



INDUSTRY REPORT

**The Connected Journey Through
Transport's Transformative Decade**



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FOREWORD

Magnus Friberg
Chief Executive Officer, Icomera



It is one thing to observe that the world is changing. It is something else to feel the impact, respond, and actively influence the direction of that change for the better.

This is the opportunity open to Icomera and the wider transport industry today.

We are at a turning point in how we travel. As with every journey, to know where we are going, we first have to understand how we got here...



Global Trends and Challenges Shaping the Goals of Passenger Transport over the Next Decade

In 2015, the United Nations produced a list of the global trends and challenges that it deemed to be the most pressing¹. In 2016, the World Economic Forum followed suit, issuing a list of the 10 most important issues from an economy-centered viewpoint². Reports by governments and other organizations have also served to highlight emerging threats to our way of life.

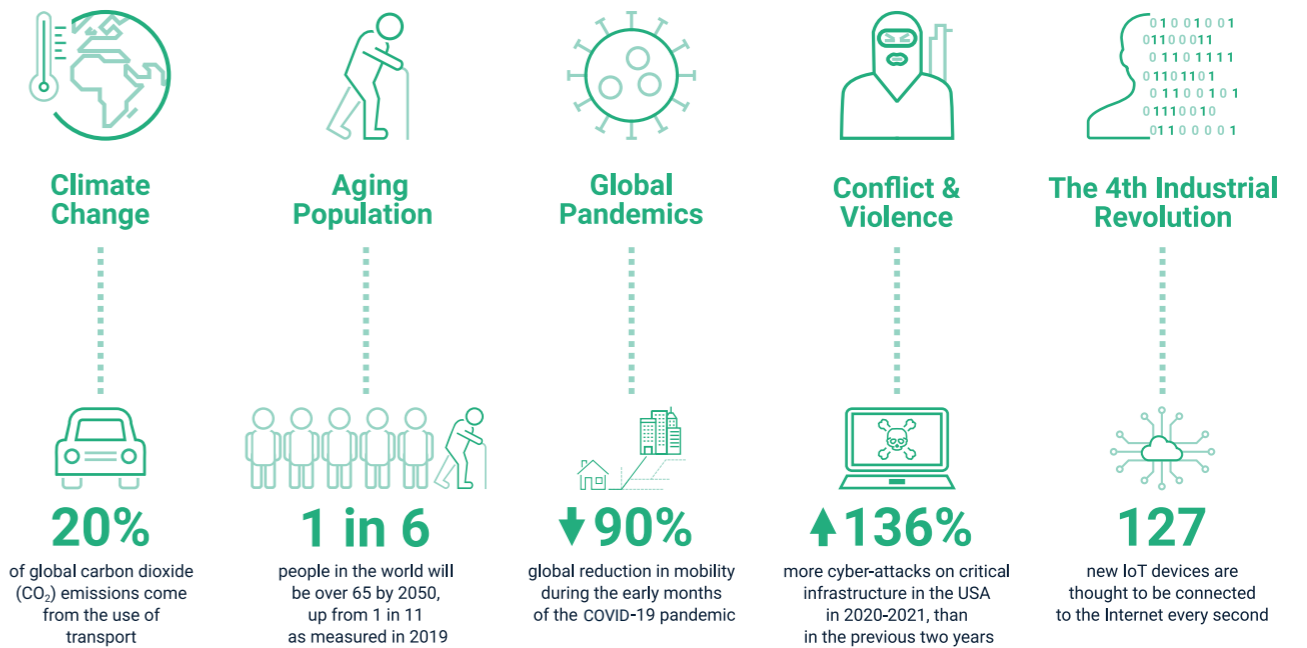
Unsurprisingly, there are trends and challenges that appear across multiple lists and reports. More interestingly, many appear to be more relevant today than at any point in living memory.

I would like to highlight just five, in no particular order:

- **Climate Change** – Global warming driven by human-induced emissions of greenhouse gases and the resulting large-scale shifts in weather patterns. Nineteen of the hottest years on record have occurred since the new millennium³ and transport accounts for around one-fifth of global carbon dioxide (CO₂) emissions⁴.
- **Aging Populations** – An increasing median age of the population because of declining fertility rates and rising life expectancy. In 2018, for the first time in history, people over the age of 65 outnumbered children under the age of five. By 2050, one in six people in the world will be over 65, up from one in 11 in 2019⁵. This increases the percentage of the population who will struggle to do certain activities, like traveling independently, if issues such as universal and inclusive design are not addressed.

- **Global Pandemics** – The rapid spread of a disease over a large number of people in different countries / on different continents and the subsequent waves and associated disruption. During the early months of the COVID-19 pandemic, travel in major cities fell by over 90%, with economic hubs like New York and London seeing mobility at 4% and 7% of pre-pandemic levels, respectively, in April 2020⁶.
- **Conflict and Violence** – Ranging from entrenched conflict, to organized crime, urban violence, and violent extremism⁷. Increasingly, these are spilling over into online attacks. For example, in 2020-2021 there were 136% more cyber attacks on critical infrastructure in the USA than in the previous two years⁸.
- **The Fourth Industrial Revolution** – The blurring of boundaries between the physical and digital worlds, encompassing advances in artificial intelligence (AI), robotics, the Internet of Things (IoT), and other technologies for increased automation and improved data exchange. It is estimated that 127 new IoT devices are connected to the web every second in the pursuit of the benefits on offer⁹.

These issues will continue to dominate the global agenda over the next decade, due to the cyclical causality of their relationships with one another.



Current events are focussing the minds of political and business leaders to address these global trends and challenges by working together to achieve global goals. Headline activities include:

- Reducing human-induced emissions of greenhouse gases to fight climate change
- Catering for an aging population and those with accessibility needs
- Reducing the spread of disease to mitigate against the effects of global pandemics
- Protecting citizens from physical and cyber threats arising from conflicts and violence
- Accelerating the Fourth Industrial Revolution in a smart, clean, and safe way, so that it can play a more central role in addressing all of the above

The transport industry has an important role to play here.



As I said earlier, we are at a turning point in how we travel, in terms of frequency, distance, mode, our whole approach. But importantly, we will continue to travel – for work, leisure, or access to services.

