and Signal & Telecommunication department plays an important role in safe running of trains on Indian Railways. The Train Collision Avoidance System (TCAS) being implemented on Indian Railways has been designed in a manner to prevent Signal Passing at Danger (SPAD) cases, unsafe situations arising due to over speed and train collisions in station area as well as block section. The advanced accident prevention measures, under which trains will be in constant communication with the protection systems through UHF/LTE communication, will be implemented over Indian Railways in a phased manner.

Although, Indian Railways have less experience in this field, CAMTECH has made an effort to cover all the relevant information about TCAS in this handbook. As the subject covers the concepts of both Signalling and Telecommunications, it will be of interest for both Signal as well as Telecom. Engineers of Indian Railways.

I am sincerely thankful to Shri M. Muni Kumar, Dy. CSTE/Projects/Tele/SC/SCR and Shri R.N. Singh, ADE/RDSO, Lucknow, who have provided valuable inputs for this handbook. I also appreciate the assistance provided by M/s Medha Servo Drives Pvt. Ltd., M/s HBL Power Systems Ltd. and M/s Kernex Microsystems (India) Ltd., Hyderabad in preparing this handbook. Since technological upgradation and learning is a continuous process, you may feel the need for some addition/modification in this handbook. If so, please give your valuable comments on email address [dirtsntcamtech@gmail.com](mailto:dirtsntcamtech@gmail.com).

**CAMTECH Gwalior**

**Dinesh Kumar Kalame**  
**Director (S&T)**

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# Table of Contents

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<b>Foreword.....</b>	<b>iv</b>
<b>Preface .....</b>	<b>vi</b>
<b>Table of Contents.....</b>	<b>viii</b>
<b>Issue of correction slips.....</b>	<b>xi</b>
<b>Disclaimer .....</b>	<b>xii</b>
<b>Our Objective .....</b>	<b>xiii</b>
<b>CAMTECH Publications .....</b>	<b>xiv</b>
<b>Abbreviations .....</b>	<b>xv</b>
<b>List of Figures.....</b>	<b>xix</b>
<b>List of Tables .....</b>	<b>xxi</b>
<b>Terms &amp; Definitions.....</b>	<b>xxii</b>
<b>Chapter I.....</b>	<b>1</b>
<b>Train Collision Avoidance System.....</b>	<b>1</b>
<b>- An Overview.....</b>	<b>1</b>
1.1 Introduction.....	1
1.2 System Overview .....	1
1.3 Operational functions of TCAS.....	6
1.4 Salient features of TCAS .....	8
1.5 Operational modes in Loco TCAS.....	9
1.6 Static Speed Profile (SSP).....	11
1.7 Dynamic speed profile (DSP).....	12
1.8 Movement Authority.....	12
1.9 Sub-systems of TCAS .....	14
1.9.1 Trackside Sub-system.....	17
1.9.2 On-board Sub-system (Loco TCAS Unit) .....	21
1.10 Connectivity of Stationary TCAS unit with interlocking .....	27
1.11 Failures & Fallback procedures.....	28
1.12 Protection Functions .....	29
1.13 Protection during transient conditions .....	32

<b>Chapter II .....</b>	<b>33</b>
<b>Communication techniques used in TCAS.....</b>	<b>33</b>
2.1 Introduction.....	33
2.2 Radio Communication .....	33
2.3 GSM & GPRS Communication .....	40
2.4 GPS/GNSS Communication.....	43
<b>Chapter III.....</b>	<b>45</b>
<b>Network Monitoring System .....</b>	<b>45</b>
3.1 Introduction.....	45
3.2 Hardware requirements.....	45
3.3 STCAS to NMS & STCAS to STCAS Communication on E1 Interface .....	45
3.4 Loco TCAS to NMS Communication on GSM interface .....	46
3.5 Salient feature of NMS.....	47
<b>Chapter IV .....</b>	<b>49</b>
<b>TCAS Survey.....</b>	<b>49</b>
4.1 Introduction.....	49
4.1.1. Absolute Location Survey.....	49
4.1.2 Collection of trackside data from Engg. department.....	49
4.1.3 Site survey for Tower location & Radio Signal Strength (Ref.: Mugat station SCR, RSSI Survey Report).....	49
4.1.4 Site survey for spare relay contacts and space .....	55
4.1.5 Site survey for RFID tag locations.....	57
4.1.6 Site survey for cable laying .....	58
4.1.7 Survey for Loco nomination .....	58
<b>Chapter V.....</b>	<b>59</b>
<b>TCAS Design, Planning &amp; Documentation .....</b>	<b>59</b>
5.1 Introduction.....	59
5.2. WPC licensing & ISA.....	60
5.3 Tower Design .....	60
5.4 Relay Interface Circuits .....	62
5.5 Preparation of TCAS RFID Tag -TIN Layout.....	63
5.5.1 Classification of RFID Tags.....	63

5.5.2 Track Identification Number (TIN) .....	63
5.5.3 Guidelines for preparation of RFID TAG-TIN layout.....	64
5.6 Preparation of TCAS Control Table .....	67
5.7 Numbering scheme for Stationary TCAS .....	70
5.8 Power Supply requirements .....	71
5.9 Trenching and cabling requirements.....	71
5.10 Station /LC/RIU/TCAS .....	72
5.11 Station/Frequency/Time slot plan for FDMA-TDMA.....	72
5.12 TCAS Radio Modem Requirements .....	73
<b>Chapter VI.....</b>	<b>75</b>
<b>TCAS Field Execution &amp; Commissioning.....</b>	<b>75</b>
6.1 Introduction .....	75
6.2 RFID Tag installation .....	76
6.3 Tower related activities .....	78
6.4 Installation of communication equipments .....	78
6.5 Station/IB/LC TCAS related activities .....	80
6.6 Testing & Commissioning .....	80
<b>Chapter VII.....</b>	<b>83</b>
<b>Assessment of Material Requirement for TCAS.....</b>	<b>83</b>
7.1 Introduction.....	83
7.2 Details of items for assessment of material for TCAS .....	89
<b>Annexure - I .....</b>	<b>97</b>
<b>RDSO Technical Advisory Note No. STS/E/TAN/5001 .....</b>	<b>97</b>
<b>for.....</b>	<b>97</b>
<b>System Improvements regarding Installation of Stationary Train Collision Avoidance System .....</b>	<b>97</b>
<b>References .....</b>	<b>103</b>
<b>Annexure II.....</b>	<b>105</b>
<b>TCAS RFID Tag Layout , TCAS RFID Tag Data &amp; TCAS Table of Control .....</b>	<b>105</b>
<b>for Mugat Station, Nanded Division.....</b>	<b>105</b>
<b>South Central Railway.....</b>	<b>105</b>

Where “XX” is the serial number of the concerned correction slip (starting from 01 onwards).

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# Disclaimer

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*It is clarified that the information given in this handbook does not supersede any existing provisions laid down in the Signal Engineering Manual, Railway Board and RDSO publications. This document is not statutory and instructions given are for the purpose of guidance only. If at any point contradiction is observed, then Signal Engineering Manual, Telecom Engineering Manual Railway Board/RDSO guidelines may be referred or prevalent Zonal Railways instructions may be followed.*

## Our Objective

---

*To upgrade Maintenance Technologies and Methodologies and achieve improvement in Productivity and Performance of all Railway assets and manpower which inter-alia would cover Reliability, Availability and Utilisation.*

*If you have any suggestion & any specific comments, please write to us:*

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CAMTECH is continuing its efforts in the documentation and up-gradation of information on maintenance practices of Signalling & Telecom assets. Over the years a large number of publications on Signalling & Telecom subjects have been prepared in the form of handbooks, pocket books, pamphlets and video films. These publications have been uploaded on the internet as well as railnet.

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# Abbreviations

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Abbreviation	Description
ABS	Automatic Block Signalling
AC	Alternating Current
ACK	Acknowledge
ASCR	Advanced Starter Signal Control Relay
ATP	Automatic Train Protection
ATS	Actual Toe of Switch
BER	Bit Error rate
BIU	Brake Interface Unit
BSLB	Block Section Limit Board
BTM	Balise Transmission Module
CD	Compact disc
CE	European Conformity
CRC	Cyclic Redundancy Check
CPRI	Central Power Research Institute
CPU	Central Processing Unit
CCTV	Closed Circuit Television
CENELAC	European Committee for Electro-technical Standardization
CTS	Clear To Send
CUG	Closed User group
dB	Decibel
dB <sub>i</sub>	Decibel relative to isotrope
dBm	Decibel Milliwatts
DC	Direct Current
DECR	Green Lamp Checking Relay
DEMU	Diesel-Electric Multiple unit
DG	Diesel Generator
DMI	Driver Machine Interface
DMU	Diesel Multiple Unit
DWC	Double Walled Corrugated
E1	E-Carrier system
EC	Emergency Communication
ECR	Lamp Proving Relay
EI	Electronic Interlocking
EMI	Electromagnetic Interference
EMU	Electrical Multiple Unit
EOA	End of Authority
EPC	Evolved Packet Core, Engineering Procurement & Construction
FAT	Factory Acceptance Test
FCC	Federal Communications Commission



FDMA	Frequency Division Multiple Access
FRMCS	Future Railway Mobile Communication System
FS	Full Supervision
FSK	Frequency Shift Keying
FSS	First Stop Signal
G	Gate
GI	Galvanized Iron
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
HDPE	High Density Poly Ethylene
HECR	Yellow Lamp Checking Relay
HHECR	Second Yellow Lamp Checking Relay
HQ	Headquarters
IBS	Intermediate Block Signalling
IC	International Company
IPS	Integrated Power Supply
IRS	Indian Railway Standards
IS	Isolation, International Standards
JE	Junior Engineer
JPO	Joint Procedure Order
K <sub>A</sub>	Authentication Key
KMPH	Kilometer Per Hour
KMS	Key Management System
K <sub>S</sub>	Session Key
LC	Level Crossing
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LP	Loco Pilot
LS	Limited Supervision
LSS	Last Stop Signal
LTE	Long Term Evolution
LXPR	Level Crossing Key Lock Relay
MA	Movement Authority
MAC	Message Authentication Code
MB	Mega Byte
MBT	Manual Brake test
MEMU	Mainline Electric Multiple unit
MHz	Mega Hertz
N	Normal
NMS	Network Management System
NWKR	Point Normal Checking Relay
OEM	Original Equipment Manufacturer
OFC	Optic Fibre Communication

OS	On Sight
OTP	One Time Password
OV	Override
PBT	Poly Butylene Terephthalate
PI	Panel Interlocking
PSR	Permanent Speed Restriction
PSC	Pre Stressed Concrete
PT	Post Trip
PVC	Price Variation Clause
RCC	Reinforced Concrete
RCIL	RailTel Corporation of India Ltd
RDSO	Research Designs & Standards Organisation
RE	Railway Electrification
RECR	Red Lamp Checking Relay
RF	Radio Frequency
RFID	Radio Frequency Identification
rites	Rail India Technical & Economical Service Ltd.
RIU	Remote Interface Unit
R <sub>L</sub>	Random Number (Loco TCAS)
RRI	Route Relay Interlocking
R <sub>s</sub>	Random Number (Stationary TCAS)
RSSI	Received Signal Strength Indicator
RTC	Real Time Clock
RTS	Request To Send
RV	Reverse
RWKR	Point Reverse Checking Relay
Rx	Receiver
S	Signal Foot
SA	Signal Approach
SACFA	Standing Advisory Committee on Radio Frequency Allocation
SAT	Site Acceptance Test
SB	Standby
SCR	South Central Railway
SE	Section Engineer
SF	System Failure
SH	Shunt
SIP	Signal Interlocking Plan
SIL	Safety Integrity Level
SIM	Subscriber identity Module
SM	Station Master
SMOCIP	Station Master Operation cum Indication Panel
SMPS	Switch Mode Power Supply
SOS	Save Our Souls (Distress message)
SPAD	Signal Passed at Danger
SR	Staff Responsible

STCAS	Stationary Train Collision Avoidance System
SSP	Static Speed Profile
S&T	Signal and Telecommunication
T	TIN Discrimination
TAN	Technical Advisory Note
TB	Terabyte
TCAS	Train Collision Avoidance System
TDMA	Time Division Multiple Access
TETRA	Terrestrial Trunk Radio
TIMS	Train Integrated Management System
TIN	Track Identification Number
TMT	Thermo-Mechanically Treated
TOC	Table of Control
TPWS	Train Protection Warning System
TPR	Track Proving Relay
TR	Trip
TSR	Temporary Speed Restriction
TV	Television
Tx	Transmitter
UAV	Unmanned Ariel Vehicle
UCR	Rote Locking Relay
UECR	Route Lamp Checking Relay
UHD	Ultra High Definition
UHF	Ultra High Frequency
WPC	Wireless Planning Commission
X	Exit

# List of Figures

Figure 1: TCAS Schematic	2
Figure 2: TCAS Functioning Schematic	4
Figure 3: Static Speed Profile (Distance-Speed graph) of a train	11
Figure 4: Dynamic Speed Profile (Distance- Speed graph) of a train	12
Figure 5: Flowchart of TCAS Sub-Systems	15
Figure 6: TCAS Key System Components	16
Figure 7: RFID Tag fixed on sleeper	17
Figure 8: Station TCAS unit Courtesy M/s HBL	18
Figure 9: Interface between Remote Interface Units (RIUs) and Stationary TCAS	19
Figure 10: Front Panel diagram of SMOCIP	20
Figure 11: Loco TCAS Unit Courtesy M/s HBL	21
Figure 12: Loco TCAS Schematic	22
Figure 14: Details of display on Driver Machine Interface	23
Figure 13: RFID Reader Courtesy M/s HBL	23
Figure 15: DMI showing Over speed	24
Figure 16: DMI showing Normal Speed	24
Figure 17 : Brake Interface Unit Courtesy HBL	25
Figure 18: Block Diagram of Brake Interface Unit	25
Figure 19: Radio communication arrangement in Absolute Block Section	35
Figure 20: Multiple Access TDMA/FDMA scheme for Stationary TCAS	35
Figure 21: Multiple Access TDMA/FDMA scheme for Loco TCAS	37
Figure 22: Communication by Loco TCAS in Absolute Block Section	37
Figure 23: Communication by Loco TCAS in emergency situation in Absolute Block Section	38
Figure 24: Radio Communication arrangement in overlap zone in Automatic Block Section	39
<b>Figure 25: Network Management System (NMS) connectivity diagram</b>	46
Figure 26: Mugat station and Loco locations	50
Figure 27: Mugat station building and Tower location	53
Figure 28: Mugat station Radio Tower position w.r.t tracks	53
Figure 29: Mugat station Radio antennae orientation on Radio Tower	54
Figure 30: TCAS Repeater Relays of ECRs	55
Figure 31: TCAS Repeater Relays of NWKRs & RWKRs	56
Figure 32: TCAS Repeater Relay of TPRs	56
Figure 33: Feed to Station TCAS taken through Parallel contacts of TCAS Repeater Relays with double cutting	57
Figure 34: Cabling scheme for TCAS	58
Figure 35: Proposed site plan for tower erection at a station	61
Figure 36: RFID Tag installation	77
Figure 37: Tower installation	78
Figure 38: Radio Modem	79
Figure 39: Station Radio Antenna	79

<i>Figure 40: GPS Antenna &amp; Loco Radio Antenna</i>	79
<i>Figure 41: FAT Test Set up arrangement</i>	81
<i>Figure 42: TCAS Loco Simulator</i>	81
<i>Figure 43: Field Simulation Panel</i>	81

# List of Tables

---

Table 1: Summary of TCAS Functioning .....	5
Table 2: Site Information for SCR recommended location - DOWN LINE (3.2 KM) .....	51
Table 3: Parameters for SCR recommended location – DOWN LINE (3.2 KM) .....	51
Table 4: Results of SCR recommended location – DOWN Line (3. 2KM) .....	51
Table 5: Site Information for SCR recommended location - UP LINE (3.2 KM) .....	52
Table 6: Parameters for SCR recommended location – UP Line (3.2 KM) .....	52
Table 7: Results of SCR recommended location – UP Line (3.2 KM) .....	52
Table 8: Summary of Survey Reports .....	52
<i>Table 9: Radio1 &amp; Radio2 antennae orientation for Mugat station .....</i>	<i>54</i>
Table 10 : RFID Tag notations .....	65
<i>Table 11: Zonal Railway wise allotted codes for Stationary TCAS .....</i>	<i>70</i>
<i>Table 12: TCAS SCR Project TIN &amp; RFID Tag Set Number Allotment (Courtesy M/s HBL) .....</i>	<i>70</i>
Table 13: Power Supply requirements for Loco TCAS .....	71
Table 14: Station Configurable parameters .....	82

# Terms & Definitions

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## 1. Automatic Train Protection (ATP)

Automatic Train Protection (ATP) is a type of train protection system which continually checks that the speed of a train is compatible with the permitted speed allowed by signalling, including automatic stop at certain signal aspects. If it is not, ATP activates an emergency brake to stop the train. In other words it provides Fail safe protection against over speed, collision & other hazardous conditions through train detection, train separation & interlocking. The main functions of ATP are:

- Detection and Prevention of SPAD
- Display of signal aspect, movement authority, target distance and speed.
- Continuous train control.
- Protection for Permanent and temporary speed restriction.

## 2. Berthing Track

This is the designated section of the track in station section on which trains normally stop e.g. Platform lines etc.

## 3. Block Section

The portion of the running line between two block stations onto which no running train may enter until Line Clear has been received from the block station at the other end of the block section

## 4. Communication Mandatory Zone

It is the area on track where continuous communication between Loco TCAS and Stationary TCAS is required.

## 5. Direction of movement of loco

This is the direction of the train as per Loco cab control e.g. Forward or Reverse or Neutral.

## 6. Dynamic Speed Profile

The speed-distance curve which a train shall follow without violating the static train speed profile till the end of movement authority. This curve depends on the braking characteristics of the train and the train length.

## 7. Emergency brake

It is fail-safe, open-loop braking to a complete stop, maximum stopping distance is assured, brake is irreversible. It involves shutting off power and full application of brakes without any loss of time.

## 8. Emergency braking distance

Emergency braking distance is the distance travelled by train before coming to a stop by sudden application of brake at one stretch.

**9. End of Authority (EOA)**

Location up to which the train is permitted to proceed and where target speed is zero.

**10. Factory Acceptance Tests**

Tests carried out by installing some equipment in the lab to prove that the system performs in accordance with this specification & the application data.

**11. Movement Authority**

The distance upto which the train is permitted to travel without danger.

**12. On-board Equipment**

This subsystem consists of a combination of vital and non-vital equipment located on the passenger train-sets and maintenance vehicles. Vital equipment is used to fulfil the ATP functions; non vital equipment is used to fulfil all non ATP functions such as ATO and displays. The equipment includes processors, firmware, software and electronics, operator displays, operator panel, data radios and antennas, transponder/balise antennas, code pick-up antennas, network components, GPS receiver and antennas, tachometers and other sensors.

**13. Permanent Speed Restriction (PSR)**

For various reasons, although mainly because of track geometry (curvature, etc.), it is necessary to limit the speed at which trains may travel over certain sections of the railway. These places are subject to what are termed 'permanent speed restrictions' (PSRs). In some instances, different speeds are specified for specific types of trains.

**14. Service brake**

Service brake is a non-emergency brake application—which is reversible. It involves only the shutting off the power and the gradual application of brakes.

**15. Service braking distance**

It is the distance required to stop the train running at the maximum permissible speed of the line, at such a rate of deceleration that the passengers do not suffer discomfort or alarm.

**16. SPAD**

SPAD stands for 'Signal Passed at Danger' and occurs when a train passes a signal in the 'on' (Red) position without authority.

**17. Static Speed Profile**

The Static Speed Profile (SSP) is a description of the fixed speed restrictions at a resolution of 5 Kmph for a part of track sent from trackside to train.

**18. Tachometer**

A tachometer is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial or digital display.



**19. Temporary Speed Restriction (TSR)**

The object of a TSR is to reduce the speed of Rail Traffic to ensure safe passage over a Section of Track when the Track is not safe for Normal Speed. A TSR is applied by a Maintenance Representative of concerned department such as Engg. or S&T. A TSR overrides any existing higher speed.

**20. RFID Tags**

RFID stands for Radio Frequency Identification. An RFID tag works by transmitting and receiving information via an antenna and a microchip. RFID tags are fitted on track in station section, point zones, near Signals & track in block section for giving Trackside information to Loco TCAS unit.

**21. Radio hole**

Strong fading of the radio signal at some position in space along an air to air or air to ground path; the effect is caused by the abnormal refraction of radio waves.

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[Table of Contents](#)

# Chapter I

## Train Collision Avoidance System

### - An Overview

---

#### 1.1 Introduction

**Train Collision Avoidance System (TCAS)** is an indigenously developed **Automatic Train Protection (ATP)** System meant to provide protection to trains against **Signal Passing at Danger (SPAD)**, **excessive speed and collisions**. TCAS provides continuous update of **Movement Authority** (distance upto which the train is permitted to travel without danger). Hence during unsafe situations when brake application is necessitated, and the Crew has either failed to do so, or is not in position to do so, automatic brake application shall take place. TCAS has additional features to display information like speed, location, distance to signal ahead, Signal aspects etc. in Loco Pilot's cab and generation of Auto and Manual SOS messages (Distress messages) from Loco as well as Station unit in case of emergency situation. The communication between Stationary TCAS and Loco TCAS units shall be **Safety Integrity Level -4 (SIL-4)** certified, while Loco TCAS to Loco TCAS communication, Non-Signalling based additional collision protection features (i.e. Head-on, Rear end & Side Collision) and Manual SoS are non-SIL (not failsafe).

#### 1.2 System Overview

The brief overview of functioning of TCAS is as given below:

The trackside sub-system of TCAS consists of *RFID tags* fitted on track in station section and block section for giving Trackside information to *Loco TCAS unit* installed in the locomotive. Portions of track including berthing tracks, point and block sections are assigned unique IDs called *Track Identification Number (TIN)*. TIN along with RFID Tags are used to determine the direction of train.

The system also consists of *Stationary TCAS unit* installed at Station with radio tower to communicate with locomotives in station area. Stationary TCAS is interfaced with station interlocking to acquire real-time dynamic information related with signalling such as various signal aspects. Route information of all the signals monitored by a specific stationary TCAS unit is configured on the basis of *TCAS Control Table* (excluding shunt signals and overlaps). Stationary TCAS unit gets real-time information regarding Locations, Speed etc of various trains in its jurisdiction through *UHF Radio Communication*.

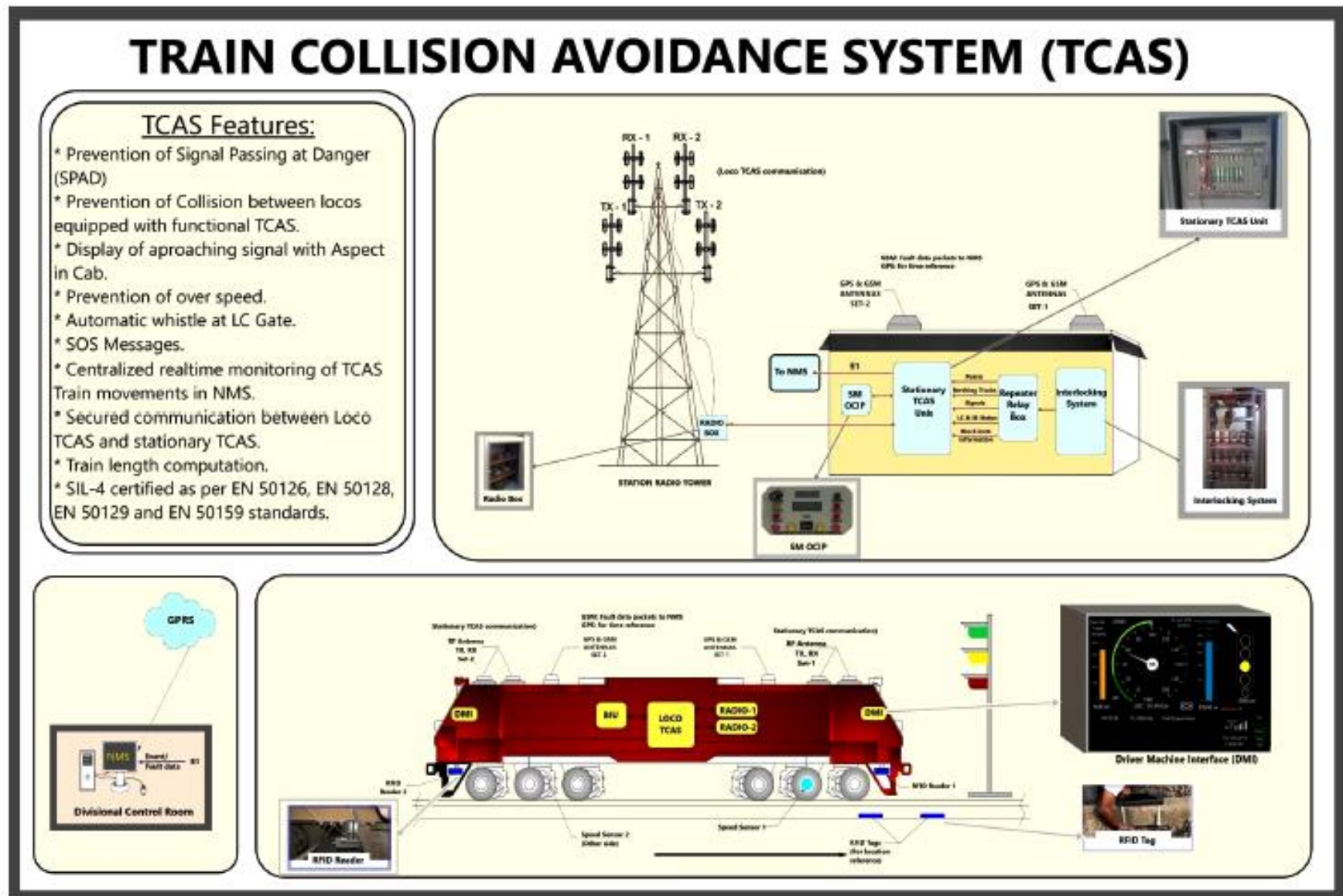


Figure 1: TCAS Schematic

Separate Stationary TCAS unit is provided at Mid –Section interlocked Level Crossing Gate and Intermediate Block Signalling (IBS) locations if they do not come within the coverage of station radio tower. Remote Interface Unit (RIU) shall be used where remote signalling functions are required to be fetched to a nearby Stationary TCAS unit for example from end cabins /distributed interlockings or LC gate/IB coming within the radio coverage of station tower.

The onboard Loco TCAS unit installed in the locomotive determines the location of train by reading pre-programmed *RFID Tag data* with the help of *RFID reader*. Loco TCAS unit sets its *absolute location* (Approaching signal distance from the train position) and TIN as undefined (zero) before determining the direction. The direction of movement of train shall be determined, when Loco/Train has passed two RFID tags sequentially with Absolute location. Loco TCAS unit calculates the location of the train between two RFID tags dynamically based on the distance travelled from last RFID tag through speed sensing arrangement provided on Locomotive. On passing through the RFID Tag, Loco TCAS unit transmits the location and direction of the train to the Stationary TCAS unit through UHF radio antenna provided in locomotive. The Stationary TCAS unit shall use the direction of movement of Loco/Train, to find approaching signal of the Loco/Train. Stationary TCAS unit shall then calculate the movement authority based on the signal aspect or/and track circuit status or/and route locking status, point position and the status of the berthing track circuit. Stationary TCAS unit shall then transmit the Movement Authority to the Loco TCAS in its jurisdiction in station area. The length of the movement authority is decided based on the signal aspect of the approaching Stop Signal. The Loco unit shall make speed profile/ brake curve for different situations based on movement authority, speed restriction and other information as received from Trackside sub-system. The Loco TCAS unit shall display the train speed, the permitted speed, the target distance and the target speed to the loco pilot through a *Driver Machine Interface (DMI)*.

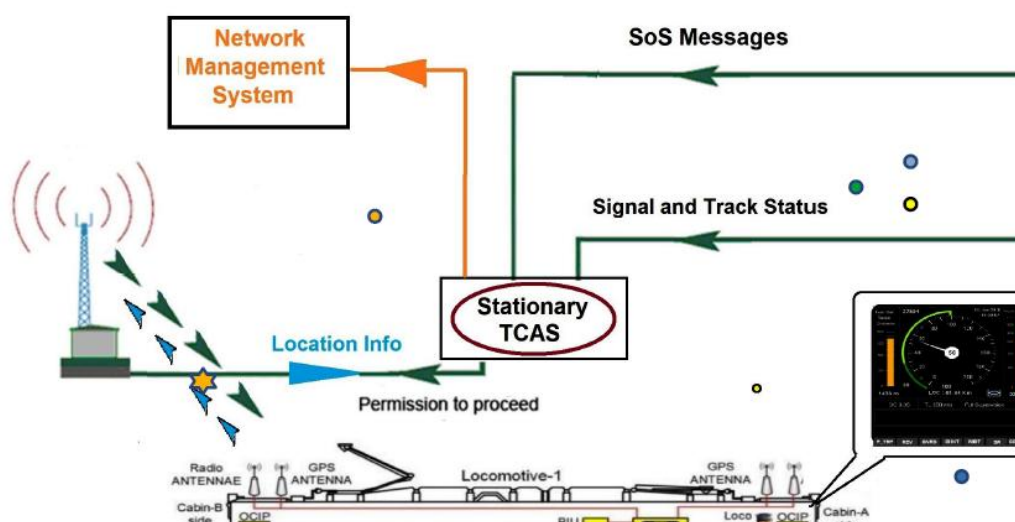
If a signal on approach is Red (Danger), the Stationary TCAS unit shall transmit this information to the Loco TCAS and reduce the movement authority to zero. If loco pilot fails to stop the train, automatic application of brakes shall take place, thus preventing *Signal Passing at Danger (SPAD)*. In case of any conflict between signal aspect, point position, berthing track section, signal aspect sequence and TIN, the Stationary TCAS unit shall transmit most restrictive aspect of that signal and shall reduce the movement authority accordingly. In this way train collisions are prevented in station section. In case of block section if two trains are detected by Stationary TCAS to be moving towards each other on

same TIN, the SoS command would be generated by Stationary TCAS for both the trains. On reception of such Loco specific SoS from Stationary TCAS Unit, the Trains would be stopped through automatic application of brakes. There is also provision for broadcasting SoS message from Loco TCAS to other Loco TCAS in case of emergencies.

Communication technique used for transfer of information between Stationary and Locomotive units in station area is *Full Duplex UHF Radio Communication* through *Multiple Access TDMA/FDMA scheme*. A specific frequency pair is allotted to a station for communication between Stationary TCAS and Loco under its jurisdiction. Loco TCAS units can also communicate with other Loco TCAS units in block section, in station area and in emergency situations (SoS, head-on, rear-end collisions) using a fixed frequency ( $f_0$ ) in its designated time slot.

For centralized monitoring of TCAS equipped Trains and Stations within the network, Network Monitoring System (NMS) with a central server in divisional office shall be provided over OFC Network. Transmission of exceptional fault/critical messages from Stationary TCAS as well as Loco TCAS to NMS is done through respective GSM interfaces available to them. Troubleshooting of error events, off line simulation, real time monitoring of TCAS loco etc. are done through NMS.

In the TCAS System Radio Communication shall use cryptographic techniques to transfer messages between Loco TCAS and Stationary TCAS units. For secured communication, Authentication keys are received by Stationary TCAS and Loco TCAS using GSM/GPRS communication through a Key Management System (KMS). Real Time Clocks (RTC) of all the TCAS systems are synchronized with GPS/GNSS.



