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Enabling Video-over-Wireless Networks

An in-depth guide on how to ensure seamless video-over-wireless transmissions for industrial applications

Contents

Reliable Video Transmission over High Bandwidth Industrial Wireless Networks

In the past ten years, huge strides have been made to improve wireless technologies; so much so that many industrial networks are being converted from wired to wireless. The reason is straightforward—with wireless communication no cabling is required, making wireless networks much cheaper and easier to implement compared to wired networks. However, because of the bandwidth constraints that come with using wireless, video-over-wireless was not really feasible until about five years ago, at which time 802.11n and 3G HSPA technologies were mature enough for use with industrial applications.

Many industrial networks are now being designed to support video data transmissions, with most of the data generated by IP surveillance systems. With security more important now than ever before, the demand for higher resolution IP cameras is also growing. However, IP surveillance systems create greater bandwidth demands on your industrial network infrastructure. To support seamless video streaming over a wireless network, operators must understand how much bandwidth each camera will need, and then calculate the total network bandwidth required for simultaneous data transmissions.

The following two tables provide valuable information for engineers who are preparing to install wireless equipment. Table 1 provides an estimate of the amount of network bandwidth required to achieve real-time video transmission based on the quality, resolution, and FPS. Table 2 gives the data rate and maximum achievable bandwidth for different network protocols.

Table 1: Video Bandwidth Requirement

Video Bandwidth Parameters		Required Bandwidth Estimate*
Quality: Resolution: FPS:	Good 640x480 20	1 to 2 Mbps
Quality: Resolution: FPS:	Excellent 720x480 30	3 to 5 Mbps
Quality: Resolution: FPS:	Excellent 1280x800 30	7 to 9 Mbps

*Generated using Moxa's online Bandwidth Calulator.

Table 2: Wireless Bandwidth Map

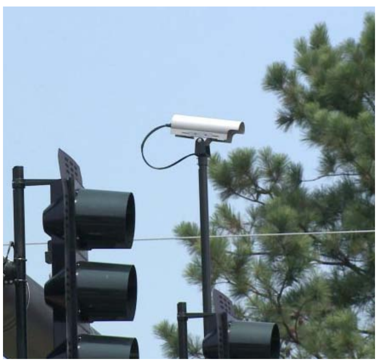
Wireless Technology	Data Rate	Max. Available Bandwidth
Wireless LAN (802.11/WiFi) Technology*		
802.11b	11 Mbps	≈ 5 Mbps (distance dependent)
802.11a/g	54 Mbps	≈ 25 Mbps (distance dependent)
802.11n (2x2 MIMO)	300 Mbps	≈ 150 Mbps (distance dependent)
802.11ac	600 Mbps	≈ 300 Mbps (limited transmission distance)
Wireless WAN (Cellular) Technology		
2G (GPRS/EDGE)	86, 236 kbps	≈ 100 kbps (ISP dependent)
3G (HSPA)	14.4 Mbps	1 to 3 Mbps (ISP dependent)
Pre 4G (LTE)	100 Mbps	20 Mbps (limited coverage)

*Generated using Moxa's online WLAN Range Calculator.

Knowing how to calculate both video data and wireless network bandwidth is an essential first step in planning a video-over-wireless network, and although choosing wireless devices is driven primarily by the amount of network bandwidth you'll need, it is also important to ensure that the devices will work smoothly under different application scenarios.

Video-over-Wireless Application Scenarios

Although 802.11ac and LTE are the latest wireless technologies, in terms of interoperability and coverage, they still aren't mature enough for use with industrial applications. Currently, the key technologies available for enabling video-over-wireless are 802.11n and 3G. Based on our experience helping end-users implement real-world applications, we can categorize industrial video-over-wireless communication into one of the following three scenarios.



Scenario 1: Remote IP Surveillance

Intersection monitoring, factory surveillance, and harbor surveillance are good examples of applications that will inevitably require removing existing nodes or adding new nodes. The main problem faced by our customers is that if they're stuck using a wired network connection, there's a good chance they will need to lay new cables when adding new nodes. If using wireless communication is an option, they can easily add the new nodes without installing additional data line cabling. Two key factors that must be considered when doing this are wireless coverage and real-time communication.

