Draft Specification

of

Integrated Communication System for Tunnels

SPECIFICATION NO. RDSO/SPN/TC/109/2019

Revision 0.0

Number of Pages: 18

TELECOM DIRECTORATE

RESEARCH DESIGNS & STANDARDS ORGANISATION

LUCKNOW-226011

DOCUMENT DATA SHEET		
Specification **RDSO/SPN/TC/109/2019**		Revision **0.0**
Title of Document RDSO Specification for Integrated Communication System for Tunnels		
Author **Director/ Telecom-I/ RDSO**		
Approved by **Executive Director/ Telecom/ RDSO**		
Abstract **This document specifies technical specification of Integrated Communication System for Tunnels.**		

DOCUMENT CONTROL SHEET

NAME	ORGANIZATION	FUNCTION	LEVEL
Director/ Telecom-I	RDSO	Member	Prepare
Executive Director/ Telecom	RDSO	-	Approve

I. SUMMARY:

This document covers the technical requirements of Integrated Communication System for Tunnels on Indian Railway network of varying lengths.

II. SOURCE:

Draft specification RDSO/ SPN/ TC/109/2019, Rev 0.0 have been prepared by RDSO, Lucknow as per Railway Board letter No. 2006/Tele/TC/1/Pt dated 15/07/2015.

III. FOREWORD:

RDSO/ SPN specification is issued as draft specification. This specification is circulated to customers/ Railways and field inspection units for comments.

In the absence of IRS specification, procurement may be made as per RDSO/ SPN specification.

Wherever, reference to any specifications appears in this document, it shall be taken as a reference to the latest version of that specification unless the year of issue of the specification is specifically stated.

RESEARCH DESIGNS & STANDARDS ORGANISATION
MINISTRY OF RAILWAYS
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Specification of Integrated Communication System for Tunnels

RDSO Specification No. RDSO/SPN/TC/109/2019 Revision 0.0

1.0 SCOPE:

1.1 This specification covers technical requirement of equipments for Integrated Communication System for Tunnels on Indian Railway network of varying lengths.

1.2 These tunnels can broadly be categorized in three categories i.e. tunnels less than 500 meters per Bore, more than 500 meters to 5000 meters per Bore and tunnel more than 5000 meters length per Bore. Requirement of Integrated Communication System for above categories will be slightly different.

When a tunnel length is less than 500 meters but is one of the cluster of many tunnels, this should be considered as more than 500 meters and continued as the part of nearby tunnels of the cluster.

1.3 VHF Simplex, LocoTrol, GSM-R/LTE, TCAS etc. communication are to be extended as per Railway Requirement in Tunnels for communication during maintenance and constructional blocks, communication in the train in between Guard & Driver, Emergency radio communication between driver, guard, station master & Cabin, Train Control etc.

1.4 Frequency Band 146-163MHz for VHF Simplex communication, LocoTrol 406-407 MHz & 433-434 MHz, 876-915 MHz(Uplink) & 921-960 MHz(Downlink) for GSM-R communication and TCAS 405-512 MHz are allotted in Indian Railways. 700 MHz band are recommended to be allotted for LTE for Indian Railways. (Exact Bands and Channels authorized for use by Railways will be communicated at time of Order).

1.5 Integrated Communication System in tunnels where ever provided on Indian Railway shall be able to extend following communications in Tunnels as per Table - 1 below :

Table-1

S. No.	**Communication system Description**	**Tunnels less than 500 meters**	**Tunnels more than 500 meters to 5000 meters**	**Tunnels more than 5000 meters**
1.	VHF Simplex	Yes	Yes	Yes
2.	LocoTrol	Yes	Yes	Yes
3.	TCAS	Yes	Yes	Yes
4.	GSM-R/LTE	Yes	Yes	Yes
5.	PA System	No	Yes	Yes
6.	Video Surveillance System	No	Yes	Yes

1.6 For Tunnels less than 500 meters per Bore are to be covered with High Gain Off-Air Channelized Repeaters feeding Dual Radiating Cable Systems. The Repeaters cover VHF Simplex, LocoTrol, GSM-R/LTE, TCAS etc. Schematic diagram is mentioned at figure-1of specification.

1.7 For Tunnels more than 500 meters to less than 5000 meters per Bore, a Master/Remote Optical System is to be installed. This System consists of a VHF Simplex, LocoTrol®, GSM-R/LTE and TCAS Master Unit, feeding Optical Remote Units. These Remote Units are housed in an IP65 Case. Appropriate Antennas and Leaky Cables are to be deployed. Schematic diagram is mentioned at figure-2of specification.

