Passenger Rail Internet Access with Digi Transportation Solutions

As transit agencies deploy new onboard systems to improve operational efficiency, convenience, safety and security, and to attract and retain passengers, they also have the opportunity to dramatically improve Wi-Fi performance. Digi's cellular router solutions for transportation support the ever-increasing demand for ultra-reliable bandwidth for both passengers and rail operators. Each **Digi TX router** functions as a central gateway for all off-vehicle communications, using every available wireless interface to maintain an active link. High-level features of the Digi solution include:

Security
for protection against misuse and attack and to ensure data integrity.

Management
with integrated software that is flexible, intuitive, and scalable for large fleets.

Performance
to maintain the fastest connections with the highest reliability.

Versatility
to support the complexities of today's many types of IP systems and devices.

Agility
in supporting multiple carrier networks and future wireless standards.

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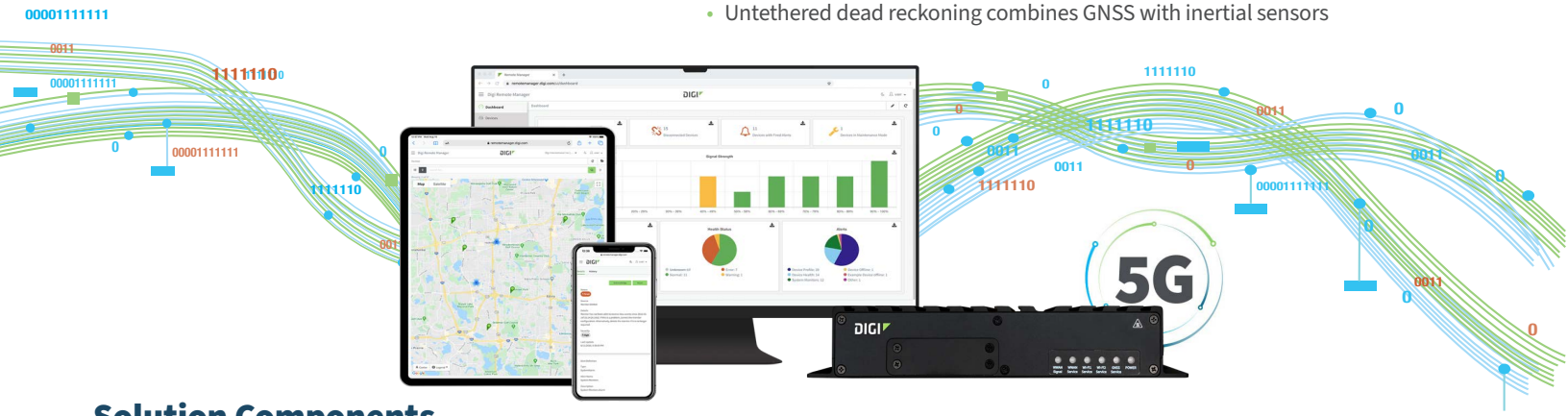
Digi TX Solution Overview

The **Digi TX64 5G Rail** router is well-suited for any application requiring continuous connectivity, field longevity and edge computing. It is an enterprise-class cellular router designed to provide secure routing and gateway functions across traditional and wireless communication networks, protocols and interfaces. It bridges local private wired or wireless subnets across public or untrusted networks, ensuring message privacy and integrity, using trusted channels with authenticated systems. System operation is assured through design and verification to all relevant industry standards. In addition, an embedded Python environment and containers enable quick adaptation to evolving system requirements.

The operating system is embedded Linux, which is universally supported within the developer community and by virtually all

suppliers of protocol stacks and software libraries. This enables Digi to quickly add functionality by incorporating commercially available software suites and largely avoids the typical line-by-line code development process. Features include:

- Hardened compact enclosures designed for mission-critical rail applications
- TNC connectors for RF and X-code M12 Gbps connectors for Ethernet
- High-speed 5G and LTE Cat 20 cellular with support for dual APN / split tunnel
- Dual concurrent 867 Mbps 802.11ac dual band (2.4/5 GHz) Wi-Fi
- Extended temperature range -34° C to 74° C, IP65 enclosure rating
- Untethered dead reckoning combines GNSS with inertial sensors



Solution Components

The Digi transportation solution consists of a router, antennas, and **Digi Remote Manager®** for provisioning, security and ongoing management.