**Figure 2: TCAS Functioning Schematic**

**Table 1: Summary of TCAS Functioning**

<b>Requirement</b>	<b>Mechanism in TCAS</b>
Direction of trains	Comparing Absolute location of two RFID tags passed by train.
Location of Trains	Distance traversed beyond a RFID tag on Track Sleeper (Rail-road Tie) through speed sensing arrangement (Tachometer)
Extraction of dynamic Signalling information	Interfacing to station interlocking (PI/RR/EI)
Transfer of Signalling related information from Station TCAS to Train (As per SIL-4)	Radio Communication between Stationary unit & Train units through dynamic TDMA on a specific frequency pair in station area. Stationary units are allocated timeslots according to Topography and their size. Mobile units i.e. trains are assigned slots dynamically. This provides efficient utilization of channels.
Loco to Loco message broadcast (Non-SIL-4)	In block section, in station area and in emergency situations (SoS, head-on, rear-end collisions) using a fixed frequency (f0) in its designated time slot.
Knowledge of Braking Characteristics of Train	Crude but adequately reasonable braking characteristics are determined by carrying out Brake Test at the start of mission. Adaptive braking logic to control brakes seamlessly based upon deceleration and closed loop control.
Prevention of over speed and SPAD	By reducing the movement authority based on the aspect of approaching signal.
Prevention of collisions between two trains	Through conflict between signal aspect, point position, berthing track section, signal aspect sequence and TIN in station area and through TIN conflict in block section.
Centralized monitoring of TCAS equipped trains and stations	Through Network Monitoring System (NMS)
Security of radio communication between Stationary TCAS and Loco TCAS	Using GSM/GPRS communication techniques through a Key Management System (KMS)
Real Time Clock (RTC) synchronization	Through GPS/GNSS



## 1.3 Operational functions of TCAS

### Information received by Stationary TCAS unit from Loc TCAS unit

- Direction of train movement
- Location of train
- Emergency messages

### Information received by Stationary TCAS unit from interlocking

- Approaching Signal aspect (ECRs)
- Berthing track circuit status (TPRs)
- Point status (NWKR/RWKR)
- Route locking status (UCRs)
- Status of block instrument Line Closed condition

### Information received by Loco TCAS unit from Stationary TCAS unit

- Aspect of the approaching signal on route.
- Approaching signal distance from the train position (absolute location).
- Approaching signal identity.
- Next signal aspect and its distance in the territory of same stationary TCAS unit, if signal on approach is OFF.
- Movement authority (the distance for which the train is authorized to travel).
- Static Speed Profile.
- Temporary Speed Restrictions

### Determination of direction

- The direction of movement of train shall be determined through RFID Tags.
- There shall be three types of direction of movements, one for train such as forward or reverse, second for traffic such as UP or DN and the other for movement of direction such as Nominal or Reverse.
- The direction shall be derived when Loco/Train has passed two RFID tags with Absolute location (except Adjustment tag).
- If Absolute location value is incrementing, it shall be treated as Nominal direction. If Absolute location is decrementing, it shall be treated as Reverse direction.



- The direction of movement of train and TIN shall be used for determining whether two trains are approaching, one following the other or going away from each other.
- The Stationary TCAS unit shall use the direction of movement of Loco/Train, to find approaching signal of the Loco/Train.

### **New Train Formation**

A train shall be considered as a new formed train by Loco TCAS unit under one or more of the following conditions:

- When Loco TCAS unit has been switched on or restarted
- When Loco TCAS unit has come out of Non-Leading/Shunt mode/System failure mode/Isolation mode.
- When driving cab/desk is changed except when Loco TCAS is in Shunt mode.

### **Train Length Assignment**

- Every stationary TCAS unit shall monitor the status of track section identified for measurement of train length. (Only applicable to Station TCAS units).
- Based on the time of occupation and clear status of these track sections, communicated by Stationary TCAS unit, Loco TCAS unit shall calculate its train length.
- Two track circuit (say AT & BT in sequence in the traffic direction of train movement) at the entry to block section shall be identified at each station for train length measurement. The track circuits identified shall be such that all the trains entering into a block section pass over these track circuits.
- The status of these track circuits shall be taken as input to stationary unit.
- Stationary unit shall communicate the time offset from frame cycle reference for 'BT occupied' and 'AT cleared' to concerned Loco unit, which shall be used by Loco unit for precise location for train length calculation.
- In case of overlapping territories, the train length measurement information shall be passed on by taking over station.

### **Train Location**

- The Loco TCAS unit shall determine the location of the train with the help of RFID tag data and Speed sensor output.
- Loco TCAS unit shall transmit the location of the train to the Stationary TCAS unit every 2 seconds in Full Supervision mode.

**Visual and Audio warnings on the DMI**

- As long as the current speed is less than or equal to permitted speed indicated on DMI, in Full Supervision mode, the Loco TCAS Unit shall neither generate warning for brake application nor apply the brakes.
- Visual and audio warnings about expected brake intervention by Loco TCAS unit shall be given to the Loco pilot to enable the loco pilot to react and avoid intervention.

**Supervision of movement authorities and speed limits**

- The Loco TCAS unit shall supervise the end of movement authority, if this information is available onboard.
- A train shall be supervised to its static and dynamic train speed profiles.
- If the train speed exceeds the permitted speed by 2 kmph (configurable), warning for over-speed would be generated.
- If the train exceeds the permitted speed by 5 kmph (configurable), the Loco TCAS unit shall execute a brake intervention along with warning until the actual speed is not more than permitted speed.

**1.4 Salient features of TCAS**

- Prevents SPAD by automatic application of brakes in case Loco Pilot fails to do so.
- Control train speed within specified limits
- Reduce the probability of train collisions in block sections and on running lines at stations.
- Indicate Movement Authority or/and display Signal Aspect in Loco pilot's cab
- Cab-Signalling feature useful for high speed trains, foggy weather.
- Works on the principle of continuous update of Movement Authority.
- TCAS can be interfaced with existing interlocking including relay based interlocking.
- Loco pilot to follow line-side signals as per extant rules.
- TCAS shall conform to Safety Integrity Level -4 (SIL-4) as per CENELEC or equivalent standards.
- Non-Signalling based additional collision (i.e. Head-on, Rear end & Side Collision) protection features & Manual SoS are non-SIL (not failsafe).

## 1.5 Operational modes in Loco TCAS

The TCAS loco equipment shall be capable of supervising the following operational Modes:

- (i). Stand By (SB)
- (ii). Staff Responsible (SR)
- (iii). Limited Supervision (LS)
- (iv). Full Supervision (FS)
- (v). Override (OV)
- (vi). On Sight (OS)
- (vii). Trip (TR)
- (viii). Post Trip (PT)
- (ix). Reverse (RV)
- (x). Shunt (SH)
- (xi). System Failure (SF)
- (xii). Isolation (IS)

Brief description of above modes is given in the following paragraphs.

### **Stand By Mode**

The Stand-By mode shall be default mode and shall not be possible to be selected by the loco pilot.

The Loco TCAS unit shall perform the Standstill Supervision in Stand-By mode

### **Staff Responsible Mode**

The Staff Responsible mode allows the loco pilot to move the train under his own responsibility in TCAS territory.

If MA or SSP is received from Stationary TCAS unit, Loco TCAS unit shall exit from this mode.

### **Limited Supervision Mode**

The Limited Supervision mode enables the train to be operated in areas where partial trackside information (Movement Authority/Section speed) is available for supervision of the train.

### **Full Supervision Mode**

The Loco TCAS unit shall be in the Full Supervision mode when all train and track data including Movement Authority and Static Speed Profile up to Movement Authority or up to

3000m, whichever is less, which is required for a complete supervision of the train, is available and in case of new train formation, train has crossed at least one stop signal in OFF condition.

Full Supervision mode cannot be selected by the loco pilot, but shall be entered automatically when all the necessary conditions are fulfilled.

The Loco TCAS unit shall supervise train movements against a dynamic speed profile.

The Loco TCAS unit shall display the train speed, the permitted speed, the target distance and the target speed to the loco pilot.

### **Override Mode**

The Override mode enables the train to pass the signal at danger.

Entry to override shall be selected by the loco pilot.

### **On Sight Mode**

The On Sight mode enables the train to enter into a track section that could be already occupied by another train.

On Sight mode shall be entered automatically.

### **Trip Mode**

When a Train in Full Supervision or Limited Supervision Mode passes a stop signal at ON or End of Authority + 30m, the loco TCAS unit shall enter into Trip Mode.

The Loco TCAS unit shall perform the Standstill Supervision in Trip mode.

The emergency brake shall be applied until the Train comes to halt.

Operation of the train trip shall be indicated on the DMI.

When the Train is stationary, the loco pilot shall be required to acknowledge the train trip condition. This acknowledgement will release the emergency brake.

### **Post Trip Mode**

The Post Trip mode shall be entered immediately after the loco pilot acknowledges the trip mode.

Loco TCAS unit shall supervise the train against a ceiling speed of Post Trip Mode (Default: 15 kmph) and shall exit the Post Trip Mode after crossing the next approaching signal at OFF.

### **Reverse Mode**

The Reverse mode allows the loco pilot to change the direction of movement of the train and drive from the same cab, i.e. the train orientation remains unchanged.

**Shunt Mode**

A TCAS equipped traction unit shall be capable of being moved in shunt mode. Shunt mode shall be selected by the loco pilot. It shall only be accepted when the train is at standstill.

**System Failure Mode**

The Loco TCAS unit shall switch to the System Failure mode in case of a fault, which affects the functioning of Loco TCAS.

The Loco TCAS unit shall permanently command the Emergency Brakes. The Loco Pilot shall isolate TCAS, which means that Loco shall be no more under the control of Loco TCAS unit.

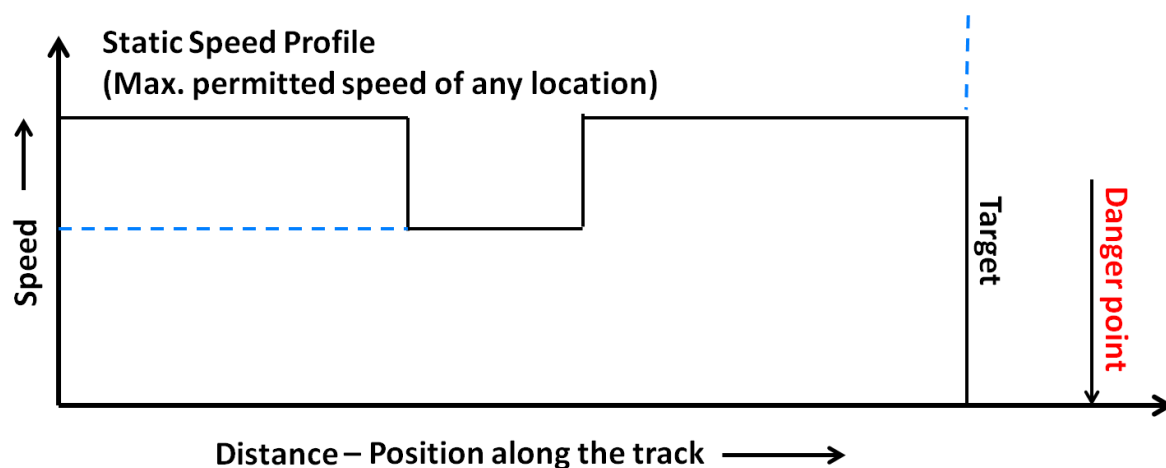
**Isolation Mode**

In Isolation mode, the Loco TCAS unit shall be physically isolated from the brakes.

Loco TCAS Unit shall attempt to transmit an Onboard-to-Stationary Radio Packet at a periodicity of not less than 02 minute on encountering any tag (excluding LC Gate Tag) in one of the randomly selected access timeslots merely to indicate the Loco TCAS isolation mode to NMS through Stationary TCAS Unit.

**1.6 Static Speed Profile (SSP)**

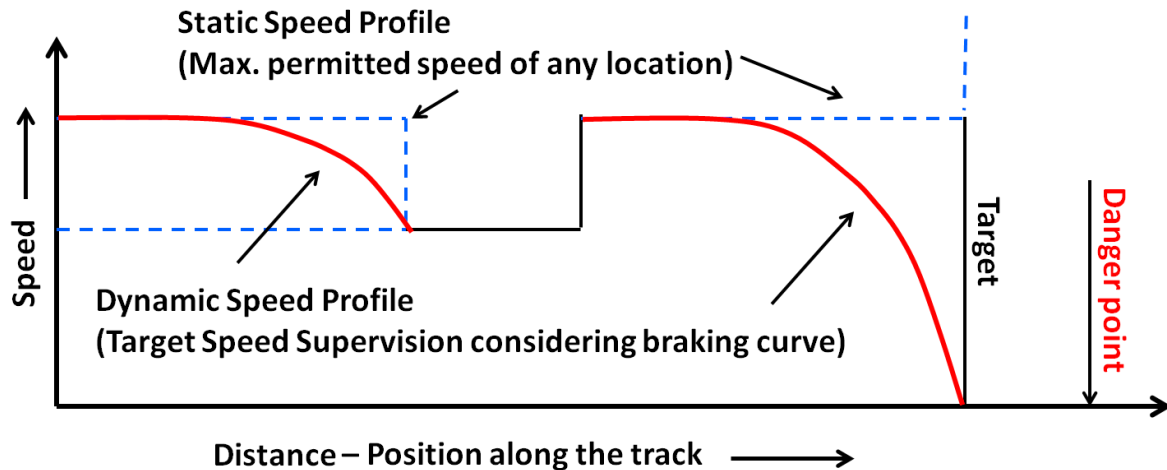
The Static Speed Profile (SSP) is a description of the fixed speed restrictions for a part of track sent from trackside to train. The SSP addresses the maximum permitted speed at any location. The static speed profile is a parameter that gives; the maximum permitted speed, that can be reached on the track based on physical characteristics of the track (curves, restriction to pass a point). The SSP is one of the data that allow the train to manage the supervision (Full Supervision, On Sight); for this the train will have to know the SSP throughout the Movement Authority.



*Figure 3: Static Speed Profile (Distance-Speed graph) of a train*

## 1.7 Dynamic speed profile (DSP)

Dynamic Speed Profile is the speed-distance curve which a train shall follow without violating the static train speed profile till the end of movement authority. This curve depends on the braking characteristics of the train and the train length. The dynamic speed profile considers the possible acceleration or deceleration curve of the movement of the train.



*Figure 4: Dynamic Speed Profile (Distance- Speed graph) of a train*

## 1.8 Movement Authority

- **Movement Authority (MA)** is the distance upto which the train is permitted to travel without danger.
- The length of the movement authority is decided based on the signal aspect of the approaching Stop Signal.
- Aspect control chart is used to define the length of Movement of authority.
- In case of permissive signals, where the inputs for signal indications are available, the ECR shall be used for the purpose of displaying signal aspect. However, movement authority shall be decided based on the signal aspect of the approaching Stop Signal.
- In case of permissive signals, where the inputs for signal indications are not available, the signal aspect and movement authority shall be derived based on the signal aspect of approaching stop signal.
- The Movement Authority for the last signal of stationary TCAS shall be the physical distance between the last signal of stationary TCAS and the foot of next approaching Stop Signal. The Movement Authority shall be specified in meters. This movement Authority shall be used for train entering the block section

- Stationary TCAS unit shall calculate the movement authority based on the signal aspect or/and track circuit status or/and route locking status, point position, status of the berthing track circuit and status of the block instrument line closed condition. Stationary TCAS unit then shall transmit the Movement Authority to the Loco TCAS in its jurisdiction. The Movement Authority transmitted shall be the distance of End of Authority from actual Absolute Position of the train.
- For adapting TCAS to an Auto section, it is necessary to communicate the signal aspects or / and Track occupancy status to Stationary TCAS, which then determines movement authority and communicates the same to the Loco TCAS on radio. The Movement Authority shall be restricted to maximum three sections after the exit signal (next signal to approaching signal on the route) in four aspect territory. MA= three signals beyond exit signal in 4-aspect and two signals beyond exit signal in 3-aspect, or configurable as per railways for cases where no signals are available.
- In the case of single line working, TCAS shall extend Movement Authority after ensuring the establishment of direction of traffic and all stop signals (if available) against the established direction shall be at ON.

## 1.9 Sub-systems of TCAS

The Train Collision Avoidance system broadly comprises of following components:

- (i). Trackside equipment including Stationary TCAS Unit and
- (ii). On-board equipment.

### **Track side Sub-systems**

The Trackside subsystem shall be composed of

- (a). RFID tag
- (b). Stationary TCAS Unit
- (c). Tower and Antennae

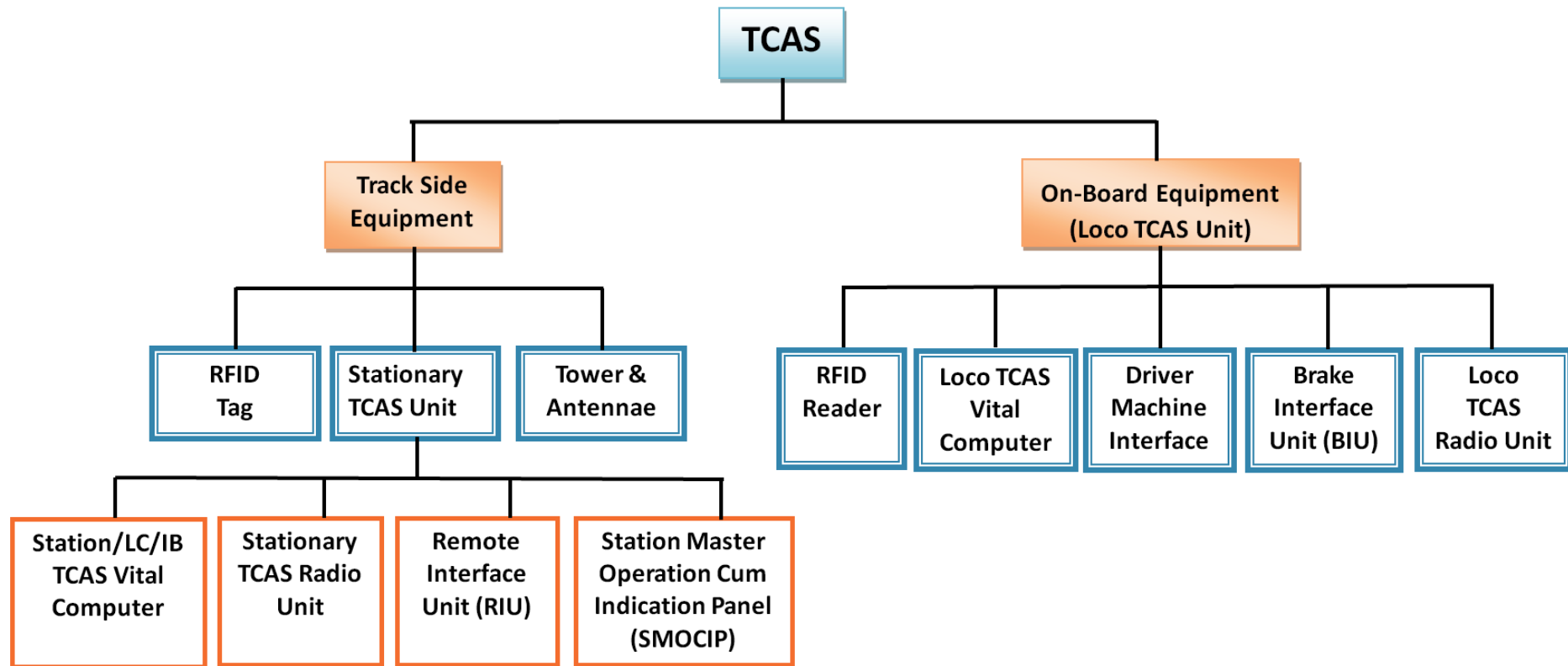
### **On-Board Sub-Systems**

The On-board subsystem shall be comprised of

- (i). Loco TCAS Vital Computer
- (ii). RFID reader
- (iii). Loco TCAS Radio Unit
- (iv). Driver Machine Interface (DMI)
- (v). Brake Interface Unit (BIU), where required

Details of sub-systems are given in the flowchart below and in following paragraphs.





*Figure 5: Flowchart of TCAS Sub-Systems*

## TCAS KEY SYSTEM COMPONENTS

LOCO



Loco TCAS



Loco Pilot - OCIP



Brake Interface Unit



RFID Reader

STATION



Station TCAS



Radio Tower



Station Manager - OCIP

TRACK SIDE



On Track RFIDs

Figure 6: TCAS Key System Components

### 1.9.1 Trackside Sub-system

The Trackside subsystem shall be composed of

- (d). RFID tag
- (e). Stationary TCAS Unit
- (f). Tower and Antennae

#### (A) RFID Tag

RFID Tags provide site specific static information to Locomotive. Apart from acting as Location references, these relieve the Radio Channels and provide immediate information such as crossing the signal etc. to Loco Unit.

RFID tags shall be fitted on track in station section, point zones, near Signals & track in block section for giving Trackside information to Loco TCAS unit.

The RFID tags shall be fitted on the sleepers between the rails as per guidelines given for Indian Railways.

RFID tag shall be as per following specifications:

- Suitable for reliable working at train speed upto 200 KMPH (minimum).
- Frequency of operation: 865-867 MHz.
- Can be programmable with minimum 128 bits (including CRC) of user data.
- Shall be able to work even when submerged in water up to rail level.
- Under field operating conditions RFID reader antenna shall be able to read
- RFID tag from a vertical distance of 700 mm from bottom of RFID reader antenna to top of the rail level.



*Figure 7: RFID Tag fixed on sleeper*

#### (A) Stationary TCAS Unit

Stationary TCAS Unit shall be universally suitable for various types of signalling of Indian Railways with provision of colour light signalling. By default, it shall be suitable for interfacing with Panel Interlocking and Electronic / Solid State Interlocking. Normally

Stationary TCAS Unit shall be provided at Stations to cover all the trackside signals. It shall also be provided at Intermediate Block Locations (IBS) and midsection interlocked Level Crossing Gates where the radio signal coverage of station TCAS tower is not adequate. This shall be interfaced with interlocking equipment to acquire real-time dynamic information related with signalling such as various signal aspects. It has database of static signalling related information such as location & details of RFID tags and Speed Restrictions. It gets real-time information regarding



**Figure 8: Station TCAS unit**  
*Courtesy M/s HBL*

Locations, Speed etc of various trains in its jurisdiction through UHF Radio Communication. On the basis of this information, it detects any emergency situation and can direct the command to Loco to take action to stop.

Stationary TCAS Unit shall comprise of:

- (a). Station/LC/IB TCAS Vital Computer
- (b). Stationary TCAS Radio Unit
- (c). Remote Interface Unit
- (d). Station Master Operation cum Indication Panel (SMOCIP)

#### **Station/LC/IB TCAS Vital Computer**

The Vital Computer of Station/LC/IBS TCAS Unit is a computer-based system that generates messages to be sent to the train on basis of information received from interlocking inputs and on basis of information exchanged with the Loco TCAS units. Vital Computer architecture shall be minimum 2 out of 2. Station/LC/IBS Vital Computer shall have Real Time Clock synchronization facility with GNSS clock to synchronize with other TCAS systems in hot standby manner.

Station/LC/IBS Vital Computer shall have provision for the following:

- To interface with signalling inputs in fail-safe manner.
- Ethernet/E1 port and two GSM interfaces for connectivity with Network Monitoring System (NMS) and Key Management System.
- To interface with OFC (E1 interface / Dark Fibre) for connectivity with Remote Interface unit (minimum six).
- USB interface for downloading of log & other data for diagnostic purposes.

- To interface with Video Display Unit (VDU) to show real time display of Loco movements and signal aspects of the yard, (to be provided separately).

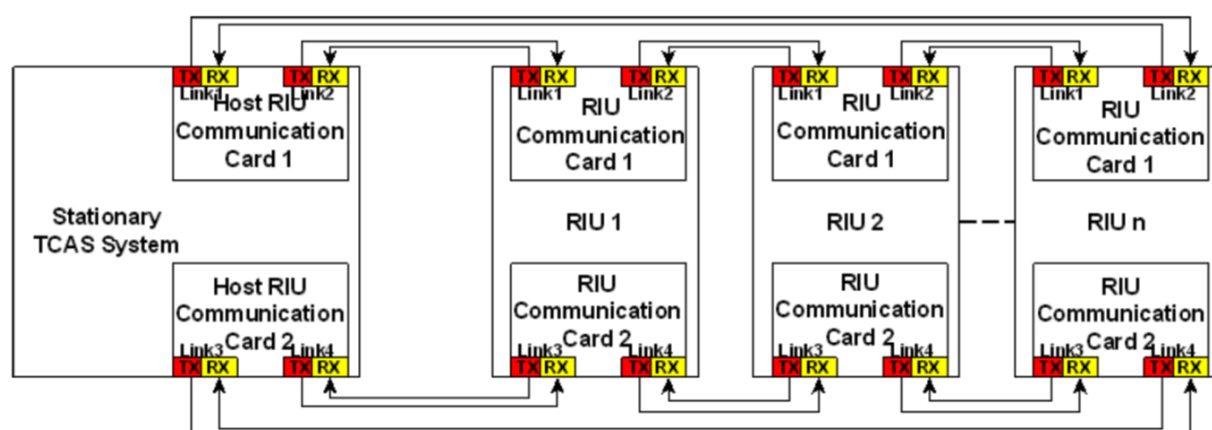
### Stationary TCAS Radio Unit

Radio communication network shall be used for the bi-directional exchange of messages between Loco TCAS unit and Stationary TCAS units.

Stationary TCAS Radio Unit shall have two UHF full duplex Radio modems with separate cable and antennae in hot standby mode to communicate with Loco TCAS unit.

### Remote Interface Unit (RIU)

Remote Interface Unit (RIU) is a miniature version of STAS without radio communication unit, which captures (multiplexing) the relay information wired to it and exchanges the data with master STCAS directly without any relay interfaces. Remote Interface Unit (RIU) shall be used where remote signalling functions are required to be fetched to a nearby Stationary TCAS unit, for example from end cabin, distributed interlocking, a nearby LC Gate, Intermediate Block or Automatic Signalling section. RIU at such end cabins /distributed interlockings or LC gate/IB shall be installed if they are coming within the radio coverage of station tower. RIU is used to communicate remote signalling inputs to STCAS over OFC media. In multiple RIUs scheme these are connected in a Ring network topology to increase the availability of the network. In a Ring network, each RIU is connected to two adjacent RIUs in primary and secondary. A single RIU shall be capable of communicating with two adjacent RIU units so that the operations are not affected in case of communication link failure on one side only. A single RIU shall be capable of handling at least 32 field inputs. RIU TCAS unit shall consist of Vital Input modules with minimum Two-Out- Of-Two architecture.



*Figure 9: Interface between Remote Interface Units (RIUs) and Stationary TCAS*



### Station Master Operation cum Indication Panel (SMOCIP)

SMOCIP consists of following:

- LED Indications
- Switches
- LCD Panel
- Buzzer
- 6 digits counter which are updated on pressing of manual SOS switch
- Station Master's key.

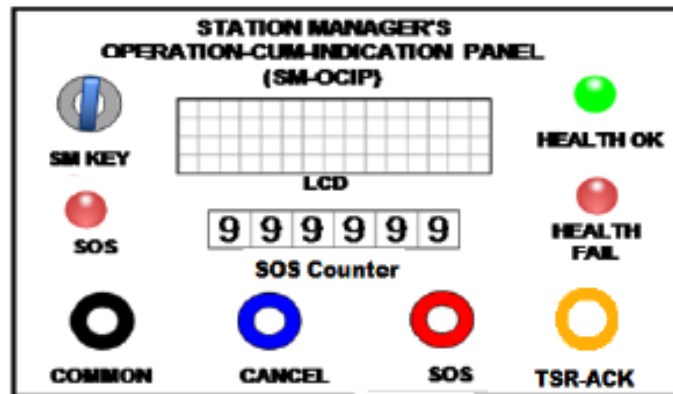


Figure 10: Front Panel diagram of SMOCIP

It has the following LED Indications on the Console :

Sr. No.	LED Name	Colour	Description
1	HEALTH OK	GREEN	Indicates Station TCAS Healthy
2	HEALTH FAIL	RED	Indicates Station TCAS Un Healthy
3	SOS	RED	When SOS generated from Station

It has the following switches on the Console :

Sr. No.	LED Name	Colour	Description
1	COMMON	BLACK	Common switch to press along with SOS switch
2	CANCEL	BLUE	To cancel the SOS from station
3	SOS	RED	To generate SOS from Station

No functionality of switches is allowed without SM-KEY insertion into SM-OCIP.

The SM-OCIP shall display the following information on LCD:

- Station ID KMS Key Index, TSR Count along with the Station TCAS OK or FAIL.
- Software checksums of all modules along with the Application data checksum on pressing COMMON button).
- Sub - System faults information & Station TCAS Manual SOS generated information

When manual SOS is generated - SOS LED blinks and a buzzer is sounded.

Electromechanical non-resettable counter is incremented when manual SOS switch is pressed.

**(B) Tower and Antenna**

The antennae for stationary communication system at station/ IBS/ midsection interlocked Gate unit shall be combination of vertically polarized omni and/ or directional antennae. The antenna cable & antenna shall be suitable to provide a minimum range of communication approximately 1.5 km on approach of first signal of the Stationary TCAS unit (typically 4.5 kms in case of Double-Distant territory of Indian Railways).

**1.9.2 On-board Sub-system (Loco TCAS Unit)**

The On-board subsystem shall be comprised of

- (vi). Loco TCAS Vital Computer
- (vii). RFID readers consisting of two RFID Reader Antenna in hot standby
- (viii). Loco TCAS Radio Unit consisting of two Radio Modems in hot standby with separate cables and antennae for each radio or LTE unit (XX Nos) as prescribed by the purchaser.
- (ix). Two Driver Machine Interface (DMI) for each locomotive or one DMI for each Driving motor coach of EMU/DMU/MEMU/DEMU etc.
- (x). Brake Interface Unit (BIU), where required
- (xi). The system shall be interfaced with LTE BTM Reader, for TPWS.

**(A) Loco TCAS Vital Computer**

The Loco TCAS vital computer is a system that supervises the movement of the train to which it belongs, on basis of information exchanged with Stationary TCAS units and other Loco TCAS units. Vital Computer architecture shall be minimum 2 out of 2.



*Figure 11: Loco TCAS Unit Courtesy M/s HBL*

Loco TCAS vital computer shall have Real Time Clock synchronization facility with GNSS clock to synchronize with other TCAS systems in hot standby manner.

Loco TCAS vital computer shall have provision for the following:

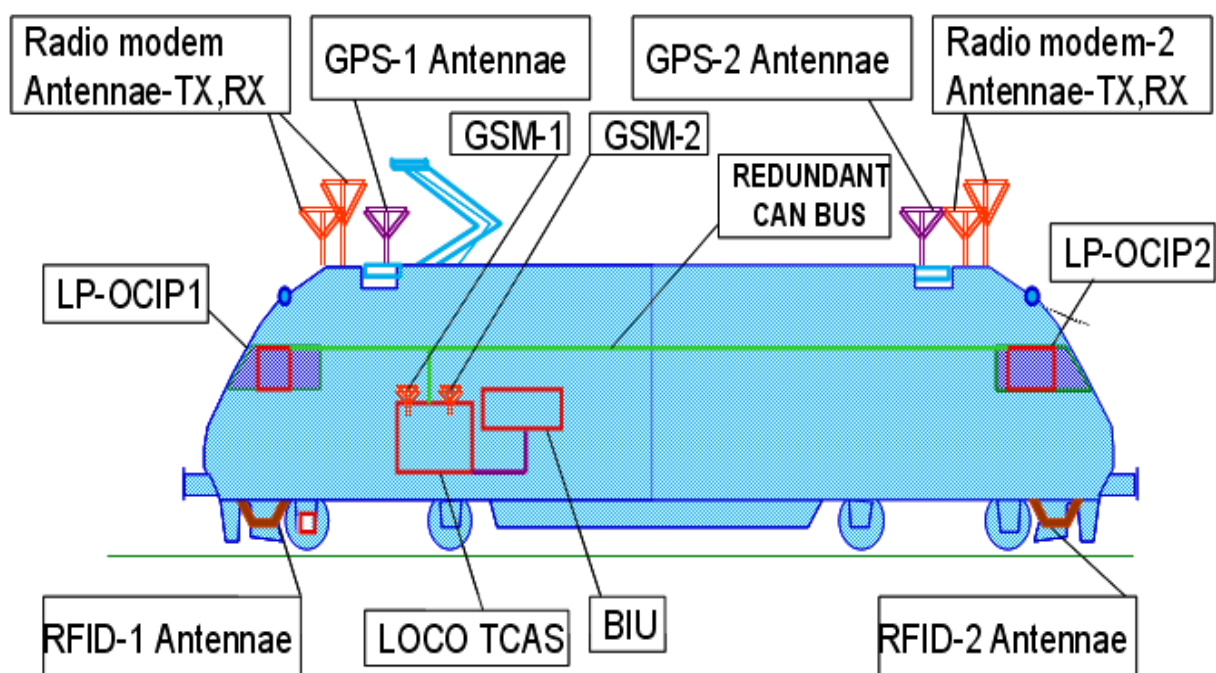
- To interface with train interface unit & brake interface unit.
- Two Direction sensing type Speed Sensor interface for distance and speed measurement.
- To interface with RFID reader to read RFID tags fitted on the track.
- To interface with BTM reader to read Balise fitted on the track in TPWS sections.
- To interface with Driver Machine Interface (DMI) consisting of display arrangement & buttons/ switches for operation.
- Two GSM interfaces for connectivity with centralized Network monitoring System (NMS) and Key Management System (KMS). It shall be also to be operable with LTE where LTE is proved.
- USB interface for downloading of log & other data for diagnostic purposes.