1.8 For Tunnels more than 5,000 meters per Bore, a Redundant Master Unit as per para 1.7 may also be deployed for complete Redundancy. Schematic diagram is mentioned at figure-3of specification.

2.0 General Requirement:

2.1 Original Equipment Manufacturer (OEM) of Integrated Communication System for Tunnels or its authorized representative shall have service facility in India.

2.2 All software and firmware upgrades shall be free of cost for a period of five years or as specified by purchaser.

2.3 The integrated communication system shall be connected to centralized tunnel control room which shall be either at adjacent Railway station or Divisional Control HQ controlling 2 or more tunnels.

2.4 The Tunnel Radio System shall provide an uninterrupted radio communication inside tunnel with the headquarters and operation centers and handheld devices of the tunnel operator’s staff, emergency staff and trains which pass the tunnel.

2.5 The communication of all channels in the tunnel shall be independent, simultaneous and failure-free.

2.6 It shall be possible to continuous coverage over the entire length of the tunnel, clear audio though out with no interference, reliable system operation under harsh tunnel environmental conditions, trunked radio channels across many bands and ease of system operation and maintenance.

2.7 Voice recording arrangement as per RDSO/SPN/TC/38/2002 or latest for all communication through the Master unit should be provided at the location of the Master unit for analysis and accountability.

2.8 The VHF simplex communication being the lifeline of train operation, Tunnel Radio System should be able to provide an uninterrupted radio communication between the radios located anywhere inside a tunnel (inner tunnel) and also between radios of other tunnels / master unit location (inter tunnel) of the same network.

3.0 **System Description:**

3.1 Following systems are required to extend VHF Simplex, LocoTrol, GSM-R/LTE, TCAS(As required) communication in Tunnels as per Table -2 below:

Table: 2

SN	**Systems**	**Tunnels less than 500 meters length**	**Tunnels more than 500 meters to 5000 meters**	**Tunnels more than 5000 meters length**
1.	Master Unit with Power supply unit	No	Yes	Yes
2.	Fibre Junction Box	No	Yes	Yes
3.	Optical Remote Unit	No	Yes	Yes
4.	Off-Air Channelized Repeater	Yes	No	No
5.	Leaky Cable (Two sets)	Yes	Yes	Yes
6.	Antenna for system	Yes	Yes	Yes
7.	Optic Fibre cable	No	Yes	Yes
8.	Power supply unit for Optical Remote unit/Repeater in Tunnels	Yes	Yes	Yes

3.1.1 **Master Unit:**

The Master Unit is used to convert signals from RF to light when fibre fed repeaters is used at the remote end of the optical link. Master Unit shall be used in more than 500 meters lengths tunnels.

Master Unit system may consist of following sub-system:

(i) Channelized VHF Simplex Off-Air Repeater and VHF Simplex Optical Master Unit.

(ii) GSM-R/LTE Off-Air Repeater and GSM-R/LTE Optical Master Unit.

(iii) Channelized TCAS/LocoTrol Off-Air Repeater and TCAS/LocoTrol Optical Master Unit.

Item	**Master Unit**				
	VHF Band	**LocoTrol**	**GSM-R**	**LTE**	**TCAS**
Frequency Range(Customized)	146-163 MHz	406-407 MHz & 433-434 MHz	907.8-914.8 MHz/ 952.8-959.8 MHz	700 MHz Band	405-512 MHz
Number of Channels for each service should be normally 4 or user may specify their specific requirements	4 Channels				
Channel Bandwidth	25KHz	25KHz	200KHz	10MHz	25KHz
Maximum input power	DL: ≤ 10dBm				
System Gain (Master + Remote)	40±3dBm				
System Gain Adjustment Range	30dB in 1dB step				
Passband Ripple	≤±2.5dB				
Uplink Noise Figure @ Max Gain	≤5dB (1 Master Unit and 1 Remote)				
AGC	≥30dB				
VSWR	<1.5				
Optical Input/ Output Configuration	DL/UL combined				
Number of Optical Output Ports	Min 8				

I/O Impedance	50Ω
MTBF	80,000 Hours
Temperature range	-5°C to +55°C
Relative Humidity	Max 95%
Power requirement	230V AC 50Hz or -48V DC
Power consumption	≤150W
Master Unit Alarm	PSU alarm, Optical Transceiver alarm
Mounting	Rack Mounted

3.1.2 **Fibre Junction Box:**

Fibre Junction Box should be as per specification no. RDSO/SPN/TC/68/2014 or latest.

3.1.3 **Optical Remote Unit:**

Optical Remote unit is used at the remote end to convert Optical Signal to RF Signal and then transmit it into Leaky cable in the particular area to cover the tunnel for the wireless communication. It is connected to Master Unit.