ITEM	DESCRIPTION
Digi Remote Manager (Digi RM)	Cloud-based device management and data enablement platform, offered under subscription.
Digi TX64 5G Rail	High-capacity rail-rated 5G router with true rail hardening in the enclosure, TNC connectors for cellular and Wi-Fi, and M12 connectors for Ethernet.
Exterior Antenna	A .178 m x .025 m (7 in x 1 in) radome antenna with elements for GPS (1), Wi-Fi (2) and 5G cellular (4) is mounted on the roof of the vehicle. Available products are equipped with high voltage and current protection for use under catenary lines.
Interior Antenna	A simple MIMO dual-band (2.4 and 5 GHz) antenna can be installed almost anywhere, facing into the passenger compartment.
Optional Hotspot Management	Hotspot management systems provide cloud-based management for businesses that want to provide Internet for their customers.

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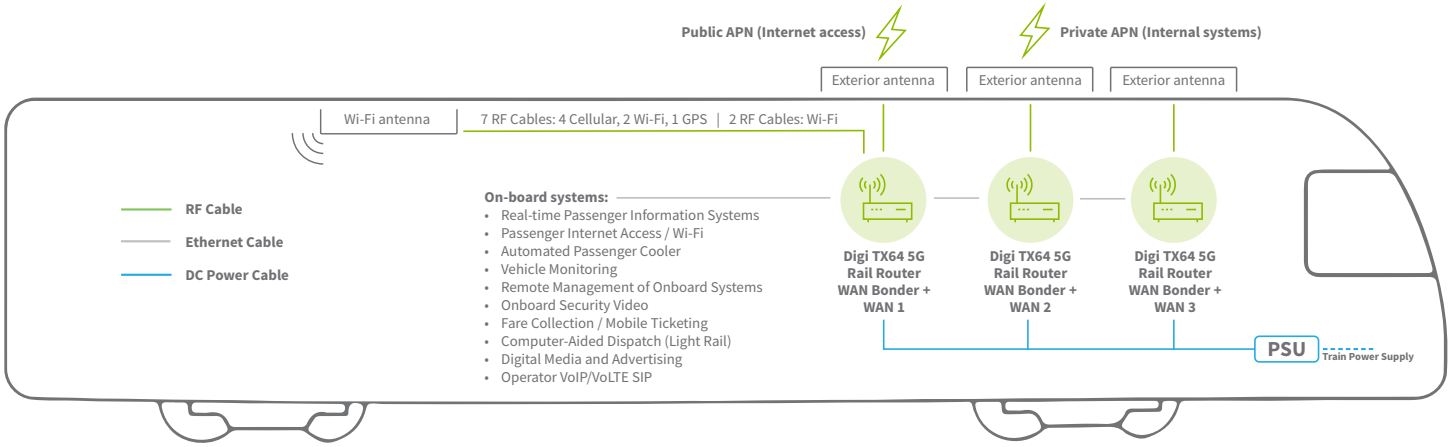

Internet Access

The Digi TX router includes comprehensive Wi-Fi hotspot functionality with the latest features expected in today's connected world. Its flexible design enables a broad range of hotspot service offerings. Built-in capabilities provide a fully functional basic system, with captive portal, configurable splash page, and per-user speed limits, plus "whitelist" and "walled garden" access control. For enhanced content filtering, it can be easily connected to a third-party service. Optional advanced hotspot features such as user management, session control, access vouchers, surveys and advertisement campaigns can be included by connection to hotspot management systems. Such hotspot management systems are not generally used for free rider Wi-Fi. However, it is an option, should users find the features appealing.

Architecture

A distributed system, where each railcar has a router, provides the best performance and is the simplest to install. This is shown in the diagram above. The router can be mounted in the most convenient location in the railcar. This may be where power is readily available, or where access to the exterior antenna is easiest. The interior Wi-Fi MIMO antenna can also be installed adjacent to the router, even at a car end, as there is normally ample signal strength to reach throughout the passenger compartment.