Sustainability will be key to traveling in a way that supports humanity’s pursuit of global goals –environmentally, economically, and socially. Passenger transport is the most sustainable form of transport – moving more people with fewer vehicles and reducing greenhouse gas emissions. But the industry has undoubtedly been hit hard by the COVID-19 pandemic. It will have to overcome many challenges on its journey back to pre-COVID usage levels and, beyond that, to meet the increase in demand that comes from shifting society’s travel habits further towards sustainable, green mobility.

So how can the industry attract more passengers in a post-pandemic world?

Simply put, it must support the global goals that have arisen from global trends and challenges:

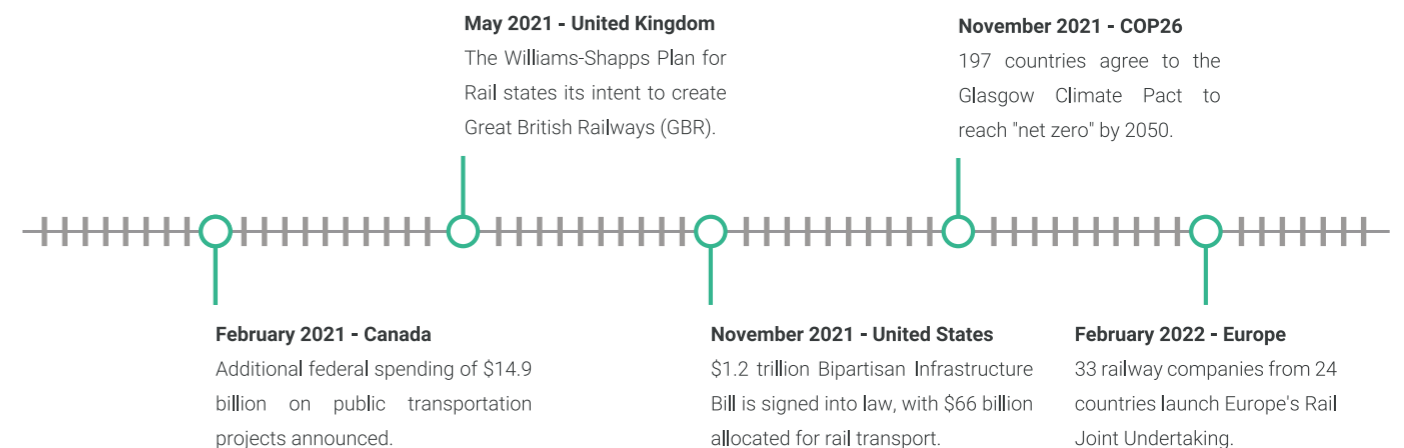
1. **Passenger transport must cater for the evolving needs of business and leisure commuters**, regardless of age or disability.
2. **It must offer a safe environment** that minimizes the spread of disease, and guards against physical and cyber threats to the individual and to wider infrastructure.
3. **It must do this in a cost-effective and resilient way** that also allows it to adapt to rapidly changing environmental, societal, and economic needs in the future.

A Transformative Decade

Around the world, plans, targets, and funding to support the pursuit of these goals are starting to materialise. Collectively, they lay the foundations for a transformative decade for passenger transport. Highlights include:

- **Canada** – In February 2021, Canadian Prime Minister Justin Trudeau announced plans for the federal government to spend an additional \$14.9 billion on public transportation projects across the country over the next eight years, with a permanent transit fund of \$3 billion per year starting in 2026¹⁹. The funding will offer city planners long-term predictability, supporting a large-scale upgrade and expansion of services.

- **United Kingdom** – In May 2021, the UK Department for Transport published the Williams-Shapps Plan for Rail, stating its intent to create a new state-owned public body that will oversee Rail transport in Great Britain from 2023. Great British Railways (GBR) will integrate the previously fragmented running of the national Rail system, owning the infrastructure, setting most fares and timetables, and planning and running the network¹¹. This announcement came only months after the publication of a strategy for better bus services in England through an ambitious reform of the way they are planned and delivered¹².
- **United States** – In November 2021, US President Joe Biden signed a \$1.2 trillion infrastructure bill into law. The package provides \$39 billion to modernize and expand public transit to meet rider demand and \$66 billion for passenger and freight Rail, making it the largest ever federal investment in public transit, and the largest in passenger Rail since the creation of Amtrak over 50 years ago¹³.
- **United Nations Climate Change Conference (COP26)** – In November 2021, 197 countries agreed to the Glasgow Climate Pact, aimed at staving off dangerous climate change. This reaffirms the Paris Agreement’s goals of keeping the increase in global average temperatures below 2 °C above pre-industrial levels, and pursuing efforts to limit the increase to 1.5 °C. The pact also recognizes that these goals require rapid, deep, and sustained reductions in global greenhouse gas emissions, reducing global carbon dioxide emissions by 45% by 2030, and to net zero by 2050¹⁴.
- **Europe** – In February 2022, 33 railway companies from 24 European countries officially launched Europe’s Rail Joint Undertaking, aiming to significantly increase the modal share of Rail transport by 2030. The group committed to reducing Rail transport greenhouse gas emissions by 30% by 2030, and to reaching climate neutrality by 2050, in line with the European Union’s overall objectives. Expectations were also expressed for Europe’s largest Rail research and innovation program worth €1.2 billion¹⁵.



The Connected Journey

When Icomera developed and deployed the world’s first onboard Wi-Fi service in 2003, we created a new amenity that brought the passenger experience into the 21st century. This was four years ahead of the first iPhone, and even 4G networks were still another six years away. We subsequently became the world’s leading provider of wireless connectivity for trains, trams, buses, and coaches, and in the same period, established a track record of consistently identifying and meeting the future requirements of the passenger.

While making no claims to have seen in advance how all recent global events would unfold, the future of our industry will be heavily based on digitalization, using the same technologies that Icomera has consistently presented over many years, albeit the timelines for mass adoption have now been massively accelerated, and there will be a greater-than-expected emphasis placed on making safety and operational improvements visible to passengers.

One thing that many of the technologies and strategies underpinning the future of travel have in common is the importance of, and reliance on, real-time or on-demand access to information for all parties – Restoring confidence from door to destination, making every ride time-efficient for the passenger, and cost-effective for the operator.

With an increasing number of onboard devices or systems requiring connectivity, the increasing value of the data they generate, and the increasing importance of its timely availability, ensuring the reliable and secure transmission of the data that all these systems generate and utilize, to and from the moving vehicle, is key.