Optical Remote Units to accept for VHF Simplex, LocoTrol, GSM-R/LTE and TCAS. The Case is an IP65 rating construction Housing. Remote unit are Monitored, Controlled and Alarmed Remotely from the Master Unit over Fibre and Remotely using an Ethernet Modem.

Optical Remote unit shall be used to provide coverage in more than 500 meters lengths tunnels. Details of Remote unit are as under:

Item	**Optical Remote Unit**				
	VHF Band	**LocoTrol**	**GSM-R**	**LTE**	**TCAS**
Frequency Range (Customized)	146-163MHz	406-407 MHz & 433-434 MHz	907.8-914.8 MHz/ 952.8-959.8 MHz	700MHz Band	405-512 MHz
Passband Ripple	<±2.5dB				
AGC	>30dB				
Maximum input power	UL: ≤ 10dBm				
VSWR	<1.5				
Alarm Detection	Optical Remote Unit: Optical Transceiver Link alarm, Door open alarm				
Optical Input/ Output Configuration	DL/UL combined				
RF Input/ Output Configuration	DL/UL combined				
DL output power	33 dBm or better				
Gain	40±3dBm				
I/O Impedance	50Ω				
IP Rating	IP65				
MTBF	80,000 Hours				
Temperature range	-5°C to +55°C				
Relative Humidity	Max 95%				
Power requirement	230V AC 50Hz or -48V DC				
Power consumption	≤150W				
Mounting	Wall Mounted				

3.1.4 **Off-Air Channelized Repeater:**

For less than 500 meters Tunnels are to be covered with High Gain Off-Air Channelized Repeaters feeding Dual Radiating Cable Systems. The Repeaters cover VHF Simplex/LocoTrol, GSM-R/LTE and TCAS communication per Bore.

Item	Digital Off-Air Channelized Repeater				
	VHF Band	**LocoTrol**	**GSM-R**	**LTE**	**TCAS**
Frequency Range(Customized)	146-163MHz	406-407 MHz & 433-434 MHz	907.8-914.8 MHz/ 952.8-959.8 MHz	700MHz Band	405-512 MHz
Number of Channels for each service should be normally 4 or user may specify their specific requirements	4 Channels				
DL Power	33 dBm or better				
UL power output	33 dBm or better	33 dBm or better	3 dBm adjustable	3 dBm adjustable	33 dBm or better
System Gain	90±3dBm				
Noise Figure @ Max Gain	≤5dB				
I/O Impedance	50Ω				
IP Rating	IP65				
MTBF	80,000 Hours				
Temperature range	-5°C to +55°C				
Relative Humidity	Max 95%				
Power requirement	230V AC 50Hz or -48V DC				
Power consumption	≤130W				
Master Unit Alarm	Power alarm				
Mounting	Wall Mounted				

3.1.5 **Leaky Cable:**

For Wireless communication (VHF Simplex, LocoTrol, GSM-R/LTE and TCAS) inside the tunnel FRLS-0H rated Leaky cable shall be provided.

Two 7/8" Leaky Cable shall runs per tunnel tube length for VHF Simplex, LocoTrol, GSM-R/LTE and TCAS communication.

Specifications	
Construction Materials	
Jacket	LSZH Polyolefin or PE
Dielectric	Foam PE
Inner Conductor	Smooth/Corrugated copper tube
Jacket Color	Black
Outer Conductor	Copper foil
Dimensions	
Diameter Over Jacket, maximum	27.7 mm
Inner Conductor OD	9.50 mm ±0.2mm
Cable Weight	0.42 kg/m ±0.02Kg/m
Electrical	
Operating Frequency Band	75 – 2700 MHz
Polarization	Vertical/Horizontal
Velocity	89 %
Cable Impedance	50 ohm ±2 ohm
DC Resistance, Inner Conductor(Max)	1.69 ohms/km
DC Resistance, Outer Conductor(Max)	3.5 ohms/km
Insulation Resistance(Min)	10000 MΩkm
Jacket Spark Test Voltage (rms)	8000 V

Peak Power		91.0 kW	
Environmental			
Operating Temperature		-30 ℃ to +80 ℃	
Mechanical			
Tensile Strength(Min)		215 kg /2100N	
Fire Retardancy Test Method		IEC 60332-1	
Smoke Index Test Method		IEC 61034	
Toxicity Index Test Method		IEC 60754-1	
Standard Conditions			
Attenuation Test Method		IEC 61196-4	
Attenuation Tolerance		±10%	
Attenuation, Ambient Temperature		20 ℃	
Coupling Loss Test Method		IEC 61196-4	
Coupling Loss Tolerance		±5 dB	
Electrical Performance			
Frequency	Attenuation (dB/100 m)	Coupling Loss 50%	Coupling Loss 95%
150 MHz	1.42	59	61
400 MHz	2.55	61	65
450 MHz	2.60	61	64
700 MHz	3.34	67	77
900 MHz	4.15	60	65

3.1.5 **Antenna and its arrangement:**

3.1.5.1 For Tunnels less than 500 meters, Antenna shall be installed at tunnel site for VHF Simplex, LocoTrol, GSM-R/LTE, TCAS etc.

