A Train-to-Ground Network for Onboard CCTV, Voice, and Data

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Executive Summary

The T2G (Train-to-Ground) link is quickly becoming a lynchpin in modern metro and train systems, and for this critical link rail operators and system integrators need communications solutions that are proven to meet their needs. Between video traffic, voice data, passenger comfort systems, and potentially even CBTC data, the T2G link has more demands on it than ever before. In order to meet these demands, the T2G link must be able to achieve a certain level of network performance. However, the T2G network must fulfill these communications requirements not in a lab, but in the real world of rail operations, which adds a substantial number of practical challenges that make it more difficult for networks to achieve the performance they need. Before any rail operator or system integrator puts their CCTV or train control operations at risk, the T2G solution must be thoroughly validated while running real-world applications, in a real-world setting, facing real-world challenges and obstacles. Thorough testing and validation prior to procurement and deployment is the best and most cost-effective way to deploy a T2G network.

T2G Communications are Vital

In train and metro operations, video is fast becoming an indispensable system. Train and metro CCTV systems provide invaluable information to system operators, giving staff in control rooms and on the trains themselves a real-time picture of operational status, dramatically improving the safety and security of regular operations as well as the response time to emergency events. The next step is to make the CCTV system more pervasive, so that it extends seamlessly from the station onto the train itself and can follow activity no matter where it occurs. In order for this to happen, there needs to be a solid wireless train-to-ground (T2G) network that can transmit video data from the onboard IP cameras to the trackside network and control center.

At the same time that IP-based video is becoming more pervasive, rail system integrators have also begun to contemplate the possibility of converging more systems on the same network. Communication-Based Train Control (CBTC), IP-based CCTV, and passenger comfort/information services could all conceivably operate on the same fundamental IP-based infrastructure and use the same train-to-ground connection. Given how all of these systems are increasingly using the same communications protocol, convergence appears to be the likely future of train communications.
CCTV is becoming a more pervasive system that extends seamlessly from the station to the train itself.

Naturally, the T2G connection must be absolutely rock-solid if it is to be trusted with a CBTC role, and should possess the necessary qualities to shoulder the many responsibilities it is expected to bear in the future. In this white paper, we identify the specific requirements and challenges a T2G network must meet in order to support CCTV, voice, and data traffic simultaneously on one network, and how the challenges of operating onboard a moving train present practical obstacles towards achieving those network requirements.

Communication Requirements for T2G Networks

Between video traffic, voice data, passenger comfort systems, and potentially even CBTC data, the T2G link has more demands on it than ever before. In order to meet these demands, the T2G link must be able to satisfy the following communications requirements:

**Low Handover Time:** The T2G link must remain solid even as the train travels quickly down the track. This means that the onboard wireless devices must be able to quickly establish new links to trackside access points, even as they quickly traverse from one to another. If handover time is too long, the traffic will be interrupted. Even brief network interruptions would compromise the continuity of network streams and create unwanted artifacts such as frozen video, and voice jitter. Practically speaking, an extremely brief handover time is needed to deliver smooth, interruption-free video and voice streams.

**Low Latency:** When it comes to surveillance or control applications, the data needs to arrive on time if it’s to provide system operators an up-to-date understanding about train operations. The T2G network must have low latency in order to support critical systems or deliver real-time situational awareness.
**High Throughput:** More systems mean more traffic, and between infotainment, video, control, and even passenger WiFi data, the T2G link must support a great deal of traffic. For example, the T2G link must have enough throughput to support high-resolution, high-frame-rate video traffic.

**Wireless Network Security:** The data being sent over the T2G communications link is vital to train operations and must be secured against malicious tampering or interdiction. This means that the network must support up-to-date security protocols that prevent any unauthorized manipulation of the data traffic.

**Traffic Prioritization:** When multiple applications share the same communications link, the network must be able to prioritize traffic such that critical and time-sensitive traffic will never be compromised in order to deliver lower-priority traffic. Thus, the T2G communications link must also possess Quality of Service (QoS) functionality in order to support multiple applications.

**Real-World Challenges in Meeting T2G Communications Requirements**

The long list of T2G communications requirements is already a challenge to achieve on a purely theoretical level. However, the T2G network must fulfill these communications requirements not in a lab, but in the real world of rail operations, which adds a substantial number of practical challenges that make it more difficult for networks to achieve the performance they need. The physical reality of onboard rail operations means that in order to succeed, any T2G link must address the following obstacles:

**High Speed Operations:** Trains travel at up to 100 km/h in light rail and metro line networks. The network must be able to maintain a consistent T2G connection while travelling at that speed, without any interruptions while roaming.