In a centralized system, the router is installed in only one railcar and inter-car links (ICL) connect access points in each railcar. This may be an option where existing inter-car links are already in place and have ample bandwidth available for the service. Otherwise, the cost and effort of installing ICL bridges, end-to-end cabling and access points will be significant. Also, a distributed system has higher fault tolerance, especially since the Wi-Fi signal can travel to adjacent cars.

Scalability

Demands on the system can be expected to grow over time. With the Digi solution, increasing capacity is simply accomplished by adding an additional router, then activating WAN bonding. This is shown in the diagram above. The primary router runs the WAN bonding software module which disperses IP packets across the multiple WANs. There is a corresponding WAN bonding software module at the data center, which disperses IP packets in the other direction, and also restores the TCP streams by combining the arriving packets in their original order. WAN bonding is the performance component of SD-WAN systems. A key benefit is the added resilience, especially in a mobile application where wireless WAN links can suffer degradation due to multipath and other environmental factors. WAN bonding automatically compensates for degraded WAN links by shifting the load to the high-performing WAN link.

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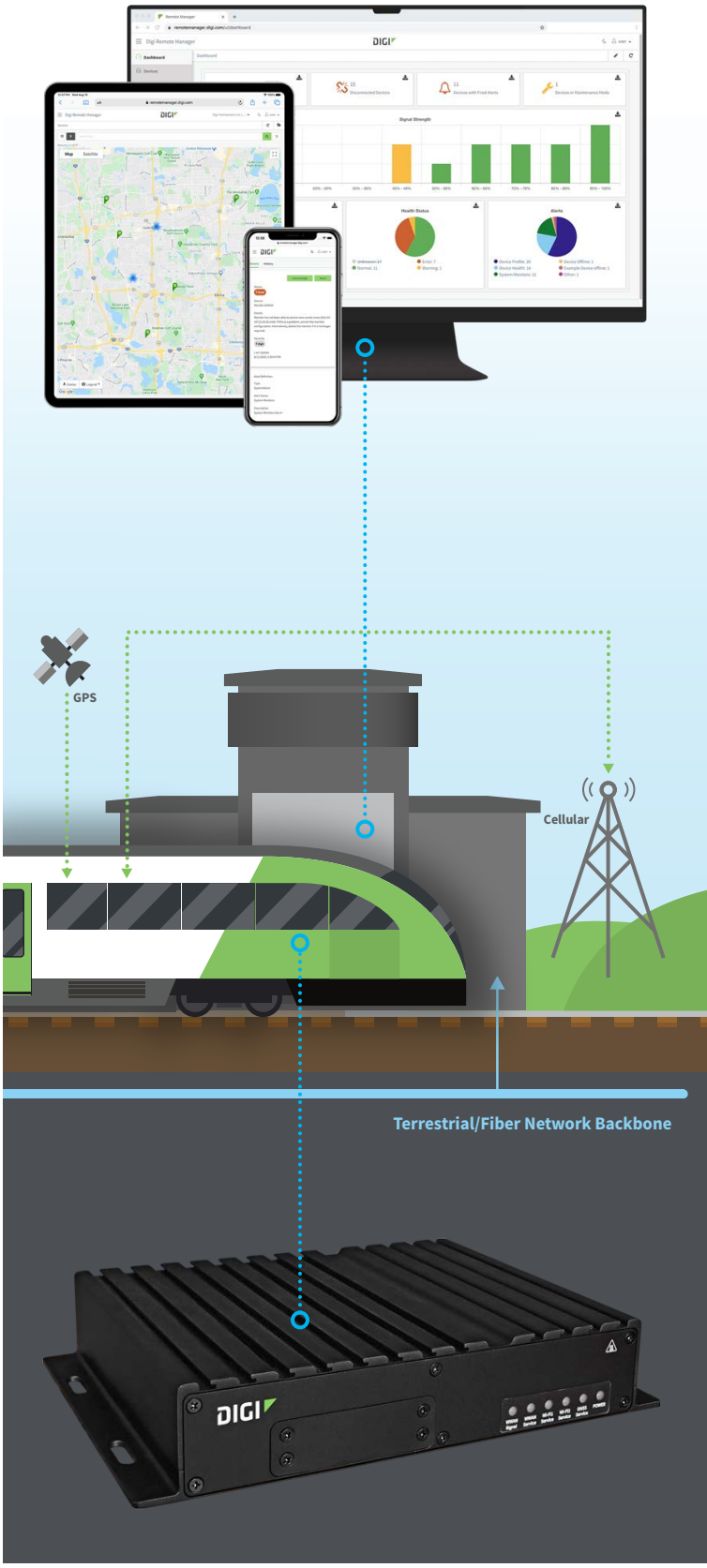
Digi Remote Manager