**(B) Loco TCAS Radio Unit (If UHF is used)**

Loco TCAS Radio Unit specifications shall be similar to Stationary TCAS Radio unit.

Loco TCAS Radio Unit shall have two UHF full duplex Radio modems with separate cable and antennae in hot standby mode to communicate with Stationary TCAS unit.

Loco unit Antenna shall be Omni-directional & shall have vertical polarization preferably with a gain of 3 dBi.



*Figure 12: Loco TCAS Schematic*



**(C) RFID Reader**

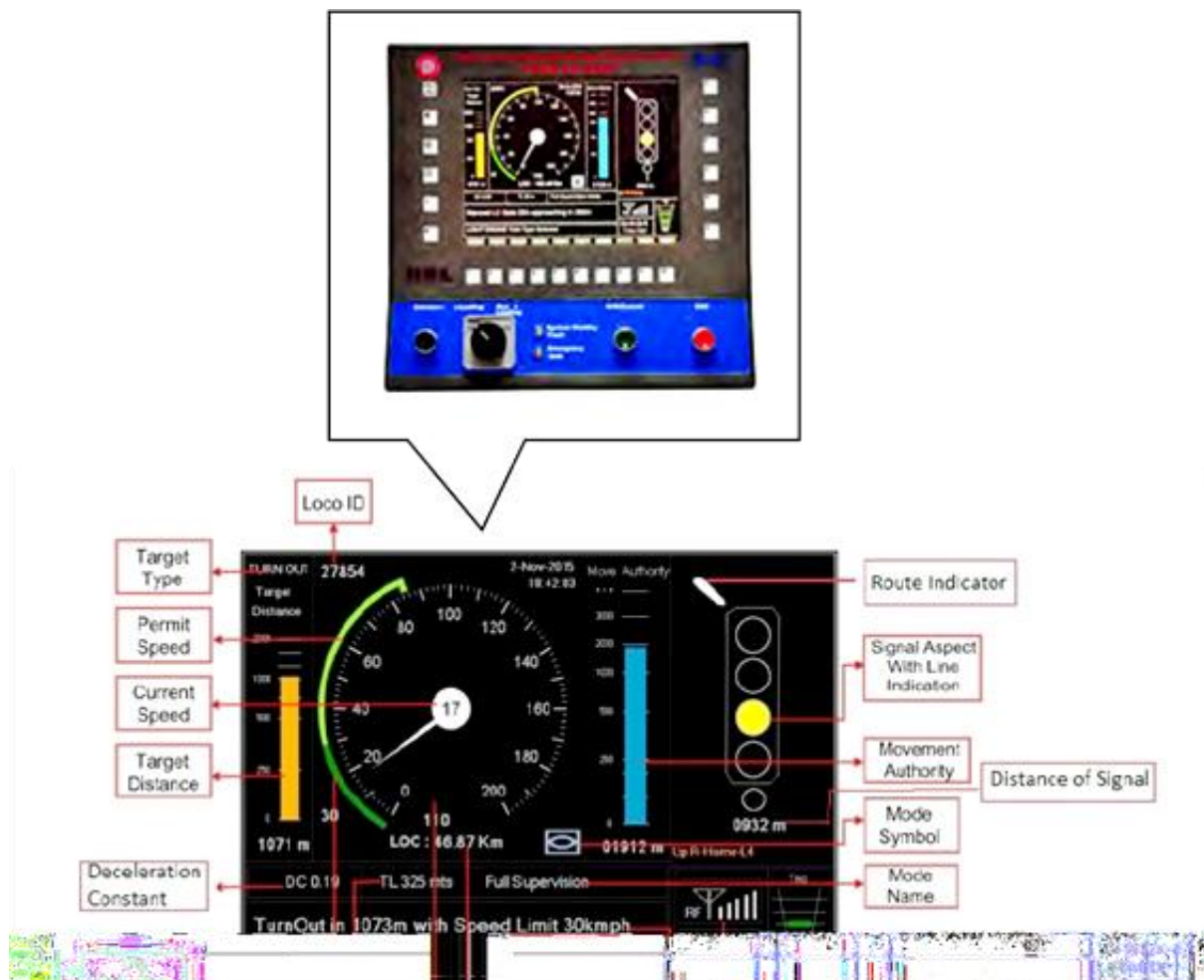
Each Loco TCAS unit shall have two RFID readers for getting the information from RFID tags fitted on the trackside in hot standby manner.



**Figure 13: RFID Reader**  
Courtesy M/s HBL

**(D) Loco Pilot Machine Interface (DMI)**

Most of the information displayed is in form of Analog Displays in form of Circular Gauges (Arcs) and bars keeping ergonomics and convenience of Loco Pilots. Digital values have also been additionally displayed. Audio prompts and warnings also are implemented.



**Figure 14: Details of display on Driver Machine Interface**

Loco Pilot's Operation-cum-indication panel (LP-OCIP/DMI) shall consist of suitable arrangements and buttons/ switches for display/operation of following functions:

- (i) Communication with Loco TCAS.
- (ii) Train type selection by the loco pilot.
- (iii) SOS operation by the loco pilot.
- (iv) Signal aspect display.
- (v) Train length display
- (vi) Train type display
- (vii) Display of all modes of loco operation
- (viii) Current speed
- (ix) Over speed
- (x) Permitted speed
- (xi) Target speed (For entering into loop line)
- (xii) Movement Authority (MA)
- (xiii) The function in DMI for displaying the context messages for Loco Pilot's attention.



**Figure 16: DMI showing Normal Speed**



**Figure 15: DMI showing Over speed**

**Brake Interface Unit (BIU)**

BIU shall apply normal, service & emergency brakes of locomotives respectively based on the type of brake command received from Loco TCAS unit. In addition to these brakes, it shall also apply Loco brake, if Loco Brake command is generated by Loco TCAS.



*Figure 17 : Brake Interface Unit Courtesy HBL*

BIU consists of two modules:

**Electronic Module:**

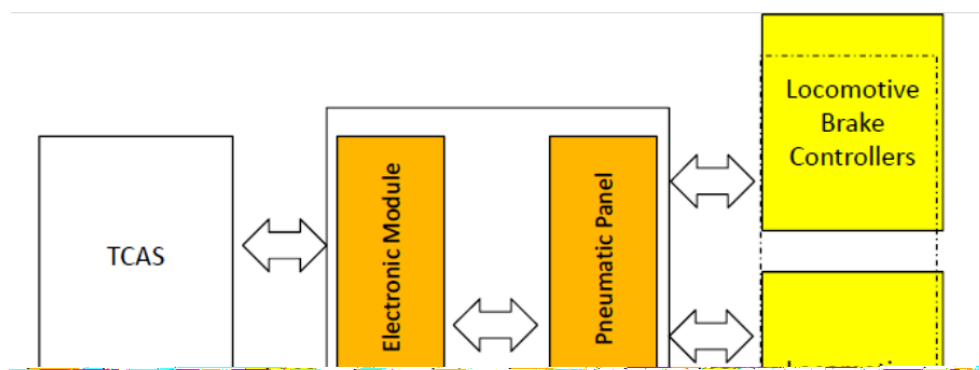
It consists of a Control Card having built-in air brake control logic. Control Card interfaces with Analog Input Module, Digital Input Module & Digital Output Module to monitor and control air brake application/release.

**Pneumatic Panel:**

It consists of different valves, pressure transducers and manual cocks-Interfaced with IRAB system & Electronic Module for brake control purpose.

**Working of BIU**

- TCAS identifies the braking requirement.
- TCAS communicates braking signal(s) to BIU.
- BIU communicates signals to existing brake system of locomotive



*Figure 18: Block Diagram of Brake Interface Unit*

- BIU communicates signal for cutting off traction of locomotive
- BIU generates audio-visual indication for Loco Pilot
- BIU gives status of execution of braking command to TCAS

**Features of BIU**

- BIU works parallel to Locomotive Brake System.
- Does not affect brake characteristics of locomotive/train.
- Can override the Loco Pilot Braking and Vice-Versa- Higher braking prevails.
- BIU initiated braking cannot be reduced by Loco Pilot.
- Manual and automatic isolation possible.

**Health Monitoring by BIU**

- Periodical monitoring of pressures at short interval- Confirms required pressures are maintained.
- If feedback is not correctly received- Automatic Emergency Brake
- Analyzes brake application commands for correct execution-BP drop or BC build up.
- Heart-beat monitoring of pneumatic valves- voltage and current once every 200ms - Any failure, message alert to LP through TCAS display and automatic Emergency Brake
- Power supply 'ON' health monitoring -Alert to LP through TCAS display.

**Fail safety**

- Loss of electric power leads to Automatic Emergency Brake
- Loss of communication between Loco TCAS unit and BIU results in Automatic Emergency Brake
- For any brake application Traction power is cut-off .

**Brake characteristics**

- The onboard equipment shall have provision for acquiring the braking characteristics through DMI as per the selections made by Loco Pilot at the start of mission or whenever there is change in train consist.
- The brake characteristics shall be such that in the event of perceived danger, the loco unit shall be able to stop train short of safe distance or control the speed to desired value before target. This distance should be possible to be configured during installation with nominal values as 300m for Rear end Collision prevention, stop immediately on

detection of Head-on Collision prevention and short of Signal at Danger in case of SPAD prevention.

- By pressing Manual Brake Test (MBT) button by the Loco Pilot in stationary condition of the train, working of all brake valves of Brake Interface Unit (BIU) can be tested.
- The braking logic of the Loco unit shall be so intelligent that based on the (i) brake characteristics of the train, (ii) speed of the train and (iii) gradient of the location & the target, Loco unit shall decide which type(s) of brake and when to be applied to stop the train short of safe distance or control the speed to desired value before target without frequent repeated braking.
- Design of the Loco unit equipment shall be such that its brake interface unit can be isolated by the Loco Pilot as and when required.
- The isolation of brake interface shall be communicated to the Network Monitoring System (NMS) through GSM/LTE.
- Traction cut off feature through TCAS shall also be isolated under such events.

### **1.10 Connectivity of Stationary TCAS unit with interlocking**

- Stationary TCAS unit shall be capable of taking potential free inputs from interlocking through double cutting arrangement. It shall be capable of taking minimum 256 inputs. (The maximum number of field inputs are 2048). There shall be provision for expansion by providing additional Input cards or Multiple Field Input Units (FIUs). Each Vital Input Card/FIU can accommodate 256 inputs. Based on the Field inputs required to be connected with each stationary TCAS units, the requisite number of Vital Input cards/FIUs shall be procured for each stationary TCAS.
- The break status of potential free contact shall indicate absence of input.
- Signal aspect status, position of points, berthing track circuit status, status of track circuits nominated for computing train length, status of block instrument Line Closed condition shall be interfaced to Stationary TCAS. IBS & Gate unit shall not require inputs for point position, track circuits nominated for computing train length & berthing track circuit status. Gate unit shall not require input for status of block instrument Line Closed condition

## 1.11 Failures & Fallback procedures

### (A) Radio communication failures

- A radio communication failure shall be deemed to have occurred when 30 seconds for Absolute Block Section and 10 seconds for Automatic Block Section have passed since the last packet received from Stationary TCAS in **communication mandatory zone**.
- If the last packet received from Stationary TCAS unit is more than 6 seconds older, the signal aspect and signal description shall be made blank. However, the Loco TCAS shall continue to function in Full Supervision mode and shall supervise the Movement Authority received in latest packet.
- In the event of a Radio Communication failure longer than applicable time-out, the Loco TCAS unit shall transit from Full Supervision mode to Limited Supervision Mode and if Loco Pilot does not acknowledge within stipulated time Loco TCAS unit shall apply service brake. In addition, it shall send the message to Network Monitoring System (NMS) through GSM/LTE.
- Stationary TCAS unit shall send the Fault message to NMS through Ethernet/GSM/LTE interface.
- In the event of a failure of only one radio when other radio is providing radio communication in hot standby, the Loco TCAS unit should log the fault. Loco TCAS Unit shall also send the message to NMS through GSM/LTE. Stationary TCAS unit shall send the Fault message to NMS.

### (B) RFID Reader failures

- If both RFID readers fail, Loco TCAS unit should stop radio communication and shall switch to System Failure mode. it shall send the message to Network Monitoring System (NMS) through GSM/LTE.
- In the event of any one RFID reader failure, Loco TCAS unit should log the event. In addition, it shall send the message to NMS through GSM/LTE.

### (C) GPS/GNSS failure:

- Station/LC/IBS Vital Computer shall have Real Time Clock (RTC) synchronization facility with GPS/GNSS clock to synchronize with other TCAS systems in hot standby manner
- Incremental difference between the CPU time and GPS time is to be cross checked. If the incremental difference between CPU and GPS time is not matching, the time reference

shall change to other GPS. If the difference between two GPS is greater than the frame interval, message shall be sent to Network Monitoring System (NMS).

- Diverse make of GPS are preferable to avoid common cause failures.
- In the event of failure of both – GPS/GNSS and Real Time Clock (RTC), the Loco TCAS unit shall stop radio communication and shall switch to System Failure mode. In addition, it shall send the message to NMS through GSM/LTE.
- In the event of failure of both – GPS/GNSS and RTC, Stationary TCAS unit should stop radio communication and shall switch to System Failure mode. Fault message shall be communicated to NMS through Ethernet interface. In addition, it shall send the message to NMS either through Ethernet or GSM/LTE.
- If the incremental difference is also not matching with second GPS or both systems are failed, then the system shall work on CPU time for 30 minutes, (default, Min:10, Max:60) until the situation is stabilized. If there is no stability after GPS time-out, the Loco shall transit out of Full Supervision Mode.

**(D) Driver Machine Interface (DMI) communication failures**

- In the event of Active Cab/Desk DMI communication failure, Loco TCAS unit shall switch to System failure mode. In addition, it shall send the message to Network Monitoring System (NMS) through GSM/LTE.
- In the event of Non-Active Cab/Desk DMI communication failure, Loco TCAS unit shall log the fault. In addition, it shall send the message to NMS through GSM/LTE.

## **1.12 Protection Functions**

**(A) Prevention of Signal Passing at Danger (SPAD)**

- Stationary TCAS unit shall calculate the movement authority based on the signal aspect or/and track circuit status or/and route locking status, point position and the status of the berthing track circuit.
- In case of any conflict between signal aspect, point position, berthing track section, signal aspect sequence and TIN, the Stationary TCAS unit shall transmit most restrictive aspect of that signal and shall reduce the movement authority accordingly.
- Stationary TCAS unit shall check route information configured on the basis of the TCAS Control Table of the stationary TCAS Unit (excluding overlaps).
- The off aspect and movement authority for LSS shall be transmitted by Station/IBS unit only when LSS is off and it is ensured that the concerned Line Clear is available.



**(B) Unusual Stoppage in Block Section**

In case of unusual stopping of train in the block section, if Movement Authority is greater than 300m (configurable), Loco TCAS unit shall transmit the 'Side Collision' message, after a delay of 15 seconds (configurable) of stoppage of the train unless acknowledged by the Loco Pilot.

**(C) Protection of Roll Back**

Loco TCAS unit shall be capable of detecting Roll Back of the train through train interface. It shall apply brake and give audio/ visual warning if train has rolled back by more than 5 meters (configurable). TCAS needs Direction sensing type speed sensor.

**(D) Prevention of Head on & Rear end Collisions in Block Section**

- Loco TCAS units either directly or through Stationary TCAS unit, shall be capable of detecting head on collisions, rear end collisions of trains/locos on single line, multiple lines in all possible scenarios based on the track identification, speed of the trains, train location, train length, train direction movement (Nominal/Reverse) etc.
- In case of head on collision situation, Loco TCAS units of both the trains shall automatically apply brakes immediately with warning either in Absolute or in Automatic Block Section.
- In case of rear end collision situation, Loco unit of only rear train shall automatically apply brakes to bring it to stop short of stipulated distance (300m in block section, configurable) from the train ahead.
- In Station sections, Stationary TCAS shall prevent train collisions with the help of SPAD and TIN conflict.
- In case two trains are detected by Stationary TCAS to be moving towards each other on same TIN in adjacent block section, the SoS command would be generated by Stationary TCAS for both the trains. On reception of such Loco specific SoS from Stationary TCAS Unit, the Trains would be stopped through automatic application of brakes.
- In case of Multiple locos, the rear end collision message shall be displayed with the details of approaching loco/train only

**(E) Manual SoS generation/Cancellation**

- Loco as well as Stationary TCAS unit shall have provision of sending SoS message by pressing SoS and Common buttons together.
- Loco as well as Stationary TCAS unit shall have provision to cancel the Manual SoS message by pressing 'Common' and 'ACK/Cancel' buttons together.



- When the SoS and Common buttons are pressed simultaneously in Loco or Stationary TCAS units, the Loco TCAS units of all the trains/Locos within 3000m of Location of SoS originating source as well as self-train (if SoS is generated by Loco unit) and approaching towards Location of SoS originating source, shall apply brakes to bring the train/locomotive to standstill before reaching the originating Location of “SoS” message. After the train speed is reduced to zero kmph, train speed shall be supervised for 30kmph (configurable) till the train passes the originating Location of “SoS” message.
- SoS sending as well as receiving TCAS equipment shall log sending & receiving of SoS message. In addition, the information shall be sent to Network Management System by Loco TCAS through GSM/LTE and Stationary TCAS units either through Ethernet or GSM/LTE.

**(F) Train trip**

- When a Train in Full Supervision or Limited Supervision Mode passes a stop signal at ON or End of Authority + 30m, the emergency brake shall be triggered.
- Operation of the train trip shall be indicated on the DMI.
- The emergency brake shall be applied until the Train comes to halt.
- When the Train is stationary, the loco pilot shall be required to acknowledge the train trip condition. This acknowledgement will release the emergency brake.

**(G) Auto whistling on approach of Level Crossing Gate**

- Auto whistling feature on approach of level crossing gate is optional.
- Loco TCAS unit shall display the level crossing gate information (Gate ID) on DMI, when approach of LC Gate is detected through LC Gate Tags.
- Loco TCAS unit shall blow the Loco horn at LC gate, based on the information received from LC gate tag / SSP
- Loco TCAS unit shall not blow the horn for LC gate, if movement authority is less than the LC gate distance from its current position.
- Continuous whistling shall commence from a distance of 600m on approach of a LC Gate till the time that train reaches LC Gate. Whistling pattern shall be configurable.

### 1.13 Protection during transient conditions

**(i) Radio Communication failure**

If the communication timeout is longer than 6 seconds, the signal aspect and signal description shall be made blank. However, the Loco TCAS shall continue to function in Full Supervision mode and shall supervise the Movement Authority received in latest packet.

If Radio Communication failure is longer than 30 seconds, the Loco TCAS unit shall transit from Full Supervision mode to Limited Supervision mode and shall seek acknowledgement from Loco Pilot. If Loco Pilot does not acknowledge within stipulated time of 15 seconds (Configurable), Loco TCAS unit shall apply service brake. In addition, it shall send the message to Network Monitoring System through GSM/LTE. Stationary TCAS unit shall send the Fault message to Network Management System through Ethernet/GSM/LTE interface.

In the event of a failure of only one radio when other radio is providing radio communication in hot standby, the Loco TCAS unit should log the fault. Loco TCAS Unit shall also send the message to Network Management System through GSM/LTE. Stationary TCAS unit shall send the Fault message to Network Management System.

**(ii) Signal goes to danger on approach**

When a stop signal on approach is thrown back to danger, and the train in Full Supervision or Limited Supervision Mode passes the stop signal at ON or End of Authority + 30m, the emergency brake shall be applied until the Train comes to halt.

Operation of the train trip shall be indicated on the DMI.

When the Train is stationary, the loco pilot shall be required to acknowledge the train trip condition. This acknowledgement will release the emergency brake.

After the acknowledgement, the loco pilot shall be able to continue the movement in Post-Trip Mode.

Loco TCAS unit shall supervise the train against a ceiling speed of Post Trip Mode (Default: 15 kmph) and shall exit the Post Trip Mode after crossing the next approaching signal at OFF.

**(iii) Signal, point or track circuit, failure**

As mentioned earlier, Stationary TCAS unit is interfaced with station interlocking and calculates the movement authority based on the signal aspect or/and berthing track circuit status or/and route locking status or/and point position. Hence in case of any abrupt failure of signal aspect, point position or berthing track in the face of an approaching train, the movement authority is reduced accordingly and an automatic application of brakes is initiated.

# Chapter II

## Communication techniques used in TCAS

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### 2.1 Introduction

Communication plays a vital role in the working of TCAS. The following three techniques shall be used in TCAS for communication:

- (i). Radio Communication
- (ii). GSM /GPRS Communication
- (iii). GPS/GNSS Communication

Radio communication is used for communication between Stationary TCAS and Loco TCAS as well as Loco TCAS and Loco TCAS. GSM/GPRS communication techniques are used for transfer of Authentication keys to Stationary TCAS and Loco TCAS through a Key Management System (KMS) Server for establishing radio communication between them. Fault messages from Stationary TCAS and Loco TCAS are also communicated to the Network Monitoring System (NMS) through respective GSM interfaces. GPS and GNSS are used for time synchronization purposes. The details are given in following paragraphs:

### 2.2 Radio Communication

The communication between STCAS and Loco TCAS as well as Loco TCAS and Loco TCAS shall be Full Duplex Radio Communication through Time Division Multiple Access (TDMA)/Frequency Division Multiple Access (FDMA) scheme under Radio communication protocol for Loco and Stationary TCAS sub-systems.

#### 2.2.1 Initiating Radio communication

- As soon as a train enters a TCAS territory by reading Signal / Signal Approach/ Normal/TIN Discrimination RFID tag, the Loco TCAS unit shall commence transmission of the Radio message packet to Stationary TCAS unit.
- Before establishing the direction, it shall send Absolute location and TIN as zero along with the last Signal / Signal Approach/Normal / TIN Discrimination RFID tag read, in this packet.
- After establishing the direction, Loco TCAS unit shall commence transmission of absolute location and TIN as per the direction on the basis of data read from RFID Tag.
- The Stationary TCAS unit shall transmit the Radio message packet to Loco TCAS unit, if it receives the radio packet from Loco TCAS unit with valid absolute location and direction.

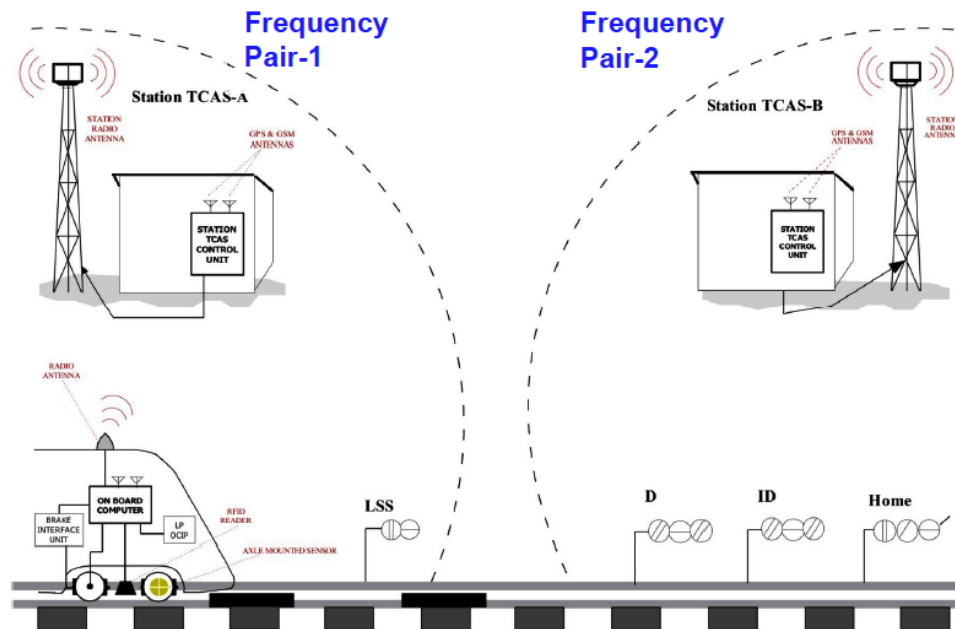
- Whenever Loco TCAS unit establishes communication with a new Stationary unit for the first time, it shall do so by Random Access Method within the time slots reserved for this purpose on frequency  $f_0$ .

### 2.2.2 Establishing Radio Communication

- On recognition of radio message from a fresh loco pertaining to the territory of Stationary TCAS unit, the Stationary TCAS unit shall allocate a Timeslot and Frequency Channel pair (e.g.  $f_1$  &  $f_2$ ) for Communication with that particular Loco unit. Allocated Loco TCAS slot shall not fall in the Stationary TCAS TDMA slot.
- Stationary and Loco TCAS timeslots and frequency channel pairs shall be approved by User Railway. The frequency pairs allotted for two adjacent stations shall be different. (TAN 5001).
- Once, Loco TCAS unit receives regular packet from Stationary TCAS unit, Loco TCAS unit shall continue further transmission in the frequency channel and time slot as specified in the Access Authority packet sent by Stationary TCAS unit.
- For communication among different Loco TCAS units in block section, in station area and in emergency situations (SoS, head-on, rear-end collisions), Loco TCAS shall use transmit frequency ( $f_0$ ) in its designated time slot.

### 2.2.3 TCAS Multiple Access Scheme & Radio Communication Protocol

- Full Duplex UHF Radio Communication is used for transfer of information between Stationary and Locomotive units. A specific frequency pair is allotted to a station for communication between STCAS and Loco in station area. For example, if a Stationary Unit transmits on a frequency channel  $f_1$  and receive on  $f_2$ , then Locomotive Units in its jurisdiction shall transmit on frequency channel  $f_2$  and receive on  $f_1$ . The frequency pairs allotted for two adjacent stations shall be different. Stationary TCAS System shall transmit the Radio packet in its designated time slot. Loco TCAS System shall transmit the radio packet in its designated time slot (different from Stationary TCAS TDMA slot) and designated frequency channel received from stationary TCAS Unit.



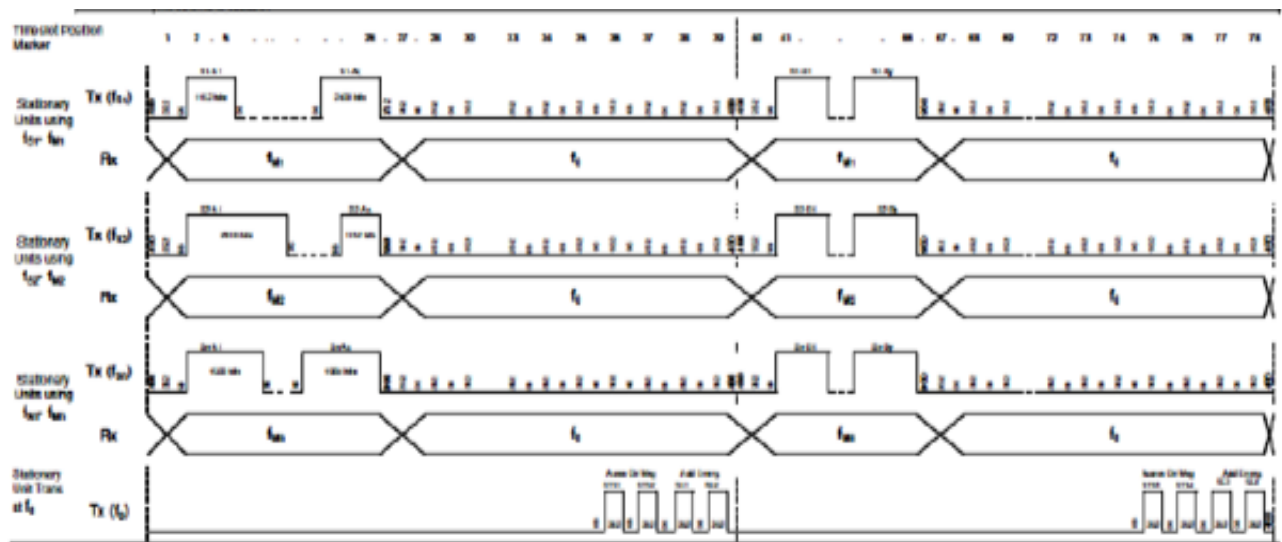
**Figure 19: Radio communication arrangement in Absolute Block Section**

Each Multiple Access TDMA/FDMA frame cycle shall be of 2000 milli seconds.

The frequency range of communication is 406 MHz to 470 MHz.

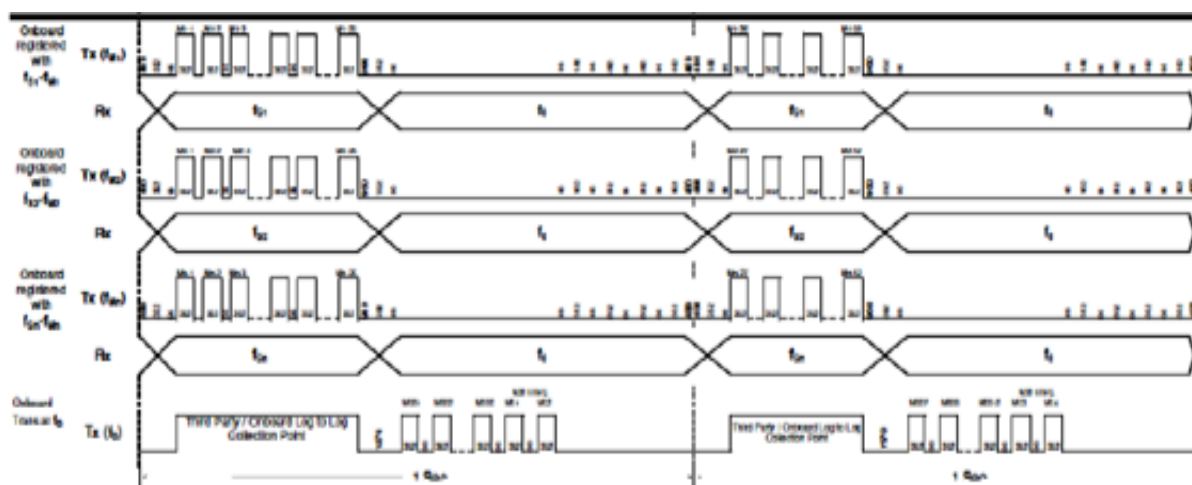
The optimized frame cycle structure of the TDMA/FDMA scheme for Stationary TCAS is shown in *Figure 20*. Suppose there are  $n$  stations ranging from 1,2,3,4..... $n$  which come under TCAS territory.

- *Figure 20* shows pair of frequencies  $f_{S1}$  -  $f_{M1}$ ,  $f_{S2}$  -  $f_{M2}$ .....  $f_{Sn}$  -  $f_{Mn}$  allotted for stationery TCAS units of adjacent stations where  $f_{S1}$  is the frequency on which Station1 TCAS transmits and  $f_{M1}$  is the frequency on which it receives and so on.



