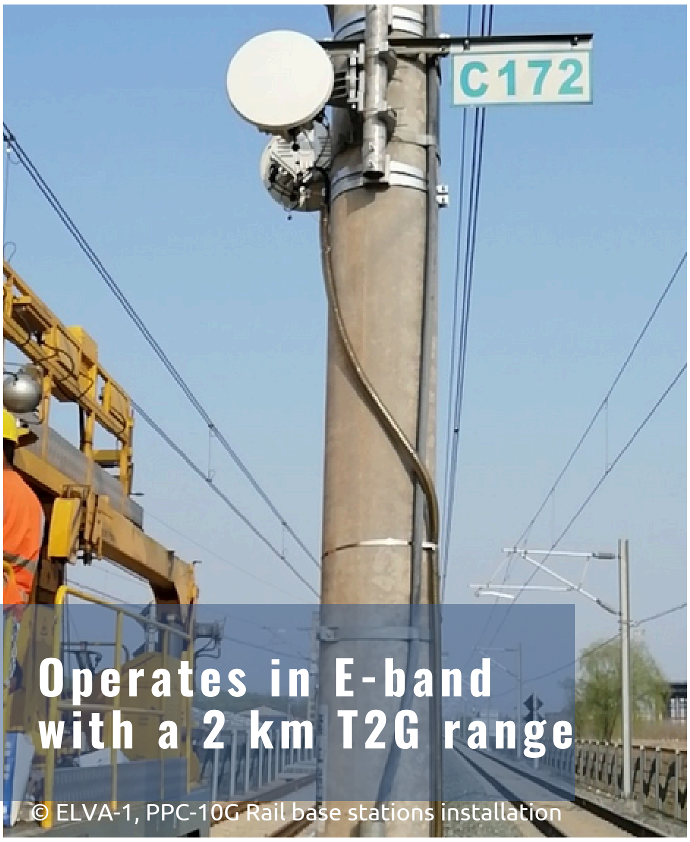
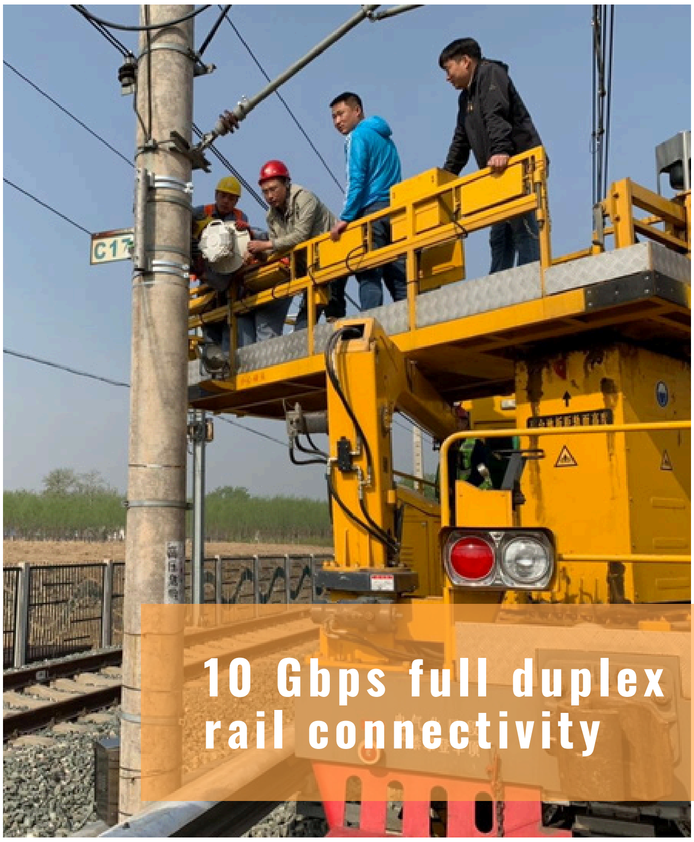
10 Gbps Train-to-Ground Communication

ELVA-1
Millimeter Wave Division



© ELVA-1, PPC-10G Rail base stations installation



FULL DUPLEX 10 GBPS WIRELESS LINK SOLUTION FOR RAIL CONNECTIVITY

PPC-10G-Rail is an all-weather, compact E-band 70-80 GHz radio link designed for duplex 10-gigabit communication of high-speed trains on straight track sections with 2 km hops on average. The complementary V-band 60 GHz MobiBridge-10G is an ultra-compact short-range radio with a phased array antenna that can be used for train-to-ground communication at stations, depots, and on curved track sections.