Digi Remote Manager® (Digi RM) is the technology platform that brings networks to the next level, allowing networks — and the people who manage them — to work smarter. It transforms a multitude of dispersed IoT devices into a dynamic, intelligent network. Now you can easily activate, monitor and diagnose hundreds or even thousands of mission-critical devices from a single point of command. The device management functions enable efficient and effective operation across the entire system. Operators can use Digi RM to:

- Easily integrate legacy systems into the communications network.
- Use a dashboard to gain access to a data repository and generate reports showing device and performance data, including link uptime, network response and data throughput.
- Use the Digi RM APIs to transfer device and performance data to other systems using restful API and JSON formats.
- Ensure that all TX routers are up-to-date with the latest security patches, firmware, and configurations.
- Set up health metrics to track the state of the system at a high level, and then drill down to assess any issues.
- Set up alerts to inform system administrators or other connected systems of any warning or alarm conditions.
- Perform automated remediation if any router configuration is detected as out-of-compliance.
- Schedule operations to automate common management tasks on a single router or on a group of routers. Schedules can be run once or configured to recur as needed.

Digi RM is hosted in the Amazon Web Services (AWS) Virtual Private Cloud (VPC). All communications between the router and Digi RM are protected using TLS v1.3. No transit system communications are routed to AWS, only router performance and configuration data. Transit operations personnel access Digi RM using secure HTTPS. Optionally, a VPN connection can be established between AWS and the customer operations center to provide an extra layer of security.

Should there be a loss of connectivity to AWS, the transit system continues to operate normally. In such a case, management of routers will be less efficient; however, it can be preserved using traditional SSH and HTTPS from the customer operations center.



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Automatic Configuration

Router configuration management is automated to gain efficiencies and to ensure consistency across fielded routers having similar functionality. This is accomplished by establishing reference configuration profiles in Digi RM which are then associated with router groups and/or by individual router selection. When a router first comes online, or when it is scanned according to a schedule, its configuration is checked against the associated reference. Any difference is considered a compliance deviation, which generates an alarm and/or triggers an automatic update to remedy the deviation.

The system also provides automated configuration of replaced routers. Digi RM is made aware of the replacement by a shift of an established Digi RM device name to a different physical router. For example, if an installed router has a Digi RM device name of Car 1234, and the device name Car 1234 is shifted to a different router during a swap move, Digi RM will update the new router with the exact same configuration as the original router. The Digi RM device name can be created by the Digi RM administrator or established and uploaded automatically by the router, based on information obtained locally from the asset.

Often, fielded routers have vehicle-unique settings. This can also be managed within Digi RM by identifying those specific parameters and uploading the actual values from a spreadsheet indexed by the Digi RM device name.

Hotspot Telemetry

The router captures performance telemetry on all subsystems and interfaces, and in particular the hotspot. Key hotspot data items are recorded at a configurable interval such as the number of users, maximum and average session duration, or transmitted and received bytes. Everything is time and geolocation stamped and can be exported via the Digi RM API into other customer systems.

Maintenance Mode

A router can be placed in Maintenance Mode whenever advanced troubleshooting or replacement is necessary. When a router is in maintenance mode, alerts for the router fire and reset, but alert notifications for the router are not sent. In Digi RM, routers in maintenance mode show in the Connection Status column, along with the message “Maintenance Mode On” in the Connection Status details. Routers in maintenance mode are excluded from all dashboard charts. Routers scheduled for installation can be held in a “staging” group in maintenance mode, then moved into an operational group after successful installation checkout.