This is precisely the challenge that Icomera has been addressing for the last 20 years, and it is the cornerstone of the role we intend to play in redefining the way we travel over the next 10.

The Building Blocks for Delivering The Connected Journey

1. Connectivity

When Icomera was founded in 1999, we took our name from the phrase 'Intelligent COMmunication ERA'. Providing the fastest, most reliable connection available for moving vehicles and the passengers on board, along the entirety of their routes through rural and urban landscapes, was at the core of everything we set out to do.

We continue to be the world leader in this area today. In 2020, Icomera successfully designed, manufactured, and trialled the world's first 5G-enabled router for connected Rail vehicle solutions¹⁶, integrating it with the rest of our next-generation hardware and software connectivity platform. We delivered over one gigabit of data per second to a train using only commercially available 4G and 5G cellular networks, surpassing the benchmark referred to in the industry as 'the Gigabit Train'.

Now, this foreseeable-future-proof technology is being installed on vehicles in countries around the world, ready to simultaneously support the myriad of connected onboard systems and services that will collectively address the overarching goals of the transport industry.

2. Connected Applications

Historically, Passenger Wi-Fi has been the most obvious application for 'Internet on board', turning travel time into productive time. But as an increasing number of other passenger services go digital, they too are becoming connected.

Icomera acquired passenger infotainment providers GoMedia in September 2020. We are now utilizing this dedicated team to deliver some of the key services required for the contemporary digital passenger experience – business or leisure. These range from personalized journey information for all passengers, including those with accessibility needs¹⁷, before they travel, to onboard entertainment and two-way communication channels¹⁸ with the operator while the journey is in progress – something that is just not possible with traditional information channels.



In addition to solutions that directly deliver passenger satisfaction, we are also witnessing a period of intensive digitalization when it comes to improving safety and operational efficiency. Given our large installed base, Icomera has been involved in many of these trials, developing and deploying solutions that are natural extensions of our core competencies, or working with other industry leaders. These include real-time monitoring of passenger numbers with AI software-enhanced cameras¹⁹, making it easier for passengers to choose less crowded environments to travel in, and feeding back into operators' fleet and staff capacity planning [Learn more in our **South Western Railway Project Spotlight** on page 28]. Sensors that monitor the condition of infrastructure along a route can also be supported to ensure a resilient and reliable 'predict and prevent' maintenance strategy.²⁰ [Learn more in our **Network Rail Project Spotlight** on page 29].

3. Expertise at Every Step

As vehicles become ever more complex digital ecosystems, the skills required to design, install, maintain, and support the onboard network also increase.

Successfully bringing new technologies into a passenger transport environment requires deep expertise in electrical and mechanical design and integration. To this end, Icomera acquired UK-based DG8 Design and Engineering in 2019. DG8 have long been seen as the industry experts when it comes to physically integrating new technology with existing assets. As a case in point, they were responsible for the mechanical and electrical installation design of the retrofitted 'HydroFLEX' hydrogen train that was showcased at COP26²¹. [Learn more in our **HydroFLEX Project Spotlight** on page 39].

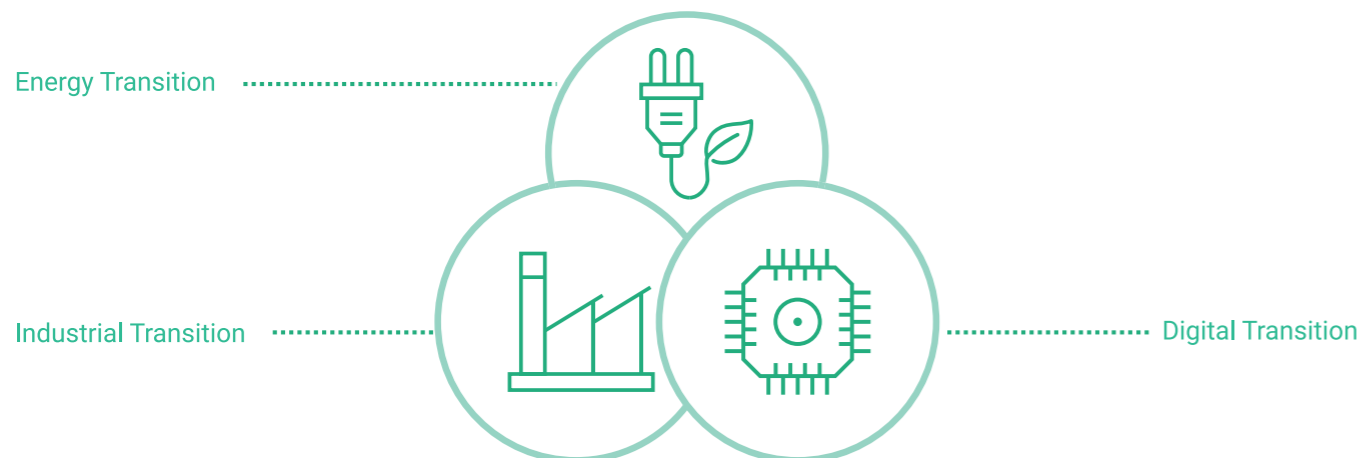
Since bringing this deep design and engineering knowledge into Icomera, we have successfully delivered some of the most fully-realized Digital Vehicle projects for passenger transport to date²². Post-launch, these vehicles are monitored by our Network Operations Centre (NOC), providing round the clock proactive and reactive support and contributing to a high performance and high availability environment.

4. Scale

Successfully connecting tens of thousands of vehicles worldwide, we know what it takes to introduce, deliver and support new technologies as they are adopted en masse.

Icomera is part of EQUANS, with the reach to operate locally in all geographical regions. We believe that being on the ground alongside transport operators' teams, wherever they are, is vital to delivering a first-class service and solution. Our partners in EQUANS' Transport group augment our offering with additional digital solutions and expertise in infrastructure, a combination that allows the group to address transport systems as a whole.

Of course, the future of transport will not develop in isolation. It will be important to understand the interplay between every area of smart connected modern living as it evolves. This is where Icomera and our partners benefit from the foresight afforded by EQUANS' global view, employing 74,000 people working alongside industries and local authorities to connect, power, and protect buildings, cities, and infrastructure.