Antenna arrangement consists of:

a) RG217 Coaxial cable with proper connectors
b) RF Lightning & Surge Protector
c) Tower at Tunnel for fixing antenna.

3.1.5.2 For Tunnels more than 500 meters, Antennas shall be installed on a Tower for VHF Simplex, LocoTrol, GSM-R/LTE, TCAS etc.

3.1.7 **Optical Fibre:**

Master Unit at Base station shall be connected to the tunnel optical remote unit through Fibre Junction Box.

Video Surveillance System and PA Systems shall be also connected though same Optic Fibre system as per Railway requirement in para 13.2.

3.1.8 **Power Supply unit for Master Unit:**

For Integrated Communication System in Tunnel, power supply unit with 12 Hrs. battery backup (230VAC 50Hz or -48 VDC) for Master Unit should be provided by supplier. For installing of system Railway shall ensure that 230V AC, 50Hz is available at the location of the Master Unit at base station site.

3.1.9 **Power Supply unit for Optical Remote unit/Repeater in Tunnels:**

For Integrated Communication System in Tunnel, power supply unit with 12 Hrs. battery backup (230VAC 50Hz or -48 VDC) for Optical Remote unit/Repeater in Tunnels should be provided by supplier. For installing of system Railway shall ensure that 230V AC, 50Hz is available at the entrance of Tunnel.

4.0 **PA system:**

A Public address system shall be provided to inform/warn maintenance and service staff and give instructions to people in abnormal conditions during incident. Therefore loudspeakers shall be installed every 100 m in the tunnel. Purchaser should list out the items required to be installed in tunnels as per RDSO specification no. RDSO/SPN/TC/78/2008 Rev. 0.0 or latest.

5.0 **IP Based Video Surveillance System:**

IP based Video Surveillance System shall be provided inside tunnels to ensure that there are no blank spots over the tunnels. All the camera feed will be transferred to Tunnel Control Center/Divisional Control Room for viewing, recording and monitoring of tunnels through cameras. Purchaser should list out the items required to be installed in tunnels as per RDSO specification no. RDSO/SPN/TC/65/2019 Rev. 5.0 or latest.

6.0 **Test Requirement:**

6.1 **Condition of Tests:**

6.1.1 Unless otherwise specified all tests shall be carried out at ambient atmospheric conditions.

6.1.2 Inspection and testing shall be carried out to the effect that all requirements of this specification are compiled with.

6.1.3 Inspection shall be carried out for one complete system of Integrated communication system for tunnel.

6.2 **TYPE TEST:**

6.2.1 For type test, one complete system shall be subjected to following tests as applicable.

a) Visual Inspection (Clause 7.1)
b) Performance test(Clause 7.2)
c) Climatic and environmental requirements (Clause 7.2.2)
d) Endurance test(Clause 7.3)

6.2.2 Any other tests shall be carried out as considered necessary be the inspection authority

6.3 **ACCEPTANCE TESTS:**

6.3.1 The following shall constitute the acceptance tests which shall be carried out by the inspecting authority for the purpose of acceptance on randomly selected 20% of items offered from the lot (minimum 1 each type of item) offered for inspection by the supplier:

a) Visual inspection of complete system (Clause 7.1)
b) Performance test (Clause 7.2)
c) Endurance Test(Clause 7.3)

6.3.2 Any other tests shall be carried out as considered necessary by the inspecting authority.

6.4 **Routine tests:**

6.4.1 The following shall comprise the routine tests and shall be conducted by manufacturer on every equipment and the test results will be submitted to the inspection authority before inspection.

a) Visual Inspection of complete system (Clause 7.1)
b) Performance test (Clause 7.2)

7.0 **Test Procedure:**

The test procedure shall be based on the system design. The methodologies to be adopted for various tests shall be decided taking into account the system design/configuration.

7.1 **VISUAL INSPECTION:** Each equipment of the system shall be visually inspected to ensure compliance with the requirement of clause 3 of this specification.