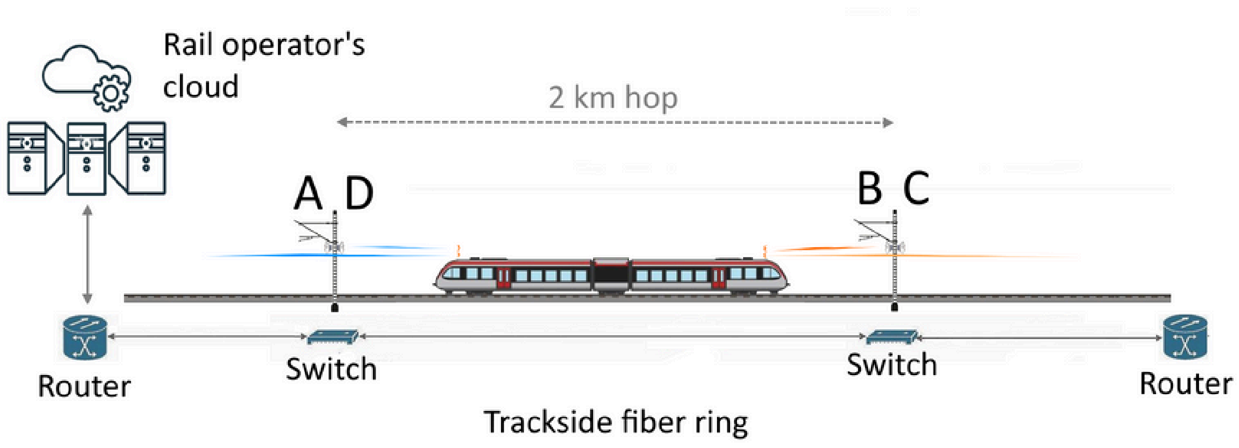
Train-to-ground communication is provided by two 10 Gbps radios (with aggregation up to 20 Gbps) located at the head and back side of the train. For any mm-wave communications, a line of sight is required.


PPC-10G-Rail radios on the carriage roof

PPC-10G-RAIL HIGHLIGHTS

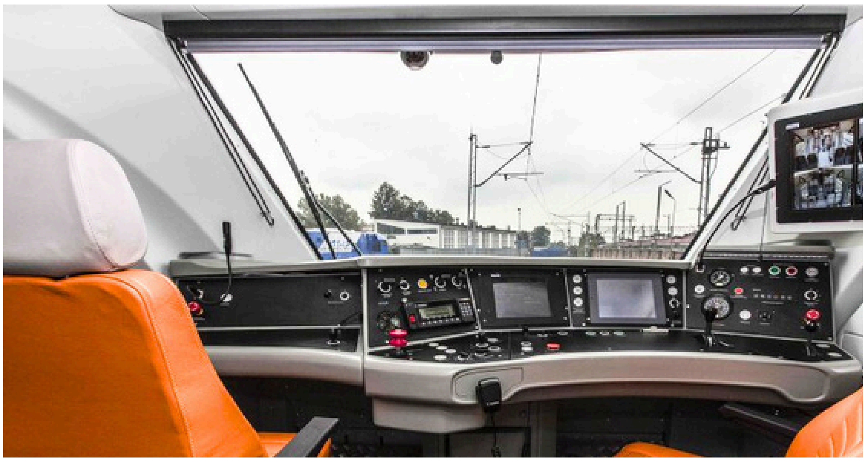
- Data transfer rate up to 10 Gbps per channel
- Full duplex mode
- Zero handover
- Up to 4 km operating distance (2 km recommended)
- Operates in rain, snow, fog and smoke
- Convenient installation of base stations along tracks on catenary system poles or other supports
- Lght licensing for 71-76/81-86 GHz spectrum
- Adaptive modulation up to QAM256

How E-band PPC-10G-Rail radio link works



Each set of PPC-10G-E-Rail radios is designed for a point-to-point data transmission of up to 10 Gbps. The PPC-10G-Rail communication system in the 70-80 GHz millimeter wave band works reliably on straight sections of track with a line-of-sight between base stations (BS) and train radios. The 'forward' and 'reverse of the train' communication channels are aggregated by the train's on-board network equipment. Base stations are installed on the catenary system poles or other trackside supports.

