Synopsis

Cisco’s Connected Rail solution was developed by a transportation focused engineering team to address the needs and outcomes of a modernizing transit agency. In short, it is a set of validated reference architectures, design documentation, and implementation guides that were also co-created with global rail industry stakeholders. It provides an intelligent, multiservice, secure, and standards-based infrastructure on top of which passenger and operational capabilities can be delivered. Further, it replaces redundant, proprietary, and single application solutions with limited or no interconnectivity and can be deployed onboard trains, at the trackside, and/or within the station itself with a single converged, end-to-end network.

With these capabilities, rail operators can reduce capital expenses (CapEx), increase ridership, and improve safety for both passengers and employees. They can also team with service providers to deliver voice, video, and data to passengers and improve operational efficiencies while allowing for new and future innovations. Through proven and well-established standards based technologies, Cisco Connected Rail solutions maximize implementation success and significantly reduce installation risk, cost, and deployment time.
Socioeconomic trends

According to the United Nations’ Department of Economic and Social Affairs, by 1950, about one-third of the world’s population lived in urban cities and two-thirds lived in rural areas (Figure 1). By 2050, that distribution will reverse itself, with more than 6 billion people needing a way to commute. The rapid rate of global urbanization will likely put additional pressure on already strained infrastructure, which needs to be able to expand with the growth of urbanization as well as be as efficient as possible. Because of this, operators need to evaluate whether their legacy networks will be able to meet future demands. On the positive side, urbanization brings an increased tax base that, with a growing opportunity for private investment, can potentially fuel growth in public-private partnerships. So rail has room to grow, especially with the expected increase in commuting time and congestion among travelers in the future. In fact, a report published by SCI Verkehr of Germany stated that global passenger rail is expected to grow at an average rate of 3.75 percent per year up to 2025, while urban rail (metro, subway, light rail) is expected to grow by more than 5 percent per year during the same period. Still, to stay competitive in the marketplace, rail operators need to stay up to date with compliance issues and growing passenger expectations while reducing operational and capital expenditures.

Figure 1. Urban growth rate

Recent developments surrounding the rail industry

Rail operators today are starting to see their world in a different light. Recent socioeconomic and technology trends have dictated the direction of future rail ventures, while the marketplace itself has quickly adapted to meet the needs of a digitized consumer base. Subsequently, operators need to be confident, rather than conservative, in their approach moving forward amidst these trends.

- To stay up-to-date on current threats, mitigation strategies, and best practices, join the Surface Transportation Information Sharing and Analysis Center.

Technology trends

It’s no secret that cybersecurity is top of mind for many rail operators in today’s world, especially after what happened in May 2017 at the Frankfurt am Main station in Germany. However, as operators adopt more technology throughout their rail systems (train, trackside, station), connectivity becomes irreversible and, if not secured properly, gives cybercriminals many more ports of entry. Multiple scenarios can be considered: operational controls can be breached, which can cause accidents, delays, and injuries; data, whether it be technical, financial, or passenger related, can be breached, exposing operators to severe economic losses; and more. Further, both the magnitude of damage that cybercriminals can enact and the frequency at which these incidents occur will surely increase in the future. Those who are best prepared for possible breaches often have executives with well-defined roles and responsibilities for security, well-documented procedures for incident response and tracking, and a higher priority for thinking beyond the perimeter (for example, a breach with one supplier can affect the entire supply chain).

Another trend is that for end users, the ability to select Wi-Fi over cellular for most of their data consumption is an important consideration for staying within the limits of their mobile data plans. Service providers and rail operators should recognize that the resulting growth in Wi-Fi traffic has strong implications for planning their future networks to accommodate onboard and in-station Wi-Fi. For example, according to the Cisco Visual Networking Index™: Global Mobile Data Traffic Forecast Update, 2015–2020 (February 2016), the following will be seen by 2020:

- 51 percent increase in mobile-ready devices and connections, reaching 11.6 billion
- 250 percent increase in the average mobile connection speed (2 Mbps to 6.5 Mbps)
- 634 percent increase in global mobile IP traffic, reaching an annual run rate of 367 exabytes

Marketplace trends

As passenger expectations rise, stations are now offering commuters more amenities, such as smart ticketing (ticketless travel) and real-time digital signage, to stay relevant in a technology-driven world. Stations are also making themselves into places to stay and enjoy, especially with Wi-Fi connectivity, shops, restaurants, and even business waiting rooms, which offer travelers either more entertainment options or enhanced productivity. All these options help to increase ridership and revenue opportunities for rail operators, including a myriad of different advertising methods, facilitating quicker payback periods and returns on investment.