7.2 **PERFORMANCE TEST:**

7.2.1 The equipment shall comply with the requirements as specified in clauses 2 & 3.

7.2.2 **CLIMATIC AND ENVIRONMENTAL REQUIREMENTS:**

7.2.2.1 The equipment shall meet the following climatic and environmental requirements:

SN	TEST	REFERENCE
1.	Cold test	Category B2 of QM-333
2.	Dry heat test	-- do --
3.	Damp heat test (Cyclic)	-- do --
4.	Rapid temperature cycling test	-- do --
5.	Damp heat test (Steady state storage)	-- do --
6.	Vibration test	-- do --

7.3 **ENDURANCE TEST:**

7.3.1 During type test, endurance test shall be conducted on complete system for continuous operation which shall be 168 Hrs at ambient room temperature without giving any deterioration.

7.3.2 During acceptance test, endurance test shall be conducted on complete system for continuous operation which shall be 48 hrs at ambient room temperature without giving any deterioration.

8.0 **QUALITY ASSURANCE:**

8.1 All materials & workmanship shall be of good quality.

8.2 Since the quality of the equipment bears a direct relationship to the manufacturing process and the environment under which it is manufactured, the manufacturer shall ensure Quality Assurance Program of adequate standard.

8.3 Validation and system of monitoring of QA procedure shall form a part of type approval. The necessary Plant, Machinery and Test instruments as mentioned in Schedule of Technical Requirements (STR) shall be available with the manufacturer.

9.0 **REJECTION:**

9.1 Any of the materials which do not comply with the requirements of this specification may by rejected.

10.0 **MARKING & PACKING:**

10.1 The following information shall be clearly marked at a suitable place on each equipment:

a) Name and address of the manufacturer.
b) Year of the manufacturer.
c) Serial number of equipment.
d) Specification Number
e) Schematic diagram of the equipment at suitable place.

10.2 The equipment and its sub assemblies shall be packed in suitable boxes and the empty spaces shall be filled with suitable filling material. The equipment shall be finally packed in a wooden/suitable case of sufficient strength so that it can withstand bumps and jerks encountered in a road/rail journey.

11.0 **TRAINING:**

11.1 Onsite training shall be provided to the Railway staff which shall include complete assembly of the system through the use of various modules, integration of hardware with software and complete operation of the system.

11.2 Sets of training manual in two hard copies and two soft copies containing details of technical specifications, installation and commissioning, trouble shooting & maintenance schedule etc. shall be supplied along with the equipment.

12.0 **DOCUMENTATION:**

12.1 The following documents should be supplied along with the system:

12.1.1 Mechanical drawings of each sub system/ rack.

12.1.2 Installation and maintenance manual incorporating trouble shooting exercises, printed cards patterns, software etc.

12.1.3 Operating and troubleshooting manual including maintenance schedule.

12.1.4 Pre-commissioning check list.

12.1.5 Detailed installation and commissioning document including site topology diagram.

13.0 Following Details are required for Integrated Communication System for Tunnel:

13.1 **Supply, Installation, Testing and Commissioning of following item by the supplier for Tunnel communication:**

SN	Item	Nos.	Condition of requirement
1.	Master Unit	As per site requirement	Tunnel length > 500 meters
2.	Fibre Junction Box	As per site requirement	Tunnel length > 500 meters
3.	Optical Remote unit	01 No. at every interval of 500 meters length	Tunnel length > 500 meters
4.	Off-Air Channelized Repeater	01 No. Repeater	Tunnel length < 500 meters
5.	7/8" Leaky cable	One both side of Tunnel	all type of tunnels
6.	Antenna for each system	For VHF Simplex, LocoTrol, GSM-R, LTE, TCAS etc. as per Railway Requirement	all type of tunnels
7.	OFC Cable	Fibre Junction box to length of tunnel	Tunnel length >500 meters
8.	Power supply unit for Master Unit	As per site requirement	Tunnel length >500 meters
9.	Power supply unit for Optical remote units in Tunnels & Cables	As per site requirement	Tunnel length >500 meters
10.	Power supply unit for Repeaters in Tunnels	01 no. for per Repeaters	Tunnel length <500 meters
11.	7/8" & 1/2" RF Feeder Cable with proper connectors	as per requirement	all type of tunnels
12.	Leaky Cable accessories kit, connectors & installation kit for Leaky cables	as per requirement	all type of tunnels
13.	Cross band couplers, Dividers,	as per requirement	all type of tunnels

	Directional Couplers, RF terminations and RF accessories		
14.	RF cable with proper connector	length as per site requirement	all type of tunnels
15.	Tower at Tunnel for fixing antenna	01 no.	Tunnel length< 500 meters
16.	RF Lightning & surge protector for Tower at Tunnel	01 no. each	Tunnel length <500 meters
17.	Video Surveillance System	as per purchaser requirement	Tunnel length > 500 mtr.
18.	PA System	as per purchaser requirement	Tunnel length > 500 mtr.