EQUANS employs 74,000 people working alongside industries and local authorities to **connect**, **power**, and **protect** buildings, cities, and infrastructure.

Empowering Transitions

Icomera supports EQUANS' ambition of "Empowering Transitions" by accelerating passenger transport's digital transition. We will continue to draw on past experiences and explore new approaches to be the right Digital Partner for an industry whose work is taking on a greater significance.

The next leg of The Connected Journey is only just beginning, but looking ahead we can see a path that will forever change the way we travel, making passenger transport more attractive, more seamless, and part of a smarter, greener future for everyone.



PART ONE

Catering for the Evolving Needs of Business and Leisure Commuters, Regardless of Age or Disability

Onboard Wi-Fi Welcoming New and Returning Passengers in Record Numbers

AUTHOR: PAUL BARNES

Paul Barnes is Icomera's Chief Marketing Officer. Based in Cambridge, UK, Paul utilizes his background in analytics, strategic development, and communication to identify and promote technologies that encourage sustainable travel choices.



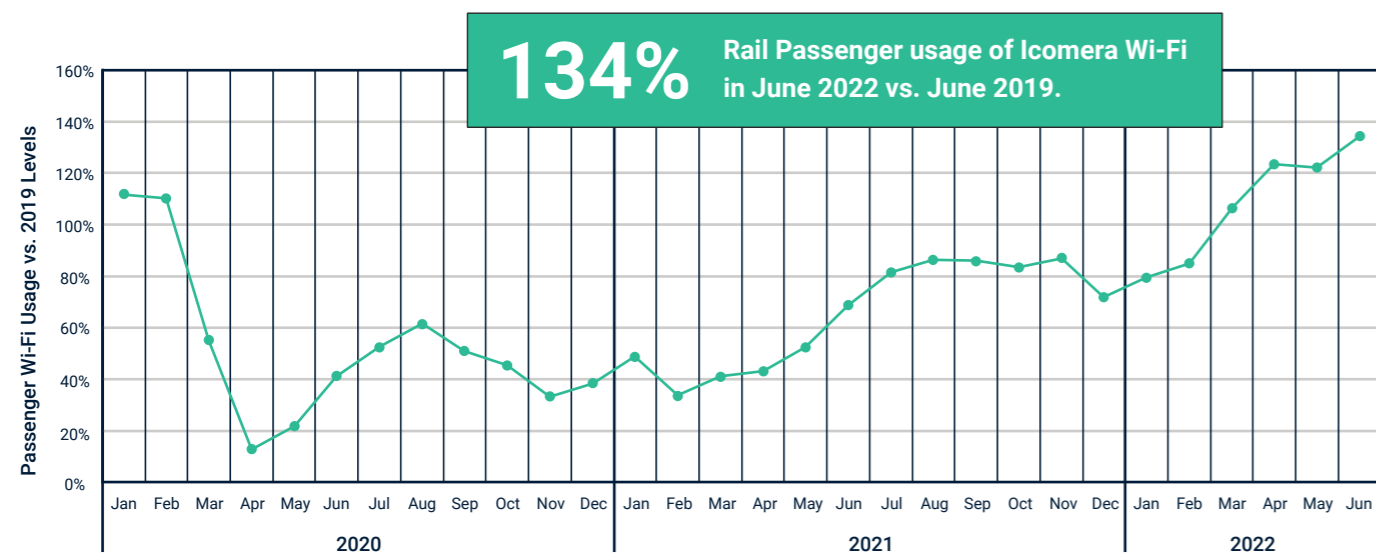
It's been two decades since Icomera deployed the Rail industry's first commercial onboard Passenger Wi-Fi service, creating the market segment. In the years since, fast and reliable connectivity on the go has evolved from being a luxury consideration to an essential service, keeping travelers connected for both work and leisure purposes.

While we witnessed first-hand the impact of COVID-19 on travel as we saw Wi-Fi session numbers falling across the world in real-time, today, Icomera is connecting more Rail users than ever before, as part of the new post-pandemic passenger experience.

Passenger Wi-Fi Usage Through the Pandemic

Icomera Passenger Wi-Fi usage figures provided an international view of emerging trends during the pandemic. We made this data available to transport authorities and operators to support short-term operational decision-making – such as service schedule adjustments where Wi-Fi session usage and transport service capacity did not tally – and longer-term strategic planning.

In the graph below, Icomera's large dataset of Rail Passenger Wi-Fi usage in Europe and North America is presented monthly as a percentage of the corresponding month in 2019.



After the dramatic drop-off in March 2020, when governments and businesses around the globe issued social distancing guidelines, both regions' low points occurred in the w/c April 6th. Over the next 24 months we observed the (at times fragile) recovery of Wi-Fi usage to March 2022, before finally seeing new all-time high usage levels in the second quarter of the year, **peaking in June at 134% of 2019 levels**. This is driven by a combination of the following:

1. The phasing out of COVID-19 testing and isolation rules in many countries, leading to an increase in travel as we learn to "live with COVID", attend more in-person events, and gradually return to office work.
2. Passenger Wi-Fi becoming more widely available as transport operators in many countries pushed ahead with technology upgrade programs over the last two years to keep pace with society's shifting approach to travel.