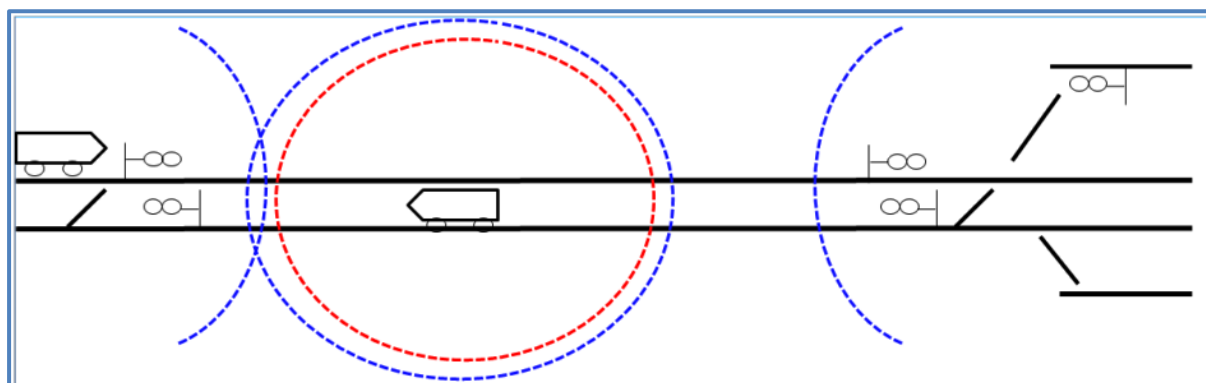
**Figure 20: Multiple Access TDMA/FDMA scheme for Stationary TCAS**

- The frame cycle is divided into basic 78 time slot position markers (position nos. 1 to 78) each of width 352 bits (18.33 m-sec).
- Out of 78 time slots, 50 Time slots shall be used for communication between Stationary TCAS and Loco TCAS. These timeslots have been marked as M-1 to M-50.
- These 50 time slots are distributed among adjacent stations sequentially till the last time slot, thereafter the sequence is repeated. Each station is allotted a block consisting of a number of time slots in 2000 milli seconds frame. A particular Station TCAS communicates with all the Loco TCAS units in its jurisdiction in these allocated time slots in a specific frequency pair (say  $f_{S1}$  - $f_{M1}$  for Station 1). The number of time slots allotted to a station depends upon the size of the station. Smaller stations like 3 or 4 line stations shall require less number of time slots, while stations with bigger yards may require more number of time slots.
- The remaining Time slots other than the 50 mentioned as above shall be used by Stationary TCAS and Loco TCAS for communication in frequency  $f_0$  for various other purposes.
- Some specific Time slots in  $f_0$  shall be used by the Stationary TCAS for broadcasting additional emergency (SoS) messages.
- Some other Time slots in  $f_0$  shall be used by the Stationary TCAS for broadcasting Access Authority messages.
- *Figure 21* shows pair of frequencies  $f_{S1}$  - $f_{M1}$ ,  $f_{S2}$  - $f_{M2}$ .....  $f_{Sn}$  -  $f_{Mn}$  allotted at adjacent stations for respective Loco TCAS units where  $f_{M1}$  is the frequency on which Loco TCAS unit in Station1 area transmits and  $f_{S1}$  is the frequency on which it receives and so on.
- On receipt of radio message from a fresh loco falling in the jurisdiction of Stationary TCAS unit, the Stationary TCAS unit shall decide the Timeslot in which that particular Loco unit shall communicate.
- Stationary TCAS and Loco TCAS shall use different timeslot(s) for communication. It means that Stationary TCAS and Loco TCAS shall use their respective timeslot(s) in the Multiple Access within their channel for the transmission.
- Although the frame cycles for Stationary TCAS and Loco TCAS are different at a particular station, Stationary TCAS and Loco TCAS time slots shall not overlap.
- The Loco time slots for the same station shall not be adjacent to each other (minimum one time slot gap shall be kept).(TAN 5001).



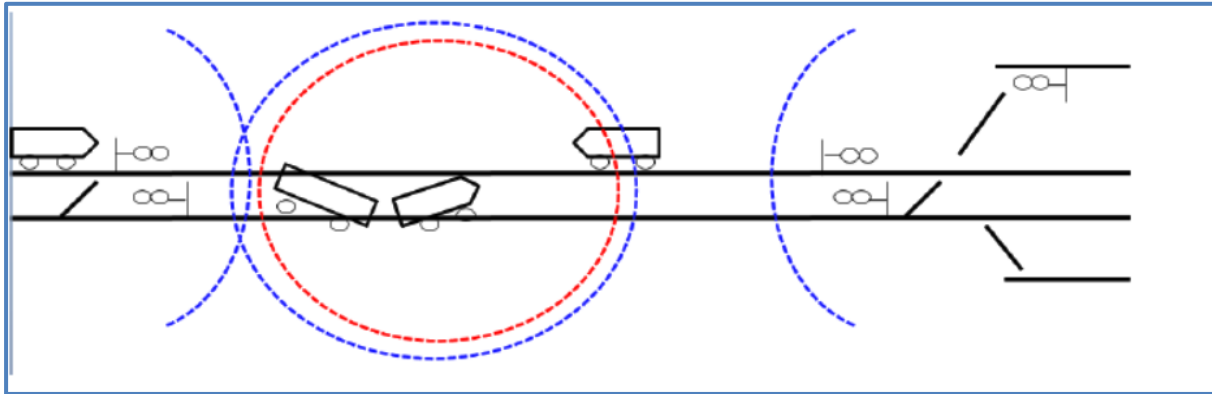
**Figure 21: Multiple Access TDMA/FDMA scheme for Loco TCAS**

- In block section, Loco TCAS System shall switch its Tx frequency to  $f_0$  and shall transmit the radio packet in some specific time slots for communicating with Stationary TCAS.



**Figure 22: Communication by Loco TCAS in Absolute Block Section**

- In emergency situation, Locomotive shall additionally transmit on  $f_0$  in a particular timeslot and tune back to receive on  $f_0$ . Transmission of SoS messages by Locomotive on  $f_0$  in case of emergency situation shall enable other trains in vicinity to get the immediate message without routing through Stationary Unit.
- Loco TCAS unit while transmitting on frequency  $f_0$  shall not interfere with the portion of the frame cycle nominated for transmission of Stationary TCAS units.



*Figure 23: Communication by Loco TCAS in emergency situation in Absolute Block Section*

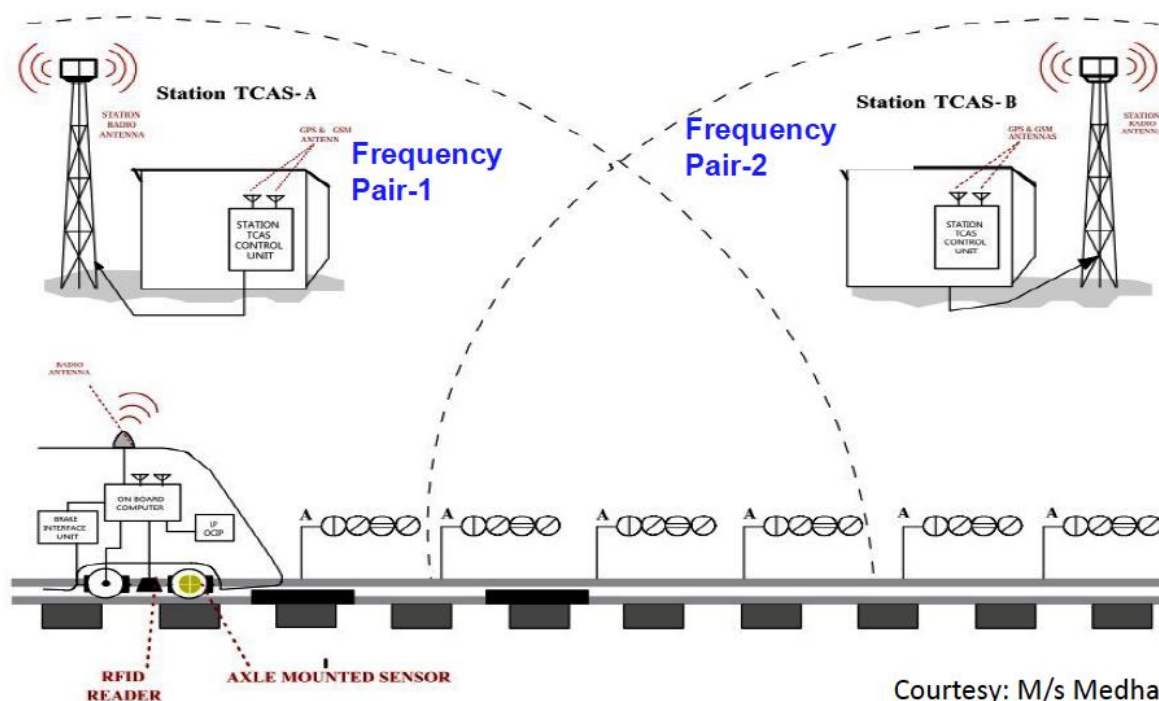
#### 2.2.4 Communication in overlap zone

The **communication mandatory zone** for a stationary TCAS unit shall include at least two RFID tags prior to a distance of 1 km from first approaching signal of the respective stationary TCAS unit in Absolute Block Section.

In case there is no gap between Communication Mandatory Zones of two adjacent Stationary Interlockings, there shall have to be overlapping zone in which Loco TCAS Unit would receive messages from both the Stationary TCAS Units. On receiving **Access Authority** from Stationary TCAS Unit on approach, Loco TCAS Unit shall relinquish communication with preceding Stationary TCAS Unit and start communication with approaching Stationary TCAS Unit.

Unlike absolute block section, Radio communication is mandatory for the entire automatic block section. RF overlap in auto section is required to be achieved by using two frequency pairs in adjacent stations.





**Figure 24: Radio Communication arrangement in overlap zone in Automatic Block Section**

### 2.2.5 Terminating a Radio Communication

Stationary TCAS shall stop communication with Loco TCAS unit, when one of the following conditions occurs:

- When the Loco moves beyond the Last Stop Signal of the Stationary TCAS Unit as per boundary configured (typically 1.5 km from Last Stop Signal of Stationary TCAS).
- If the direction is invalid in Standby or Staff Responsible mode.
- No radio packet is received from Loco TCAS for more than 60 cycles.
- In the event of failure of both – GPS/GNSS and RTC,

If no communication is received from a registered loco TCAS unit in communication mandatory zone for continuous 2 minutes, the same shall be deregistered by the stationary TCAS unit.

## 2.3 GSM & GPRS Communication

The GSM/GPRS communication is used for following purposes in TCAS:

### (A) Communicating Fault messages to NMS

The exceptional fault/critical messages logged by Stationary TCAS and Loco TCAS unit are transmitted to NMS through respective GSM interfaces provided in hot standby mode.

Stationary TCAS shall log fault messages and transmit to Network Monitoring System in following cases:

- Radio Communication failure longer than applicable time-out (30 seconds).
- Failure of only one radio out of two radios in hot standby in Loco TCAS.
- CPU time and GPS time out of synchronization.
- Failure of both – GPS/GNSS and Real Time Clock (RTC).
- Active Cab/Desktop DMI communication failure in Loco TCAS.

Loco TCAS shall log fault messages and transmit to Network Monitoring System in following cases:

- RFID reader failure
- In Post Trip (PT) Mode or Isolation (IS) Mode.
- On receiving Missing RFID Tag information.
- Radio Communication failure longer than applicable time-out (30 Seconds).
- Failure of only one radio out of two radios in hot standby.
- Failure of both GPS/GNSS and Real Time Clock (RTC).
- Active Cab/Desktop DMI communication failure.

### (B) Transmission of Authentication keys for radio communication between Stationary TCAS and Loco TCAS

When the Stationary TCAS unit communicating the safety related data with Loco TCAS, it shall verify that communication is established with an authorized Loco TCAS unit and vice versa. Consequently the authenticity and integrity of any information exchanged between Loco TCAS and Stationary TCAS unit shall also be verified. In order to establish secured communication between Stationary TCAS and Loco TCAS units, Authentication keys are transmitted to all Stationary TCAS and Loco TCAS units through a Key Management System (KMS) using GSM communication. Stationary or Loco TCAS units shall send the request to

KMS for Authentication key by using GPRS. Authentication key will have certain valid time period for its usage. The communication between Stationary TCAS and Loco TCAS units is encrypted through Authentication key and thus the authenticity and integrity of transmitted information is ensured.

**Note:**

All messages in timeslots reserved for emergency messages and Loco-to-LoCo direct communication, are not subjected to aforesaid procedure of Identification and Authentication dialogue and are non-SIL -4 due to nature of the information conveyed by such messages.

## **Key Management System (KMS) Server**

- KMS is responsible for distribution of authentication keys to TCAS systems for radio security.
- Communication between Stationary and Loco TCAS Units is based on AES-128 encryption.
- GSM communication is used to transfer Keys to Loco and Stationary TCAS.
- A central KMS server is hosted at RCIL Secunderabad to communicate authentication keys to Loco TCAS and Stationary TCAS.
- Single KMS is sufficient for all Railways. All the stationary TCAS and Loco TCAS IDs and SIM card numbers are to be provided to Railtel, to update the same in the KMS.
- Communication between KMS and TCAS is on GPRS and currently being upgraded to LTE.

### **Key Definition & Type of Keys**

Key is defined as a sequence of 128 bits. The following table summarizes the key types and usage of each type of key.

#### **Authentication Key ( $K_A$ )**

Authentication key is used for session key derivation in order to establish a safe connection between Stationary & Loco TCAS units. This key will be communicated by Key Management System (KMS) to all Loco and Stationary TCAS units and it will have valid time period for its usage. It can be changed from time to time. Key Management System would be centralized for Indian Railways. KMS shall use OTP (One Time Password) over SMS technique, through GSM, to authenticate the TCAS systems before sharing the Authentication Keys. TCAS units shall store the Authentication Keys.

**Session Key ( $K_s$ )**

Session key is used for protection of data transfer between Stationary & Loco TCAS units. This key will be computed by Loco TCAS and Stationary TCAS units at the time of establishment of communication session between Stationary TCAS unit and Loco TCAS Unit.

On entering into “Communication mandatory Zone” in vicinity of Stationary TCAS territory, Loco TCAS unit sends the Access Request packet to Stationary TCAS system in “f<sub>0</sub>” frequency.

Stationary TCAS unit transmits the Access Authority message with Message Authentication Code (MAC). Loco TCAS unit receives the Access Authority message packet with MAC and compute the session key  $K_s$ . The MAC will be computed for the Access Authority message packet and verified with received MAC. If the computed MAC matches with the received MAC, Loco starts communicating the regular packet.

## 2.4 GPS/GNSS Communication

- Time synchronization is very important for seamless data communication among various TCAS units. Absence of time synchronization often results in error/faults. Multiple Access TDMA scheme is used in TCAS which requires unified time synchronization. We do not have a Universal Time clock in India, hence we use GPS/GNSS Clock to correct the Real Time Clock (RTC) of any system.
- Station/LC/IBS Vital Computer shall have Real Time Clock (RTC) synchronization facility with GPS/GNSS clock to synchronize with other TCAS systems in hot standby manner.
- GPS antenna is installed at the stationary TCAS unit for time synchronization. Two separate antennas for GPS shall be installed using diverse path for high availability. Diverse make of GPS are preferable to avoid common cause failures.
- The Station/LC/IBS Vital Computer RTC should be synchronized with the RTC of all Loco TCAS Vital Computers and other TCAS systems. The RTC of all the TCAS units are set with time reference to GPS/GNSS.
- The factors affecting time synchronization are temperature, inferior quality clocks, resource constraints, high density and node failures. When RTC of any Station/LC/IBS TCAS or Loco TCAS is not matching with the RTC of other TCAS units, it synchronizes with GPS/GNSS clock.
- When CPU time of Station/LC/IBS TCAS or Loco TCAS and GPS time are not synchronized, the time reference shall change to other GPS.
- If both GPS are failed, then the system shall work on CPU time for 30 minutes until the situation is stabilized. If there is no stability after GPS time-out, the Loco shall transit out of Full Supervision Mode.

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# Chapter III

## Network Monitoring System

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### 3.1 Introduction

Network Monitoring System (NMS) shall be provided over OFC Network for centralized monitoring of TCAS equipped Trains and Stations within the network. It is used for troubleshooting of error events, off line simulation, real time monitoring of TCAS loco etc. Stationary TCAS and Loco TCAS transmit exceptional fault/critical messages to NMS through their respective GSM interfaces. A Central Server is present in the Division Control Room. All relay information and radio packets exchanged between Station and Loco are logged in Central Server and accessed through NMS.

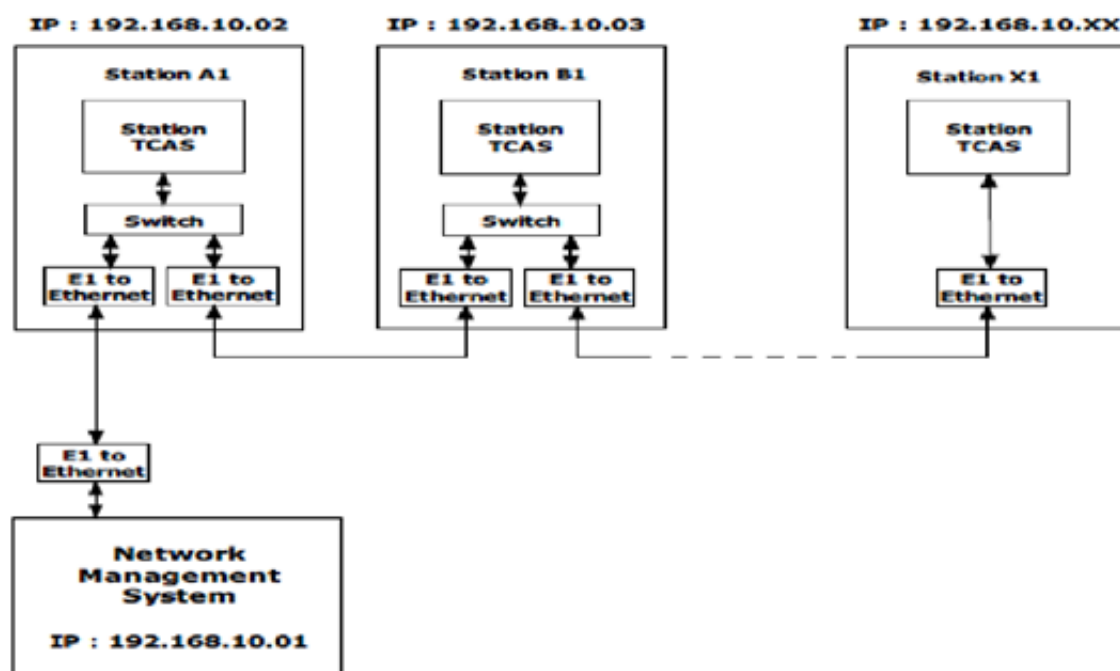
### 3.2 Hardware requirements

The hardware requirements of NMS are as follows:

- 2 Nos. Servers for redundancy with Windows Professional on both servers  
(NMS data shall be logged onto each server) and Shared Firewall on both servers
- Keyboard and Mouse  
55" 4K/UHD Professional TV. (if one screen is insufficient for display, separate screen shall be provided with seamless integration to enable complete view of TCAS territory).

### 3.3 STCAS to NMS & STCAS to STCAS Communication on E1 Interface

- TCAS NMS Network shall be built on E1 interface which is provided by the Indian Railways. Centralized monitoring of a group of stations is achieved by collecting signal aspects, track occupancy, loco absolute position etc., from each of the Stationary TCAS unit within the network. Network monitoring is limited to its own network. Stationary TCAS units shall communicate with NMS unit using the predefined packets.
- Using E1 interface, each Stationary TCAS unit is connected to adjacent stationary TCAS unit/Network Management System to form a network, as shown in *Figure 25*. Using Ethernet protocol over this network, Stationary TCAS units will exchange Stationary-Stationary communication packets with adjacent Stationary TCAS units and NMS.
- Number of Stationary TCAS units in one E1 ring shall be limited to 5-7. The IB huts shall be connected to the nearest Station in T network.



*Figure 25: Network Management System (NMS) connectivity diagram*

Stationary TCAS shall log fault messages and transmit to Network Monitoring System through Ethernet or GSM interfaces in the following cases:

- In the event of a Radio Communication failure longer than applicable time-out.
- In the event of a failure of only one radio of Loco TCAS, out of two radios in hot standby.
- If the incremental difference between CPU and GPS time is not matching and the difference between two GPS is greater than the frame interval.
- In the event of failure of both – GPS/GNSS and Real Time Clock.
- In the event of Active Cab/Desktop DMI communication failure.

### 3.4 Loco TCAS to NMS Communication on GSM interface

The communication between Loco TCAS and Network Monitoring System (NMS) shall be through two GSM interfaces provided in Loco TCAS Vital Computer. The exceptional fault/critical messages logged by Loco TCAS unit are transmitted to NMS through two GSM interfaces provided in hot standby mode.

Loco TCAS shall log fault messages and transmits to Network Monitoring System through GSM interfaces in the following cases:

- In the event of a RFID reader failure (any one or both readers).



- To indicate the Loco TCAS mode to NMS through Stationary TCAS Unit on encountering any tag (excluding LC Gate Tag), when Loco TCAS unit is in Post Trip (PT) Mode or Isolation (IS) Mode.
- In case of missing RFID Tag information received from Stationary TCAS. This in turn shall send SMS alert to the Maintenance Staff.
- Information to NMS if turn out tag is over read by Loco TCAS unit.
- In the event of a Radio Communication failure longer than applicable time-out (30 Seconds).
- In the event of a failure of only one radio out of two radios in hot standby.
- In the event of failure of both GPS/GNSS and Real Time Clock (RTC).
- In the event of Active Cab/Desktop DMI communication failure.

### 3.5 Salient feature of NMS

- Real time display of train movement on NMS monitors.
- Offline display of train movement on NMS monitors at Normal, 2x, 4x, 8x, 16x & 32x speed.
- Display of Datalog in Spreadsheet (Excel Format).
- Display of "Permitted Speed+ Current Speed Vs Location" and " Permitted Speed+ Current Speed V/s Time" including information whether brake command is applied by TCAS or not.
- Ability to watch the NMS at Distant Location through Internet (Password protected)
- Ability to extract offline data log through NMS
- Generation of Exception Reports - Loco TCAS Unit-wise, Stationary TCAS Unit-wise, RFID Tag Set wise.
- Prompt through NMS for missing one of the two RFID tags of same set.
- Prompt through NMS for missing both RFID tags of same set.
- Prompt through NMS for missing communication packets overall below a set level (say 20%) for moving train in Communication mandatory zone.
- SMS Alert for repeated same RFID tag missing events in Full Supervision Mode.
- SMS Alert for any brake application command by TCAS Loco forcing train to bring to dead stop in Full Supervision Mode.
- SMS Alert for SPAD.

- SMS Alert for SPAD Prevention by TCAS.
- Capturing of speed restrictions imposed by TSR Management System from Stationary TCAS after every update.
- Capturing of health status and event log from Loco TCAS if LTE is available.

# Chapter IV

## TCAS Survey

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### 4.1 Introduction

The survey for installation of TCAS covers following items:

- Absolute location survey
- Collection of trackside data from Engg. department.
- Site survey for tower location
- Site survey for Radio signal strength for tower locations
- Site survey for spare relay contacts and space in relay room
- Site survey for RFID tag locations
- Site survey for cable laying
- Survey for Loco nomination

#### 4.1.1. Absolute Location Survey

Absolute location survey is conducted by rodometer and drone, to map every km from station to station.

#### 4.1.2 Collection of trackside data from Engg. department

Before commencing survey, following track side data is to be collected from Engg. department:

- Permanent Speed Restriction (PSR)
- Gradient profile, LC gate locations
- Sectional speed

#### 4.1.3 Site survey for Tower location & Radio Signal Strength (Ref.: Mugat station SCR, RSSI Survey Report)

Preliminary survey of Tower location in (latitudes and longitude) is to be conducted along with Radio signal Survey Strength. The following information is to be provided for Tower location at a particular station:

- Proposed location for tower installation with GPS co-ordinates.
- Tower position w.r.t. track and Tx/Rx Antenna locations
- Antenna orientation
- Proposed Loco location in UP direction

- Proposed Loco location in DOWN direction.
- Other parameters like Radio type, Antenna type, Antenna polarization, Antenna height, Antenna Gain, Frequency, Climate etc. are to be considered.

The following example illustrates the survey details for Tower location:

**Station RSSI Survey Report (Ref.: Mugat station SCR, RSSI Survey Report, Courtesy: M/s HBL Power Systems Ltd.)**

**Date: 11/01/2020**

### Survey Description

Mugat station location with loco at 3.2 KMs away on DOWN and 3.2 KMs away on UP direction is shown in the figure given below. In the image, white line indicates the track topology.



**Figure 26: Mugat station and Loco locations**

For Mugat station, SCR gave a location for tower installation with GPS co-ordinates (19° 10' 26.00" N, 77° 25' 40.00" E). Based on the GPS co-ordinates, HBL had analysed the RF coverage for the station using Ligowave Link calculator tool. From the analysis, HBL observed that the RF coverage is good in UP direction and minimal obstructions in 60% Fresnel zone for RF coverage in DOWN direction.

The notations of locations used are

- STN\_MGC\_SCR indicates tower location at MUGAT station recommended by SCR
- LOCO\_UP indicates loco location 3.2 KM from station in UP direction towards MUDKHED (MUE)
- LOCO\_DOWN indicates loco location 3.2 KM from station in DOWN direction towards MALTEKDI (MTDI)

The survey results are tabulated below:

[Table of Contents](#)

**Table 2:Site Information for SCR recommended location - DOWN LINE (3.2 KM)**

Sr. No.	Parameter	Units	Value	Sr. No.	Parameter	Units	Value
1	TX site name	--	STN_MGC_SCR	1	RX site name	--	LOCO_DOWN
2	Radio Type	--	Custom PTP	2	Radio Type	--	Custom PTP
3	Latitude	--	19° 10' 26.00" N	3	Latitude	--	19° 11' 01.55"N
4	Longitude	--	77° 25' 40.00" E	4	Longitude	--	77° 23' 57.15" E
5	Tx Power	dBm	40.0	5	Rx Threshold	dBm	-85.0
6	Antenna Gain	dBi	3.0	6	Antenna Gain	dBi	3.0
7	Antenna height	Mtrs	40.0	7	Antenna height	Mtrs	6.0

**Table 3:Parameters for SCR recommended location – DOWN LINE (3.2 KM)**

Sr. No.	Parameter	Units	Value	Sr. No.	Parameter	Units	Value
1	Frequency	MHz	441.8	4	Climate	--	Continental Subtropical
2	Antenna polarisation	--	Vertical	5	Measurement system	--	Metric System
3	Miscellaneous Loss	dBm	1.0	6	Rain rate	mm/Hr	1.0

**Table 4:Results of SCR recommended location – DOWN Line (3.2KM)**

Sr. No.	Parameter	Units	Value	Sr. No.	Parameter	Units	Value
1	Total Path loss	dB	97	4	Thermal fade margin	dB	34
2	Rx signal level	dBm	-50.927	5	Distance between sites	KM	3.196
3	EIRP	dBm	43.0	6	Link availability due to rain	--	>= 99.999

**Table 5:Site Information for SCR recommended location - UP LINE (3.2 KM)**

Sr. No.	Parameter	Units	Value	Sr. No.	Parameter	Units	Value
1	TX site name	--	STN_MGC_SCR	1	RX site name	--	LOCO_UP
2	Radio Type	--	Custom PTP	2	Radio Type	--	Custom PTP
3	Latitude	--	19° 10' 26.00" N	3	Latitude	--	19° 09' 55.21" N
4	Longitude	--	77° 25' 40.00" E	4	Longitude	--	77° 27' 24.71" E
5	Tx Power	dBm	40.0	5	Rx Threshold	dBm	-85.0
6	Antenna Gain	dBi	3.0	6	Antenna Gain	dBi	3.0
7	Antenna height	Mtrs	40.0	7	Antenna height	Mtrs	6.0

**Table 6:Parameters for SCR recommended location – UP Line (3.2 KM)**

Sr. No.	Parameter	Units	Value	Sr. No.	Parameter	Units	Value
1	Frequency	MHz	441.8	4	Climate	--	Continental Subtropical
2	Antenna polarisation	--	Vertical	5	Measurement system	--	Metric System
3	Miscellaneous Loss	dBm	1.0	6	Rain rate	mm/Hr	1.0

**Table 7: Results of SCR recommended location – UP Line (3.2 KM)**

Sr. No.	Parameter	Units	Value	Sr. No.	Parameter	Units	Value
1	Total Path loss	dB	97	4	Thermal fade margin	dB	34
2	Rx signal level	dBm	-50.788	5	Distance between sites	KM	3.198
3	EIRP	dBm	43.0	6	Link availability due to rain	--	>= 99.999

**Table 8: Summary of Survey Reports**

Tower location	Loco location	Table reference	Line of sight	Terrain obstruction	Rx signal level at Rx Radio	Criteria range	Result
SCR recommended	DOWN (3.2 KM)	Table 1,2,3	Clear	Minimal Obstruction in 60% of first Fresnel zone	-50.927 dBm	> -85 dBm	PASS
	UP (3.2 KM)	Table 4,5,6	Clear	No obstruction	-50.788 dBm	> -85 dBm	PASS

**Conclusion on tower location**

Based on the above survey results, SCR recommended location is acceptable

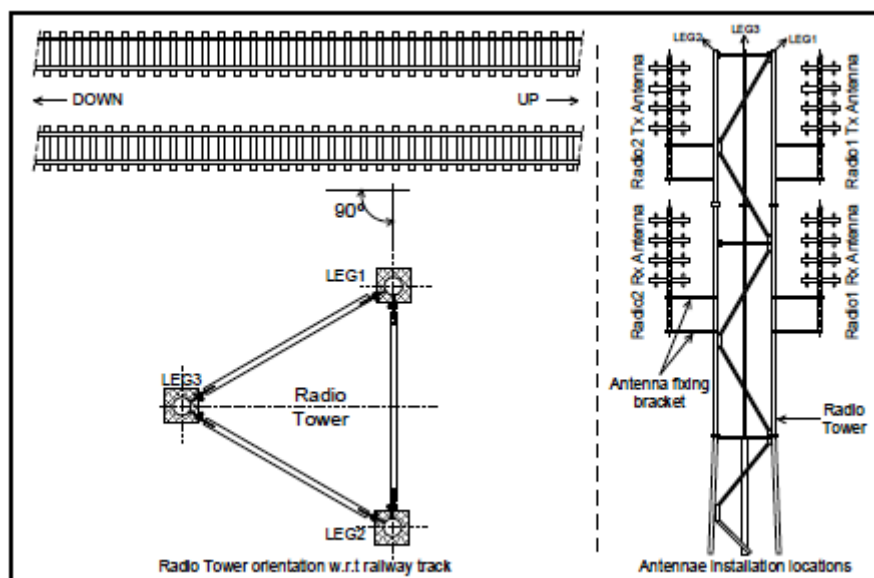


## Station Building and Tower Locations



*Figure 27: Mugat station building and Tower location*

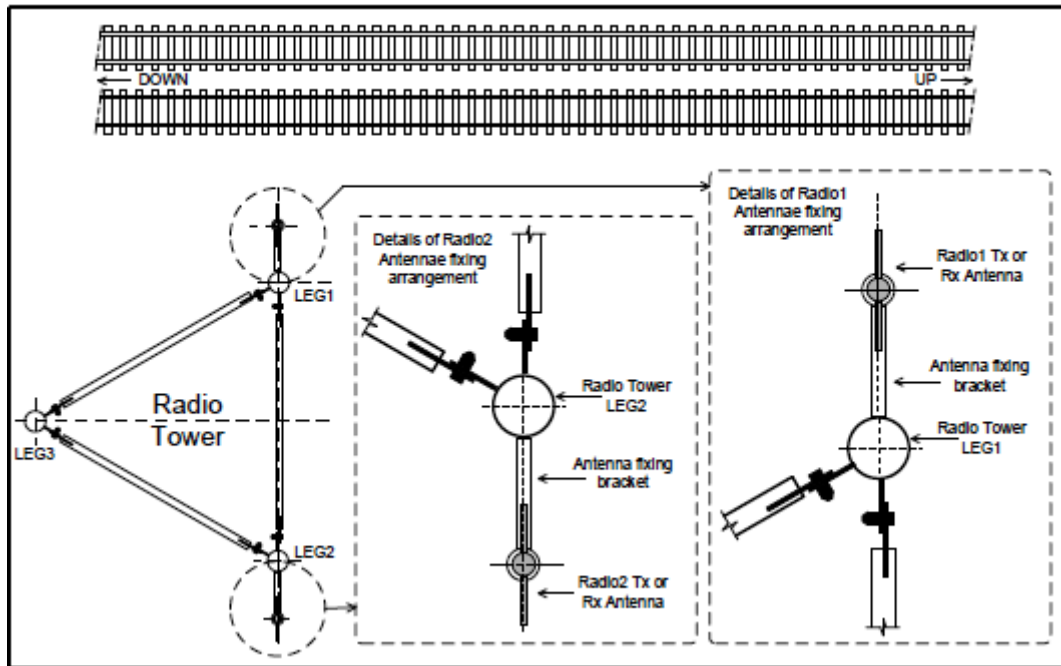
## Tower position w.r.t track and Tx/Rx antennae locations



*Figure 28: Mugat station Radio Tower position w.r.t tracks*

The Radio Tower LEG1 & LEG2 shall be perpendicular to the UP & DOWN tracks and LEG3 shall be towards DOWN direction, as shown in Figure 7. Radio1 & Radio2 Tx antennae are fixed on top and Rx antennae below Tx antennae as shown in Fig.3.