**Wireless Interference:** Metro and train stations are public spaces where multiple wireless broadcast devices, such as cell phones and radios, are present. This is a high-interference environment, but the T2G wireless devices must still operate flawlessly despite the presence of many other transmitting devices.

**Onboard Vibrations and Shock:** A fast-moving and constantly vibrating train is far from a stable platform, and any devices deployed onboard a train must be able to keep running even while the train is in motion. Vibrations and sudden shocks cannot be allowed to disrupt the performances of the devices on board.

**Exposure to the Elements:** Devices deployed trackside do not suffer the same degree of vibrations as those deployed onboard though the motion of trains passing by may still rattle the trackside systems. However, they do need to contend with possible exposure to the elements, including rain and extreme heat or cold. In particular, wireless access points are often deployed in exposed locations, and must be able to operate despite environmental hazards.

**Network Coverage and Site Surveys:** Given the sheer geographic scope of a rail line, the train-to-ground communications network must also be able to achieve network coverage over the entire line. APs will need to be deployed in a variety of locations and conditions, and a complete network coverage plan will need to be produced from extensive site surveys. The

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quality of the site survey is important, as it is during this process that important decisions are made about the optimal deployment location for APs, how to avoid wireless interference, and which antenna types to deploy.

The bottom line is that it’s not enough for a network to theoretically achieve the necessary network performance characteristics on paper, or even in a lab. Before any rail operator or system integrator puts their CCTV or train control operations at risk, the T2G solution must be thoroughly validated while running real-world applications, in a real-world setting, facing real-world challenges and obstacles. The more thorough and the testing prior to procurement and deployment, the lower the risk of costly mistakes and the higher the confidence the operator or integrator can have in their chosen solution. This means that thorough testing and test results should be a high priority for any T2G system integrator.

**Moxa’s T2G Solutions: Proven in the Field**

According to their specifications, Moxa’s wireless, networking, and IP video solutions can possess the qualities needed to succeed as rail T2G solutions. But Moxa has also taken the next step in validating these solutions. In addition to thoroughly testing our T2G solutions in our state-of-the-art testing labs, Moxa has also field-tested our devices onboard actual trains in operation while running real-world T2G applications, including video, voice, and data applications. Through these field tests, Moxa can collect detailed data about how our solutions perform in realistic operational conditions, giving our product specifications the weight of actual experience.

By applying Moxa’s decades of industrial networking expertise and leveraging Moxa’s exclusive technologies, Moxa was able to overcome the challenges of operating onboard and trackside in a test T2G network deployed onboard real trains. In our testing, Moxa’s wireless, networking, and IP video devices, such as the AWK-3131 and VPort P06, were able to support an actual video and voice application running consistently at over 25 FPS, with no video latency, frozen video frames, or audio jitter. The train was able to upload secure encrypted traffic at 150 Mbps while at stations, and achieve 70 Mbps throughput while roaming. More specific throughput figures, latency figures, and handoff times, as well as test conditions, are all detailed in a complete test report and available to qualified customers.

*Moxa devices are rigorously tested both in the lab and in the field to give system operators the most accurate and dependable information about performance characteristics possible.*
This train-to-ground test report is one example of how Moxa’s deep industry know-how and commitment to service delivers practical benefits for rail operators and system integrators beyond the quality Moxa product in a box. By partnering with Moxa, customers receive more than just a product in a box: value-adds such as access to Moxa’s solution labs, consultation with Moxa’s industry experts, and Moxa’s library of pre-validated test results all give rail operators and system integrators a more complete, convenient, and cost-effective networking solution.

The Trusted Partner for Rail Train to Ground Communications

The T2G link is a lynchpin in modern metro and train systems, and for this critical link rail operators and system integrators need communications solutions that are proven to meet their needs. Moxa’s wireless, networking, and IP video devices have proved themselves every way possible: on spec, in the lab, in field tests, and in hundreds of live deployments in major projects across the world. To review a copy of the confidential onboard CCTV T2G test report, including details about the exclusive technologies Moxa used to meet T2G network requirements, contact a Moxa sales representative. For details about the many major projects that are already using Moxa’s proven solutions, visit www.moxa.com/rail.

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