13.2 **Details to be furnished by Purchaser:**

SN	Details
1.	Length of tunnel
2.	Number of Tunnel Bores
3.	Type of communications to be extended (VHF, LocoTrol, GSM-R/LTE, TCAS etc.).
4.	Number of Channels for each service (VHF, LocoTrol, GSM-R/LTE, TCAS etc.) should be specified.
5.	Single mode OFC connectivity for Master Unit (from base station site to Fibre junction box) and for Video Surveillance System & PA System at the entrance of tunnel to be provided by purchaser.
6.	230V AC, 50Hz at the entrance of Tunnel and the location of Master Unit at base station site.
7.	List out the item and quantity required to be installed in tunnels for Video Surveillance System as per RDSO specification no. RDSO/SPN/TC/65/2019 Rev. 5.0 or latest.
8.	List out the item and quantity required to be installed in tunnels for PA System as per RDSO specification no. RDSO/SPN/TC/78/2008 Rev. 0.0 or latest.
9.	Size of Tower at Tunnel for fixing antenna.
10.	Exact Bands and Channels authorized for use by Railways for VHF/LocoTrol/GSM-R/LTE/TCAS.
11.	Number of Earthing arrangement required (≤ 1Ω) (Earthing arrangement should normally be provided at every 500 meters inside of Tunnel)