### Antenna orientation



**Figure 29: Mugat station Radio antennae orientation on Radio Tower**

**Table 9: Radio1 & Radio2 antennae orientation for Mugat station**

Sr. No.	Parameter	θHPBW	Antenna Orientation
1	Half Power Beam Width for TX1 antenna	0°	<del>Omn</del> i-directional / Directional
2	Half Power Beam Width for TX2 antenna	0°	<del>Omn</del> i-directional / Directional
3	Half Power Beam Width for RX1 antenna	0°	<del>Omn</del> i-directional / Directional
4	Half Power Beam Width for RX2 antenna	0°	<del>Omn</del> i-directional / Directional

**Note:**

As per RDSO Specification no. RDSO/SPN/196/2012 Ver.3.2, The Radio Network Link shall be designed so as to have received signal strength generally not poor than -85 dBm and packet error rate of 95% throughout the Communication Mandatory Zones.



#### 4.1.4 Site survey for spare relay contacts and space

Site survey for spare relay contacts, space in relay room, such as availability and type of spare ECR contacts and location of ECR (at signal post/relay room/goomties in block section) is to be done.

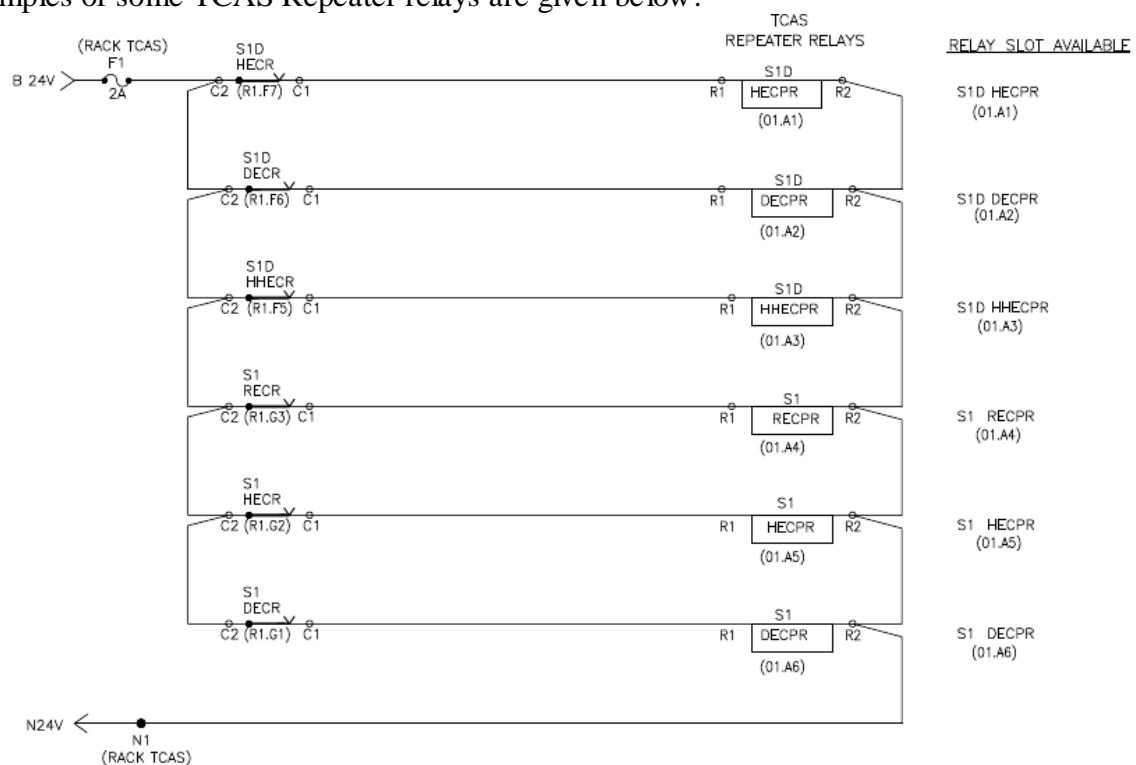
Spare contacts of following relays in existing interlocking installation are required to be identified for picking up of corresponding TCAS Repeater relays:

Signal Lamp Proving relays of all the signals - RECR, HECR, DECR, HHECR & UECR whichever are applicable.

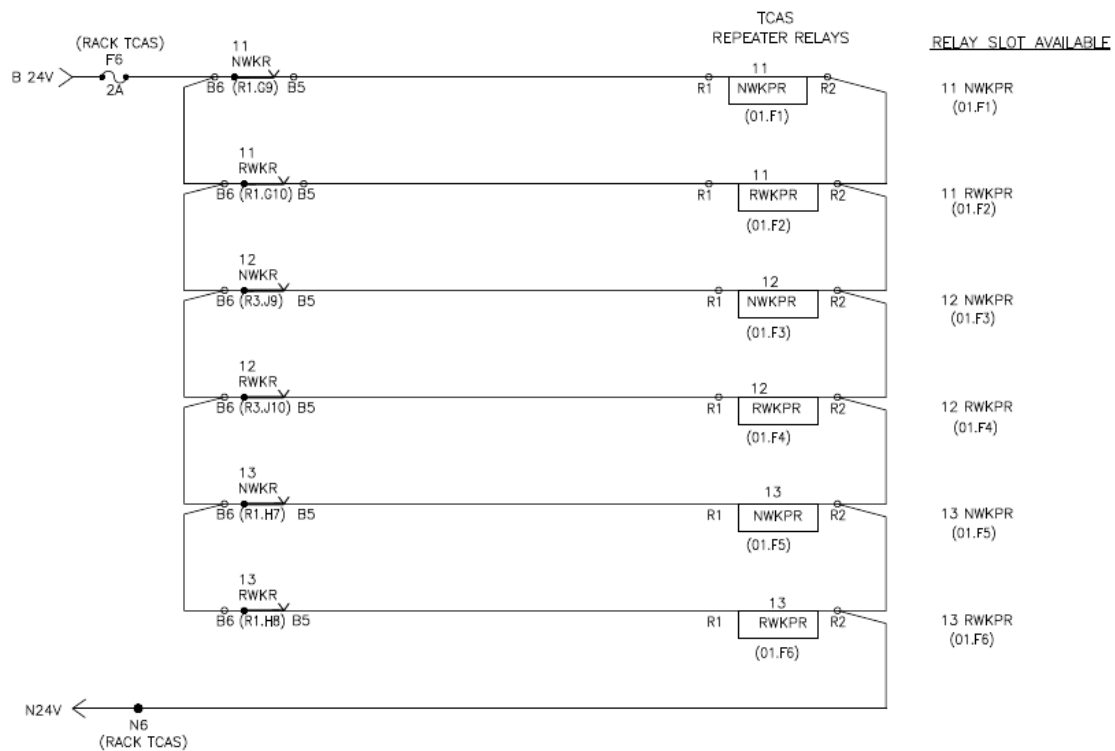
Point Indication relays of all the points - NWKR & RWKR

Track Proving relays of all the track circuits - TPR

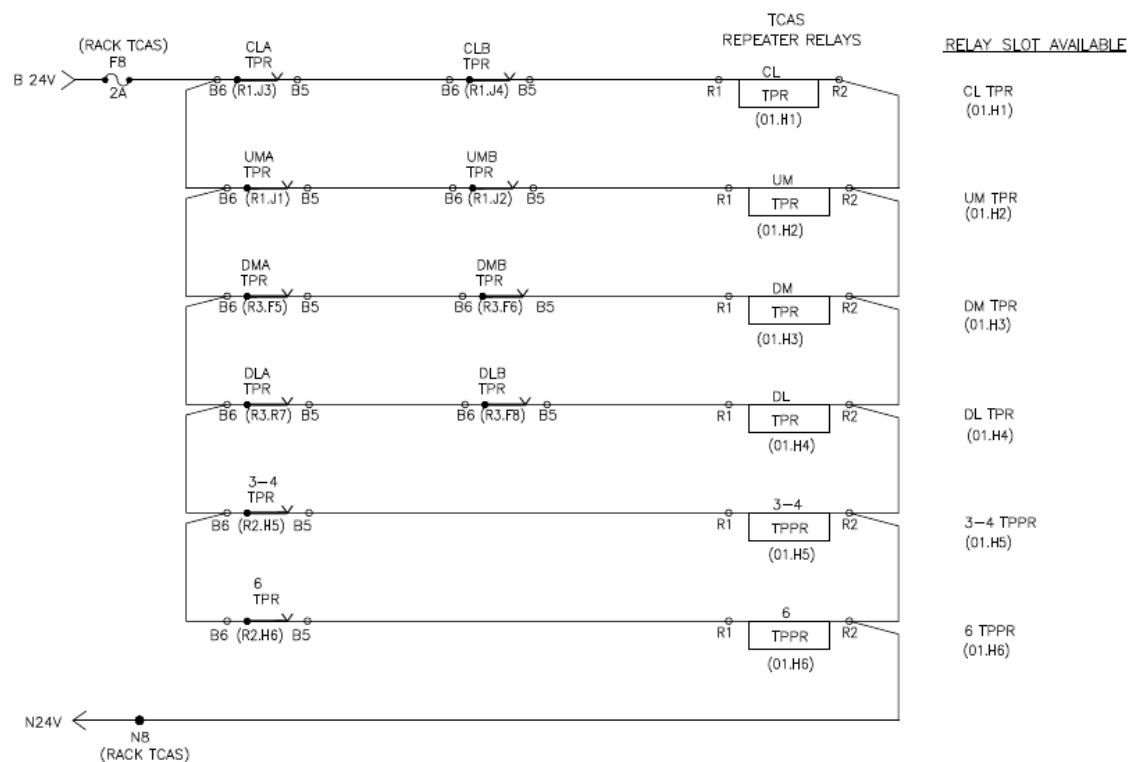
Examples of some TCAS Repeater relays are given below:



**Figure 30: TCAS Repeater Relays of ECRs**



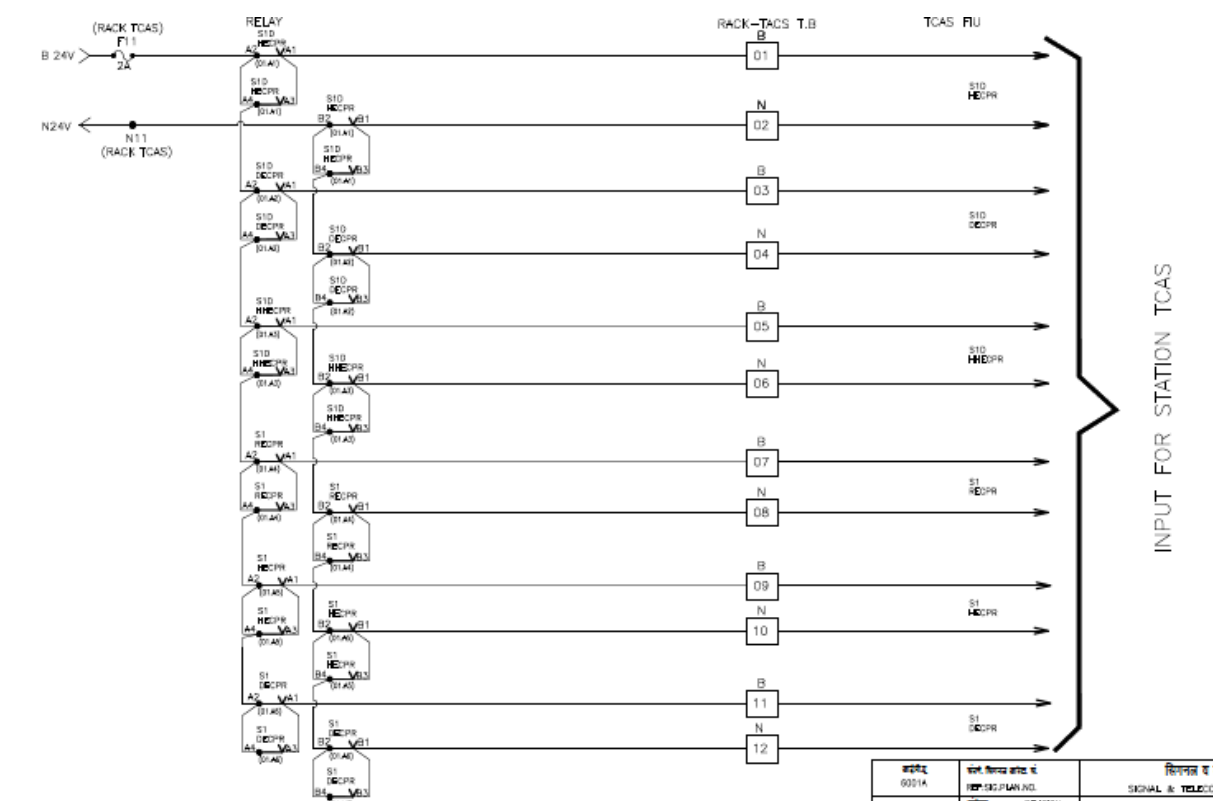
**Figure 31: TCAS Repeater Relays of NWKRs & RWKRs**



**Figure 32: TCAS Repeater Relay of TPRs**

Space for new opened TCAS Repeater relays in existing relay racks is required to be identified. If space is not available then installation of new relay rack is to be planned.

The inputs for station TCAS are taken through the front contacts of these TCAS repeater relays (Parallel contacts with double cutting) as shown in following circuit diagram:



**Figure 33: Feed to Station TCAS taken through Parallel contacts of TCAS Repeater Relays with double cutting**

#### 4.1.5 Site survey for RFID tag locations

Absolute location survey to be conducted by rodrometer and drone, to map every km from station to station. Absolute location measurement (In metres) required to map RFID locations.

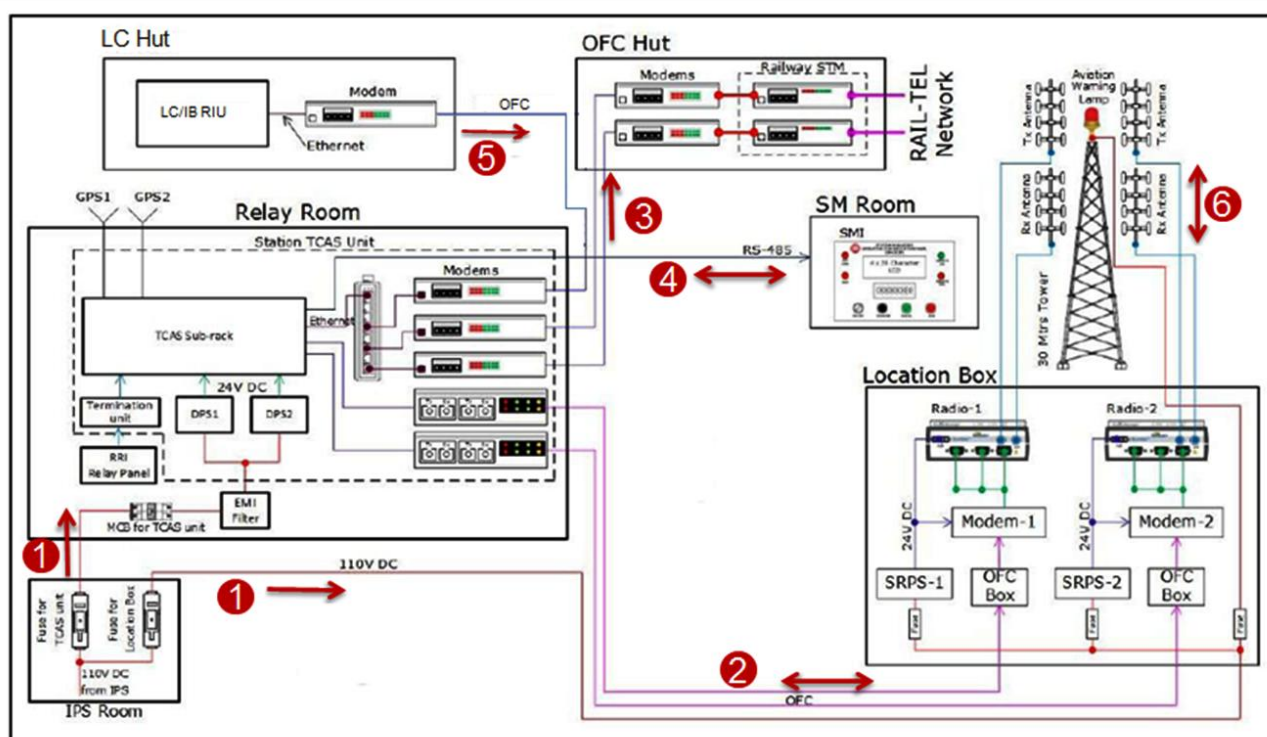
While deciding the location for RFID installation following aspects shall be kept in view (Ref.: RDSO Draft SPN/196/2020 Ver. 4.0 d1):

- RFID tags and fixtures shall be avoided in turnout portion in general. In any case, these shall not be located in switch portion of turnout i.e. from Actual Toe of Switch (ATS) to heel of switch.
- The installation of RFID tag and fixture should be avoided at locations susceptible to ballast accumulation at the center of sleeper such as level crossing etc. This aspect needs to be taken care at the time of survey itself.
- The performance of RFID tag may get degraded during RFID Fixture getting submerged in water. Therefore, installation should be done considering this fact.

#### 4.1.6 Site survey for cable laying

Most of cable requirement is in Station area. Site survey for following cables and their routes is required to be done (refer *Figure 34* below):

- (1). Power cable from IPS to Tower and IPS to STCAS (110V DC) .
- (2). OFC from Station TCAS to Tower (to Radio modems).
- (3). Comm. Cable from STCAS to OFC hut (for NMS).
- (4). Cable Laying for SMOCIP in SM Room.
- (5). OFC Cable from STCAS to RIU (at LC/cabin) in diverse path.
- (6). RF Cable from Radio Modem to Radio antenna.



*Figure 34: Cabling scheme for TCAS*

#### 4.1.7 Survey for Loco nomination

- This survey is critical to ensure maximum run of TCAS equipped locos in nominated TCAS territory.
- Locos running in closed circuit are preferably selected.
- Department maintaining Rolling Stock is involved in the process.
- Survey of Loco is done to check availability of space to install TCAS equipment.
- Survey is done for a mix of Diesel/Traction Loco for
  - RE Vs Non RE area
  - Passenger Vs Goods Loco
  - Type of Braking System (IRAB, E70, CCB)

# Chapter V

## TCAS Design, Planning & Documentation

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### 5.1 Introduction

To bring an uniformity in TCAS installation all over Indian Railways and to ease the process of understanding the items involved in planning, the following Design rules have been followed in line with the RDSO specification RDSO/SPN/196/2012 Ver. 3.2 and RDSO TAN No. STS/E/TAN/5001 Ver. 10, dt: 20.02.2019. However these are broad guidelines only and vary from railways to railways based on local signalling arrangements such as availability and type of spare ECR contacts and location of ECR (at signal post/relay room/goomties in block section), type of locos, location of towers, tower design, wind zone, factor of safety for towers etc.

The process of design and documentation of TCAS shall cover following items:

- Wireless Planning Commission (WPC) licensing & Independent Safety Assessor (ISA) verification and validation
- Tower design
- Floor plan of TCAS installation
- Stationery TCAS numbering scheme
- Relay interface circuits
- RFID TAG numbering, TIN numbering
- RFID TAG - TIN layout
- Table of Control (TOC)
- RFID TAG Data
- Station/Frequency/Time slot plan for FDMA-TDMA

The brief guidelines related to design and documentation of TCAS items is given in the following paragraphs:

## 5.2. WPC licensing & ISA

- Wireless Planning Commission license is required for use of radio frequencies. To be taken by Purchaser Railway
- Standing Advisory Committee on Radio Frequency Allocation (SACFA) license is required for tower (30m and above).
- Application of WPC and SACFA to be filed by Railways through the website [www.wpc.dot.gov.in](http://www.wpc.dot.gov.in) (Register and file application)
- License is based on number of fixed and mobile radio used.
- The contractor shall submit all required documents.
- Payment towards license fee, SACFA and WPC charges, Royalty etc charged on annual basis by the contractor/Railways as per provision in contract.
- Contractor shall communicate the ISA for the project safety assessment.
- Verification & Validation of the software and hardware shall be done by Independent Safety Assessor (ISA) as per Safety Integrity Level – 4 (SIL-4) of CENELEC standards or equivalent standards.

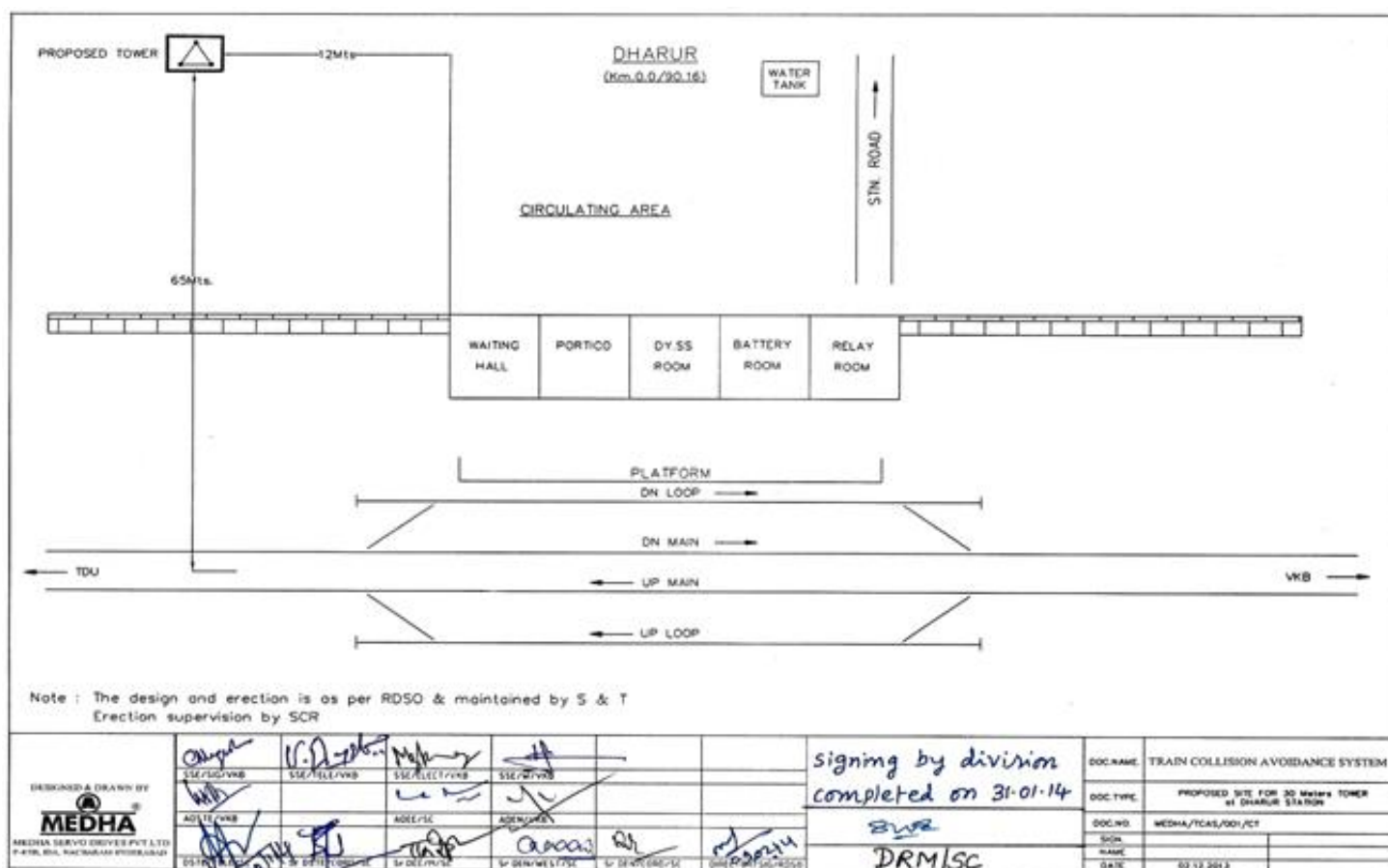
## 5.3 Tower Design

In reference to RDSO/SPN/196/2012 Ver. 3.2, for design of Stationary TCAS tower and foundation, purchaser railway has to take following actions:

- Purchaser railway shall decide type of Tower - Whether Lattice type or Concrete type or any other type.
- Purchaser railway shall decide height of tower. Minimum height of self supported tower shall be of 30m (for future installations tower height shall be 40m) height above ground level. In case of tower on top of building, the typical height shall be on 4 m on top of building.
- Purchaser railway to ensure that basis of design of tower and foundation shall include wind velocity, soil bearing capacity, tower site, Ladder, Platform, Staging, Aviation Lamp and Earthing arrangement.
- Design of tower and its foundation shall have acceptance of purchaser railway prior to commencement of their execution work.
- Required WPC, SACFA and any other regulatory authority clearances shall be obtained by Purchaser Railway.

- Tower location drawing should have Joint approval of S&T, Civil, Electrical departments of division.
- Zonal railway S&T organization to ensure that tower design and drawing meets requirement of IRS/IS codes. Other design document as required may be submitted
- Tower foundation & structure design and drawing should be proof checked by independent 3<sup>rd</sup> party (e.g. CPRI).
- Final approval of Bridge department of Zonal Railway should be obtained for Tower foundation & structure design and drawing.
- Zonal railway shall have clarity on supervision of execution of Tower works (Engg vs S&T vs Outsourcing).

An example of site plan for tower erection is given below:



**Figure 35: Proposed site plan for tower erection at a station**

## 5.4 Relay Interface Circuits

Stationary TCAS unit takes potential free inputs from interlocking through double cutting arrangement. It shall be capable of taking minimum 256 inputs. The maximum number of field inputs are 2048. There shall be provision for expansion by providing additional Input cards or Multiple Field Input Units (FIUs). Each Vital Input Card/FIU can accommodate 256 inputs. Based on the Field inputs required to be connected with each stationary TCAS units, the requisite number of Vital Input cards/FIUs shall be procured for each stationary TCAS. There shall be provision for expansion by providing additional Input cards or by cascading multiple Remote Interface Units.

The status of track circuits nominated for computing train length measurement shall be read through Vital Input Cards only. If these relay status are read through Remote Interface Units, the delays are to be accounted for by the Stationary TCAS.

The capacity of Stationary TCAS shall be restricted to 70% of its “Design Capacity” in terms of number of inputs, number of routes and number of trains (whichever is lower) that can be handled, to avoid undesired behaviour of TCAS when its operation reaches beyond design capacity.

The break status of potential free contact shall indicate absence of input.

Signal aspect status, position of points, berthing track circuit status, status of track circuits nominated for computing train length, status of block instrument Line Closed condition shall be interfaced to Stationary TCAS.

IBS & Gate unit shall not require inputs for point position, track circuits nominated for computing train length & berthing track circuit status. Gate unit shall not require input for status of block instrument Line Closed condition.



## 5.5 Preparation of TCAS RFID Tag -TIN Layout

RFID tag-TIN layout shall be prepared as per guidelines given in RDSO Draft Specification no. RDSO/SPN/196/2012 Ver 3.2 or latest. For preparation of Tag-TIN Layout, one should have a fair idea about classification of RFID Tags and Track Identification Numbers (TIN). The details are given in following paragraphs:

### 5.5.1 Classification of RFID Tags

RFID tags are categorized as follows:

- (a). Normal tag
- (b). Signal foot tag
- (c). Signal approach tag
- (d). TIN Discrimination tag
- (e). LC gate tag (optional)
- (f). Tunnel tag (for future use)
- (g). TCAS Exit tag

Following are the guidelines for provision of RFID tags in Tag-TIN layout:

- (i). Normal tags shall be provided in the block section as well as in station section. The maximum distance between the two normal tags shall not be more than 1000m. Each Normal tag shall be linked to next two normal tags in both the directions (Nominal & Reverse).
- (ii). Signal foot tags shall be provided at foot of every signal post.
- (iii). Signal approach tags shall be provided before the approach of (typically 150 ~ 250m) every signal post to correct the odometry error.
- (iv). TIN Discrimination tags shall be used to indicate change in the TIN of track section. Normally it will be placed at turnouts.
- (v). LC gate tag (optional) shall be provided at both sides of LC gate as required by operating Railway.
- (vi). TCAS Exit tag shall be provided at TCAS territory exit point.

### 5.5.2 Track Identification Number (TIN)

- (i). Each track shall have designated Track Identification Number (TIN).
- (ii). Each Block section shall have single unique designated TIN. Block Section TIN can be repeated after a designated distance (50 km minimum along the track route).

- (iii). To avoid unnecessary SOS generation, adjacent TINs to be incorporated in the radio packet and adjacent line tag info. Also, location adjustment details shall be sent on radio only after there is physical separation between the tracks.
- (iv). Each line in the station section having berthing portion shall have different TINs. TIN can be repeated after a designated distance (10 km minimum along the track route).
- (v). TINs shall be allotted in such a manner not to inhibit permissible simultaneous movements.
- (vi). Loco TCAS unit shall be able to self-deduce the change in its TIN whenever it changes the TIN section.

### 5.5.3 Guidelines for preparation of RFID TAG-TIN layout

Following guidelines shall be followed while preparing RFID tag-TIN layouts for Station/IB/LC or block sections:

- (1). RFID tag-TIN layout shall be prepared with Station yard layout as reference. However, the actual site considerations shall be taken into account prior to its preparation. A site survey shall be conducted to mark the locations where tags need to be placed.
- (2). The centre of Station Master's panel shall be taken as station's Centre Line for reference purpose.
- (3). Normal tags shall be provided in the block section as well as in station section. The maximum distance between the two Normal tags shall not be more than 1000m.
- (4). Every signal, including shunt signals, shall be provided with Signal foot tag.
- (5). The permanent EoA (End of Authority) Locations such as Stop Boards, BSLB, Ends of berthing track (may be with shunt signal sometimes) shall have Signal foot tag.
- (6). Signal Approach tag shall be provided for every Signal foot tag. They shall be provided at a distance of 150-250m from Signal foot tag. The distance from Signal Approach tag to Signal shall be mentioned on the layout.
- (7). All type of tags, except Junction and Adjustment tags, can be placed instead of Signal Approach tag if it offers some other advantage like reduction in number of tags.
- (8). To ensure linking up to the nearest location to the approaching signal, Normal tag shall be provided, in lieu of signal approach tag on Main lines.
- (9). To demarcate TIN sections, TIN discrimination tags shall be placed.
- (10). Gate tags shall be placed at such a distance that Auto whistling for approaching LC gate can commence from at least 600m on approach of LC gate.
- (11). Adjustment tag shall be used, if possible, in a non-signalling area. The layout shall only mention the programmed absolute location. However, the physical distance between the

Adjustment tag and nearest tag, from where physical and programmed distances are different, shall be mentioned.

- (12). Junction tag shall be used, if possible, in a non-signalling area. The layout shall only mention the programmed absolute location. However, the physical distance between the Junction tag and nearest tag, from where physical and programmed distances are different, shall be mentioned.
- (13). While moving from TCAS to non TCAS territory, Exit tags shall be provided at the exit boundary of Last Stationary TCAS unit in TCAS territory. Exit tags shall be provided in 3 sets of tags.
- (14). The distance between two different type of tags shall not be less than 40m. However, in case of Exit tags, the same may be reduced to 20m.
- (15). The distance between duplicated tags shall not be more than 2 meter.