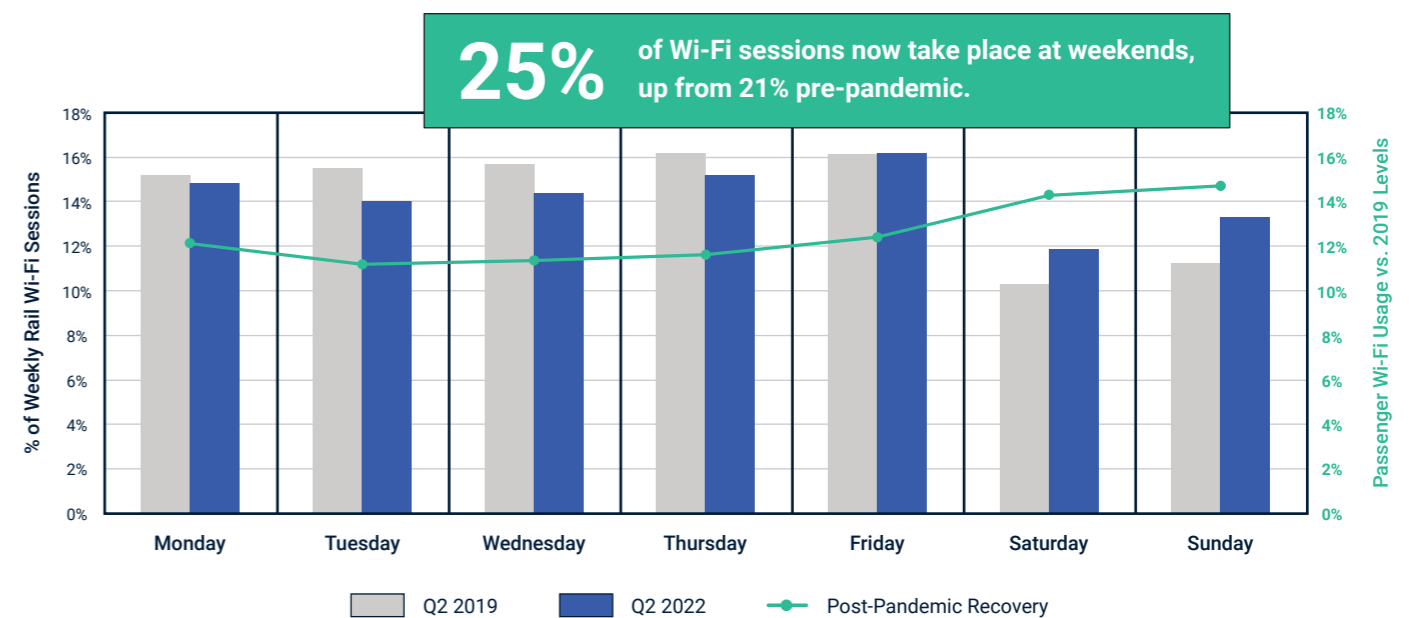
The Evolving Landscape of Passenger Routines

In our conversations with transport operators over the last 12 months, we repeatedly heard the same three goals:

1. Regain customers who stopped using passenger transport because of the pandemic
2. Attract new customers
3. Adapt to changing commuting patterns

Speaking to CBC news in June 2022, the Toronto Transit Commission (TTC) revealed that weekends are their new peak times, now that their previously regular weekday riders are heading into the office less frequently and at varying times throughout the week²³. Germany's national Rail operator, **Deutsche Bahn**, reported that Monday - Friday passenger numbers in May 2022 were just below pre-pandemic levels, while Saturdays were 18% higher, and Sundays 25% higher²⁴. As TTC's spokesperson Stuart Green highlighted, "These are things that we need to be aware of so that we can make sure we're delivering the best service, at the right times of day, on the right routes".

Our own Passenger Wi-Fi usage data from the second quarter of 2022 gives some indication of how travel patterns are changing. Although we still see higher Wi-Fi usage on weekdays, weekend travel now accounts for a greater percentage of weekly Wi-Fi sessions (25%) than during the same period in 2019 (21%). Saturday and Sunday Wi-Fi usage is currently at 143% and 147% of pre-pandemic levels respectively, while the traditional working weekdays range from 112% - 124%.



A significant percentage of the population has transitioned to hybrid home and office working. In a recent survey by business travel management company TravelPerk, **76% of respondents confirmed a shift to hybrid work in their companies**²⁵. With employers becoming more open to employees working from any location, many passengers are keener than ever to take advantage of their commute to carry out work-related tasks and stay productive.

For business commuters, the increased availability and reliability of Wi-Fi on trains and buses can support the flexibility in work hours and locations that the “work from home” transition has introduced, allowing them to send emails, research information for work-related tasks, and make conference calls. Passenger transport was listed as one of the most popular means by which people chose to participate in Zoom conference calls last year, with **11% of Zoom users joining a call while traveling on board**²⁶.

For leisure travelers, Passenger Wi-Fi offers an immersive experience; when passengers are engaged, the perceived journey time is reduced, and this has a positive impact on propensity to travel. Passengers can communicate with friends and family via social media, shop online, catch up with the latest news, or even learn a new language. Many travelers also use their commute to carry out digital chores such as paying bills, renewing insurance policies, and searching for new properties or jobs.

If an individual’s journey can contribute towards their day, and not disrupt it, then passenger transport will become the obvious and most effective modal choice. Anne Marie Aikins, Head of Media and Public Relations for **Metrolinx**, agrees, adding *“That’s going to be a key element – to use the commute as part of your workday or relaxing”*. This is partly why Metrolinx, the Canadian transportation authority serving the Province of Ontario, has implemented free Wi-Fi on trains, buses and in stations for their GO Transit service.



Wi-Fi That Works!

To deliver on its productivity promise, it’s vital that the Wi-Fi offered on vehicles not only works, but works well; indeed, a quality, reliable Wi-Fi connection can prove as important as seat availability or punctuality in enhancing the passenger experience.

This consideration is especially important if operators are to be more successful in attracting ‘Generation Z’ – digital natives born since the mid-1990s – to travel by passenger transport, rather than using the next modes of personal transport (e.g. ride-hailing services and autonomous vehicles). Less likely to drive cars, and more acutely aware of issues around the climate emergency, this demographic group could be key in helping drive the return to passenger transport post-pandemic. However, Generation Z are also the most discerning group of consumers to cater for, raised in a world of near-instant delivery of services and with very high expectations of quality and reliability.

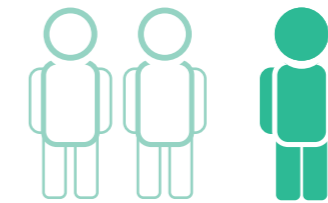
According to recent data from UK Rail operator LNER²⁷, passengers now expect instant, flawless connectivity on trains:

69% of customers



see good quality Wi-Fi as an important consideration when choosing how to travel

This rises to **75%**



for those passengers who are traveling by themselves

...and **79%**



for business travelers who now expect office-grade working conditions on board

The pressure is on transport operators to meet these new standards of service. Fortunately, the investment in Passenger Wi-Fi has been shown to pay off time and again. Studies have found the introduction of free Wi-Fi on trains increases frequency of travel for both new and existing passengers²⁸, and that mobile Internet access has improved the value of travel time on trains to the point where it can reduce car dependency for commuters²⁹.