Mobile App

A router can be registered via a QR code with the Digi RM mobile app. Once a router is registered, a custom configuration can be automatically applied using the Configuration Manager feature. The overall health of the network, as well as individual router status, can also be viewed using the Digi RM Mobile App.

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List of Digi RM Functions

The major functions of Digi RM are listed in the table below. New features and functions are often added to Digi RM in major releases, which occur every three months.

FEATURE	DESCRIPTION
View and Group Router	Add routers to a group to logically organize and manage them, without restriction. For example, Digi TX64 and Digi TX54 can be
Update Individual Router	Configure an individual router by using the built-in configuration interface or loading configuration files.
Update Router Settings in Bulk	Multi-select routers in the list and load configuration files onto them. This is a basic configuration method, not as powerful as
Custom Configuration and	Automatically load configuration and firmware onto a Router when it first connects to Digi RM.
Configuration Manager	A very powerful feature that can create a snapshot of a unit's configuration, firmware and file system contents (e.g. Python scripts), then propagate it to other units for the purpose of rolling out a group configuration or firmware changes and managing
Automatic Configuration by Unique Device Name	Associate a configuration including both common and unique settings to a unique device name (e.g. Car 1234), then, at initial installation or if the router is swapped out, Digi RM monitors and enforces the configuration. The device name can be established automatically by the router or by the Digi RM administrator.
Update Individual Router	Click on a router in a list and upgrade the firmware.
Device Health Metrics	Routers can push their "health metrics" to Digi RM, which can then be used to trigger alarms and show status on a global dashboard, or they can be viewed in detail on a router's individual dashboard to aid troubleshooting and can be exported to other agency systems using the Digi RM API.
SMS Remote Commands/	Supports sending and receiving SMS messages between Digi RM and a Digi RM-registered router.
Automatically Manage Router Security Compliance	Use the Configuration Manager to ensure that the configuration, firmware and files loaded onto a router remain compliant with the "gold standard." Configuration Manager can be configured to create an alarm and/or correct non-compliance if a router is found to be non-compliant. This important security feature prevents outside tampering.
SM/UDP	The SM/UDP (Short Message/User Datagram Protocol) feature allows routers to leverage the very small data footprint of the Digi
Carrier Integration	Utilize information from cellular carriers to facilitate SIM provisioning, SIM activation/deactivation, data usage reporting and alerting (from carrier rather than router perspective).
Scheduled Operations	A very powerful mechanism to schedule complex tasks to be carried out on routers or groups of routers — immediately, at a
Sub-Accounts	Create sub-accounts that can be managed from the parent account. Sub-accounts allow the parent account owner to restrict
Web Service APIs	Link programmatically to Digi RM using RESTful web service APIs. This facilitates the ability to send data from Digi RM (or routers connected to Digi RM) to third-party systems such as AWS or Azure and connect Digi RM to a customer's own CRM or management platforms.
Data Streams	Allows you to store time-series data in Digi RM that can be retrieved later by an external application using web services.

System Features

The integrated system provides seamless and secure network functionality. A more recent focus on the refinement of automated operations has improved the security, availability and operational efficiency of the network. Automated operations reduce avoidable service degradation events, such as those caused by human error. And Quality of Service (QoS) technologies help keep a lid on network overload, by ensuring that high priority data transmission is maintained. The sections below describe these and other key system-level features of the mobile network solution.

System Performance

The assessment of system performance typically includes three measurements: availability, network response and capacity. Availability is presented as a percentage of time in which the network is able to transmit and receive data. Network response is presented as a latency value, indicating the amount of time required for a data packet to traverse the network as a round trip time (RTT). And capacity is presented as peak throughput, which is the maximum rate of transmitted and received data.

The Digi TX router automates the measurement of availability and network response, using WAN and VPN probes. The router records the arrival and round-trip time (RTT) of each probe, then uploads to Digi RM for dashboard presentation and reporting.

A measurement of peak throughput (aka “speed test”) is a good diagnostic tool for isolating network performance problems. Gathering multiple peak throughput measurements at regular intervals is a method to characterize network performance over a period of time, for example to confirm if network infrastructure upgrades are effective.