IT in the operational domain is also making huge strides. Operators across the world are converging their networks for many reasons – greater reliability between systems, operational efficiencies, fewer capital expenses, etc. Wi-Fi aboard railcars makes it easier to track the location of trains, both saving money in reducing the number of lost railcars and increasing productivity by closing the time gap between train departures, thus facilitating shorter, yet more frequent trips and allowing passengers more flexibility in their departure time.

Automation in rail can, in the future, open new doors to improved safety and operations; issues such as vehicles or pedestrians on the track or level crossings can not only be detected but also acted upon by slowing trains automatically and warning citizens of hazards. Lastly, big data and data analysis allow organizations to become more financially nimble by enabling predictive maintenance warnings and energy-efficiency optimization, and by enhancing the passenger experience (such as heat maps showing clusters of open seats), which helps increase ridership and retention.

What is Cisco solving in the rail industry?

At Cisco, we want to shape a better future for transportation. We believe a world that is fully connected can make each of our lives easier, safer, and better. Because of that, we’ve made major improvements in our competitive offerings through close collaboration with both our rail customers and industry experts. The result is Cisco Connected Rail.

Cisco Connected Rail provides a converged, multiservice, secure, and standards-based infrastructure, on top of which passenger and operational capabilities for the rail operator can be delivered. Further, it replaces redundant, proprietary, and single-application solutions that have limited or no interconnectivity, and it can be deployed onboard trains, at the trackside, and within the station itself. With these capabilities, operators can reduce CapEx, increase ridership, and improve safety for both passengers and...
employees. Operators can then team with service providers to deliver voice, video, and data to passengers and improve operational efficiencies. In fact, our Connected Rail solutions help rail operators solve these common challenges:

- Aging systems, which require an increased effort to maintain and are prone to fail more often, resulting in increased costs and safety concerns
- Downtime issues intensified by different levels of reliability between systems
- Compliance issues, since safety mandates now require automated capabilities between trains and back-end systems
- Safety and security concerns, such as train crashes and network breaches
- Passengers’ need for Wi-Fi access and more amenities while commuting
- Environmental and geographic limitations:
  - Ability for high-speed networks (train and trackside) to withstand extreme weather, shock, and vibration
  - Implementation of high-speed wireless coverage across the entire rail infrastructure; geographic factors, right-of-way concerns, and interference often prevent consistent cellular and Wi-Fi coverage

Oftentimes, sunk costs hold investment back. Yet building a foundational future infrastructure and concurrently solving these problems with Cisco Connected Rail can increase your ROI over a longer term.

How is Cisco different?

Only Cisco Connected Rail solutions can help you achieve a wide range of safety, mobility, and efficiency objectives by:

- Providing an end-to-end architectural framework that delivers high-speed voice, video, and data services – from the train to the trackside to the station
- Building on top of existing architecture; there is no set starting point
- Testing and approving products in real-world scenarios under the highest standards (via Cisco Validated Designs)

Other marketplace solutions offer individual solutions that fit only either the train, trackside, or station, and most haven’t been previously tested in real-life scenarios before deployment. This translates to customers risking time, energy, and money and hoping that their investment pays off. Additionally, often the entire legacy network needs to be overhauled, creating long installation processes and reliability issues between systems that are still not solved. The end to end IP architecture addresses three key areas for rail operators, which are shown in Figure 2.