- (16). A single TIN section shall be represented using a single colour. The TINs in vicinity shall be represented in different colours.
- (17). Non-TCAS territory shall be represented through white colour.
- (18). The TIN layouts thus prepared, shall permit all the train movements allowed in a section as per Table of Control / Selection Table.
- (19). At all places, where the train is likely to move outside TCAS territory or remain stabilized for long duration for e.g., sidings, Exit tags shall be provided.
- (20). Following notations shall be used to denote different types of tags:

**Table 10 : RFID Tag notations**

Type of Tag	Notation
Normal	N
Signal Foot	S
Signal Approach	SA
TIN Discrimination	T
Gate	G
Exit	X

- (21). Whenever, exit tags are provided on lines permitting movement in both directions, two Normal tags shall be provided to allow the train to enter in Full Supervision as soon as possible.
- (22). Block Section TIN should be extended up to BSLB on unidirectional lines (such as Double Line) and up to opposite direction Advanced Starter on Single Line. S-tag shall be provided at the Yard Exit Points not protected by Signals like BSLB etc.
- (23). The distances from a Normal Tag to all other Normal tags ahead in the direction of movement must be same.
- (24). The distance of Signal Approach (SA) Tag from corresponding Signal Foot (S) Tag should be exact multiple of 10m (1 Decameter). This should be invariably ensured during installation and verification at site.
- (25). Tags in Block Section shall be placed with consideration to the ease of maintenance and vandalism. These should be placed, if feasible, in vicinity of EC sockets, LC gate or any other place where a maintainer is usually required to visit.
- (26). Reference drawing numbers shall be mentioned on the layout.
- (27). Tag numbers (values in the range of 1 – 1023) and TIN numbers (values in the range of 1-127) shall be allotted by the user Railways. Sufficient spares for future needs shall be taken into consideration while allotting the numbers. The allotted numbers shall also be mentioned on the RFID tag-TIN layout.
- (28). Signature Block and revision history blocks shall be prepared as per the practices of User Railways.
- (29). Legends mentioning the notation used for the purpose of preparation of layout shall be specifically mentioned on the layout.
- (30). RFID tag-TIN layout need not be up to scale. If the layout is not per scale, the same shall be mentioned on the layout.
- (31). Absolute locations of tags, LC gates, signals and turnout switches shall be mentioned on the RFID layout.
- (32). Absolute location of Station center line shall be mentioned on the layout.

## 5.6 Preparation of TCAS Control Table

Following guidelines shall be followed while preparing TCAS Control table:

1. TCAS control tables shall be based on the SIP of the station as well as approved RFID tag-TIN layout for the Station/IB/LC. However, overlap points shall not be proven in TCAS control table.
2. Shunt signals shall not be a part TCAS control tables. However, station shunt limits shall be specified in the Stationary TCAS application data.
3. TCAS control table shall include all signals which will be monitored by a specific stationary TCAS unit.
4. In case of permissive signals, where the inputs for signal indications are available, the ECR shall be used for the purpose of displaying signal aspect. However, movement authority shall be decided based on the signal aspect of the approaching Stop Signal.
5. In case of permissive signals, where the inputs for signal indications are not available, the signal aspect and movement authority shall be derived based on the signal aspect of approaching stop signal.
6. Following information shall be included as part of control tables:
  - 6.1 Entry Signal: This shall be the approaching signal for a route.
  - 6.2 Exit Signal: This shall be the next approaching signal on route.
7. **Line:** This shall describe the line for route for e.g. Down Main, Common Loop, etc.
8. **Aspect of Entry Signal:** This field shall indicate all the permissible OFF aspects of the “Entry Signal”.
9. **Requires Aspects of Exit Signal:** This field shall indicate requirement of signal aspect for exit signal for the corresponding “Aspect of Entry Signal”.
10. **Requires Points in Route:** This field shall indicate the point positions required in Normal and Reverse positions for the corresponding route. Overlap points shall not be included for the purpose of TCAS control table.
11. **Requires Track Circuit Up in Route:** This field shall indicate the track circuits required to be in picked UP condition for the signal to be taken OFF. Only platform berthing track circuits shall be included for the purpose of TCAS control table.
12. **TINs (Track Identification Number) Requires Free:** This shall mention all the TINs falling into the respective route as mentioned in approved RFID layout. TINs shall not be proved for calling on signals.

**13. Check RFID:**

- 13.1 **Entry Signal Foot Tag:** This shall indicate the signal foot tag for the Entry Signal.
- 13.2 **En-Route Tags:** This shall indicate all the RFID tags falling in the corresponding route as per approved RFID tag-TIN layout. The Signal foot tag for the “Exit Signal” shall not be included in this field.
- 13.3 **Conflicting Route Tags:** This field shall indicate all the tags on which it is possible for the train to move if the point positions are not in accordance with “Requires Points in Route”. For the unintended route in the same direction, this shall include tags up to the last tag on the unintended route. Signal foot tag of next signal and turnout tags shall not be included in the conflicting route tags. For the unintended route in opposite direction, this shall include tags up to and including the Signal foot tag for next signal. If a conflicting route tag is read by a train, the TCAS system shall generate SoS.
- 13.4 **Conflicting turnout tags:** The conflicting turnout tags shall be indicated in the TCAS Control table.

**14. Turnout:**

- 14.1 **Speed in kmph:** Permissible speed for the turnout in route. For the purpose of TCAS control table, these have been specified as 30 kmph in case of single turnout and 15 kmph in case of multiple turnouts in route. In case, the turnout portion and loop line have different permissible speeds, the speed for both the portion shall be mentioned on the control table.
- 14.2 **Distance to Commence:** This shall be the distance from foot of “Entry Signal” to the start of first diverging point in route and shall be specified in meters.
- 14.3 **Speed Restriction Distance:** This shall be the distance from first diverging point in route. In case of entry in to the station premises, this distance shall be the distance from start of first diverging point in route to the next approaching signal plus 30m. In case of exit from the station premises, this distance shall be the distance from foot of approaching signal in route to the end of last converging point plus 10m. In case, the turnout portion and loop line have different permissible speeds, the speed restriction distance for both the portions shall be mentioned on the control table.
- 14.4 **Distance between Entry & Exit Signal:** To be specified in meters.
- 14.5 **Movement Authority:** Minimum movement authority for the corresponding signal aspect to be mentioned in meters.

- 14.6 Action for generating SoS to prevent Head On Collision and Rear End Collision on received communication for Block Section TIN: Stationary TCAS unit shall generate SoS to prevent Head on collision and Rear End Collision in the block section if it receives the required information, even if the train is outside the Stationary TCAS unit communication boundary.
- 14.7 **Entry Signal for Block Section TIN:** This shall specify last stop signals in UP/DN direction to be monitored by Stationary TCAS unit.
- 14.8 **RFID Tags:** These shall specify all RFID tags on the Block Section TIN for corresponding last stop signal as per RFID tag-TIN layout.
- 14.9 **TIN:** Block section TIN for the corresponding Last Stop Signal
- 14.10 **Last Signal of Stationary TCAS and Movement Authority:** Last signal shall be the last signal in all directions which is being monitored by Stationary TCAS unit. The Movement Authority for the last signal of stationary TCAS shall be the physical distance between the last signal of stationary TCAS and the foot of next approaching Stop Signal. The Movement Authority shall be specified in meters.
15. **Radio hole:** The Radio holes shall be clearly marked in the RFID Tag layout and TCAS Control table where applicable.
16. Name and Description of Station/IB/LC shall be mentioned on top of every sheet of the TCAS control table as per User Railway's practices.
17. Signature block shall be included on every sheet as per User Railway's practices.
18. Reference of SIP and RFID tag-TIN layout used for the preparation of TCAS control table shall be mentioned on each sheet.



## 5.7 Numbering scheme for Stationary TCAS

The first two digits are allotted to each zonal railway as shown in the table below and zonal railways may decide the last three digits for the stations. A proper record shall be maintained by the zonal railways to avoid repetition of number as station ID should be unique number. A sample TIN & RFID Tag set allotment is shown in Table 12.

**Table 11: Zonal Railway wise allotted codes for Stationary TCAS**

Sr. No.	Railway Zone	Allotted Code	Sr. No.	Railway Zone	Allotted Code
1	South Central Railway	00-02	11	North Western Railway	30-32
2	Northern Railway	03-05	12	West Central Railway	33-35
3	North Eastern Railway	06-08	13	North Central Railway	36-38
4	North East Frontier Railway	09-11	14	South East Central Railway	39-41
5	Eastern Railway	12-14	15	East Coast Railway	42-44
6	South Eastern Railway	15-17	16	East Central Railway	45-47
7	Southern Railway	18-20	17	Metro Railway Kolkata	48
8	Central Railway	21-23	18	Konkan Railway	49
9	Western Railway	24-26	19	RDSO, Lucknow	50
10	South Western Railway	27-29			

**Table 12: TCAS SCR Project TIN & RFID Tag Set Number Allotment (Courtesy M/s HBL)**

S.No	Station Name	Station / Block Section	Division Code	Station Numbering	Station IDs	TIN Range		RFID Tag ID Range	
						Range	Total	Range	Total
1		MUE-BIMBARI(ADB)				118-121	4	1023-992	32
2		SVN-MUE B/S				91	1	1-32	32
3	Mudkhed	MUE	02	000	2000	1-40	40	991-922	70
4		MUE-MGC B/S				117-114	4	921-890	32
5	Mugat	MGC	02	001	2001	41-80	40	889-840	50
6		MGC-MTDI B/S				113-110	4	839-808	32
7	Maltekadi	MTDI	02	002	2002	1-30	30	807-748	60
8		MTDI-NED B/S				109-106	4	747-716	32
9	Hazur sahib Nanded	NED	02	003	2003	31-80	50	715-588	128
10		NED-LBG B/S				105-102	4	587-556	32
11	Limbgaon	LBG	02	004	2004	1-25	25	555-506	50
12		LBG-CRU B/S				101-98	4	505-474	32
13	Chudawa	CRU	02	005	2005	26-50	25	473-414	60
14		CRU-PAU B/S				97-94	4	413-398	16
15		PAU-MRV(Akola jn) B/S				93-91	3	397-382	16
16	Purna	PAU	02	006	2006	51-90	40	381-252	130
17		PAU-MQL B/S				120-117	4	251-220	32
18	Mirkhal	MQL	02	007	2007	1-30	30	219-150	70
19		MQL-PIZ B/S				116-113	4	149-118	32
20	Pingli	PIZ	02	008	2008	31-80	50	117-48	70
21		PIZ-PBN B/S				112-109	4	47-1	47
22	Parbhani	PBN	02	009	2009	1-50	50	1023-884	140
23		PBN-PG B/S				108-105	4	883-852	32
24		PBN-PKNS B/S				104-101	4	851-812	40
25	Pergaon	PG	02	010	2010	51-70	20	811-752	60
26		PG-DAV B/S				100-97	4	751-720	32



## 5.8 Power Supply requirements

### Loco TCAS Equipment

The equipment shall work on DC supply source normally consisting of accumulator battery and / or an auxiliary generator. The nominal and limits of voltage in which the equipment shall operate satisfactorily are as under.

**Table 13: Power Supply requirements for Loco TCAS**

Type of Locomotive	Nominal Voltage	Limits of Voltage
Diesel-Electric	72 Volts DC	50 to 90 Volts DC
Electric, EMUs, DEMUs, MEMUs etc.	110 Volts DC	78 to 136 Volts DC

### Station/LC/IB TCAS Vital Computer & Tower

Stationary TCAS Unit shall be capable of working in electrified as well as non-electrified territories. Station/LC/IBS Vital Computer and tower shall work with input voltage of +24V or +110 V DC, (+30%, -20%). The 110 volt DC supply from IPS room to TCAS rack at Interlocked Stations shall be provided with duplicated cable with suitable gauge (Min 10 Sq. mm) so as to ensure that voltage drop in cable shall not be more than 1.0 volt from integrated power supply (IPS). Each cable shall be protected with an individual isolator and fuse of suitable capacity. Accordingly requirement of additional DC-DC converters may be planned as per the availability of spare modules. At present one SMPS based 110V/24-32V DC- DC converter containing 4 no. of 24-32V, 5 Amps DC/DC converter (internal (1+1), external (1+1)) is considered for each typical 4 Road station.

## 5.9 Trenching and cabling requirements

Generally the cable laying confines to Relay Room, OFC hut and tower location (100m-200m approximately) in station yard.

If RIUs are needed for nearest LCs or end cabins, laying of OFC is required.

SM OCIP at SM's room will be connected to STCAS at relay room.

The requirement of cabling and trenching can be summarized as given below:

- IPS to Tower and IPS to STCAS (110V DC) - Power cable.
- From Stationary TCAS to the location box near tower - Dual OFC and dual power cable in diverse path.

- STCAS/LC TCAS to nearest station OFC hut - 6 quad cable or OFC (alternatively existing media as per availability of spares)
- For NMS connectivity SMOCIP in SM Room to STCAS in Relay Room:
  - For button, counter & power supply. - 12 Core Signalling cable.
  - For communication - 10 pair PIJF cable
- STCAS to RIU (In Auto-Section, IBS, LC Gate/cabin) in diverse path - OFC Cable.
- RF Cable from Radio Modem to Radio antenna. (min LMR 600 of amphenol/heliox)

### 5.10 Station /LC/RIU/TCAS

Requirements of Station/LC/IBS TCAS Vital Computer shall be as given below:

- Station/LC/IBS TCAS Vital Computer architecture shall be minimum 2 out of 2.
- One Station TCAS and one 40m high tower per station assuming that a 40 m high TCAS tower will have 4.5 km radio range on each side.
- If signals of the any interlocked LC gate/IB is situated beyond 4.5km from the station a separate LC TCAS and TCAS tower to be considered as per the RSSI survey.
- If signals of the any interlocked LC gate/IB are situated within 4.5 km from the station i.e. within the radio coverage of the station tower, a separate RIU may be considered without tower for capturing the signalling information.
- In case of end cabins, RIUs may be considered at cabins and connected to STCAS at central relay room location through OFC.
- In Auto-section, RIUs may be considered at each signal location at every 1km (for both up & down signals) or at signal goomties wherever radio coverage is available otherwise LC TCAS with tower may be considered.

### 5.11 Station/Frequency/Time slot plan for FDMA-TDMA

- Communication between the Stationary TCAS and Loco TCAS shall be Over-The- Air using Multiple Access.
- Each Multiple Access frame cycle shall be of 2000 milli seconds.
- It shall be suitable for communication in frequency range of 406 MHz to 470 MHz.
- Loco TCAS shall use transmit frequency (f0) in block section and at the times of emergency situations (SoS, head-on, rear-end collisions).

[Table of Contents](#)

- Stationary TCAS and Loco TCAS shall use their respective timeslot(s) in the Multiple Access within their channel for the transmission of communication packet(s).
- Stationary TCAS System shall transmit the Radio packet in its designated time slot.
- Loco TCAS System shall transmit the radio packet in its designated time slot and designated frequency channel received from stationary TCAS Unit.
- The frequency pair allotted for two adjacent stations shall be different.
- The Loco time slot for the same station shall not be adjacent to each other (minimum one time slot gap shall be kept).
- The time slot distribution charts shall be prepared for the maximum design limit and functional testing for the same shall be carried out.
- Stationary and Loco TCAS timeslots and frequency channel pairs shall be approved by User Railway. Care should be taken so as to not allocate adjacent time slots at the same station. (Ref. RDSO TAN 5001)

For detailed information on TCAS Multiple Access Scheme & Radio Communication Protocol please refer RDSO Specification No. RDSO/SPN/196/2012 Ver. 3.2 or latest.

## 5.12 TCAS Radio Modem Requirements

### UHF Radio Modem Requirements

As per RDSO Specification No. RDSO/SPN/196/2012 Ver. 3.2 or latest, UHF Radio Unit shall be as per following specifications:

- (i). Shall be FCC or IC or CE certified
- (ii). Shall possess RTS/CTS and/or DOX modes
- (iii). Shall be capable of RF Data Transfer in “Bitwise” / streaming Mode
- (iv). RF frequency range: 406-470MHz
- (v). RF Channel Bandwidth : 25kHz
- (vi). Modes of operation Full Duplex
- (vii). Modulation : 2FSK at 19200 bps with linear 8th order low pass filter (raised – cosine alpha.1 approximation).
- (viii). Deviation : 4.3 kHz +/- 0.1kHz. Occupied Bandwidth :16.35 kHz +/- 0.15 kHz
- (ix). Operating frequencies : Ranging from 406 MHz to 470 MHz
  - (a). Transmission by Station / Interlocked LC Gate / IBS : fs1, fs2, ....
  - (b). Regular Transmission by Loco : fm1, fm2, ....
  - (c). Additional Transmission by Loco dedicatedly for emergency : f0

[Table of Contents](#)

- (d). It shall be possible to set other frequencies in the range specified above, if so required at later stage.
- (x). Emission : according to 16K0F2D
- (xi). Transmitter freq. stability : 1 ppm
- (xii). Transmitter Turn-on time (Tx. Freq. stable)/ Channel Switching time: not more than 15msec.
- (xiii). Carrier Output Power: 1-10 w adjustable through software.
- (xiv). Receiver Adjacent Channel Rejection 70dB at 25kHz
- (xv). Receiver Sensitivity: 35 micro-volts for 12 dB SINAD /
- (xvi).  $1 \times 10^{-6}$  BER at -100 dBm Level for 19.2kbps and 25kHz Bandwidth
- (xvii). Interfaces: RS232
- (xviii). RF Impedance : 50 ohm
- (xix). Power Supply : 10V-30V DC
- (xx). Set-up and Diagnostic features to be available through separate port RS232 and real time non-intrusive online diagnostics.

# Chapter VI

## TCAS Field Execution & Commissioning

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### 6.1 Introduction

Field execution work of TCAS is the post-tendering stage which shall involve following stages:

- Site survey for spare relay contacts, space in relay room, tower location and cable laying.
- Site survey for Radio signal strength for towers locations
- Submission and approvals of interface circuits, RFID layouts, TOCs, RFID tag data & tower site locations.
- Design approvals for Tower structure, its foundations and inspection clause.
- Execution of Tower related activities at field like soil testing reports, excavation, foundation, tower fabrication and erection and fixing of antenna, connectivity to Radio modems.
- Relay room activities & Cable trenching and laying.
- Inspection of materials at OEM premises.
- Programming and fixing of RFID tags
- Factory Acceptance Test of TCAS
- Installation of STCAS and testing.
- Site acceptance test along with various test scenarios with loco trials.
- Interoperability trials (Vendor Interoperability and Version Interoperability).
- Dynamic testing and trials and commissioning.
- Safety case evaluations.
- Safety files containing all documentations right from conception to commissioning & handing over.

Some stages of the above list like Site survey and design approvals have been covered in Chapter IV and V respectively. The details of some of the above stages are given in following paragraphs:

## 6.2 RFID Tag installation

RFID Tags are provided in block section at every 1 km and in station yard for each track and signal. RFID Tags are used for track identification, correction of location of train and identifying train direction

### RFID Installation Guidelines

Following guidelines shall be followed while fixing RFID tags:

- RFID tags shall be fitted on track in station section, point zones, near Signals & track in block section for giving Tracksides information to Loco TCAS unit.
- RFID tags at all the places shall be duplicated with identical information related to operations except for Unique ID and other such information by OEM Factory.
- The RFID tags shall be fitted on the sleepers between the rails as per guidelines given for Indian Railways (Refer RDSO Specification no. RDSO/SPN/196/2012 ver. 3.2 or latest)
- RFID tag shall be as per following specifications:
  - (i). Suitable for reliable working at train speed upto 200 KMPH (minimum).
  - (ii). Frequency of operation: 865-867 MHz
  - (iii). Can be programmable with minimum 128 bits (including CRC) of user data.
  - (iv). Shall be able to work even when submerged in water up to rail level
  - (v). Communication Protocol – EPCGEN2-ISO-18000-6D
  - (vi). Shall have minimum IP 68 protection. It shall work after being submerged in 1 m depth water for 24 hours.
  - (vii). Other requirements like environmental, climatic etc. as per RDSO/ SPN/144.
  - (viii). Under field operating conditions RFID reader antenna shall be able to read RFID tag from a vertical distance of 700mm from bottom of RFID reader antenna to top of the rail level.
- The installation of RFID reader antenna would be done in such a manner so that the vertical distance from bottom of RFID reader antenna to top of the rail level is 450mm  $\pm$  50mm and it is normally at the centre of rolling stock with offset permissible to  $\pm$  100mm in horizontal plane..
- RFID tags shall be fixed at the center of PSC Sleepers and emit RF signal only when corresponding type of RFID antenna is in vicinity (Normally underneath a Locomotive). The normal spacing of RFID tags will be about 1 Km, which may get reduced in vicinity of stations.
- No holes shall be drilled in the Sleepers and the arrangement of fixing must be through clamps only. Due care shall be taken that damage/ puncturing to PSC sleepers is not caused.





**Figure 36: RFID Tag installation**

- The topmost portion of the Fixing Arrangement, when installed, should not be more than 75mm above the top surface of PSC Sleeper at center. The installation would be done in such a way that the width of the RFID Fixing Arrangement along the length of PSC Sleeper does not exceed 380mm.
- All the RFID Tags shall be marked at the bottom with tag number and tag type. The marking shall be as follows:
  - RFID Number
  - Type
  - Absolute Location

While deciding the location for RFID installation following aspects shall be kept in view:

- RFID tags & fixtures shall be avoided in turnout portion in general. In any case, these shall not be located in switch portion of turnout i.e. from Actual Toe of Switch (ATS) to heel of switch.
- The installation of RFID tag & fixture should be avoided at locations susceptible to ballast accumulation at the center of sleeper such as level crossing etc. This aspect needs to be taken care at the time of survey itself.
- The performance of RFID tag may get degraded during RFID Fixture getting submerged in water. Therefore, installation should be done considering this fact.

- In case of mobile flash butt welding of rails, the rail temperature may increase to 800 ~ 900° C and sometimes hot splinters may also hit the fixture with pressure. So RFID tag installation should be planned well away from Rail Joints.

### 6.3 Tower related activities

Following are the activities related to tower erection:

- Soil Test to be done by a reputed/Government approved institute
- Selection of foundation design as per soil test report : based on Soil Bearing Capacity
- Tests during
  - (a) Foundation- Sand test, Cement test, Cube test, Metal test, Bolt test, Steel test, TMT Bar test
  - (b) Erection - verticality test, galvanization check
- Foundation & Tower installation to be done in co-ordination with Civil Engineering department.
- After erection, activities like Tower painting, fencing, earthing (ring earth), Lightening arrestor & Aviation lamp fitting.
- Installation of Radio modem, protocol converter at base of tower location.



*Figure 37: Tower installation*

### 6.4 Installation of communication equipments

There are 5 Frequencies in use for TCAS installation:

441.8 MHz, 456.8 MHz, 416.8 MHz 466.8 MHz, 426.8 MHz. Communication is FDMA-TDMA based.

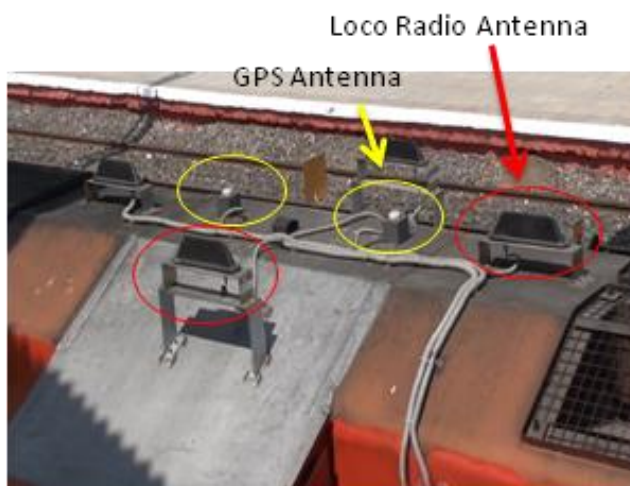
Following components are to be installed:

- Installation of Radio Modem: 406-470MHz, 25KHz BW
- Installation of Station Radio Antenna: Stacked Dipole, Omni directional, Gain 9dBi
- Installation of Loco Radio Antenna: Radome, Omni direction, Gain 3 dBi
- Installation of GPS antenna: For time synchronization





*Figure 39: Station Radio Antenna*



*Figure 40: GPS Antenna & Loco Radio Antenna*



*Figure 38: Radio Modem*

## 6.5 Station/IB/LC TCAS related activities

### Relay wiring and testing

This is done to check interface between Station interlocking and TCAS:

- WKR, ECR, Berthing TPR, Calling ON TPR, LSS TPR, ASCR, LXPR
- In case of combination signals, relevant DXR/GXR wiring to be carried out.
- The above repeater relays are picked (need based) in Relay room
- Wiring: Parallel contact with double cutting

New relays are to be wired in Data logger

### Installation of STCAS/LTCAS/RIUs

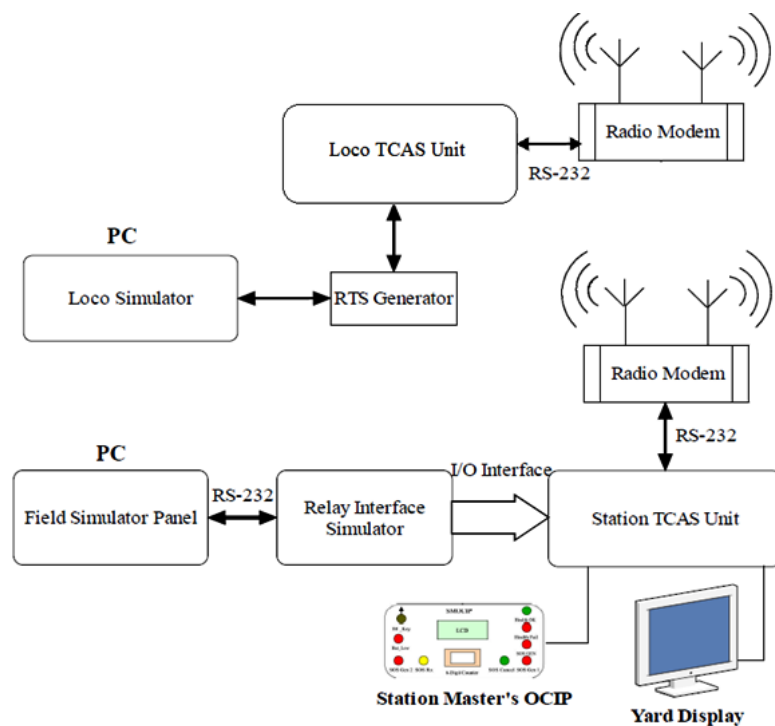
Installation of STCAS/LTCAS/RIUs is done with necessary earthing arrangement

Extension of 110V DC power supply from IPS (TCAS Load ~ 2.5Amp)

## 6.6 Testing & Commissioning

### Application logic FAT testing

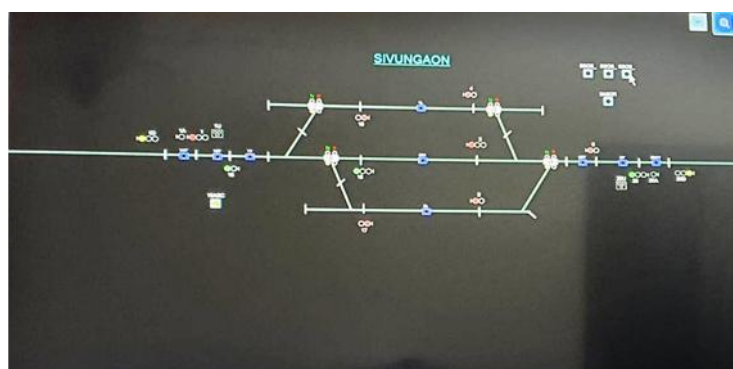
- Loading of application Logic
- For the station specific and loco specific application software, Factory Acceptance Test (FAT) will be conducted by Railways as per RDSO's guidelines. These guidelines are based on the FAT test format for Stationary TCAS equipment confirming to RDSO/SPN/196/2012 version 3.2 or latest.
- FAT to be done at officer level consisting of following:
  - Verification of STCAS Table of Control
  - Verification of Static Speed profile
  - Verification of Gradient profile of section
  - Verification of LC Gate location data
- Testing of Point status for T-tags
  - STCAS unit check the status of points, while T-tag is read. This is done to avoid SOS generation in case T-tags placed at turn-out is read while train is passing on the main line.
- Checking of Station and loco time slot allotment, frequency allotment.
- Central repository system (for application version control) must be maintained with division HQ



**Figure 41: FAT Test Set up arrangement**



**Figure 42: TCAS Loco Simulator**



**Figure 43: Field Simulation Panel**

**Other Test cases**

- RFID miss
- RFID sequence mismatch

Testing of Station Configurable Parameters (Left to the choice of Zonal Railways)

**Table 14: Station Configurable parameters**

S. No.	Parameter	Check/Remarks
1	Station Time Slot	Station TCAS Unit shall send the Radio Communication packet in its designated Time Slot.
2	Loco Time Slot	Station TCAS shall transmit the Tx window Slots to Loco TCAS units as per the configured data.
3	Station SOS	Simulate SOS from Field Simulator Panel.
4	Train Length	Simulate Train passing through AT and BT track circuits by using Field Simulator panel.
5	Station Entry & Exit points for Radio Communication	Simulate the Loco Position from the Station Entry point (Radio Communication Required from Loco)
6	Present and Next station ID	Station ID & Next Station ID are configurable in the Station Application Data.
7	Shunt Limits	Simulate Loco Movement beyond BSLB limit in shunt mode.
8	Ahead signal Aspect Time Out	Aspect of signal ahead must be verified to stabilize within 2 seconds

**Site Testing activities**

Post successful completion of FAT testing at OEM premise, site acceptance test will be conducted by Railway Official to check features such as SPAD Prevention, Override etc as per RDSO specification.

- Conducting Trials for scenario testing:
  - SPAD prevention, collision avoidance, roll back protection
  - Speed control (loop line, PSR), SOS, Signal update (format to be linked)
- Safety Case & its Approval.
- Adaptability of the System by the end user.
- Involvement of Loco Inspector, Traffic Inspector is necessary while conducting scenario testing.
- JPO to be signed with department involved in operations for conducting SPAD, collision avoidance etc.
- Stationary TCAS outputs at site can be checked using Loco simulator.

**Commissioning of STCAS/LCTCAS/RIUs**

Commissioning of STCAS/LCTCAS/RIUs is done after site testing.

# Chapter VII

## Assessment of Material Requirement for TCAS

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### 7.1 Introduction

Commissioning of a TCAS involves various stages like survey, design, planning, preparation of detailed estimates/schedule of works, tendering, execution of works (which includes trenching, cabling, installation of equipments, circuit wiring, Tower structure, foundation and civil works etc.) including testing & commissioning and maintenance aspects. An effort has been made to work out the basis for preparation of estimates for TCAS in the following paragraphs. This may help executing agencies in implementing TCAS in their respective railways.

Before preparation of estimates following information shall be collected and summarized:

- Total Route kilometre of the section in which TCAS is to be provided
- Total No. of stations in the section.
- Types of stations (3, 4 line or stations with bigger yards)
- Type of interlocking (PI/RRI/EI) provided in each station with MACLS.
- Total No. of Locos in the section likely to be TCAS equipped.
- Total No. of LC Gates falling inside Station TCAS territory.
- Total No. of Mid-Section IBs/ LC Gates. (falling outside Station TCAS territory – typically more than 5 Km from station on either side).
- Location of Network Monitoring System (NMS)
- Location & Total No. of Loco Sheds for provision of Loco TCAS Test Bench (for Maintenance, repair, testing & troubleshooting of Loco TCAS equipment at sheds).
- Location & Total No. of Stationary TCAS Test Bench (for Maintenance, repair, testing & troubleshooting of Station TCAS equipment).
- Location of Lab Model (To demonstrate entire functionality of TCAS)

Also following points shall be considered before preparation of estimates:

### 7.1.1 Stationary TCAS unit requirements

#### (a) At station

Stationary TCAS unit shall be housed at stations in Relay rooms. In case of non-availability of space, the TCAS unit may be kept in Equipment room constructed/available near by the interlocking equipment as per policy of Zonal Railway. Station TCAS installation includes modems, different antennae, relay rack erection and wiring, provision of power supply etc.

The power required for stationary TCAS will be taken from the available mains supply with suitable conversion arrangement.

#### (b) At mid-section LC Gate/IB locations

In case the radio signal strength of station tower is not adequate at adjacent mid-section LC Gate/IB locations, separate STCAS unit and tower to be installed at the said LC/IB location. Other requirements shall be same as that for stationary TCAS unit at station.