Tunnel communication System for less than 500 meters length

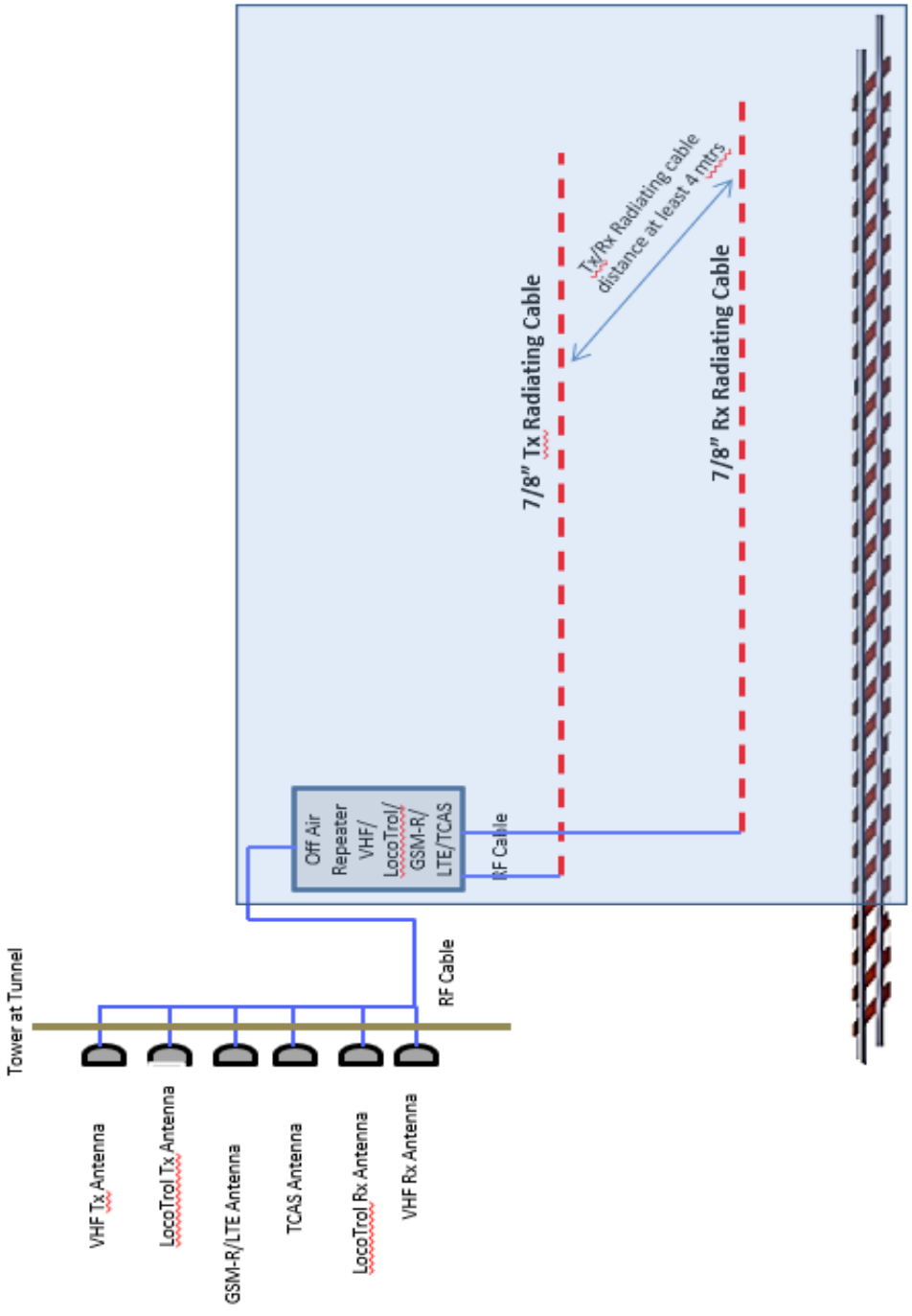

Fig-1

Tunnel communication system for more than 500 meters to 5000 meters length with Loop Redundancy