Figure 2: Cisco Connected Rail solutions

<table>
<thead>
<tr>
<th>Business Outcome</th>
<th>Safety Mandate</th>
<th>Asset Utilization</th>
<th>Increased Ridership</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Capabilities</strong></td>
<td><strong>Solution BOM</strong></td>
<td><strong>Customer Reference</strong></td>
<td><strong>NetworkRail</strong></td>
</tr>
<tr>
<td>FOG/Sensors</td>
<td>IE2K/IE4K/IE5K</td>
<td>BNSF Railway Metro</td>
<td>DB Maxima Telecom</td>
</tr>
<tr>
<td>Identity</td>
<td>AP1552/AP1572</td>
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<tr>
<td>Mobility</td>
<td>W3700AP</td>
<td></td>
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<tr>
<td>Collaboration</td>
<td>WLC5508</td>
<td></td>
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<tr>
<td>Data Center</td>
<td>ASA5500</td>
<td></td>
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<tr>
<td>WAN/Access</td>
<td>ASR1000</td>
<td></td>
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</tr>
<tr>
<td>Cloud</td>
<td>ASSR91/902/903</td>
<td></td>
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</tr>
<tr>
<td>Security</td>
<td>ASSR920</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(cyber and physical)</td>
<td>ASSR9500</td>
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<tr>
<td>Fluidmesh</td>
<td>Fluidmesh FM3500/FM3200</td>
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<tr>
<td>Lilee Virtual LMC</td>
<td>Lilee – LMC-1500</td>
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<tr>
<td>WAMS</td>
<td>IE2000</td>
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<tr>
<td>SDR</td>
<td>IE4000</td>
<td></td>
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<tr>
<td>Prime Infrastructure</td>
<td>ASR5000</td>
<td></td>
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<tr>
<td>Cisco QPS (Broadhop)</td>
<td>Prime Infrastructure</td>
<td></td>
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<tr>
<td>IP6050</td>
<td>Cisco QPS (Broadhop)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cisco UCS, VSM 7.5</td>
<td>Cisco QPS (Broadhop)</td>
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<td></td>
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</tbody>
</table>

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Table 1 lists several features and benefits of Cisco Connected Rail.

<table>
<thead>
<tr>
<th>Use case</th>
<th>Application, feature, or service</th>
<th>Benefit(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Video surveillance, communications-based train control (CBTC), and automatic train control (ATC)</td>
<td>• Reduces human error and related mishaps&lt;br&gt;• Improves situational awareness</td>
</tr>
<tr>
<td>Compliance</td>
<td>Support for PTC; automation that overrides human error</td>
<td>• Increases the ability to meet the U.S. Rail Safety Improvement Act legislative PTC mandate in the U.S. by the December 31, 2018 deadline</td>
</tr>
<tr>
<td>Passenger mobility and services</td>
<td>• Onboard Wi-Fi and other mobile Internet access services&lt;br&gt;• Internet access service bundled with monthly ticket fee&lt;br&gt;• Onboard screens that display location and weather information, travel tips, and advertisements&lt;br&gt;• On-demand entertainment services delivered to passenger devices</td>
<td>• Increases passenger retention&lt;br&gt;• Increases ridership&lt;br&gt;• Develops further revenue generation and new business models</td>
</tr>
<tr>
<td>Operations</td>
<td>• High-speed train-to-trackside wireless infrastructure to support service delivery&lt;br&gt;• Ability for train operators to communicate with passengers or crew over IP-based intercom&lt;br&gt;• High-definition IP video cameras for live monitoring of activity on trains, in stations, and at trackside&lt;br&gt;• Automated systems for correlating data instead of viewing multiple screens&lt;br&gt;• Predictive maintenance enabled through collection and correlation of sensor data&lt;br&gt;• Consolidation of multiple single-purpose applications onto one converged IP network</td>
<td>• Improves passenger safety&lt;br&gt;• Enables new services&lt;br&gt;• Improves operational efficiency by lowering expenses (OpEx)&lt;br&gt;• Reduces CapEx&lt;br&gt;• Simplifies maintenance&lt;br&gt;• Improves network security&lt;br&gt;• Moves from proprietary to open standards</td>
</tr>
</tbody>
</table>

“We now have real-time information at all our stations in our entire system – real-time diagnostics on our trains so that our maintenance department can see how our trains are operating and if we starting to see issues with thresholds, we can stop a train and do a replacement on it before we experience a major failure”

— Paul Jablonski, CEO, San Diego MTS
Cisco Connected Rail solution (with architectural diagrams)

The optimal scenario is a converged, standards-compliant network that complements existing systems while enabling smooth migration to next-generation capabilities (Figure 3). It combines best-in-class products with key ecosystem partner integration, forming validated network designs with the Connected Train, Connected Trackside, and Connected Station solutions.