It’s important to remember that, in addition to meeting the rising expectations of customers and driving ridership, the same underlying Internet connection used for Passenger Wi-Fi can also support a range of other onboard systems at minimal cost when compared to investing in separate communication pipelines for each one, further strengthening the business case.

The pace of technological change can make it difficult to forecast what applications will become possible in the next decade, how transformative they will be, or the extent of the efficiencies and cost-savings they might facilitate. But today, as we connect more users to onboard Wi-Fi than ever before, we can at the very least seize the opportunity to welcome new and returning customers, with the best first impression of how passenger transport will serve them in the years to come.

Creating Seamless, Engaging and Enjoyable Customer Journeys

AUTHOR: MATT SEAMAN

Building on a wealth of experience gained from managing various UK TV platforms (Freeview / Sky / ITV / Virgin), **Matt Seaman** founded GoMedia in 2015 with the simple aim of making travel time both enjoyable and productive.



As that wise old industry adage goes: “The Passenger Always Comes First”. It’s an integral commitment that we strive to meet, both as suppliers and operators. But what’s the secret to success? How exactly do we instigate those truly special, memorable journeys that leave a passenger feeling wowed?

Well, a key element in surpassing expectations lies in transport operators going beyond in the passenger services that they provide. Armed with the right information at the right moments, kept entertained, and able to share relevant details regarding their trip easily, a passenger’s journey will meld effortlessly into the rest of their day. **As technological advances continue to be made, passenger-centric applications which help travelers stay connected and informed will therefore undoubtedly bring significant value.**

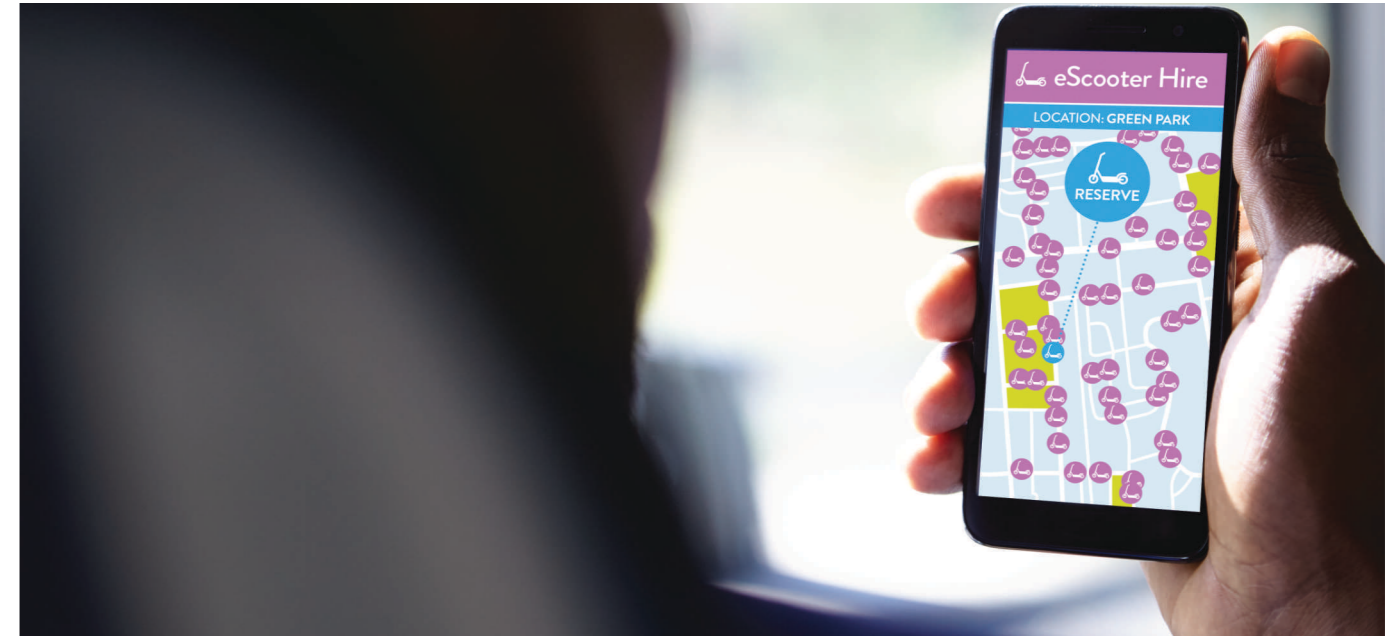
Simplifying Trip Planning

It’s vital that the increased digitalization within the industry helps simplify journey planning for passengers, empowering them to plan and book their journeys independently, quickly and easily.

Thankfully, multiple options exist to meet these challenges: Powerful real-time information solutions mean that passengers can be seamlessly guided with accurate, up-to-the-minute information on routes, services and prices...

- **Pre-boarding** - Passengers can be sent push notifications to their smart device confirming information on departure time and platform, as well as vehicle occupancy levels, for example. This helps minimize the time they need to spend in a public space waiting for a suitable service, and makes it easier to find a free seat in a quiet carriage once they board.
- **On Board** – While they travel, passengers can be given real-time access to information via their smart device or in-vehicle screens, providing them with live updates on their journey progress. The ability to alert travelers to any issues at the earliest possible moment gives them a degree of control and reassurance; though never good news, if passengers know when and why delays occur, they are far more likely to be understanding.

- **Post-Trip** - Passengers can be presented with multi-modal onward journey possibilities via their smart device. This creates a truly joined-up experience; able to view departures across various transport modes (train, bus, tram, bike, e-scooter, taxi etc.), customers are empowered to rapidly and intuitively adapt as they proceed along each step of their journey.



Facilitating an Engaging Travel Experience

The onboard experience continues to evolve in all kinds of exciting ways. Beyond a plethora of media content that can now be offered to travelers, operators are also able to provide a range of enhanced passenger-centric solutions.

Those traveling can order food and beverages from the comfort of their seat, while perks and rewards can serve as the icing on the cake when it comes to delivering a five-star service. For example, it’s possible to send selected customers messages offering them discounted drinks, complimentary snacks, or even the opportunity to watch a recently released movie for free.

Utilizing Passenger Feedback

Gathering passenger feedback is key to improving passenger satisfaction. Digital technology enables a two-way conversation between passengers and operators while the journey is in progress, providing a regular touchpoint that generates invaluable data for understanding the evolving landscape of passenger routines, sentiment, needs and expectations.