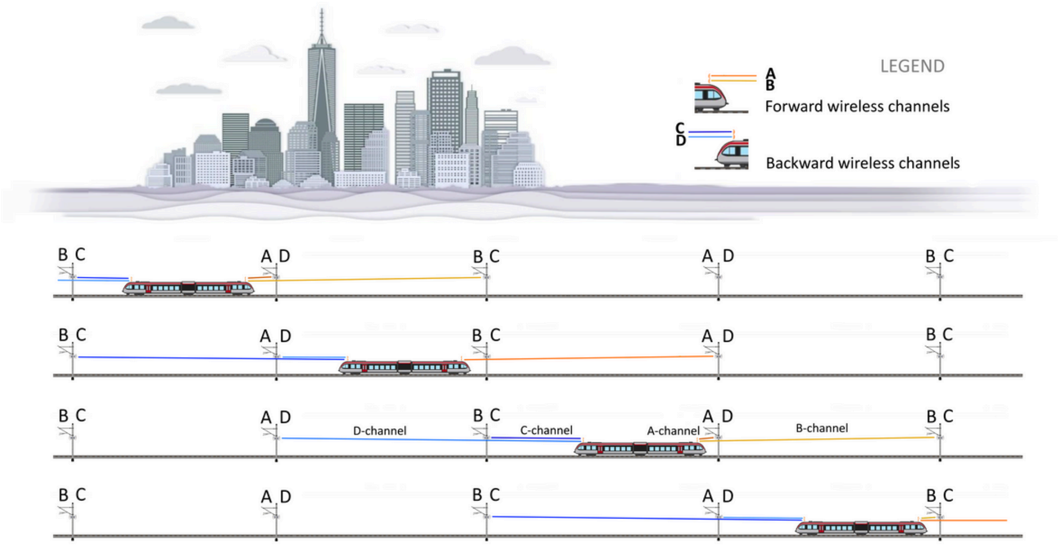
The maximum train-to-ground communication range is 4 km for 30 cm antennas. The optimal field-tested distance between base stations is 2 km, providing train-ground traffic of at least 5.6 Gbps per radio and aggregated 11.2 Gbps.



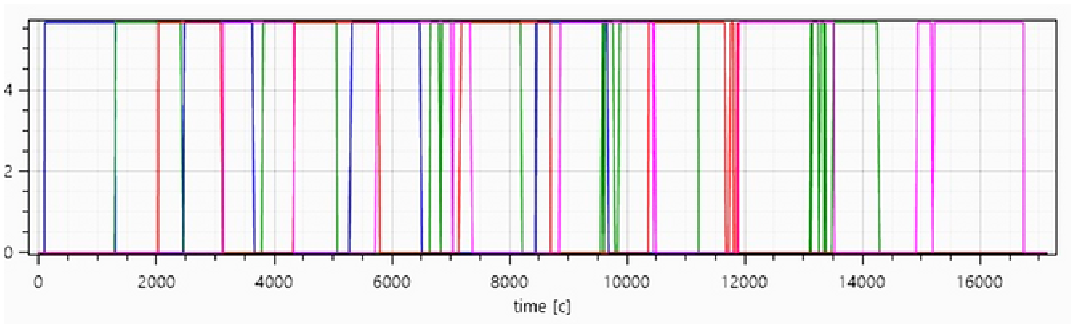
The multigigabit train-to-ground connection in the millimeter wave band enables the transmission of footage from dashboard cameras and surveillance cameras in train cars to the traffic safety monitoring center. This capability enhances the safety of passengers on high-speed trains by providing real-time video monitoring and enabling an immediate response to any incidents.

Additionally, this wideband connection allows to provide all passengers with Internet access with no limits. Improved internet connectivity is essential for increasing productivity and encouraging rail travel. A significant portion of passengers, especially young adults, would prefer train travel if high-speed Wi-Fi were available, utilizing travel time for work and reducing carbon emissions (source: GOV.UK).