Figure 3. Cisco Connected Rail architecture
Connected Train
This solution includes an onboard, high-speed, wired and wireless IP network. Operators can enhance security, wireless access, passenger services, and applications.

Cisco Connected Train integrates capabilities from multiple proprietary networks in train cars onto a new converged IP network infrastructure. The solution provides a resilient infrastructure to deliver numerous services, such as onboard safety and security (including video surveillance), passenger Wi-Fi and entertainment services, passenger information displays, and collaboration capabilities. Cisco Connected Train also provides a link to operations and control center teams for CBTC, PTC, and fleet dispatch features. The Connected Train architecture is shown in Figure 4.

The high-speed Cisco Connected Train network is built on hardened, Small-Form-Factor (SFF) switches and gateways that support consumer and business mobility features. The onboard gateway manages seamless service transport simultaneously over multiple WAN connections, including both Ethernet-connected train-to-trackside radios and multiple Long-Term Evolution (LTE) cellular links. Wireless access points provide Wi-Fi connectivity to rail personnel and passengers. The network also supports comprehensive video surveillance, with a dedicated Video Surveillance Media Server on each car to store video archives from the onboard IP cameras. This same server platform is used to host on-demand content for passenger entertainment services.

Connected Trackside
This solution replaces multiple older, proprietary railway networks with a Cisco Unified MPLS Mobile Transport (UMMT) network. Operators can expect reduced operational services, cost, and complexity, as well as enhanced security, train control and operations, and maintenance.

Trackside radios, which are ruggedized for almost any environment, provide broadband wireless connectivity between the trackside backhaul infrastructure and high-speed trains. Trackside radios connect to the transport network, using fiber or copper connections, to ruggedized Ethernet access switches, which are able to supply power via Power over Ethernet (PoE) to the radios and other trackside devices, such as video surveillance cameras. These ruggedized switches are connected in either ring or hub-and-spoke topologies via fiber connections to preaggregation nodes, which form the edge of the unified Multiprotocol Label Switching (MPLS)-based, highly scalable, converged backhaul network. The Cisco Connected Trackside architecture is shown in Figure 5.

“It’s a very good thing that you can keep up with your existing knowledge—you don’t have to retrain your operation guys or your planning guys”

— Sebastian Meissner,
Lead Architect IP Network
DB Systel GmbH
Figure 4. Cisco Connected Train reference architecture
Cisco also provides a validated design for a highly scalable and resilient converged service transport network that connects the trackside network with operations and data centers. The transport network consists of access, aggregation, and core networks. It provides a resilient communication path between the Connected Train, Connected Trackside, and Connected Station solutions and the data center. This network includes ruggedized Ethernet switching at the edge and a multipath, IP-based MPLS transport network with subsecond reconvergence for communications between trains and the data center. The architecture for train-to-data center backhaul is shown in Figure 5 above.

A Virtualized Multiservice Data Center (VMDC) validated design, also shown at the top of Figure 5, creates a data center infrastructure to support high-speed mobile networking for rail applications. The data center houses a highly scalable and virtualized server infrastructure that hosts all applications for the Cisco Connected Rail solution. These application servers may run directly on physical servers or be virtualized through the use of a hypervisor. They include the following:

- The Local Mobility Anchor (LMA) hub router for Connected Train traffic aggregation
- Wireless LAN controllers (WLCs) for managing the Wi-Fi infrastructure in the Connected Station and Connected Train solutions
- Network management systems (NMS) for managing the network infrastructure and passenger services
- Cisco Video Surveillance Manager (VSM) application servers, including Cisco Unified Operations Manager, and long-term storage, to manage video surveillance on the train, along the trackside, and in the station
- Other servers, such as the Cisco Instant Connect system, formerly known as the IP Interoperability and Collaboration System (IPICS). This system dissolves communication barriers between land mobile radio (LMR) systems and devices such as mobile phones, landline phones, IP phones, and PCs. Instant Connect is a scalable, cost-effective way for all rail and security personnel to communicate quickly using any desktop or mobile device wherever it is located. It simplifies radio dispatch operations and accelerates incident and emergency response times. It also adds new capabilities to your existing communications equipment.
Connected Station

Connected Station integrates multiple in-station networks and retail communication systems into a single standards-based IP network. Operators can improve retail offerings and revenue streams, security, and wireless access.