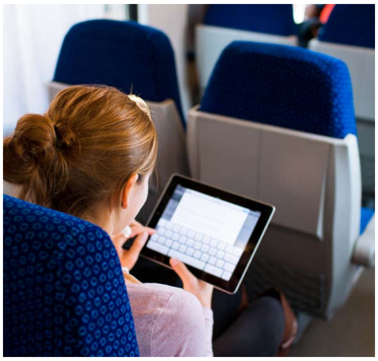
Depending on what degree of wireless coverage is required, Moxa provides a complete range of wireless solutions supporting different transmission distances. For a local wireless network, which usually means within a 300 meter transmission radius, 802.11 radios are a good choice due to their higher gain omnidirectional antennas. For longer communication distances, cellular technology can provide a more stable solution.

Once you decide to go wireless, it is important to adopt a network design that provides sufficient bandwidth to ensure that your connection will support real-time video transmissions. In this regard, Moxa provides two useful tools: a Video Bandwidth Calculator that allows users to determine how much bandwidth is required for each camera, and a WLAN Range Calculator that provides an initial estimate of data rates, ranges, and the antenna gain settings that AWK series products can support.

When operating mission-critical and safety-critical systems in hard-to-wire environments, packet loss during wireless transmissions can compromise safety and reliability. Moxa has products that overcome this problem. Moxa's dual-radio wireless solutions feature the proprietary Concurrent Dual-Radio Technology, which achieves zero packet loss for industrial applications. For cellular connections, Moxa's GuaranLink feature ensures reliable and consistent cellular connectivity, which translates into zero data loss and on-demand cellular communications.

Scenario 2: IP Surveillance for Vehicles

The development of wireless technology has made it possible to connect vehicles of various shapes and sizes to stationary networks. Applications of this type include bus surveillance, metro surveillance, and truck driver monitoring, all of which are now feasible by using wireless communication. The main hurdle that must be overcome for all of these applications is how to ensure smooth video streaming while the vehicle's wireless device is handed off from one access point to another. Moxa is an expert at wireless roaming technology, and due in part to Moxa's proprietary roaming algorithms, Moxa's wireless devices are now widely used to support wireless communications for a variety of mission-critical vehicle applications.



Scenario 3: Passenger WiFi

The previous two application scenarios implement centralized communication. That is, video streams from one or more remote sites (which could be on the move) are fed to a control center. However, with the now widespread use of handheld devices, industrial wireless is no longer just serving industrial wireless client radios. Setting up a passenger WiFi network on a passenger train is one example. In addition to the high bandwidth required to serve many handheld devices, setting up a reliable wireless backbone network is an important part of onboard WiFi applications. Inter-carriage communication needs a better solution to make setup and maintenance easier for operators, particularly since train consists frequently change during daily service. Moxa's Auto Carriage Connection technology is specifically designed to solve this problem by automating the previously manual process of creating new wireless bridges that provide broadband communications throughout the entire train, while still maintaining robust network security.

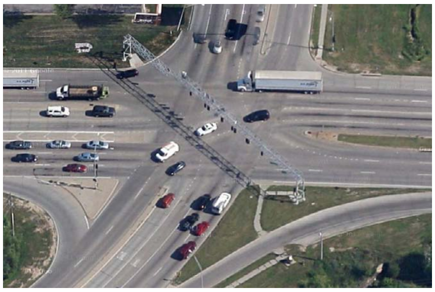
Wrap Up

As we can see from the above scenarios, different types of video applications have different concerns. One thing we can be sure of is that regardless of the scenario, providing seamless video transmissions through an industrial video-over-wireless network requires a rugged hardware design. Moxa's industrial wireless products have been designed for any kind of industrial application. Features like a wide -40 to 75°C operating temperate range, vibration-proof M12 and QMA connectors, a high level of EMS protection, and a variety of industrial certifications, ensure that your wireless transmissions are reliable.

Moxa has all of the knowledge, experience, and technology needed to deploy a video-over-wireless network. The following case studies provide greater insight into the benefits Moxa can offer customers who would like to implement seamless video transmission over high bandwidth wireless networks.

Using High Bandwidth Wireless Technology for Remote IP Surveillance

A variety of industrial applications have deployed video surveillance systems for remote monitoring and to enhance field site safety. There are many ways to implement a video surveillance system, depending on the type of cameras used and how those cameras are connected to the network. One option is to use IP cameras, with the video signal transmitted over a wireless network connection. This choice makes sense since IP cameras support digital video compression and use Internet Protocol (IP) technology, making it easy to send the video signal over an existing Ethernet network. In addition, wireless is often preferred over wired since you can easily install your cameras in hard-to-wire locations, and you can save a lot of money since you won't need to install additional wiring for long distance remote video surveillance systems. However, to ensure seamless video data transmission over a wireless network connection, your wireless, remote IP surveillance solution must be robust, versatile, and support high bandwidth data transmissions.