How seamless roaming with zero handover time works



Patented technology

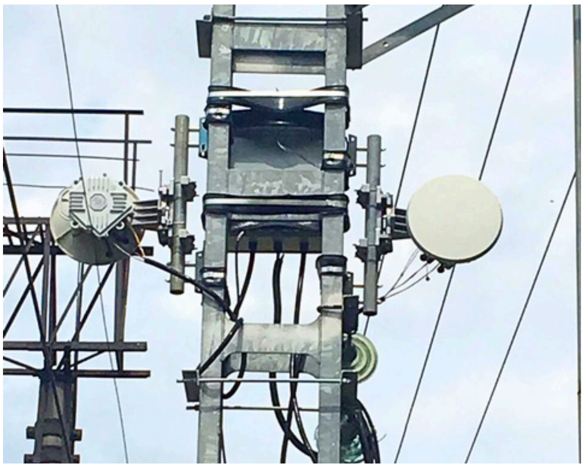


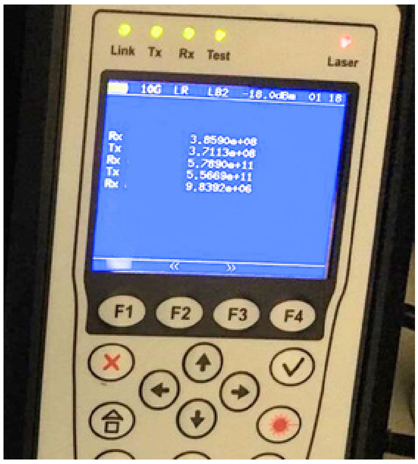
A graph of the throughput of each of the four radios on the roof of the train, using the 16QAM profile, shows a rate of 5.6 Gbps in one direction of data transmission. The different colors on the graph correspond to the connections of the different rooftop radios, respectively. The total train-to-ground (T2G) throughput is determined by the sum of the connections of all rooftop radios in contact with the base stations. Since the connection for each radio is full-duplex, the uplink and downlink bandwidths are equal. For example, there could be 4, 3, 2, or one radio in connection. This corresponds to 5.6 x 4, 5.6 x 3, 5.6 x 2, or 5.6 Gbps in the worst case. There is never a moment when none of the radios are connected to a base station.

The seamless roaming algorithm of ELVA-1 T2G connectivity is based on the following:

- Roof-top radios are installed in paires at the head and end of the train with different operating frequencies for each radio in the pair. Accordingly, the frequency plan of the BS is set so that neighboring parts of the track (aka hops) have different frequencies. In this case, when a train arrives at a particular BS and the first radio in the head of the train has been working up to that point, the second radio will already be in contact with the next BS.
- Even if any train's roof-top radio individually experiences a short switching moment, the aggregated traffic will not be interrupted, but only halved for a very short time. For each individual radio, the switching time does not exceed 10ms. Since these switches occur at different times for all 4 radios, the total handover in the system is zero.
- The connection between base stations can be built using trackside fiber backhaul or wireless.
- The backbone network, via fiber optic cable or wireless, would have routers every 2 km that transmit traffic to the base stations for the first and second tracks.

Switching traffic to an already established channel is almost instantaneous. While one channel is switched, the others remain active. All four links, including two at the head of the train and two at the end, are never switched at the same time.





The PPC-10G-Rail system is designed to be robust to angular variations of the antennas mounted on the train relative to the base station antennas. For this purpose, the pattern width of the antennas on the train is chosen to be larger (wider) than that of the base stations. The result is that any possible deviations in antenna pointing during the movement did not affect the communication capacity.

PPC-10G Rail Specifications

Maximum throughput	10 Gbps full duplex
Unlicensed band	71-76/81-86 GHz
Handover duration for one radio	10 ms (typical), while total T2G handover equals zero
Occupied bandwidth	up to 2000 MHz with adaptive modulation QAM-128 to BPSK
Ethernet ports	1 × SFP + 10GBase-LR / SR, service 1xCopper 1000/100Base-Tx
Antenna type	Parabolic type
Antenna diameter	30 cm (1 ft) or smaller
Ethernet data streams	Transparent for all services Ethernet, Flow Control 802.3x, PTP
Remote control	NMS, Network Management System
Power	60 W 230 VAC / 54 VDC or PoE cable, 12 - 75 V (optional)
Enclosure protection	IP-65 (optionally IP-68)
Ambient temperature	-50 to +60 °C / -58 to 140 °F
Relative humidity	up to 99%

sales@elva-1.com | +372 6 888 905
elva-1.com