Cisco Connected Station delivers innovative services to passengers, helps stations enhance safety and security, simplifies operations, and provides station staff with more efficient communications. With Cisco Connected Station, multiple proprietary station networks evolve into a multiservice network that unifies displays, ticketing systems, voice communications, fire and safety alarm systems, and passenger services and applications into one manageable infrastructure. In addition, the network infrastructure supports deployment of physical safety and security capabilities, such as emergency help points and video surveillance cameras, to enhance station safety and monitoring systems.

The architecture for Cisco Connected Station is shown in Figure 6.

Ecosystem partners and validated Cisco Connected Rail components

A key advantage of the Cisco Connected Rail solution is that it brings best-in-class Cisco products together with offerings from key ecosystem partners into a cohesive, end-to-end, validated design that fulfills the business needs of rail operators. Some ecosystem partner products that have been validated with the Cisco Connected Rail solution are even available on the Cisco Global Price List (GPL) to simplify your procurement process. Table 2 lists ecosystem partners whose products have been validated with the Cisco Connected Rail solution.
Figure 6. Cisco Connected Station reference architecture
Table 2. Ecosystem partners with validated solutions for Cisco Connected Rail

<table>
<thead>
<tr>
<th>Use case</th>
<th>Application, feature, or service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluidmesh Networks</td>
<td>Provides train-to-trackside radio systems for nearly seamless connectivity of high-speed trains. <a href="https://www.fluidmesh.com/">https://www.fluidmesh.com/</a></td>
</tr>
<tr>
<td>Intel</td>
<td>Provides the microprocessing chips that enable IoT data communication</td>
</tr>
</tbody>
</table>

Table 3. Cisco Connected Rail components

<table>
<thead>
<tr>
<th>Use case</th>
<th>Application, feature, or service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onboard gateways</td>
<td>A ruggedized multiservice gateway from Klas Telecom, integrating the Cisco 5921 Embedded Services Router (ESR), which offers flexible off-boarding via train-to-trackside radio and multiple LTE interfaces, as well as Layer 3 routing and security. Onboard devices use the 5921 ESR as their default mobile access gateway (MAG). The data center uses the Cisco ASR 1000 Series Aggregation Services Router as an LMA hub router for terminating tunneled connections from the onboard gateways.</td>
</tr>
<tr>
<td>Industrial Ethernet</td>
<td>The Cisco Industrial Ethernet (IE) 2000, 3000, and 4000 Series Switches provide a variety of ruggedized switching options. Onboard the train, a ruggedized rail-certified Layer 2 switch from Klas Telecom, integrating Cisco technology, provides Ethernet connectivity, PoE, and mechanical bypass to avoid having cars become isolated islands during a power failure. Off-board, standard Cisco IE switches support Layer 2 and 3 connectivity with flexible configuration options.</td>
</tr>
<tr>
<td>switchung</td>
<td></td>
</tr>
<tr>
<td>Train-to-trackside radio</td>
<td>Ecosystem partner Fluidmesh Networks provides an IEEE 802.11-based Ethernet-connected radio system to provide train-to-trackside wireless communications. Integrating their FLUIDITY technology provides high-bandwidth connectivity to high-speed trains with near-seamless roaming.</td>
</tr>
<tr>
<td>Wi-Fi access points</td>
<td>Cisco offers the Cisco Industrial Wireless 3700 Series LAN access points designed for onboard and station deployment. Another option for station deployment, the Cisco Aironet® 3700 Series wireless LAN access points may be used in climate-controlled spaces where hardened devices are not required.</td>
</tr>
<tr>
<td>Wireless LAN controllers</td>
<td>The Cisco 5500 Series Wireless Controllers provide high-performance, scalable, and reliable services for wireless networking. The controllers can support up to 500 access points. For larger deployments, the Cisco 8500 Series Wireless Controllers offer the same functions with higher scale.</td>
</tr>
</tbody>
</table>