What's Required for Seamless Video Transmission over a Wireless Network

The cameras used for remote IP surveillance applications are deployed at field sites, located some distance from the control room. Compared to wired network connections, wireless technology provides an efficient and cost-effective way to extend your network. Wireless networks must be able to provide a strong wireless signal and support a seamless video stream throughout the application site. Wireless network security is also important to protect your confidential video data from hackers. Take note of the following key criteria related to setting up and maintaining an industrial wireless network:

- Strong wireless coverage is a basic requirement for remote IP surveillance. The fact that RF signals weaken with distance affects the transmission rate for both 802.11 and cellular devices. Either way, a site survey should be done to identify the best places to set up your wireless devices.
- When setting up a wireless network to support video data transmissions, you should do a precise bandwidth calculation to ensure that you install the best devices for the job. Once you decide how many IP cameras are required and the resolution and FPS settings needed for your application, you'll be able to get a much better idea of which 802.11 or cellular devices are most suitable.
- Real-time video streams require continuous, uninterrupted wireless transmissions. Interference from multipath fading or the effects inherent in harsh environments can result in a reduced and unpredictable signal strength, coverage holes, and packet errors, making it important to identify the best hardware and software for overcoming these obstacles.
- Wireless network security is important to protect IP surveillance applications from information leakage. Safety authentication and encryption processes are available for both WiFi and cellular communication to protect video data transmitted over a wireless network. For example, for WiFi connections, WPA (WiFi Protected Access) is the most basic technology available to protect wireless transmissions. With WPA, each transmitted frame is encrypted with a TKIP (Temporal Key Integrity Protocol) key.

Challenges of Deploying a Reliable Wireless Connection for IP Surveillance Systems

The first challenge that IP surveillance systems must overcome is the various types of wireless interference that exists in a field site environment. To meet this challenge, the first step you should take is conduct an accurate site survey. RF signals are easily affected by whatever objects happen to be located between the various wireless radios connected to your wireless network, with the degree of interference depending on the distribution and types of objects. Testing the field site for interference will make it easier to design the wireless network and choose suitable devices. Once you know what you're up against, the next step is to find the best spots to deploy your wireless devices to minimize interference and maximize coverage.

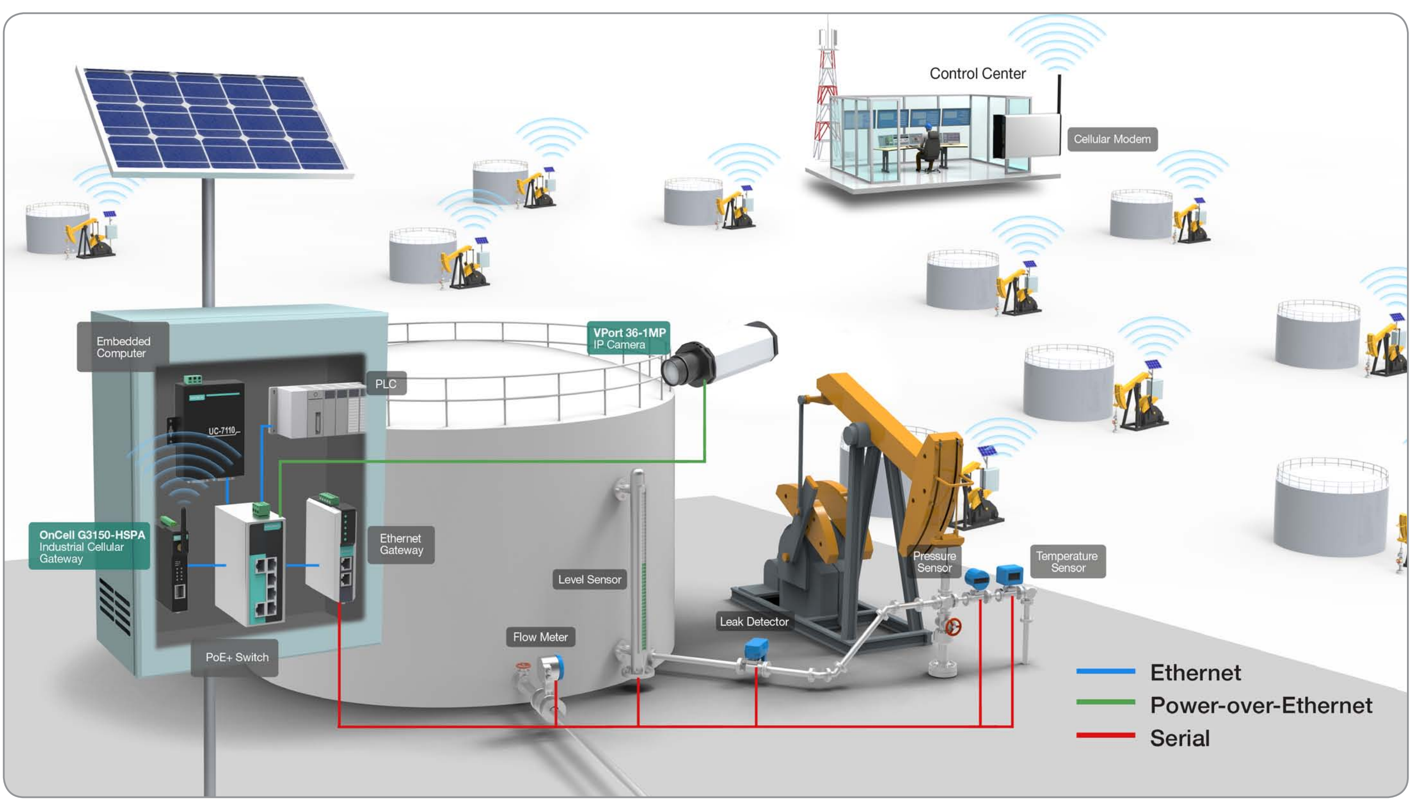
The second challenge that must be overcome is determining how much network bandwidth you'll need. With the growing demand for real-time video monitoring and the more advanced video incident detection required to enhance operational efficiency, people are demanding a higher video resolution for IP surveillance applications. These requirements can have a big effect on the amount of bandwidth you'll need, so be sure to do a careful bandwidth calculation before connecting HD IP cameras to your wireless network.