The throughput measurement system makes use of iPerf, a well-established industry method for measuring network throughput. The router runs iPerf Server, which enables it to be ready to accept a request to initiate a throughput test on any interface including the VPN. The measurement can be initiated from a PC/laptop or a server running an iPerf multi-client instance in an automated method.

Fault Tolerant Network Architecture

Cellular and Wi-Fi availability and performance are often unpredictable in mobile environments. The radio channel could be impaired due to local RF interference, blockage, multipath or excessive transmissions from nearby routers. A poor handoff between radio nodes or a protocol breakdown could also temporarily block network access. The WAN failover and fallback mechanisms in the router are designed to quickly adapt to any such situation. All configured wireless interfaces are kept active and monitored at a network level using probes. Traffic is then routed over the highest priority available interface, typically the lowest cost route.

WAN Failover / Fallback

All four wireless interfaces on the router can be enabled to support WAN communications. And since each cellular interface has two SIM slots, technically there could be six WAN interfaces on a single TX64.

The WAN interfaces operate independently and concurrently, enabling the fastest possible failover. If a WAN link fails for any reason, the router automatically fails over from one WAN to another. Following a failover, the previous active link must remain active for a configurable amount of time before fallback will occur. There are two ways to detect WAN failure: active detection and passive detection.

1. **Active detection** involves sending out IP probe packets (ICMP echo requests) to a particular host and waiting for a response. The WAN is considered to be down if there are no responses for a configured amount of time.
2. **Passive detection** involves detecting the WAN going down by monitoring its link status by some means other than sending IP probe packets. For example, if the state of a cellular interface changes from on to off, the WAN is down. This occurs

Using IP probing to detect WAN failures

Problems can occur beyond the immediate WAN connection that prevents some IP traffic from reaching its destination. Normally this kind of problem does not cause the WAN to fail, as the connection continues to work while the core problem exists somewhere else in the network.

IP probing involves configuring the router to send out regular IP probe packets (ICMP echo requests) to a particular destination. This functionality is established for each WAN interface, individually. If there are no responses to the probe packets, the router brings down the WAN and switches to another WAN until the problem is resolved. If continued probes result in no response, at a configurable count the physical wireless module can be reset. This escalation of remedies ensures resolution of the link trouble if associated with an embedded system anomaly or some sort of network protocol failure.

Automated PKI

The Simple Certificate Enrollment Protocol (SCEP) automates and simplifies the process of Public Key Infrastructure (PKI) certificate management. The TX64 SCEP client can request and retrieve a certificate over HTTP directly from the SCEP server. The SCEP server manages the signing of Certificate Signing Requests (CSRs), provides Certificate Revocation Lists (CRLs), and distributes valid certificates from a Certificate Authority (CA).

Location Assessment

All Digi TX64 5G solutions include a high-performance u-blox GPS SOM for location estimation. In addition, the Digi TX64 5G Rail includes untethered dead reckoning (UDR). The location estimation that is available to onboard Python scripts can be transmitted by TCP/UDP to other IP devices/servers, and is used to tag all telemetry data transmitted to Digi RM (aka “Health Metrics”).

Digi TX routers also include a facility to accept location data in NMEA (National Marine Electronics Association) sentences from an authorized external IP device and use it as if it was generated from its own GPS. In this situation, the location estimation from the router GPS is not used.

Watchdog

Digi TX64 has a comprehensive watchdog system to ensure continued operation in the event of a firmware fault or other anomalous CPU event. The processor includes a hardware watchdog that must be reset by a supervisor task or the system will reboot. In turn, the supervisor task monitors critical operating system tasks.

Digi TrustFence

Digi TX64 includes a suite of hardware and firmware features called **Digi TrustFence®** to protect itself and ensure the reliability and integrity of its security functions. TrustFence uses a cryptographic co-processor to protect particularly sensitive data, such as stored passwords, and encryption keys so that they are not accessible, even by an administrator. It also includes mechanisms that allow the router itself to be updated, while ensuring that the updates will not introduce malicious or other unexpected changes.