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### Solution overview

**Cisco public**

<table>
<thead>
<tr>
<th>Use case</th>
<th>Application, feature, or service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subscriber policy control</strong></td>
<td>For service providers who offer mobile services to rail passengers and operations teams, the Cisco Service Provider Wi-Fi solution offers subscriber policy control to create revenue-generating opportunities. Cisco Quantum Policy Suite (QPS) for Wi-Fi is a carrier-grade policy and subscriber data management software solution for controlling, monetizing, and personalizing Wi-Fi offerings.</td>
</tr>
<tr>
<td><strong>IP video surveillance</strong></td>
<td>Cisco provides video surveillance cameras, including the rugged, high-definition, IP67-rated Cisco Video Surveillance 3050 and 7070 IP Cameras, and media servers. The Cisco Video Surveillance Manager management suite lets you view and archive video and manage the video surveillance infrastructure.</td>
</tr>
<tr>
<td><strong>Cisco Unified MPLS for transportation</strong></td>
<td>Cisco Unified MPLS is a scalable and resilient backhaul network for mobile voice, video, and data traffic between the train, trackside, station, and data center. It complements existing backhaul networks to enhance their capacity and resiliency.</td>
</tr>
</tbody>
</table>

### Cisco Services

After you’ve chosen a focus, Cisco Services can help advise you, as well as implement, optimize, and support your solution from strategy to execution *(Figure 7)*.

**Figure 7. Cisco Services - Rail**

The Focus is on business outcomes from strategy through execution.

- **Advise**
  - Vision and Strategy
  - Connected Transportation Consulting Services
  - Connected Transportation Analytics Consulting
  - Connected Transportation Next Generation IT Consulting
  - End-to-End Collaboration Enabled Transformation
  - Connected Transportation Discovery and Strategy Workshop
  - Business Justification

- **Assessment**
  - Connected Transportation Architecture Assessment Service
  - Connected Transportation Architecture Planning and Design Service
  - Connected Transportation Architecture Strategy Service
  - Connected Transportation Security Assessment
  - Connected Transportation Wireless Assessment

- **Implement**
  - Design and Validation
  - Connected Transportation Infrastructure Build Out
  - Connected Transportation Infrastructure Solution Optimization Service
  - Connected Transportation Product Support
  - Deployment, Integration and Migration

- **Operate**
  - Optimization
  - Connected Transportation Product Support
For more information about Cisco Connected Rail solutions, visit www.cisco.com/go/connectedrail.

Advise: Strategize and consult
Cisco Services help to set expectations clearly, create a roadmap for success, and determine a strategy for tracking outcomes and impacts. We also address any architecture and security gaps and even plan for unforeseen technology trends that could negatively affect your business.

Implement: Reduce deployment risk
Cisco Services can also create a converged and secure IP-based network infrastructure, which includes an effective integration of an end-to-end solution. Project overruns are minimized and deployment risk is reduced with a thorough validation and testing process, which helps ensure that project requirements are met. This process includes factory acceptance testing, site acceptance testing, user acceptance testing, system integration testing, and/or commissioning.

Operate: Optimize performance
Finally, our services continually amplify your infrastructure and applications, delivering superior server, storage, system, and network performance. Predictive diagnostics, real-time data, and analytics also aid in anticipating future issues for maximum effectiveness.

Summary
Cisco Connected Rail is an end-to-end, standards-based infrastructure that can replace redundant, proprietary, and unreliable systems without losing your legacy networks. It can be deployed on the train, at the trackside, or in the station or, best case scenario, all three. Our validated designs help ensure that your new infrastructure is secure, robust, and ready from day one. What makes us unique in the marketplace are these three key items:

• An end-to-end architectural framework that delivers high-speed voice, video, and data services – from the train to the trackside to the station
• A solution built on top of existing architecture; there is no set starting point
• Products that have been tested and approved in real-world scenarios under the highest standards (via Cisco Validated Designs)

With Cisco Connected Rail, you can reduce CapEx, increase ridership, and improve safety for both passengers and employees. You can then team with service providers to deliver voice, video, and data to passengers and improve operational efficiencies. What are you waiting for? Join Cisco today.