A highly reliable wireless connection is necessary to maintain real-time video transmissions from field sites to the control room. Extremely reliable hardware designed for harsh operating conditions is a must to minimize the amount of maintenance required and maximum up-time.

Wireless is a good choice for many industrial IP surveillance systems, particularly those in hard-to-wire environments, such as intersection monitoring and large scale oil & gas applications for which it is difficult to use underground wiring. For example, let's see how we can achieve real-time remote IP surveillance in an intelligent wellhead automation application.

Application Note: Seamless Remote Wellhead Surveillance with Moxa's 3G HSPA Solution

Intelligent wellhead automation applications often use IP surveillance systems to supervise the operation of wellheads. In this case, the field site is usually located several miles away from the control room and contains dozens of wellheads that need to be monitored. In addition, important data from each wellhead must be collected and transmitted back to the control room. The long distance between wellheads and control room makes it impractical and expensive to set up a wired network. 3G HSPA technology is the most popular and widely adopted technology for remote wellhead monitoring, since it has the ability to simultaneously deliver real-time video and ensure seamless data acquisition. In addition to network bandwidth, operators must contend with the harsh environments encountered at wellhead sites, making it important to use rugged cellular devices designed to withstand extreme temperatures.



Solutions for Real-Time Remote Wellhead Surveillance

Moxa's high-speed 3G HSPA solutions and industrial HD IP cameras are a perfect combination for implementing a remote wellhead surveillance system, and Moxa is ready to help our oil & gas partners develop IP surveillance solutions from upstream to downstream. The benefits that Moxa offers include:

- High speed 3G HSPA cellular solutions designed for long distance industrial applications in harsh environments. Moxa's solutions are designed for the extremely hot and cold weather that wellhead applications are often subjected to. In addition, to ensure that your wireless connections are always ready to transmit, Moxa's unique GuaranLink technology uses a 3-check mechanism to ensure that a strong, wireless signal is always available for real-time video streaming.
- Rugged HD IP cameras compatible with C/CS mount lenses that support essentially any viewing angle and distance. A built-in removable IR-cut filter and automatic color mode switching enable day and night, 24-7 monitoring of wellhead status. Moreover, to ensure smooth video capture in harsh environments, the cameras have passed ATEX certification, which addresses resistance to corrosion and safety issues for explosive environments, both of which are extremely important for wellhead applications.