### 7.1.2 Remote Interface Unit (RIU) requirements

The following criteria shall be adopted for provision of RIU:

- (i). In case where concerned repeaters for signals of End Cabins/Distributed Interlockings/LC Gate/IB are not available at station, but radio signal strength of station TCAS tower is adequate at said End Cabins/Distributed Interlockings/LC Gate/IB location, separate TCAS RIU unit shall be installed at such location to bring the aspects over OFC to the nearby station whose radio tower is to be used. OFC Cable from STCAS to RIU (at LC/IB/cabin) in diverse path has to be laid to increase the availability of the network.
- (ii). In case the signal strength is not adequate at locations such as mid-section LC Gate/IB, separate STCAS unit and tower to be installed at the said LC/IB location as mentioned in 7.1.1. (b).

The locations of such installations shall be finalized based on the findings of RSSI signal strength survey, the details of which are mentioned in Chapter IV.

As a thumb rule, RIU may be placed at all LC locations which are less than 5 km from station. This is because radio signal strength may be adequate at such locations. For LC gates, which are more than 5 kms from station and radio signal strength is weak, separate TCAS unit and Tower may be installed.

In double distant territory, where distant or inner distant signal aspect is not available at station, the same shall be extended to approaching station by laying of cable. Cable for this



purpose will be supplied by the Railways. Alternately, the aspects of these permissive signals can be detected. The Railway will decide which option to exercise.

Suitable RIUs shall be provided in Automatic block section where Automatic Signalling is implemented by providing Signal Interlocking circuits in location boxes or Auto huts provided near signal posts to capture signal aspects. These RIUs shall be connected to a centralized Stationary TCAS unit to ensure functioning of TCAS in Automatic Signalling territory. Suitable power supply arrangement for RIUs is to be done by the concerned agency for this purpose.

### **7.1.3 Relay requirements**

The interface between Stationary TCAS and any interlocking system is through vital relay interface such as aspect relays (ECRs), Track circuits (Berthing track TPR), Point status relays (NWKR & RWKR), Route checking relays if any (UCR) and status of block instrument Line Closed condition. This interface is suitable to all types of interlocking systems but requires additional relays (repeaters), even if spare relay contacts are available. The wiring has to be done in a double-cutting arrangement with parallel contacts for each signalling input wired to TCAS. On an average, 60 nos. non-AC immunized relays are required for one Stationary TCAS unit.

### **7.1.4 Power Supply requirements**

#### **Loco TCAS Power Supply**

The DC power supply available in the locomotive (normally 72V DC in Diesel locomotives & 110V DC in Electric locomotives/EMU/MEMU) shall be used as a source of power supply for loco TCAS equipment. The contractor has to provide suitable arrangement for conversion of DC voltage to the level required for Loco TCAS equipment. Loco TCAS may use existing batteries in locomotive for TCAS equipment considering space constraints in locomotive to put additional battery.

### **7.1.5 Stationary TCAS Power Supply**

AT/Commercial power of 230VAC 50 Hz power supply shall be made available by the Railways in equipment room and 110V DC will be provided from IPS. TCAS power supply source shall be extended from the equipment room. Stationary TCAS shall require SMPS based 110V/24-32V DC-DC converters containing 4 no. of 24-32V, 5 Amps DC/DC converters [Internal (1+1), External (1+1)], if STCAS installations are of Medha & Kernex make. In case of HBL make STCAS installations shall require 110 V DC supply which will be taken from existing IPS. In case existing Power supply arrangement is not capable to cater

the power supply requirements of TCAS, augmentation of batteries/charger/IPS has to be done.

At LC gate locations in Non-Electrified Areas, capacity enhancement of solar panel OR batteries OR Provision of Mini IPS with 110V DC 200AH battery backup OR provision of DG set at such location shall be considered.

Power Supply Equipment shall include provision of 24V supply for Signal ECR repeater relays and any other conversion required for other modules.

#### **7.1.6 Tower location Power Supply**

Power supply (110 V DC) for both radio modems at tower location and aviation lamp shall be taken from power room in diverse path to ensure high availability of the system. Radio modems work on 24 DC hence DC-DC Converters 110 V/24 V DC are provided in Tower Location.

#### **7.1.7 Radio Communication & Tower requirements**

Every TCAS unit at station requires a tower with UHF transmitter/receiver to provide adequate radio coverage around the station for communication with the locomotives. Installation of tower includes, foundation, installation of necessary antenna (2 transmitting and 2 receiving), radio cables along with interfaces, all radio and OFC modems, surge protection devices, EMI filters, painting and fencing of tower, supply and fixing of aviation lamp along with necessary power supply arrangement for aviation lamp, modem etc.

Adjacent IBS/ mid- block section interlocked level crossing gate, where radio signal strength of station tower is not adequate, separate STCAS unit and tower to be installed.

Note:

*At present UHF Radio communication technique is being used for communication in TCAS and upgradation to LTE is underway. Specification for upgradation of the system to LTE for strategic communication applications is being done by RDSO. Hence the communication interfaces for TCAS shall be designed such that at a later stage if the system is upgraded to LTE then it shall be compatible to the upgraded technology without any major modification in current system.*



**7.1.8 Network Monitoring System (NMS) requirements**

Centralized Management System with connectivity to all Stationary TCAS units & GSM interface for connectivity with Loco TCAS units shall be provided for Monitoring, Diagnostic and Maintenance purpose. 2MB connectivity from station to station on existing OFC network of the railways is to be provided. The entire network connectivity of station/IBS/ mid-block section interlocked Level Crossing Gates and locomotive TCAS equipments is to be arranged. Necessary hardware, power supply etc. will have to be provided. In case of mid –section IB/LC location, provision for laying of separate cable for communication purpose should be done to provide NMS connectivity from the nearest OFC hut.

**7.1.9 Radio Signal Strength Survey requirements**

RSSI signal strength survey should be done by an expert agency to assess the strength of radio communication in the nominated TCAS section including LC gates. Tower location, height etc. may be finalized after initial radio signal strength survey to avoid failure due to obstruction like building, terrain etc. This includes site survey to finalize the location for installation of TCAS tower adhering to the stated guidelines and in agreement with Electrical, S&T and Civil engineering department and furnishing details to Railways for necessary approval.

**7.1.10 Track survey using Aerial Videography requirements**

The complete mapping of absolute location of the entire track for TCAS territory shall be done in the aerial survey. This should help in identifying the absolute location of nominated position of RFID tags and absolute location of signals.

**7.1.11 Loco TCAS Test Bench requirements**

Loco TCAS equipment shall be maintained in the Diesel and Electric loco sheds nominated by Railways. The purpose of test benches for Loco TCAS is to provide maintenance and repair of Loco TCAS equipment at sheds and also test and troubleshoot the Loco TCAS equipment when it is coming out of loco shed. Manual describing installation details of Loco TCAS test bench and its subsystems interconnectivity diagram and User manual for operating Loco TCAS test bench shall be supplied with the test bench.

**7.1.12 Stationary TCAS Test Bench requirements**

The purpose of test benches for Stationary TCAS is to provide maintenance, repair, testing and troubleshooting of Stationary TCAS equipment at designated locations. Manual describing installation details of Stationary TCAS test bench and its subsystems interconnectivity diagram and User manual for operating Stationary TCAS test bench shall be supplied with the test bench.

**7.1.13 LAB Model requirements**

LAB Model includes Two Stationary TCAS units, two Loco TCAS units along with Brake Interface unit, set of RFID tags with spares including all the components and simulator with final firmware suitable for lab demonstration as well as functioning in field with facility to test Multi-Vendor Interoperability. This shall include supply and installation of full components such as radio modem, power supplies, SMOCIP and other modems as deemed fit. LAB model shall be capable of simulating the entire field scenarios for a loco movement and shall be complete to convey the entire functionality of TCAS including collision prevention features.

## 7.2 Details of items for assessment of material for TCAS

The details of items for assessment of material for TCAS given in the tables below schedule wise. The quantity given under each item is for a **typical 4 line station on double line**.

### 7.2.1 Supply and Installation of TCAS

#### (1) Station TCAS Equipment

One set of Station TCAS equipment installation shall consist of following items as per RDSO/SPN/ 196/2012 Version 3.2 or latest:

- Suitable Rack consisting of Vital computer peripherals
- SMOCIP (Station master Operation Cum Indication Panel)
- 2 full duplex Radio modems
- OFC modems
- UHF antenna
- GPS and GSM antenna and interfaces.
- Earthing (Earth resistance less than 1 ohm) as per RDSO/SPN/197 Ver 1.0.
- Wiring of Electrical/Quad/OFC/Power cable.
- Relay wiring
- Connecting SMOCIP from station TCAS
- Tool kit
- Interlocking of relays including DC-DC converter and suitable power supply arrangement.
- Alteration in wiring for Data logger

One set of Station TCAS equipment shall be required per station.

#### (2) RFID tags with enclosures and fixtures.

- One set of RFID tags shall cover Supply Installation, Programming, Verification and Commissioning at Station and Block section. (Station and adjoining block section counted as one set).
- Installation as per guidelines available in RDSO's specification for TCAS RDSO/SPN/196/ 2012 ver.3.2 or latest and RDSO's Technical Advisory Note 5001 dated 20.02.2019

#### (3) IB/LC TCAS Equipment

One set of IB/LC TCAS equipment installation shall consist of following items as per RDSO/SPN/ 196/2012 Version 3.2 or latest:

- Suitable Rack consisting of Vital computer peripherals
- SMOCIP (Station master Operation Cum Indication Panel)

- 2 full duplex Radio modems
- OFC modems
- UHF antenna
- GPS and GSM antenna and interfaces.
- Earthing (Earth resistance less than 1 ohm) as per RDSO/SPN/197 Ver 1.0.
- Wiring of Electrical/Quad/OFC/Power cable.
- Relay wiring
- Connecting SMOCIP from station TCAS
- Tool kit
- Interlocking of relays including DC-DC converter and suitable power supply arrangement.

One set of LC/IB TCAS equipment shall be required per LC/IB location if it is not within the radio coverage of adjoining Station Tower.

#### **(4) RFID tags for mid section LC gates**

One set of RFID tags shall cover Supply Installation, Programming, Verification and Commissioning at mid section LC Gate.

#### **(5) TCAS Remote Interface Unit (RIU)**

One set of TCAS RIU installation shall consist of following items as per RDSO/SPN/196/2012 Version 3.2 or latest:

- All modems
- OFC termination box for 24 fibres
- Interface
- Earthing
- Wiring
- Signal functions etc.

- RIU should have provision of OFC or Quad Interface and connected to central TCAS in a Ring network.
- RIU to be provided at LC/IB locations where adequate radio signal strength of adjacent station tower is available.
- RIU can be provided at End Cabins/Distributed Interlocking Cabins for which concerned repeater relays are not available at station and adequate radio signal strength of station tower is available.

1 Set of RIU is required per LC/IB Location within radio coverage of adjacent Station Tower or per End Cabin/Distributed Interlocking Cabin with adequate radio signal strength of station tower and for which concerned repeater relays are not available at station.

**(6) Loco Equipment****(i) Loco TCAS Equipment**

1 set of Loco TCAS equipment installation shall consist of following items as per RDSO/SPN/ 196/2012 Version 3.2 or latest:

- Vital computer
- Driver Machine interface
- 2 RFID Readers
- 2 full duplex Radio modems
- 4 UHF antenna
- 2 GPS and GSM antenna
- 2 Pulse generator/Wheel Sensor with direction sensing
- Associated cabling
- Power supply arrangement

- This shall not include Brake Interface Unit.
- Initial survey of locomotives to be done to check the availability of space for installation of equipment with the approval of concerned Loco Shed officer-in-charge.

**(ii) Brake Interface Unit**

This shall be suitable for different locomotives in the section as per RDSO/SPN/196/2012 Version 3.2 or latest.

**(iii) Video Surveillance Camera**

This shall be for the purpose of Audio recording in loco with long distance coverage.

The quantity may be decided based on initial trials of loco.

**7.2.2 Testing & Training**

This shall cover Supply, Installation and Commissioning of following items for testing purposes and training of manpower:

- (i). Test Bench for Loco equipment (Diesel/Electric) – per loco shed
- (ii). Kit for configuring, programming and downloading RFID Tag data as per RDSO issued guidelines.
- (iii). Test Bench for Station TCAS equipment as per RDSO/SPN/196/2012 Version 3.2 or latest.
- (iv). Network Monitoring System (NMS) for Centralized monitoring of TCAS station and Loco equipment as per RDSO/SPN/196/2012 Version 3.2 or latest.

1 set is required at Divisional Control office

This shall include:

- Server of approved source in redundancy with 16GB DDR4 RAM, 1TB HDD.
- Windows Professional server 2012 or above, on both servers.
- Shared Firewall on both servers.
- Keyboard and Mouse, 55" 4K/UHD Professional TV.

*Note:*

- *2MB connectivity from station to station on existing OFC network of the railways is to be provided.*
- *In case of mid –section IB/LC location, separate cable for communication purpose to be laid to provide NMS connectivity from the nearest OFC hut.*

- (5) Kit for configuring, programming and downloading the execution and application data for Loco equipment.
- (6) Kit for configuring, programming and downloading the execution and application data for Stationary TCAS equipment.
- (7) Lab Models of station equipment, loco equipment, trackside components and simulator at designated location as per RDSO/SPN/196/2012 Version 3.2 or latest.

The lab model shall consist of:

- 2 Stationary TCAS units,
- 2 Loco TCAS units along with Brake Interface unit,
- Set of RFID tags with spares,
- Radio modem,
- Power supplies,
- SMOCIP
- Other modems
- All the components and simulator with final firmware suitable for lab demonstration as well as functioning in field with facility to test Multi-Vendor Interoperability.

### 7.2.3 Survey

#### (1) Site Survey

Site Survey shall cover following items:

- Survey for Tower erection.
- RSS Signals strength measurement
- Measures to improve signal strength.
- Study of braking characteristic of electric /diesel loco.
- Submission of drawings for installations of train borne and track equipments.
- Design and installation of track equipments
- Design and installation of system for radio survey
- Cable route survey

Note:

- (i). Tower location, height etc. may be finalized after initial radio signal strength survey to avoid failure due to obstruction like building, terrain etc.
- (ii). Design of tower and foundation shall include wind velocity, soil bearing capacity, tower site, Ladder, Platform, Staging, Aviation Lamp and Earthing arrangement.

The job shall cover the entire section likely to come under TCAS territory.

#### (2) Aerial videography by unmanned Aerial vehicle (UAV-Drone)

The track survey shall be conducted using Aerial drone vehicle to study the complete track layout and identify curves. The complete mapping of absolute location of the entire track for TCAS territory shall be done in the aerial survey. This shall help in identifying the absolute location of nominated position of RFID tags and absolute location of signals. This is done to give entire track profile for placement of RFID tags and mapping of absolute location for signals etc. The unit is taken in Route kilometres.

### 7.2.4 Testing & Commissioning

Testing & commissioning of TCAS system in the entire system

One job is taken as entire section

### 7.2.5 Drawings & Documents

#### (1) This shall cover Design & Supply of following drawings/documents :

- Cable route plan
- Circuit diagram
- Contact analysis

- RFID tag data
  - Stationary TCAS connectivity diagram
  - RFID Tag- TIN layouts
  - Table of Control for entire section
  - Stationary and Loco TCAS interface diagrams
  - Power supply diagram
  - Frequency plan
  - TDMA based time slot allotment chart.
  - Other manuals and technical documents.
- 6 sets per station or as per railways' requirement.

### 7.3 Signalling items

Following signalling items shall be required for commissioning of TCAS:

- (1) Relay, Non-AC immune plug in type, style QN1, DC neutral line, 24 V, 12F/4B contacts, metal to carbon with plug board, retaining clip & connectors conforming to BRS: 930, IRS S34 & IRS: S 23 (as applicable)
  - To pick up repeaters of internal relays of station TCAS.
  - 60 Nos. per station/IB/LC Gate STCAS location
- (2) Relay AC immune, plug -in- type Style 'QNA1, DC neutral line, 24V, 12F/4B contacts, metal to carbon with plug board retaining clip and connectors conforming to BRS 931A, IRS-S60, IRS-S34 and IRS-S23 (as applicable).
  - To pick up repeaters of relays outside station TCAS such as Lamp proving relays of distant signal.
  - As per requirement at station.
- (3) Lead Acid Secondary cells of capacity 2V, 200AH
  - For provision with Mini IPS at LC locations in non -RE area.
  - 55 Nos. Per LC Location in Non-RE area
- (4) 2 way Relay Rack universal type with scaffolding complete
- (5) SMPS based 110V/24-32V DC-DC converters
  - 4 nos. of 24-32V, 5 Amps DC/DC converter (internal (1+1), external (1+1)).
  - 1 Set per station/IB/LC Gate STCAS location, for Medha & Kernex Make STCAS installations.



#### 7.4 Other Miscellaneous items

In addition to above supply of following items shall be considered as per requirement at station /LC/IB locations and RIU locations:

- Optical Fibre Cable (from Station TCAS to Tower location, Station TCAS to OFC Hut, STCAS to RIU.
- RF Cable (from Radio Modem to Radio antenna min LMR 600 of amphenol/helias)
- 12 Core signalling cable (SMOCIP in SM Room to STCAS in Relay Room For button, counter & power supply)
- 10 pair PIJF cable (SMOCIP in SM Room to STCAS in Relay Room for communication)
- PVC insulated wire multi-strand per conductor 10 Sq mm flexible (For power supply from IPS to STCAS and Tower)
- PVC insulated wire copper conductor 16/02 mm (For relay wiring)
- Terminal block 1 Way PBT 60 mm/ 6 Way PBT 25mm
- WAGO Terminal
- Non-deteriorating type of fuse holders and fuse links
- Lightning and surge arrestors of class B&C
- Hylam sheet, resin bonded, 6mm thick,
- Relay fixing frame for Full location box
- Digital Multimeter
- Digital insulation tester
- Electronic earth tester
- Portable Cable fault locator (Metallic Time Domain Reflectometer) with all accessories for locating faults in underground telecom quad cables, signalling cables, telephone jelly filled cables, LAN etc.
- Cable Route locator
- Concrete (RCC) route indicators at intervals of 50 meters as per technical specification
- Clip On Meter
- HDPE telecom duct
- E type locks of different ward (For location boxes)
- GI Pipe 65 mm dia. with couplers.
- Double walled corrugated pipe
- DG set self start 10 KVA single phase (In Non-RE area)

## 7.5 Labour portion

This shall include following type of items:

- (1) Excavation of trench in different types of soils and cutting of rocks for laying of cables.  
When RIU is not required - 1 Route Km per Station  
When RIU is required - 5 Route Km per station per RIU.
- (2) Laying of different cables in trenches
- (3) Supply and installation of Maintenance free earth.
  - Copper Bonded Rod 10 feet long -17.2mm dia - 1No
  - Earth enhancing compound - 20kgs (as per RDSO recommended sources)
  - Copper Bus bar 25x6x150mm -1no.
  - Digging the earth to required depth
  - Insertion of 1 no of earth electrode
  - Filling of earth enhancing compound
  - Provision of exothermic weld connection on copper tape of 25mmx6mmx150mm to earth electrode
  - Provision of exothermic weld connections, one to connect the cable and another to the copper tape welded to the earth electrode
  - Provision of concrete structure of size
- (4) Erection of Relay rack 1way / 2way /4way with scaffolding.
- (5) Supply and Installation of OFC joint enclosure and splicing of Optic fiber cable (24 fibers) and testing.
- (6) Installation of OFC joint enclosure and splicing of Optic fiber cable (24 fibers) and testing
- (7) Straight through / derivation with/without transformer joints.
- (8) Blowing of armoured optic fiber cable into the duct.
- (9) Foundation and erection of Full size Location Box.
- (10) Numbering & Writing work
- (11) Installation and commissioning of SMPS based 110V/24-32V DC-DC converters
- (12) Final location survey of cable route and final preparation of cable route plan as per technical specification
- (13) Any other TCAS related works identified by respective Zonal Railways

## 7.6 Spares for TCAS

Spares shall include following items:

- (1) Spares for Stationary TCAS unit (Station/IBS/LC)
- (2) Spares for RFID tags
- (3) Spares for TCAS RIU unit
- (4) Spares for Loco TCAS Unit (Electric/Diesel)

## 7.7 Comprehensive Annual Maintenance Contract for TCAS System

The Comprehensive Annual Maintenance Contract for TCAS System shall include following items:

- (i). Comprehensive Annual Maintenance Contract for On-Board TCAS System
- (ii). Comprehensive Annual Maintenance Contract for Trackside TCAS System

Note:

AMC shall include Preventive maintenance, Proactive maintenance, Breakdown maintenance and Predictive maintenance of both software and hardware of the On Board and Trackside TCAS equipment installed under a particular tender.

The contractor shall maintain adequate spares, required for maintenance of system during such period.

## 7.8 Engineering portion

The Engineering portion shall consist of following items:

- Design, supply, Installation & Commissioning of 40 Meter Lattice tower at station including foundation work, fencing, painting, earthing (earth resistance less than 1 ohm).
- Earth work – Excavation, Filling, Watering and Ramming.
- Various civil construction, repairs, painting and alteration works near tower and in buildings/floors/ceilings/doors/windows of station master's room/power equipment room/battery room/relay room/LC Gate hut/IB hut/OFC hut in connection with TCAS installation.

## 7.9 Electrical portion

Electrical portion shall consists of following items:

- Supply of various electrical wires, fuses, MCBs etc.
- Supply and erection of electrical junction boxes, distribution boards, surge protectors, structural bonds etc.
- Supply and erection of electrical appliances such as ceiling fans, CFL/LED lights, exhaust fans etc.
- Provision of ordinary earthing arrangements including earth pit chamber, earth electrode and earth bus.

**Annexure - I**

**RDSO Technical Advisory Note No.**  
**STS/E/TAN/5001**

**for**

**System Improvements regarding**  
**Installation of Stationary Train Collision**  
**Avoidance System**



भारत सरकार – रेल मंत्रालय  
Government of India –  
Ministry of Railways  
अनुसंधान अभिकल्प और मानक संगठन  
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No: STS/E/TCAS/Vol-XIX

Dated :20.02.2019

CSTE/Project  
South Central Railway  
Rail Nilayam, Secunderabad,  
Telangana-500025

**Sub:** Technical Advisory note for System improvements regarding installation for Stationary Train Collision Avoidance System

**Ref:** TCAS specification RDSO/SPN/196/2012 ver 3.2

Please find attached Technical Advisory note No STS/E/TAN/5001 Ver 1.0 dated 20.02.2019 regarding installation for stationary Train collision Avoidance System.

The Technical Advisory note No: STS/E/TAN/5001 ver 1.0 dated 20.02.2019 regarding installation for stationary Train collision Avoidance System shall be implemented in all the future work of TCAS project.

*G. Pavan Kumar*  
(G. Pavan Kumar)

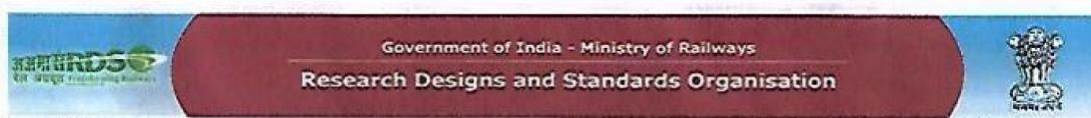
Director/Signal-V  
for Director General/Signal

DA: As above

**Copy To:**

- I. Dy CSTE/Tele/Project/SC, South Central Railway, Rail Nilayam, Secunderabad, Telangana-500025.
- II. Medha Servo Drives Pvt. Ltd., P-4/5 P-4/5B, Industrial Park, Nacharam, Hyderabad-500076
- III. Kernex Microsystems (India) Ltd., "THRUSHNA", Plot No. 7, Software Units Layout, Infocity, Madhapur, Hyderabad – 500081
- IV. HBL Power Systems Limited, 8-2-601, Road No.10, Banjara Hills, Hyderabad-500034 (A.P.)





TECHNICAL ADVISORY NOTE			
Subject	System Improvements regarding Installation for Stationary Train Collision Avoidance System		
Document No.	STS/E/TAN/5001	Version	1.0
Date	20.02.2019	Pages	04

**1. Scope:-**

These guidelines are issued based on field experiences of Stationary Train Collision Avoidance System during the development project period. These guidelines shall be followed by the Zonal Railways during the installation to reduce the failures of system. These guidelines will help in further improving the reliability of TCAS installation.

**2. Installation arrangement of RFID Tags:-**

**2.1 Installation of RFID Tag in sleeper: -**

The RFID tag enclosure shall be good quality of FRP material and fitment clamp shall be made of stainless steel of grade 316 to avoid the corrosion and environmental effect.

**Reason:**

*As the clamps are being used on sleepers, these are prone to different environmental conditions such as dampness, wetness, heating, UV-IR exposure, human excreta; it is proposed to use high quality metallic as well as non metallic material for fitment.*

**2.2 Placement of adjustment tag/ junction tags:-**

Adjustment tag shall be placed beyond 350 meter of Communication Mandatory Zone.

**Reason:**

*This will remove the unnecessary EBs or SOS Messages (Fault code) as Loco TCAS is not in communication mandatory zone i.e., minimum 1850m beyond the Last Stop Signal (Clause 6.8.3.1 a).*

**2.3 Distance between the two Normal Tags:-**

The maximum distance between the two normal tags shall not be more than 1000m.

**Reason:**

*To minimize the accumulated odometric error (Clause 5.4.1.2.6.2).*

**2.4 Provision of S-type Tags at the Block Section limits (Yard exits):-**

S-type tags shall be provided at the Yard Exits not protected by signals like BSLB etc.,.

**Reason:**

*To protect the TCAS equipped train not to enter into block section in shunt mode.*

Document No:STS/E/TAN/5001	Dated :20.02.2019	Page 1 of 4
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### 2.5 Provision of Normal-Tags in lieu of Signal Approach Tags:-

Normal Tags only can be linked. Hence, to ensure linking up to the nearest location to the approaching signal, Normal Tags shall be provided in lieu of Signal Approach Tag in future installations.

### 2.6 Marking of RFID Tag number and Type at the bottom:-

All the RFID tag shall be marked at the bottom with tag number and tag type. The marking shall be as follows:-

RFID NO:

Type :

Location :

**Reason:**

*To facilitate easy identification for re-installation of RFID Tags removed during PQRS works.*

### 3. Installation of stationary TCAS:-

### 3.1 Numbering Scheme for Stationary TCAS:-

The **first two digits** are allotted to each zonal railway as shown in the table below and Zonal railways may decide the **last three digits** for the stations. A proper record shall be maintained by the Zonal Railways to avoid repetition of number as station ID should be unique number.

Sl. No	Name of the Railway Zone	Allotted code	Sl. No	Name of the Railway Zone	Allotted code
1.	South Central Railway	00-02	11.	North Western Railway	30-32
2.	Northern Railway	03-05	12.	West Central Railway	33-35
3.	North Eastern Railway	06-08	13.	North Central Railway	36-38
4.	Northeast Frontier Railway	09-11	14.	South East Central Railway	39-41
5.	Eastern Railway	12-14	15.	East Coast Railway	42-44
6.	South Eastern Railway	15-17	16.	East Central railway	45-47
7.	Southern railway	18-20	17.	Metro Railway Kolkata	48
8.	Central railway	21-23	18.	Konkan Railway	49
9.	Western Railway	24-26	19.	RDSO, Lucknow	50
10.	South Western Railway	27-29			

3.2 TCAS Wiring Diagram and configuration detail shall form part the S&T circuit diagrams issued by Zonal Headquarters and these documents shall be placed in all the relay rooms and shall be treated as part of station S&T documents.

## Reason:

*This will ensure that TCAS circuits are also altered whenever signal alterations are carried out by the Zonal Railways.*

3.3 Parallel Wiring of Relay Contacts read by Stationary TCAS shall be carried out.

Document No:STS/E/TAN/5001	Dated :20.02.2019	Page 2 of 4
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**Reason:**

*To minimize the failure of Movement Authority/out of correspondence of signal aspect at site and Loco OCIP, due to high contact resistance of relays, the parallel wiring of relay contacts.*

**3.4 Unavailability of repeaters ECRs for inner Distant and Distant Signal of IB:-** If such IBs are available, the OFC need to be tapped at the signals and RIU can be installed or the aspects of these permissive signal can be deduced. Zonal Railways can choose either of these options.

**3.5 Wiring of SM OCIP:-** 12 Core Signalling cable shall be used for button, counter & power supply. 10 Pair PIUF cable shall be used for communication portion.

**3.6 Diverse Path for routing of GSM and GPS Cables:-** The cables for one set of GSM/GPS Antenna shall be routed in one path and another set shall routed in diverse path to avoid failures due to cable cuts at a single location.

**3.7 Diverse path for wiring of RIU:-** In Auto-Section, IBS, Gate, RIU shall be connected to stationary TCAS with diverse path of OFC in redundant manner.

**3.8** All the cable entry and exit at relay room and location box near tower shall be completely sealed to avoid rodent entry.

**3.9 Power Supply arrangement:-** The 110 volt DC supply from IPS room to TCAS rack at Interlocked Stations shall be provided with duplicated cable with suitable gauge (Min 10 Sq. mm) so as to ensure that voltage drop in cable shall not be more than 1.0 volt from integrated power supply (IPS). Each cable shall be protected with an individual isolator and fuse of suitable capacity.

**Reason:** *Duplicated cable is provided from IPS to TCAS to have redundancy of power supply connection to equipment and to prevent failure due to rat cut or any other damage.*

*Cable voltage drop is restricted to 1 volt to avoid overloading of cable & also ensure correct AWG and quality wires.*

**3.10** Reliable Power supply such as mini IPS with backup of 8-10 hour shall be provided at mid section, LC gates specially in Non RE area section to avoid failure due to non-availability of power.

**3.11** The DC-DC converters provided for stationary TCAS unit shall be systems along with segregation of cabling and termination for power supply up to DC-DC converters shall be in N+1 configuration. It is advised that reliable DC-DC converters advised by OEMs shall be considered for better reliability.

**3.12** It shall be ensured that the TCAS equipments are earthed with shortest path to common earth bus bar in Relay equipment room. It shall be also ensured that front and back doors of TCAS cabinet shall be earthed using copper braid.

**4. Communication**

**4.1** Proper Radio Survey shall be carried out before deciding up on the location and height of towers to avoid failure due to obstructions like buildings, terrain etc.,.

**4.2** The mounting of all the antennae on the tower shall be at same level.





- 4.3 RF coaxial cable for the two Radios shall be routed in the different path. The coaxial cable shall be minimum LMR-600 of Amphenol/ heliax. As connectors are open to environment, they shall be provided with weather proof sealing.
- 4.4 The Radio tower shall be provided with lightening arrester (Franklin rod) and connected to earth along with aviation lamp.
- 4.5 Cable joints shall not be permitted from location box to antennae.
- 4.6 Dual OFC and dual power cable in diverse path shall be provided from Stationary TCAS to the location box near tower to avoid common mode failures.
- 4.7 The frequency pairs allotted for two adjacent stations shall be different. The loco time slots for the same station shall not be adjacent to each other (minimum one time slot gap shall be kept). Also slots, P2, P27, P41 and P65 shall be kept as reserved.
5. **General:**
  - 5.1. A policy at Zonal Railway shall be issued to get the changes in SiP/Table of control/field relay interface circuit/location change of signal post /PSR/LC Gates/Gradient is reflected in TCAS.
  - 5.2. It shall be ensured that Zonal Railway SIP and Table of Control shall be adhered for deducing the signal aspects and Movement Authority in TCAS.
  - 5.3. The Factory Acceptance Test (FAT) shall be verified by Railway official and Sample verification shall be done by minimum JAG officer during SAT (Site Acceptance Test)
  - 5.4. The pre-installation and pre-commissioning checklist for concerned TCAS shall be thoroughly checked at the site at the minimum Assistant officers' level jointly with the executing OEM.
  - 5.5. The modification in the application logic, TCAS control table, RFID layout shall be controlled with version control software station wise to avoid human error.
  - 5.6. The quality and integrity of the installation remains complete responsibility of the OEM. The firm must provide an OEM certificate regarding this before commissioning of any installation, any deficiency pointed out later, shall be done free of cost by OEM, this shall be confirmed by OEM before commissioning.