Data Security

Digi TX64 5G Rail security features such as bridging, management, data transfer, routing and firewall, use built-in protocols and methods that support message integrity, authentication and encryption. These are listed on the **Digi TX64 5G Rail datasheet**. The security functions can be grouped into three categories:

- Encryption of packets to prevent snooping by an unauthorized source
- Message integrity to ensure that a packet has not been tampered with in transit
- Authentication to verify that the message is from a valid source

A typical secure configuration includes an IPSec VPN tunnel established between the router and the application server. This is best accomplished using AES-256 encryption, Diffie-Hellman IKEv2 key agreement and RSA/PKI authentication. Up to 32 such tunnels can be established, enabling individual onboard subsystems to maintain isolated and secure communication with

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Firewall

The stateful firewall keeps track of the state of network connections traveling across it. The firewall is programmed to distinguish legitimate packets for different types of connections. Only packets matching a known active connection will be allowed by the firewall; others will be rejected. All rejected packets increment an easily viewed counter and are logged, should detailed analysis be required.

Wi-Fi Operation

Digi TX64 5G Rail routers have two Wi-Fi modules. Each module can support a combination of up to four access point (AP) or client instances. For passenger Internet access, one module is configured as an AP with multiple AP instances and the other as a client, providing backhaul communications through authorized agency access points. The AP module can manage many simultaneous client sessions, with each active AP instance having a unique SSID, DHCP server, QoS settings, etc. Each Wi-Fi module can be configured for typical security settings up to WPA2-Enterprise, enabling an AP or client instance to run with that security setting or with no security.

Prioritized Traffic

Should there be a need to prioritize vehicle systems traffic over passenger Wi-Fi traffic, the best way to accomplish this is by using the IETF standard for Differentiated Services (RFC 2474). Critical traffic is given priority over lower priority traffic. This method involves setting the importance level in the IP header, specifically the 6-bit differentiated services code point (DSCP) value. Then transit operations data will always have the lowest latency and highest priority over passenger Wi-Fi traffic. This method is universal, so the IP packet is given priority throughout its journey beyond the cellular network to routers/switches in the private or public networks, as the case may be.

The Digi TX product line supports Differentiated Services and can even compensate for other systems that do not. The router can overwrite the DS field of IP packets originating from a vehicle's onboard computer with a high-priority DSCP value. Then IP packets from the vehicle computer will take priority over Wi-Fi in the router and in downstream routers.

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Digi designs and manufactures industrial-grade communications solutions used in transportation and transit systems around the world.

Digi cellular routers, servers, adapters and gateways support the latest applications in rail, bus, traffic management, energy and Smart Cities. They enable connectivity to standards-based and proprietary equipment, devices and sensors, and ensure reliable communications over virtually every form of wireless or wired systems. An integrated remote management platform, Digi Remote Manager®, helps speed deployments, using highly efficient network operations for mission-critical functions such as mass configuration and firmware updates, including system-wide monitoring with dashboards, alarms, and performance metrics, accessible through tablet, laptop or mobile device.

As a communications solution manufacturer, Digi puts proven technology to work for our customers so they can light up networks and launch new products. Machine connectivity that's relentlessly reliable, secure, scalable, managed — and always comes through when you need it most. That's Digi.

Support Services

Digi provides primary technical support via email for all of its hardware, software and subscription services without charge. This ensures all customers are able to engage our technical support team when configuring or troubleshooting, in addition to accessing our online knowledge base, product documentation, training videos and firmware updates. Engagement by phone and with priority response is included in the Expert Support level, offered under an annual fee with 12 x 5 and 24 x 7 service plans.

Digi Professional Services can also provide dedicated resources for meeting the objectives of a customer project, including system integration and deployment. Our developers frequently write custom Python scripts to support the integration of local non-IP devices or unique network-level functionality. Assistance can include support for system deployment, where task automation, training, installation support and configuration management are key to the success of a project. Professional Services can also build custom applications for greater operational efficiency.

Next Steps

- **Contact us** to talk to a Digi expert.
- **Sign up for our newsletter** to learn about trends and solutions.
- **Shop for solutions** from Digi and our partners.

Company Background

DGII	NASDAQ
1985	Year Founded
800+	Employees Worldwide
310	Million+ Annual Revenue
285	Patents Issued and Pending
100	Million+ Connected Devices

Download the Digi TX64 5G Rail datasheet, or visit our website to learn more about Digi solutions for passenger rail and public transit.

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