Products Used

OnCell G3150-HSPA

Advanced five-band GSM/GPRS/EDGE/ UMTS/HSPA IP gateways

- High speed 3G HSPA cellular connection
  - Download: Up to 14.4 Mbps
  - Upload: Up to 5.76 Mbps
- GuaranLink 3-tier cellular connection check
- - 30 to 70°C operating temperature
- Built-in VPN IPSec PSK client

VPort 36-1MP

Rugged HD day-and-night box type H.264 IP cameras

- -40 to 75°C operating temperature, heater and fan not required
- 1280 x 720 resolution with DNR/BLC/WDR
- Up to 3 independent video streams (2 x H.264, 1 x MJPEG)

Seamless WLAN Communication for Video Surveillance on Vehicles

Rolling stock applications have benefited greatly from wireless technology, which is now being used to enable data transmission between control centers and whatever equipment or device is on the move. In fact, in recent years, several wireless train-to-ground applications have been implemented, including communication-based train control (CBTC), auto train control (ATO) for platform screen doors, and real-time passenger information systems (PIS). However, the bandwidth required for these applications is relatively small. With the higher bandwidth 802.11n technology now mature, train operators have turned their sights on a range of new applications, with real-time onboard high resolution (HD) video surveillance seeing the greatest demand. There are several reasons why operators want to see what's happening in their trains. The ability to see inside each carriage increases security, improves passenger safety, and makes it easier to manage accidents. In addition, train operators can react faster when unforeseen situations occur or something goes wrong.

Requirements for Onboard Wireless Networks

With the ever increasing concerns about public safety, video surveillance is playing an essential role in today's intelligent transportation systems. Operators are now seeking higher quality IP cameras that deliver better quality HD images to make it much easier for security personnel to see exactly what's happening during an emergency. To ensure that HD video can be delivered from the train to the ground quickly enough, it is important to analyze the requirements of your entire wireless network during the design stage. Not only will you need to conduct a thorough analysis of your bandwidth needs, you should also use the best train-to-ground wireless technology available.

Unlike stationary wireless communication, moving equipment is always more difficult to design for, and is harder to implement. That's why some systems integrators specialize in helping operators plan the structure and bandwidth requirements of their wireless networks. However, even if you hire a specialist, you should still be aware of the following critical requirements for the wireless devices themselves:

- Wireless roaming technology with millisecond-level latency to ensure real-time, train-to-ground video transmission that allows the control center to respond immediately to emergencies.
- Railway-certified hardware design for uninterruptable wireless communication. Your wireless devices need to be compliant with several railway certifications to ensure stable operation in the field.
- The required wireless device certifications for the region in which your application will be implemented. In general, FCC is for the US and CE is for Europe, but you may also need to verify that the device manufacturer can provide certifications for specific countries.

Challenges of Deploying Train-to-Ground Video Surveillance

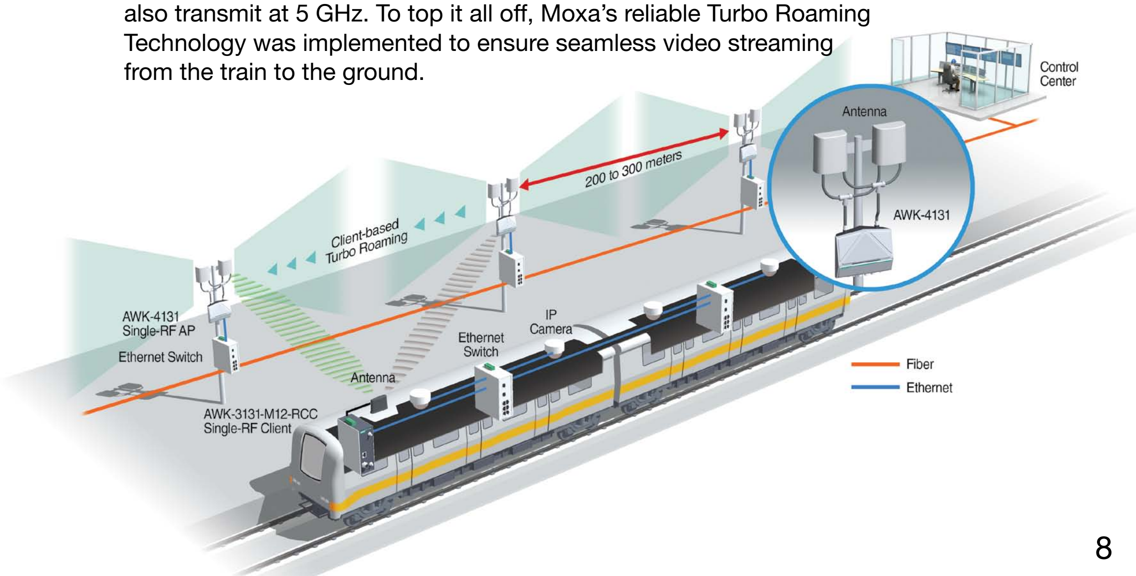
Two key challenges are commonly encountered when building video-over-wireless networks for train-to-ground applications.