Travelers can provide feedback in a myriad of different ways. Simple multiple-choice questions allow passengers to quickly express their views using happy face / sad face emoticons, and surveys can be created to add additional layers of information, delivering further valuable insights.

Feedback can be tagged with the vehicle and service that a passenger is traveling on, enabling operators to build a clearer picture of which vehicles, routes, time periods and / or staff consistently encounter the same issues, so that services in need of a particular focus can be identified.



Case Study: Vy Group

Amazing Entertainment through Spectacular Scenery

Norwegian transport operator Vy recently upgraded the digital passenger experience for its customers traveling on the Bergen Line, a Rail route which runs over the highlands between Oslo and Bergen. The line offers one of the most breath-taking travel experiences in Europe but also suffers from limited cellular coverage and capacity. Overcoming potential issues caused by this, the content behind GoMedia's onboard entertainment solution for Vy is securely uploaded to Icomera's hardware, meaning that it does not require an external Internet connection to be played; this allows Vy's passengers to enjoy the onboard entertainment on offer even in the most remote rural areas that they pass through.

"We are shaping our business around our customers' needs in order to deliver the best journey, and work hard to make it easy to travel in an environmentally friendly way and use public transportation. The digital passenger experience delivered by Icomera and GoMedia will advance us further along our smarter, greener, safer, and more profitable journey".

Linda Kragseth, Head of Customer and Product Development at Vy



Case Study: West Midlands Metro

Real-time Sentiment Analysis Leveraging the Power of 5G

In a significant step towards realising the full potential of passenger feedback solutions, live trials have been conducted in the UK by GoMedia, alongside Wordnerds, West Midlands 5G and West Midlands Metro (WMM) on the country's **first 5G-enabled tram**.

In the trial, free text feedback supplied by WMM's passengers was analyzed using Wordnerds' specialized AI-led sentiment analysis system. Cloud-based dashboards then gave WMM unprecedented access to measurable and actionable live passenger feedback on multiple levels (e.g. vehicle type, route, or time of day). There was also an alert tool that automatically notified the operator of any priority issues needing to be addressed.

The speed at which the feedback data could be processed was dramatically increased over the 5G network used. It also allowed for the use of different types of passenger-generated data, such as videos and images of any issues. 91% of test responses that should have triggered an alert were correctly identified by the Wordnerds platform, and the average time between response submission and alert receipt was just 2 minutes³⁰. As Wordnerds' CEO Pete Daykin explains, *"Immediate problems can be resolved in real-time, and a database of categorized issues provide insights for the operator to improve services."*

Accessible to All

Digital Technologies Overcoming Physical and Linguistic Barriers to Passenger Transport Use

AUTHORS: SVEN KOSTER & LYNN BACIGALUPO

Sven Koster is Head of New Business Development and Innovation for our GoMedia team, spearheading our efforts across the industry to deliver more accessible passenger transport experiences. **Lynn Bacigalupo** is a project manager for Icomera in North America and draws on her extensive experience in UX design to deliver transport experiences that blend physical and digital journeys.



Sven Koster



Lynn Bacigalupo

Modern, inclusive, and fully accessible transport systems should be stress-free to navigate for all people, regardless of age, medical factors, disabilities, or native language.



As one of the greenest and safest modes of transport, we want to see more people using Rail. Everyone should be able to take the train, and do so with ease.³¹

Adina Vălean, European Commissioner for Transport



The Value of Accessible Transport Systems

The Commissioner's statement above highlights an environmental benefit to the increased usage of passenger transport; however, there are also immediate economic benefits to be realized by providing easier access to education, work, and healthcare through a more accessible passenger transport system.

This creates an important question: Of the people who could be using passenger transport and, by extension, contributing to the economy by purchasing tickets and traveling for work or leisure, how many are actually able to do so?

24.6 million Americans aged 18 and older have self-reported travel-limiting disabilities, and less than half of these passengers are aged 65 and older³². In the UK, more than 60% of users with accessibility needs do not attempt or struggle to make independent journeys on passenger transport³³.

Making travel experiences more accessible will improve journey satisfaction and overall quality of life for these passengers while reducing the estimated impact of inaccessible transport on the national economies, which runs into tens of billions of pounds, euros, and dollars per year³⁴.

The ergonomic design of stations and vehicles will, of course, play a significant role in improving the accessibility of passenger transport. However, alongside these major infrastructural changes, digital technologies which use personal smart devices will provide personalized and at-hand support, reducing the barriers to use for visual and hearing-impaired customers – and addressing some hidden needs of a broader audience as well.

These innovations provide cost-effective “quick wins” for transport operators and authorities due to the comparatively small amount of capital investment required to develop and deploy them, and the rapid speed with which this can be done.



In the US...

24.6 million

adults have self-reported travel-limiting disabilities



In the UK...

60%

of users with accessibility needs do not attempt or struggle to make independent journeys on passenger transport