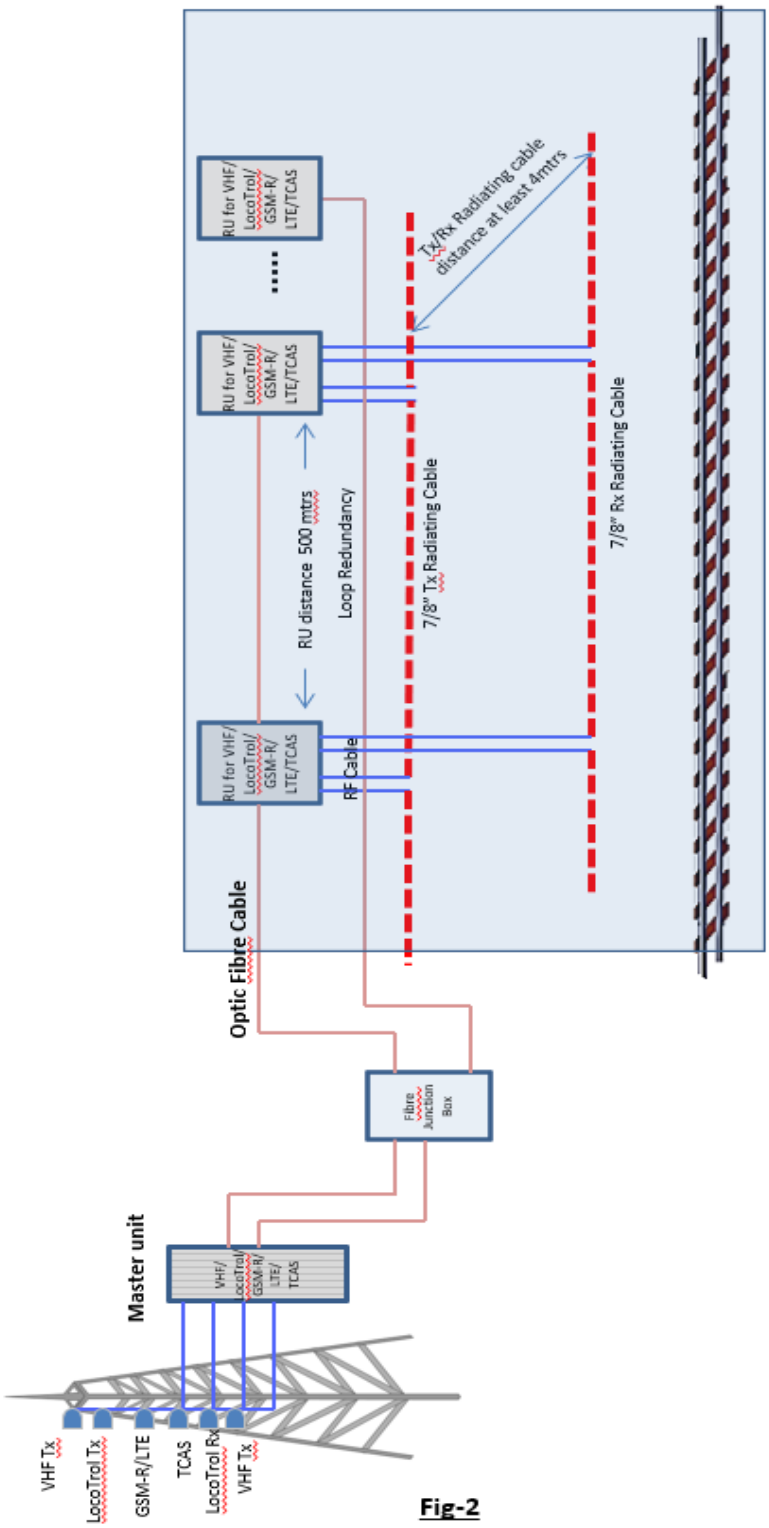

Fig-2

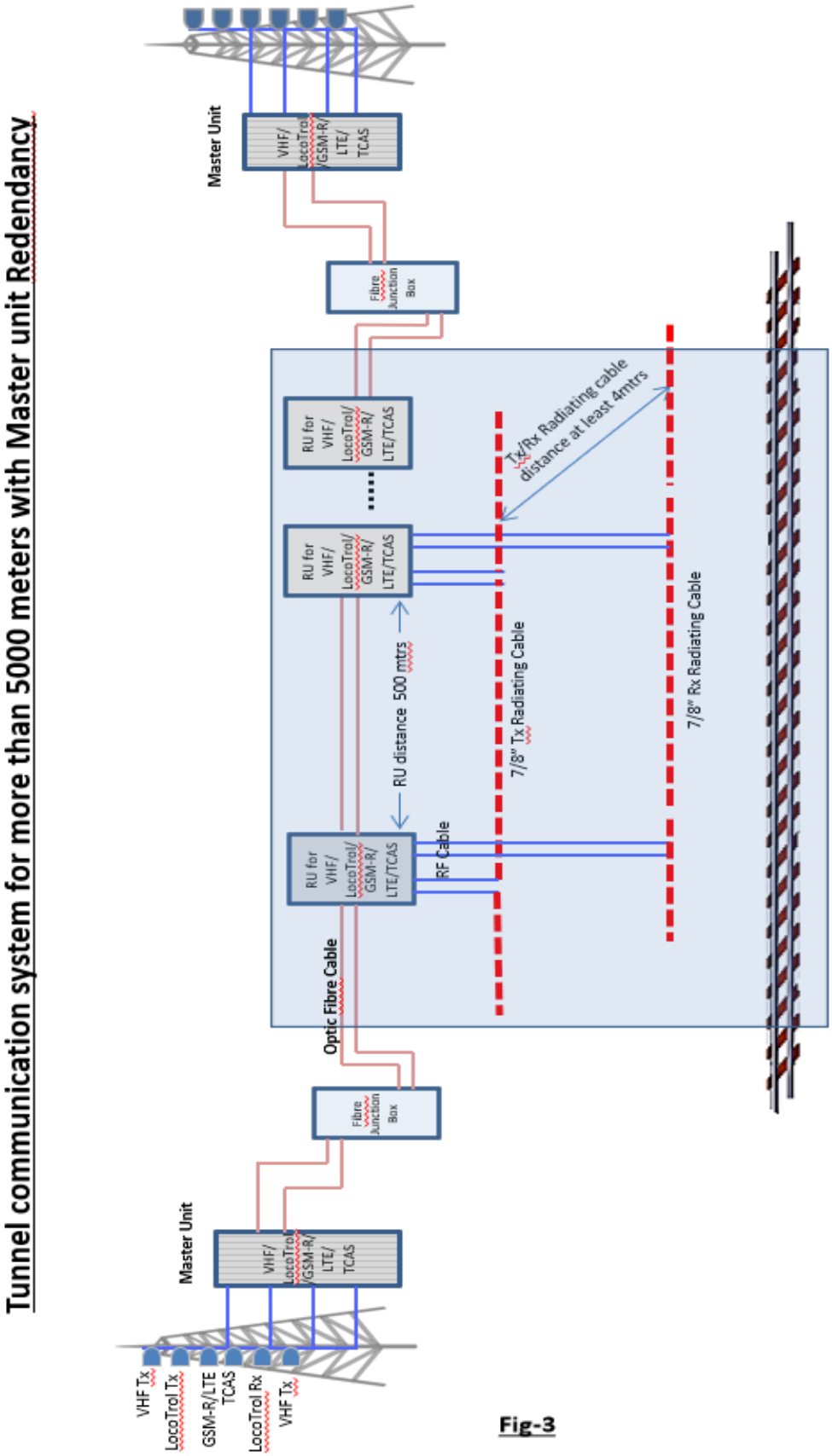
Tunnel communication system for more than 5000 meters with Master unit Redendancy
Master Unit
VHF/ LocoTrol/ GSM-R/ LTE/ TCAS
Fibre Junction Box
RU for VHF/ LocoTrol/ GSM-R/ LTE/TCAS
Tx/Rx Radiating cable distance at least 4mtrs
RU distance 500 mtrs
7/8" Tx Radiating Cable
7/8" Rx Radiating Cable
RF Cable
Optic Fibre Cable
Master Unit
VHF Tx
LocoTrol Tx
GSM-R/LTE TCAS
LocoTrol Rx
VHF Tx

Fig-3