The first challenge you'll face when designing the structure of a wireless network is estimating the distance required between the network's APs. Unfortunately, there is no simple, straightforward way to compute the optimal distance between access points. We usually start by identifying certain key factors that come into the analysis. These include transmission power, types of antennas, free space loss, and bandwidth requirements. Operators often seek advice from a professional field applications engineer provided by the device manufacturer; the engineer estimates a suitable access point distribution scheme by checking the strength of the WiFi signal as a client roams between different APs.

The second challenge is how to deliver reliable, high bandwidth data transmission, such as is needed to transmit video from a fast moving train. A train comprises many carriages, with multiple HD IP cameras installed in each carriage to ensure passenger safety. Suppose, for example, that 4 HD IP cameras are installed in each carriage. If each camera is configured to transmit 1280 x 800 resolution images at 30 FPS, then one camera alone will need 7 to 9 Mbps of bandwidth to provide excellent video quality. This means that each carriage must support 28 to 36 Mbps of bandwidth, just for transmitting video images. Since the 802.11a/g protocols only require at most 25 Mbps of bandwidth, to ensure smooth video streaming you'll need to use APs that support a higher bandwidth technology, such as the bandwidth required by 802.11n. However, real-time wireless communication relies on more than bandwidth alone. For fast moving trains, your APs will also need to support millisecond-level roaming to avoid the video lagging that would otherwise occur as the train's wireless signals are transferred from one access point to another.

Success Story: Using 802.11n Turbo Roaming to Ensure a Continuous Video Feed from Rail-Shuttle Surveillance Cameras to the Wayside

One of the major international airports in the Asia-Pacific region has been working on a renovation project to deploy an IP surveillance system on their rail shuttle. In order to obtain a higher resolution and add more onboard cameras to ensure the safety of onboard passengers, the project engineers looked for a reliable solution that supports a higher bandwidth than that provided by 802.11b/g radios. This application required security personnel in the wayside control center to continuously monitor real-time surveillance video from the shuttle's cameras. Using devices that support a higher bandwidth would help improve airport security, since security personnel would be able to respond more quickly to situations and accidents. Another mark against 802.11b/g is that it only transmits at 2.4 GHz, which is a relatively noisy radio transmission environment due the interference caused by access points and handheld devices. For this reason, the project engineers requested devices that can also transmit at 5 GHz. To top it all off, Moxa's reliable Turbo Roaming Technology was implemented to ensure seamless video streaming from the train to the ground.



Seamless Video-over-Wireless Solution for Vehicle Networks

Moxa's product portfolio includes reliable 802.11n wireless APs/clients for train-to-ground applications. Moxa's wireless solutions for onboard and wayside usage offer several benefits, including assistance from professional field applications engineers who are available to support customers from the planning stage to the end of the project. In addition, Moxa also provides:

- 2x2 MIMO 802.11n solutions that provide up to 150 Mbps of available wireless bandwidth.
- Turbo Roaming technology that uses a client-based roaming algorithm with under 200 ms handoffs, ensuring a consistent and stable connection suitable for CCTV communication.
- For the wayside, an IP68-rated, wide temperature (-40 to 75°C) access point to ensure reliable operation under extreme weather. A higher level of electrical interference immunity is also supported for harsh wayside environments.
- For onboard radios, an M12 and QMA design allows radios to operate reliably on vibrating vehicles.

Products Used

AWK-3131-M12-RCC (onboard)

Industrial IEEE 802.11n wireless client

- Up to 300 Mbps throughput for high bandwidth device communication
- Compliant with essential sections of EN 50155 to resist surge, vibration, and EMI
- Supports client-based, millisecond-level Turbo Roaming

AWK-4131-M12-T (wayside)

Industrial IEEE 802.11n IP68 wireless AP

- Up to 300 Mbps throughput for high bandwidth device communication
- Rugged IP68-rated housing and -40 to 75°C operating temperature
- Supports client-based, millisecond-level Turbo Roaming

High Throughput for Railway Onboard Passenger WiFi Systems

As the availability of media content on the Internet continues to increase, the general public's need to access this content is also rapidly increasing. In fact, people now expect to be able to access online media files while commuting. To meet this ever increasing demand, today's passenger infotainment networks not only offer travel information through a media server, but also provide broadband access to the Internet to allow passengers to access content that includes documents, audio files, images, and even videos. The challenge faced by multimedia service providers is how to provide wireless communication that is reliable enough to ensure seamless access to WiFi hotspots and onboard infotainment services—and here's the kicker—for both new and refurbished trains and buses.