*G. Pavan Kumar*  
20/2/19  
(G. Pavan Kumar)

Director/Signal-V  
for Director General/Signal

Encl : As above

For any issues related to this TAN (Technical Advisory Note) please contact Director/Signal-V at RDSO, Lucknow (Rly phone- 032-42652, DOT-0522-2465750, Email: [dsig5rdsso@gmail.com](mailto:dsig5rdsso@gmail.com))

Document No:STS/E/TAN/5001	Dated :20.02.2019	Page 4 of 4
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# References

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- RDSO Specification of Train Collision Avoidance System, No. RDSO/SPN/196/2012 Ver. 3.2
- RDSO Technical Advisory Note for System improvements regarding installation of Stationary Train Collision Avoidance System, No.STS/E/TAN 5001 Ver. 1.0 dated 20.02.2019
- Information on TCAS provided by M/s HBL Power Systems Ltd., Hyderabad, M/s Medha Servo Drives Pvt. Ltd., Hyderabad and M/s Kernex Microsystems (India) Ltd., Hyderabad

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## **Annexure II**

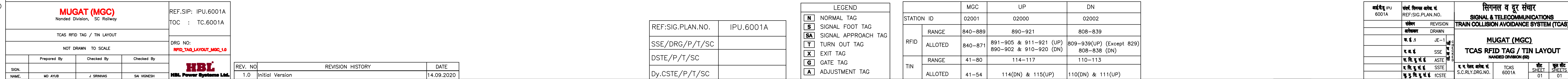
# **TCAS RFID Tag Layout , TCAS RFID Tag Data & TCAS Table of Control for Mugat Station, Nanded Division South Central Railway**

**Courtesy: M/s HBL Power Systems Ltd., Hyderabad**

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## Station ID:02001 (km : 362.610)

362.826 Km



LEGEND	
<b>N</b>	NORMAL TAG
<b>S</b>	SIGNAL FOOT TAG
<b>SA</b>	SIGNAL APPROACH TAG
<b>T</b>	TURN OUT TAG
<b>X</b>	EXIT TAG
<b>G</b>	GATE TAG
<b>A</b>	ADJUSTMENT TAG

वाईरिंग IPU 6001A	संकेत, सिगनल नोटेशन सं. REF:SIG.PLAN.NO.	सिगनल व टूर संचार SIGNAL & TELECOMMUNICATIONS			
संश्लेषण नोटेशन	REVISION DRAWN	TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
क. ई. 1	JE - 1	MUGAT (MGC)			
द. व. ई.	SSE	TCAS RFID TAG / TIN LAYOUT			
च. सि. टू. सं. ई.	ASTE	NANNED DIVISION (02)			
द. सि. टू. सं. ई.	SSTE				
कु. टू. सि. टू. सं. ई.	FCSTE				
		द. व. संश्लेषण नोटेशन सं. S.C.RLY.DRG.NO.	TCAS 6001A	शीट 01	कुल शीट 01


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Table of Contents



FIELD NAME	Normal Tag with Speed Info		Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag
	Bit positions	No. of bits								
Type of Tag (0000 : Normal tag with Speed info)	x3 - x0	4	0	0	0	0	0	0	0	0
Unique ID of RFID Tag Set	x13 - x4	10	831	833	835	839	843	849	851	855
Absolute Loc in Decameters (11 1111 1111 1111 : Not Applicable)	x31 - x14	18	35968	35988	36070	36170	36200	36272	36299	36350
TIN in Nominal Dir	x38 - x32	7	111	111	111	111	111	43	43	47
TIN in Reverse Dir	x45 - x39	7	111	111	111	111	111	43	43	45
Whether Trans from Loco-to-Stationary is necessary in Nominal Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x46	1	1	1	1	1	1	1	1	1
Whether Trans from Loco-to-Stationary is necessary in Reverse Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x47	1	0	0	0	0	0	1	1	1
Station / Block ahead info in Nominal direction - Side Collision (0=Block, 1= Station)	x48	1	0	0	0	0	0	1	1	1
Station / Block ahead info in Reverse direction - Side Collision (0=Block, 1= Station)	x49	1	0	0	0	0	0	1	1	1
Spare	x50	1	0	0	0	0	0	0	0	0
Spare	x51	1	0	0	0	0	0	0	0	0
Distance in Decameters from this tag to next Normal Tag in Nominal Direction	x59-x52	8	20	82	100	30	72	27	51	17
Distance in Decameters from this tag to next Normal Tag in Reverse Direction	y3-y0 & x63-x60	8	77	20	82	100	30	45	27	51
Fill Zeros	y4-y13	10	0	0	0	0	0	0	0	0
Distance in Decameters from next Normal Tag to Next-to-next Normal Tag in Nominal Direction	y21-y14	8	82	100	30	72	27	51	17	100
Distance in Decameters from next Normal Tag to Next-to-next Nomal Tag in Reverse Direction	y29-y22	8	80	77	20	82	100	17	72	27
Fill Zeros	y47-y30	18	0	0	0	0	0	0	0	0
CRC	y63-y48	16	4073	0673	EBC3	A3A5	F5BA	4EC6	C36B	0300
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PAGEY			4073000014148004	0673000013590001	EBC3000005078005	A3A5000014920006	F5BA00001906C001	4EC60000044CC002	C36B000012044001	0300000006D90003

REV.NO	REV. HISTORY	DATE
1	Initial version (899 , 901,903 & 905 Tags are considered in Mudkhed)	10.10.2020

MUGAT (MGC)-02001			
REF: SIP NO:IPU.6001A & TOC:TC.6001A			
REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

JE/SSE	
ADSTE / DSTE	
Dy. CSTE / P / T / SC	

SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		1	7

FIELD NAME	Normal Tag with Speed Info		Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag
	Bit positions	No. of bits								
Type of Tag (0000 : Normal tag with Speed info)	x3 - x0	4	0	0	0	0	0	0	0	0
Unique ID of RFID Tag Set	x13 - x4	10	891	895	897	910	914	916	920	842
Absolute Loc in Decameters (11 1111 1111 1111 1111 : Not Applicable)	x31 - x14	18	36367	36467	36512	36589	36569	36492	36393	36363
TIN in Nominal Dir	x38 - x32	7	115	115	115	114	114	114	114	114
TIN in Reverse Dir	x45 - x39	7	115	115	115	114	114	114	114	114
Whether Trans from Loco-to-Stationary is necessary in Nominal Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x46	1	0	0	0	0	0	0	0	0
Whether Trans from Loco-to-Stationary is necessary in Reverse Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x47	1	0	0	0	1	1	1	1	1
Station / Block ahead info in Nominal direction - Side Collision (0=Block, 1= Station)	x48	1	0	0	0	0	0	0	0	0
Station / Block ahead info in Reverse direction - Side Collision (0=Block, 1= Station)	x49	1	0	0	0	0	0	0	0	0
Spare	x50	1	0	0	0	0	0	0	0	0
Spare	x51	1	0	0	0	0	0	0	0	0
Distance in Decameters from this tag to next Normal Tag in Nominal Direction	x59-x52	8	100	45	55	100	20	77	99	30
Distance in Decameters from this tag to next Normal Tag in Reverse Direction	y3-y0 & x63-x60	8	17	100	45	20	77	99	30	64
Fill Zeros	y4-y13	10	0	0	0	0	0	0	0	0
Distance in Decameters from next Normal Tag to Next-to-next Normal Tag in Nominal Direction	y21-y14	8	45	55	100	100	100	20	77	99
Distance in Decameters from next Normal Tag to Next-to-next Nomal Tag in Reverse Direction	y29-y22	8	51	17	100	77	99	30	64	27
Fill Zeros	y47-y30	18	0	0	0	0	0	0	0	0
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REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	<div>HBL®</div>
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

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SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		2	7

FIELD NAME	Normal Tag with Speed Info		Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag	Normal Tag
	Bit positions	No. of bits								
Type of Tag (0000 : Normal tag with Speed info)	x3 - x0	4	0	0	0	0	0	0	0	0
Unique ID of RFID Tag Set	x13 - x4	10	848	850	854	808	810	812	814	816
Absolute Loc in Decameters (11 1111 1111 1111 1111 : Not Applicable)	x31 - x14	18	36299	36272	36227	36210	36147	36047	35947	35847
TIN in Nominal Dir	x38 - x32	7	44	44	46	110	110	110	110	110
TIN in Reverse Dir	x45 - x39	7	44	44	48	110	110	110	110	110
Whether Trans from Loco-to-Stationary is necessary in Nominal Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x46	1	1	1	1	0	0	0	0	0
Whether Trans from Loco-to-Stationary is necessary in Reverse Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x47	1	1	1	1	0	0	0	0	0
Station / Block ahead info in Nominal direction - Side Collision (0=Block, 1= Station)	x48	1	1	1	1	0	0	0	0	0
Station / Block ahead info in Reverse direction - Side Collision (0=Block, 1= Station)	x49	1	1	1	1	0	0	0	0	0
Spare	x50	1	0	0	0	0	0	0	0	0
Spare	x51	1	0	0	0	0	0	0	0	0
Distance in Decameters from this tag to next Normal Tag in Nominal Direction	x59-x52	8	64	27	45	17	63	100	100	100
Distance in Decameters from this tag to next Normal Tag in Reverse Direction	y3-y0 & x63-x60	8	27	45	17	63	100	100	100	100
Fill Zeros	y4-y13	10	0	0	0	0	0	0	0	0
Distance in Decameters from next Normal Tag to Next-to-next Normal Tag in Nominal Direction	y21-y14	8	30	64	27	45	17	63	100	100
Distance in Decameters from next Normal Tag to Next-to-next Nomal Tag in Reverse Direction	y29-y22	8	45	17	63	100	100	100	100	20
Fill Zeros	y47-y30	18	0	0	0	0	0	0	0	0
CRC	y63-y48	16	094B	A759	1797	5520	D02E	0F38	EB0C	5004
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TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	<div>HBL®</div>
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

JE/SSE	
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Dy. CSTE / P / T / SC	

SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		3	7

FIELD NAME	Normal Tag with Speed Info		Normal Tag	Normal Tag	Normal Tag	Normal Tag
	Bit positions	No. of bits				
Type of Tag (0000 : Normal tag with Speed info)	x3 - x0	4	0	0	0	0
Unique ID of RFID Tag Set	x13 - x4	10	860	862	861	863
Absolute Loc in Decameters (11 1111 1111 1111 1111 : Not Applicable)	x31 - x14	18	36299	36272	36272	36299
TIN in Nominal Dir	x38 - x32	7	52	52	51	51
TIN in Reverse Dir	x45 - x39	7	52	52	51	51
Whether Trans from Loco-to-Stationary is necessary in Nominal Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x46	1	1	1	1	1
Whether Trans from Loco-to-Stationary is necessary in Reverse Dir (Access Slot) (1 if communication is required,0 if communication is not required )	x47	1	1	1	1	1
Station / Block ahead info in Nominal direction - Side Collision (0=Block, 1= Station)	x48	1	1	1	1	1
Station / Block ahead info in Reverse direction - Side Collision (0=Block, 1= Station)	x49	1	1	1	1	1
Spare	x50	1	0	0	0	0
Spare	x51	1	0	0	0	0
Distance in Decameters from this tag to next Normal Tag in Nominal Direction	x59-x52	8	64	27	27	51
Distance in Decameters from this tag to next Normal Tag in Reverse Direction	y3-y0 & x63-x60	8	27	45	45	27
Fill Zeros	y4-y13	10	0	0	0	0
Distance in Decameters from next Normal Tag to Next-to-next Normal Tag in Nominal Direction	y21-y14	8	30	64	51	17
Distance in Decameters from next Normal Tag to Next-to-next Nomal Tag in Reverse Direction	y29-y22	8	45	17	17	45
Fill Zeros	y47-y30	18	0	0	0	0
CRC	y63-y48	16	1E47	B055	59CA	6709
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REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	<div>HBL®</div>
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

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SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		4	7

FIELD NAME	Signal Foot Tag		Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag
	Bit positions	No. of bits								
Type of Tag (0001 : Signal Foot Tag)	x3 - x0	4	1	1	1	1	1	1	1	1
Unique ID of RFID Tag Set	x13 - x4	10	837	841	845	847	853	857	918	840
Absolute Loc in Decameters (11 1111 1111 1111 1111 : Not Applicable)	x31 - x14	18	36088	36195	36226	36252	36324	36362	36469	36368
TIN in Nominal Dir	x38 - x32	7	111	111	41	43	45	115	114	114
TIN in Reverse Dir	x45 - x39	7	111	111	111	41	43	47	114	114
Station Code	x55-x46	10	0	0	0	0	0	0	0	0
Applicable Direction (0=Nominal, 1=Reverse)	x56	1	0	1	1	1	0	0	1	1
Signal ID in Applicable Direction	Y2-y0 & x63-x57	10	0	0	0	0	0	0	0	0
Whether the signal has diverging routes	Y3 (y3= 0 : No, y3=1 : Yes)	1	0	0	0	0	0	0	0	0
ID of Approaching Signal ahead in Applicable Direction	y13-y4	10	0	0	0	0	0	0	0	0
Fill Zeros	y47-y14	34	0	0	0	0	0	0	0	0
CRC	y63-y48	16	26EF	B5E1	8773	F365	7B8C	9BD4	9E82	4145
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FIELD NAME	Signal Foot Tag		Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag	Signal Foot Tag
	Bit positions	No. of bits								
Type of Tag (0001 : Signal Foot Tag)	x3 - x0	4	1	1	1	1	1	1	1	1
Unique ID of RFID Tag Set	x13 - x4	10	844	846	852	856	858	864	859	865
Absolute Loc in Decameters (11 1111 1111 1111 1111 : Not Applicable)	x31 - x14	18	36347	36318	36247	36215	36318	36247	36252	36324
TIN in Nominal Dir	x38 - x32	7	114	42	44	48	54	52	51	53
TIN in Reverse Dir	x45 - x39	7	42	44	46	110	52	50	49	51
Station Code	x55-x46	10	0	0	0	0	0	0	0	0
Applicable Direction (0=Nominal, 1=Reverse)	x56	1	0	0	1	1	0	1	1	0
Signal ID in Applicable Direction	Y2-y0 & x63-x57	10	0	0	0	0	0	0	0	0
Whether the signal has diverging routes	Y3 (y3= 0 : No, y3=1 : Yes)	1	0	0	0	0	0	0	0	0
ID of Approaching Signal ahead in Applicable Direction	y13-y4	10	0	0	0	0	0	0	0	0
Fill Zeros	y47-y14	34	0	0	0	0	0	0	0	0
CRC	y63-y48	16	1C54	4215	8650	6CDD	EA31	CFE0	F674	F45B
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PAGEY			1C54000000000000	4215000000000000	8650000000000000	6CDD000000000000	EA31000000000000	CFE0000000000000	F674000000000000	F45B000000000000

MUGAT (MGC)-02001			
REF: SIP NO:IPU.6001A & TOC:TC.6001A			
REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

JE/SSE	
ADSTE / DSTE	
Dy. CSTE / P / T / SC	

SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		5	7


FIELD NAME	Tin Discrimination Tag		Tin Discrimination Tag	Tin Discrimination Tag	Tin Discrimination Tag	Tin Discrimination Tag	Tin Discrimination Tag	Tin Discrimination Tag
	Bit positions	No. of bits						
Type of Tag (0011 : Turn out )	x3 - x0	4	3	3	3	3	3	3
Unique ID of RFID Tag Set	x13 - x4	10	866	867	868	869	870	871
Absolute Loc in Decameters (11 1111 1111 1111 1111 : Not Applicable)	x31 - x14	18	36234	36342	36240	36326	36245	36331
TIN in Nominal Dir	x38 - x32	7	41	42	50	42	49	45
TIN in Reverse Dir	x45 - x39	7	46	45	46	54	41	53
Station Code	x55-x46	10	0	0	0	0	0	0
Dead end ahead in Nominal Direction (0 = No, 1= Yes)	x56	1	0	0	0	0	0	0
Distance of deadend ahead in Decameters in Nominal Direction	y0 & x63 - x57	8	0	0	0	0	0	0
Dead end ahead in Reverse Direction (0 = No, 1= Yes)	y1	1	0	0	0	0	0	0
Distance of deadend ahead in Decameters in Reverse Direction	y9 – y2	8	0	0	0	0	0	0
Fill Zeros	y47-y10	38	0	0	0	0	0	0
CRC	y63-y48	16	21CD	7D51	4631	7CF2	FAE4	AD9F
PAGEX			000017292362B623	000016AA237DB633	0000173223643643	00001B2A2379B653	000014B123657663	00001AAD237AF673
PAGEY			21CD000000000000	7D51000000000000	4631000000000000	7CF2000000000000	FAE4000000000000	AD9F000000000000

MUGAT (MGC)-02001			
REF: SIP NO:IPU.6001A & TOC:TC.6001A			
REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

JE/SSE	
ADSTE / DSTE	
Dy. CSTE / P / T / SC	

SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		6	7

FIELD NAME	Gate Tag		Gate Tag	Gate Tag
	Bit positions	No. of bits		
Type of Tag 0101 : LC Gate	X3-X0	4	5	5
Unique ID of RFID Tag Set	X13-X4	10	893	912
Absolute Location	X31 - X14	18	36445	36575
LC Gate Approach tag in direction of applicability : TCAS : 00 NON TCAS First : 01 Non TCAS Second : 10 Spare : 11	X33-X32	2	00	00
LC Gate in Nominal Direction (0 if No ,1 if Yes)	X34	1	1	0
GATE ID	X44-X35	10	154	0
LC Gate ID (alpha) 000 : None, 001: a, 010: b, 011: c, 100: d, 101: e, 110: Out of range (display xx on DMI) 111: Spare	X47-X45	3	000	000
GATE TYPE (0-MANNED/ 1-UNMANNED)	X48	1	0	1
Distance to Gate	X58-X49	10	650	0
AUTO WHISTLING (0-NO/ 1-YES)	X59	1	1	0
Type of Auto-whistling : Distance based Auto-whistling : 0 Time based Auto Whistling : 1	X60	1	0	0
LC Gate in Reverse Direction (0 if No ,1 if Yes)	X61	1	0	1
GATE ID	Y7-X62	10	0	154
LC Gate ID (alpha) 000 : None, 001: a, 010: b, 011: c, 100: d, 101: e, 110: Out of range (display xx on DMI) 111: Spare	Y10-Y8	3	000	000
GATE TYPE (0-MANNED/ 1-UNMANNED)	Y11	1	1	0
Distance to Gate	Y21-Y12	10	0	650
AUTO WHISTLING (0-NO/ 1-YES)	Y22	1	0	1
Type of Auto-whistling : Distance based Auto-whistling : 0 Time based Auto Whistling : 1	Y23	1	0	0
Fill Zeros	Y47-Y24	24	0	0
CRC	Y63-Y48	16	903A	50E1
PAGEX			0D1404D4239777D5	A001000023B7F905
PAGEY			903A000000000800	50E100000068A026

MUGAT (MGC)-02001			
REF: SIP NO:IPU.6001A & TOC:TC.6001A			
REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: RFID_TAG_DATA_MGC_1.0			
	PREPARED BY	CHECKED BY	
SIGN			
NAME	P VARALAKSHMI	SAI VIGNESH	

JE/SSE	
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Dy. CSTE / P / T / SC	

SIGNAL & TELECOMMUNICATIONS			
TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
MUGAT (MGC) - 02001			
TCAS RFID TAG DATA			
द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
S.C.RLY.DRG.NO.		SHEET	SHEETS
		7	7



SL.NO	Entry Signal	Exit Signal	Leading To Line	Aspect of Entry Signal	Requires Aspects of Exit Signal	Requires Points in Route		Requires Track Circuit "UP" in Route	TINs (Track Identification Number) Requires Free	Check RFID				Turnout			Distance between Entry & Exit Signal (Meters)	Movement Authority From Foot of Entry Signal (Meters)
						Normal	Reverse			Entry Signal Foot Tag	En-Route Tags	Conflicting Route Tags	Conflicting Turnout Tags	Speed (kmph)	Distance to Commence (Meters)	Speed Restriction Distance (Meters)		
1	S1D	S1	Up Main	Green	Green	---	---	---	---	R-837	R-839	---	---	---	---	---	1070	2740
				Double Yellow	Green													2740
				Yellow	Green													2740
				Double Yellow	Yellow													2360
				Double Yellow	Yellow with POS 1													2360
				Yellow	Yellow													2360
				Yellow	Yellow with POS 1													2360
				Yellow	Red													1070
2	S1	S3	Up Main	Green	Green	P-11,P-13	---	UMT	N-41,N-43	R-841	R-843,R-845,R-847,R-849,R-851	R-859,R-861,R-863	R-870	---	---	---	1290	8860
				Yellow	Green													8860
				Yellow	Yellow													1670
				Yellow	Red													1290
3	S1	S4	Common Loop	Yellow with POS 1	Yellow	P-11	P-13	CLT	N-41,N-49,N-51	R-841	R-843,R-845,R-870,R-859, R-861,R-863	R-847,R-849,R-851	---	30	440	880	1290	1670
					Red													1290
4	S1A	S3	Up Main	Miniature (S1- Red/ Blank)	S3- Red/ Blank	P-11,P-13	---	1AT Occupied	---	R-841	R-843,R-845,R-847,R-849,R-851	R-859,R-861,R-863	R-870	15	0	1320	1290	1290
5	S1A	S4	Common Loop	Miniature (S1- Red/ Blank)	S4- Red/ Blank	P-11	P-13	1AT Occupied	---	R-841	R-843,R-845,R-870,R-859,R-861,R-863	R-847,R-849,R-851	---	15	0	1320	1290	1290
6	S3	S6	Up Main	Green	Green	P-18,P-20	--	---	N-45,N-47	R-853	R-855	R-844,R-842,R-840	R-867	---	---	---	380	7570
				Yellow	Green													7570
				Yellow	Red													380
7	S4	S6	Up Main	Yellow	Green	P-20	P-18	---	N-53,N-45, N-47	R-865	R-871, R-855	R-844,R-842,R-840	R-867	30	0	130	380	7570
				Yellow	Red													380
8	S6	Mudkhed	Up Main	Green	--	---	---	Line Clear Available	---	R-857	R-891,R-893,R-895,R-897	---	---	---	---	---	6190	7190
9	S25	S104D Of Maltekdi	Down Main	Green	--	---	---	Line Clear Available	---	R-856	R-808,R-810,R-812	---	---	---	---	---	5880	6920
10	S26	S25	Down Main	Yellow	Green	---	P-13,P-11	---	N-49,N-41,N-46,N-48	R-859	R-870, R-866 ,R-854	R-845,R-843,R-841	---	15	0	240	370	7290
				Yellow	Red													370
11	S27	S25	Down Main	Yellow	Green	P-11	P-12	---	N-50,N-46,N-48	R-864	R-868,R-854	---	---	30	0	130	320	7240
				Yellow	Red													320
12	S28	S25	Down Main	Green	Green	P-12,P-11	---	---	N-46,N-48	R-852	R-854	---	---	---	---	---	320	7240
				Yellow	Green													7240
				Yellow	Red													320

MUGAT (MGC) - 02001			
REF: SIP NO: IPU6001A & TOC:6001A			
REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: CONTROL_TABLE_MGC_1.0			
	PREPARED BY	CHECKED BY	<div> HBL</div>
SIGN			
NAME	J. SRINIVAS	SAI VIGNESH	

JE/SSE	
ADSTE/DSTE	
Dy.CSTE/P/T/SC	


IPU.6001A & TOC. 6001A	संदर्भ. सिगनल आरेख. सं. REF: SIG. PLAN NO.		SIGNAL & TELECOMMUNICATIONS			
	संशोधन REVISION		TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
	आरेखकार DRAWN		MUGAT (MGC) - 02001			
	क. झं. JE	C H E C K E D				
	व. अ. इ. SSE					
	स. सि. दू. सं. इ. ASTE					
	व. सि. दू. सं. इ. SSTE					
	कु. मु. सि. दू. सं. इ. fCSTE					
			द. म. रेलय. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
			S.C.RLY.DRG.NO.		SHEET	SHEETS
					1	2

SL.NO	Entry Signal	Exit Signal	Leading To Line	Aspect of Entry Signal	Requires Aspects of Exit Signal	Requires Points in Route		Requires Track Circuit "UP" in Route	TINs (Track Identification Number) Requires Free	Check RFID				Turnout			Distance between Entry & Exit Signal (Meters)	Movement Authority From Foot of Entry Signal (Meters)
						Normal	Reverse			Entry Signal Foot Tag	En-Route Tags	Conflicting Route Tags	Conflicting Turnout Tags	Speed (kmph)	Distance to Commence (Meters)	Speed Restriction Distance (Meters)		
13	S30A	S28	Down Main	Miniature (S30- Red/ Blank)	S28- Red/ Blank	P-20,P-19	---	30AT Occupied	---	R-840	R-842,R-844,R-846,R-848,R-850	R-865,R-863,R-861,R-853,R-851,R-849,R-847,R-858, R-860,R-862	R-867,R-869,R-871	15	0	1240	1210	1210
14	S30A	S27	Down Loop	Miniature (S30- Red/ Blank)	S27- Red/ Blank	P-20	P-19	30AT Occupied	---	R-840	R-842,R-844,R-869,R-858, R-860,R-862	R-865,R-863,R-861,R-853,R-851,R-849,R-847, R-846,R-848,R-850	R-871,R-867	15	0	1240	1210	1210
15	S30A	S26	Common Loop	Miniature (S30- Red/ Blank)	S26- Red/ Blank	---	P-20,P-18	30AT Occupied	---	R-840	R-842,R-844,R-867,R-871, R-865,R-863,R-861	R-853,R-851, R-849,R-847,R-846,R-848,R-850, R-858,R-860,R-862	R-869	15	0	1190	1160	1160
16	S30	S28	Down Main	Green	Green	P-20,P-19	---	DMT	N-42,N-44	R-840	R-842,R-844,R-846,R-848,R-850	R-865,R-863,R-861,R-853,R-851,R-849,R-847, R-858,R-860,R-862	R-867,R-869,R-871	--	---	---	1210	8450
				Yellow	Green													8450
				Yellow	Yellow													1530
				Yellow	Red													1210
17	S30	S27	Down Loop	Yellow with POS 1	Yellow	P-20	P-19	DLT	N-42,N-52, N-54	R-840	R-842,R-844,R-869,R-858, R-860,R-862	R-865,R-863,R-861,R-853,R-851,R-849,R-847, R-846,R-848,R-850	R-871,R-867	30	380	860	1210	1530
					Red													1210
18	S30	S26	Common Loop	Yellow with POS 4	Yellow	---	P-20,P-18	CLT	N-42,N-45, N-53,N-51	R-840	R-842,R-844,R-867,R-871, R-865,R-863,R-861	R-853,R-851,R-849,R-847,R-846,R-848,R-850, R-858,R-860,R-862	R-869	15	220	970	1160	1530
					Red													1160
19	S30D	S30	Down Main	Green	Green	---	---	---	---	R-918	R-920	---	---	---	---	---	1010	2540
				Double Yellow	Green													2540
				Yellow	Green													2540
				Double Yellow	Yellow													2220
				Double Yellow	Yellow with Pos 1													2220
				Double Yellow	Yellow with Pos 4													2170
				Yellow	Yellow													2220
				Yellow	Yellow with Pos 1													2220
				Yellow	Yellow with Pos 4													2170
				Yellow	Red													1010

Action for generating SOS to prevent Head On Collision and Rear End Collision on received communication for Block Section TIN		
Entry Signal for Block SelectionTIN	RFID Tags	TIN
S6	R-891,R-893,R-895,R-897,R-899,R-901,R-903,R-905,R-911,R-913, R-915,R-917,R-919,R-921,R-923	N-115
S25	R-808,R-810,R-812,R-814,R-816,R-818,R-820,R-822,R-824, R-826,R-828,R-830,R-832,R-834,R-836,R-838,R-748	N-110

Last Signal of Stationary TCAS	Movement Authority (Meters)
S6	7190
S25	6920

Rev No.	Revision	Date
1.0	Initial version	30.09.2020

MUGAT (MGC) - 02001			
REF: SIP NO: IPU6001A & TOC:6001A			
REF: RFID_TAG_LAYOUT_MGC_1.0			
TABLE NO: CONTROL_TABLE_MGC_1.0			
	PREPARED BY	CHECKED BY	
SIGN			
NAME	J. SRINIVAS	SAI VIGNESH	

JE/SSE	
ADSTE/DSTE	
Dy.CSTE/P/T/SC	

IPU.6001A & TOC. 6001A	संदर्भ. सिगनल आरेख. सं. REF: SIG. PLAN NO.		SIGNAL & TELECOMMUNICATIONS			
	संशोधन REVISION		TRAIN COLLISION AVOIDANCE SYSTEM (TCAS)			
	आरेखकार DRAWN		MUGAT (MGC) - 02001			
	क. झं.	JE				
	व. अ. इं.	SSE	TCAS TABLE OF CONTROL			
	स. सि. दू. सं. इं.	ASTE	द. म. रेलव. आरेख. सं.	TCAS. 6001A	शीट	कुल शीट
	व. सि. दू. सं. इं.	SSTE			SHEET	SHEETS
	कु. मु. सि. दू. सं. इं.	fCSTE	S.C.RLY.DRG.NO.		2	2

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## Questions & Answers

### **Reference: Mugat station RFID TAG/TIN Layout (Drg. No. RFID\_TAG\_LAYOUT\_MGC\_1.0)**

1. What is the basis of providing RFID tags (at some places very close such as R827, R831, R833, R835) ?

Ans. R-827 Tag is for Block-section (B/S) Normal Tag (N Tags).

The reason for two N tags (R-831 & R-833) kept close because Loco shall establish communication quickly with approaching station (in this case station is Mugat).

2. Signal Approach tags wherever provided are shown as Normal (N) tags such as R861, R849, R850, R852. Why?

Ans. As per "TCAS - Specification version 3.2\_ including 17.05.2017", Clause No:2.6.1: All types of tags, except Junction and Adjustment tags, can be placed instead of the Signal Approach tag if it offers some other advantage like reduction in the number of tags.

Here the advantage obtained is that all Normal tags can be linked with other normal tags in either direction.

3. In TCAS RFID TAG Data (Table No. RFID\_TAG\_DATA\_MGC\_1.0), some tags are not mentioned, for example

- R827, R899, R901(366.67), R903 (376.17), R905 (367.67) & R911 (368.61) in UP direction
- R902 (366.89), R912 (365.75), R818 (357.47) in DN direction.
- While R814(359.47) & R816 (358.47) are mentioned in the table.

Ans. These tags pertain to the Block section (B/S), and are covered in either side stations RFID Tag Data.

4. What is the meaning of B/S in the layout?

Ans. B/S meaning Block Section. In the RFID Tag Layout, it is mentioned B/S for those tags which do not come under either side of stations.

5. What is meant by terms used in the TCAS RFID TAG Data (Table No. RFID\_TAG\_DATA\_MGC\_1.0 such as:

- Bit position and no. of bits
- Fill zeros

- CRC
- PAGEX
- PAGEY
- Any other relevant information for preparation of TAG/TIN layout and TAG data.

Ans.

- Bit position and no. of bits  
It is 128-bit data splitted into 2 x 64-bit Data.  
The Data is represented in Binary Numbering systems, (X0, X1, X2,... X63) - first group of 64-bits data (PAGEX) and Y0, Y1, Y2.....Y63 - second group of 64-bits data (PAGEY)  
Bit position indicates 0, 1, 2 ... 63 and No of Bits indicates how many bits are allocated for the parameter.
- Fill zeros  
Unused bits in a Tag Data or Bite for future use, are filled with ZEROs, similar to padding with ZEROs.
- CRC  
To know that read Tag Data is correct, CRC is calculated for the Data and this CRC is appended to Y43 to Y63 (which is a fixed position for all types of Tags)
- PAGEX
- PAGEY  
As explained in "· Bit position and no. of bits"

■■■

## **Quality Policy**

“We at RDSO Lucknow are committed to maintain and update transparent standards of services to develop safe, modern and cost effective railway technology complying with statutory and regulatory requirements, through excellence in research, designs and standards by setting quality objectives, commitment to satisfy applicable requirements and continual improvements of the quality management system to cater to growing needs, demand and expectations of passenger and freight traffic on the railways through periodic review of quality management systems to achieve continual improvement and customer appreciation. It is communicated and applied within the organization and making it available to all the relevant interested parties.”



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**INDIAN RAILWAYS**  
**Centre for Advanced Maintenance Technology**  
**Maharajpur, Gwalior (M.P.) Pin Code – 474 005**