What Is Needed to Provide Uninterrupted Onboard WiFi Access

Uninterrupted wireless access is a must if passengers are going to enjoy browsing the Internet, streaming online videos, and Video on Demand (VOD) services through their own mobile devices. To make this happen, operators should first do a simple network bandwidth calculation. The wireless link must be able to provide enough bandwidth to serve multiple WiFi client devices—including smart phones, pads, and laptops—simultaneously, while maintaining a smooth video streaming experience. In addition, they need to ensure that the infotainment service and WiFi hotspots are available in all the carriages, which requires a reliable and flexible wireless backbone for inter-carriage communication. Finally, it's important to remember that the harsh onboard railway environment requires rugged products that can work reliably day in and day out. Taking all of these facts into consideration, a wireless access point (AP) must have the following features to maintain a reliable wireless network on trains.

- Provide broadband access to online media content
- Serve multiple WiFi clients in each carriage
- Provide inter-carriage wireless connections to form a reliable wireless backbone
- Have a rugged design that can withstand harsh, onboard railway environments

The Challenges of Providing a Reliable, Onboard Wireless Network

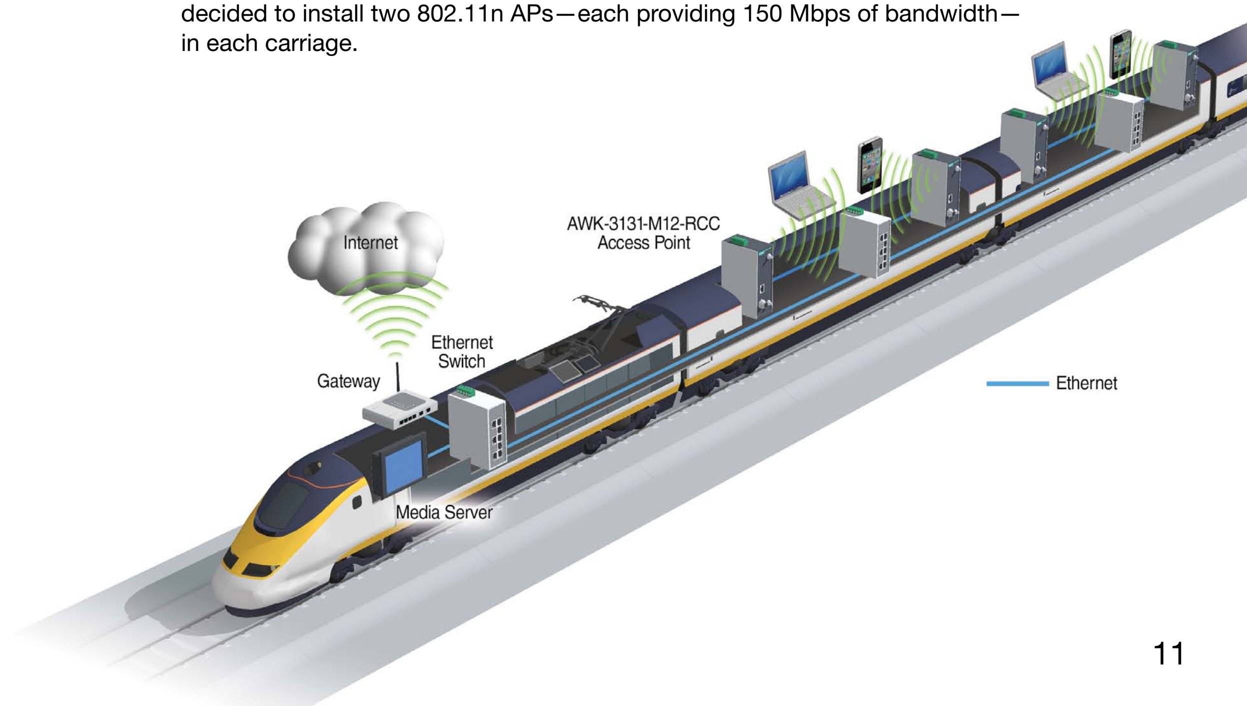
Of all the media content that passengers access through wireless networks, video data eats up the most bandwidth. In fact, to ensure good quality video, the bandwidth required to stream a video could be as high as 1 to 2 Mbps. Providing onboard passengers with an optimal video streaming experience over the wireless network requires ensuring that the wireless connection is both stable and reliable. In fact, it is common for one AP to serve more than 40 Wi-Fi clients (usually smart phones) at the same time. Let's do a simple calculation: If each Wi-Fi client device consumes 1 to 2 Mbps of available throughput, then 40 clients together would use a total throughput of 40 to 80 Mbps, which exceeds the 25 Mbps of available bandwidth required by the 802.11a/g standards. The challenge then is finding a Wi-Fi solution that can provide that much bandwidth.

The other big challenge is setting up a wireless backbone network that runs from carriage to carriage for the entire length of the train. But why would we use a wireless backbone when everyone knows a wired backbone network would be faster and more stable? Although running a cable through one carriage is easy enough, setting up reliable wired connections between carriages is extremely difficult. In addition, when train consists are changed, as is often done on a daily basis, maintenance personnel would need to manually unplug and then plug back in the connections between carriages. Using a wireless backbone eliminates these problems. However, you must make sure that the wireless backbone APs support a high enough bandwidth, and are rugged enough to withstand vibrations, surges, and the EMI found in harsh, onboard environments.

Success Story: Using an 802.11n WiFi Solution to Create a High Bandwidth Wireless Network

A high-speed rail commuter service train in Europe wanted to implement a new passenger infotainment network for its next generation of passenger entertainment service. The new infotainment system was expected to provide more media content to passengers, thereby creating a better onboard experience for the train's passengers. These services include passenger WiFi, games, multimedia, and other passenger information that can be directly accessed through the passengers' mobile devices.

The design goal was that 50 WiFi clients in each carriage would be able to simultaneously access media content by accessing the train's WiFi network—through a single AP. If, for example, all 50 passengers are busy watching YouTube videos, each of which could require 2 Mbps of bandwidth for continuous streaming, then that single AP must be able to support a bandwidth of at least 100 Mbps. To ensure complete WiFi coverage and offer passengers an even better WiFi user experience, they decided to install two 802.11n APs—each providing 150 Mbps of bandwidth—in each carriage.



Solution: Providing Seamless Passenger WiFi

For this project, Moxa provided 802.11n wireless AP solutions designed specifically for onboard railway passenger WiFi systems. In addition to the high throughput required by the 802.11n standard, Moxa's unique technology and tough hardware design make it easy to maintain a reliable wireless backbone that provides passengers with a seamless WiFi experience. The Moxa products used for this application are especially well-suited for streaming video over wireless networks, and provide the following benefits:

- Broadband throughput that supports MIMO technology, as required by the 802.11n standard, with up to 150 Mbps of bandwidth available from each AP to deliver smooth, online video streaming.
- Compliancy with standard railway certifications that require resistance to interference from surges, vibrations, and EMI, and that meet important safety standards for onboard railway environments.
- Unique Automatic Carriage Connection (ACC) feature that makes inter-carriage wireless backbone topologies much more flexible. ACC reduces the maintenance effort required and eliminates configuration errors that otherwise could occur when the train's consists change.

Products Used

AWK-3131-M12-RCC-T

Industrial IEEE 802.11n wireless AP for railways

- Up to 300 Mbps throughput for high bandwidth device communication
- Compliant with essential sections of EN 50155 related to surge, vibration, and EMI resistance
- -40 to 75°C operating temperature range
- Moxa's proprietary Auto Carriage Connection (ACC) for efficient installation and maintenance during frequent carriage re-arrangements

Conclusion

Video-over-wireless networks provide an easy and efficient way to transmit video data for industrial applications. However, as we learned from previous case studies, wireless networks require a comprehensive network design, bandwidth plan, and a robust, flexible, and intelligent wireless device to deliver real time video streaming. Moxa not only has a group of professional field application engineers ready to help you deploy your wireless network, we also offer a complete product portfolio of 802.11n and 3G HSPA wireless devices that feature unique technologies suitable for a wide range of industrial applications. In the near future, Moxa will release even higher bandwidth wireless solutions based on the latest 802.11ac and LTE technologies. Visit Moxa's website to see our most up-to-date wireless product portfolio.

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Expert Tips for Planning an Industrial Wireless Network

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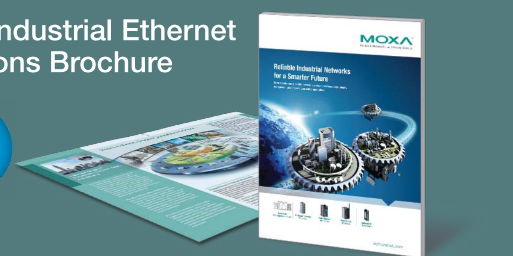

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