£72.4 billion

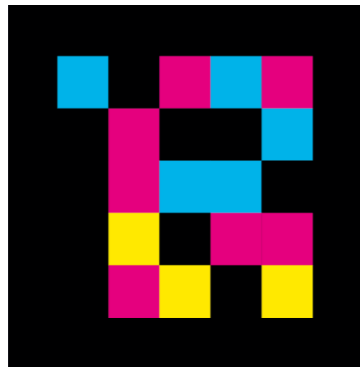
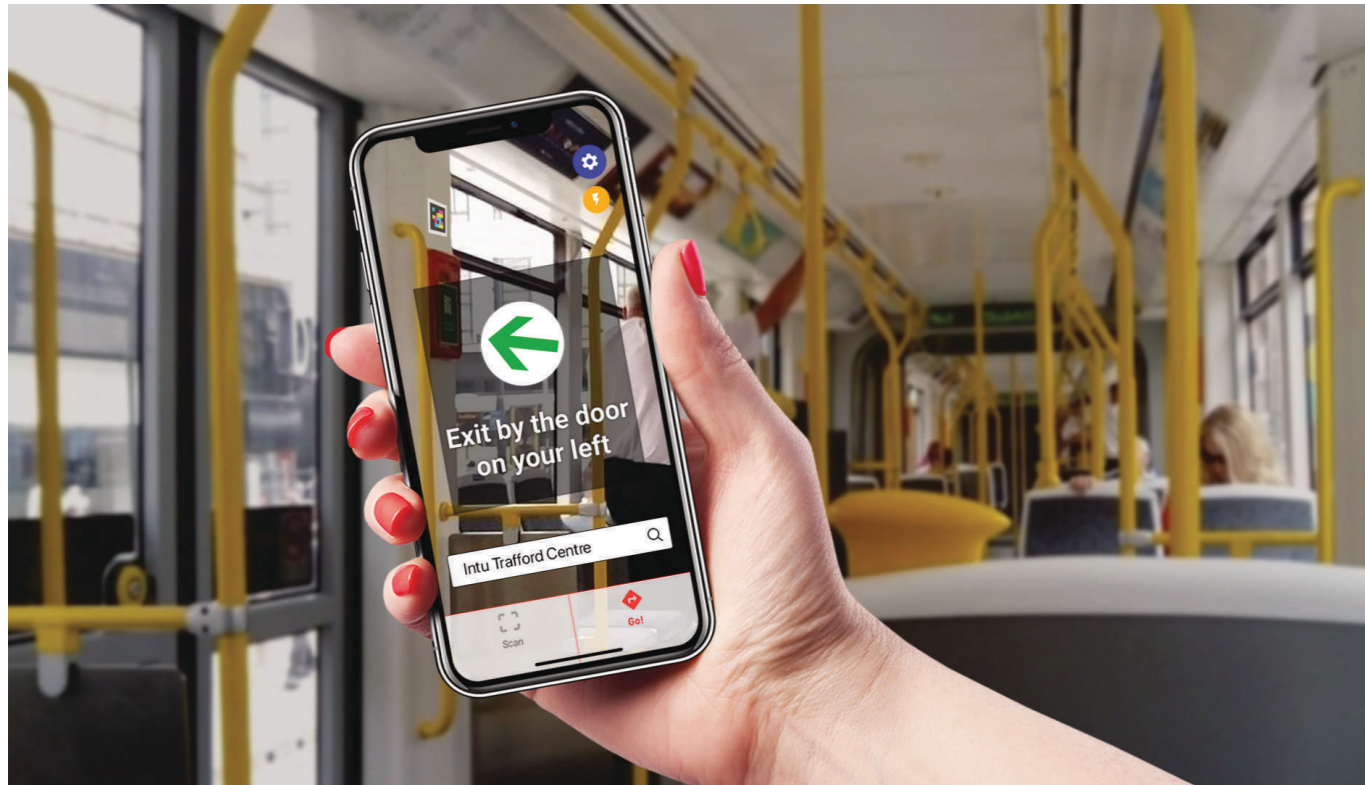
The estimated annual economic benefit of improving transport accessibility

Guided Navigation

Transport systems, pavements, and built environments are often not designed to be fully inclusive for blind and partially sighted people, making them difficult to navigate, particularly if the environment is unfamiliar. The Royal National Institute of Blind People (RNIB) reports that 4 out of 10 blind and partially-sighted passengers cannot make all the journeys they need or want to make³⁵.

In the UK, **Network Rail** chose to address this issue by trialling a guided navigation solution at **London Euston station** - the country's busiest inter-city passenger terminal - providing real-time information to guide passengers through the station and to the correct train. **The solution, named 'Visor', was developed by GoMedia in partnership with the RNIB.** It leverages NaviLens BIDI codes and GoMedia's live cloud-based passenger information system to display directions in the NaviLens and NaviLens GO apps.

Passengers simply hold up their smartphone. The device automatically recognizes any BIDI codes in view and displays location- and context-specific directions to help them reach their destinations more quickly and easily.



Brightly colored BIDI codes offer many advantages over standard monochrome QR codes when it comes to assisting visually-impaired passengers on the move:

- Easier to spot and scan from a distance (up to 30 meters away)
- Registered 12x faster by a mobile device's camera, even when they are out of focus or orientation
- Multiple codes can be scanned simultaneously
- Secure, locked-down environment compared to standard, open-source QR codes

One can say that BIDI codes are a proven technology with deployments in New York Metro, Barcelona, and LA. They are also used for applications beyond transport; for example, in supermarkets on Kellogg's cereal packaging to provide ingredient information.

Visor is easy to roll out in passenger transport environments, as it does not require the installation of any additional physical infrastructure aside from BIDI code stickers, thereby presenting an easy means of improving accessibility with minimal disruption.

Closed tests of Visor revealed the following:

- 94% of users could locate elements they were previously unable to find
- 75% would classify it as a fully inclusive service
- 86% felt it would reflect positively on the transport operator if implemented



Navigating busy train stations can be tricky for everyone and we all want to get from A to B as quickly as we can, but for people like myself, with a visual impairment, it can be even more of a challenge. [Visor] has allowed us to push the boundaries of technology to transform the passenger experience for everyone, through the lens of people with sight loss. Technology like this allows blind and partially sighted people to maintain a level of independence whilst proving that inclusive design is better for everyone.

Marc Powell,
Paralympic athlete and Strategic Accessibility Lead at RNIB



Personal Onboard Announcements

Trials of another technology have also been conducted by **Transport for Wales (TfW)** to make journeys better for passengers with hearing loss.

The application, called **HEAR (Hearing Enhanced Audio Relay)**, enables passengers connected to the vehicle's onboard Wi-Fi to receive personalized journey announcements to their smart devices in real-time.

Prior to the trials, a survey of people with hearing loss conducted by charities Hearing Link and Hearing Dogs found:

- Only 7% were somewhat confident that they would be made aware of changes and disruptions during their journey
- Only 16% felt they were treated equally compared to people without hearing loss
- 96% of respondents commented that they would love to have a solution like HEAR implemented on passenger transport

With HEAR, when an announcement occurs, the passenger receives a text notification, and the audio begins playing automatically. The passenger controls the volume and can set notifications for their specific destination or opt to hear them all. A history of announcements is always available, which allows users who need more time or those who were distracted to go back and review.

Additionally, the notifications are multi-lingual, and can be changed in the user settings. A passenger can also set an advanced notice timer when more time is needed to alight. Leveraging personal devices in this way is a viable alternative to hearing loops, and it broadens the use case to include people who have a temporary limitation such as from an ear infection, or a self-imposed limitation, such as headphones.

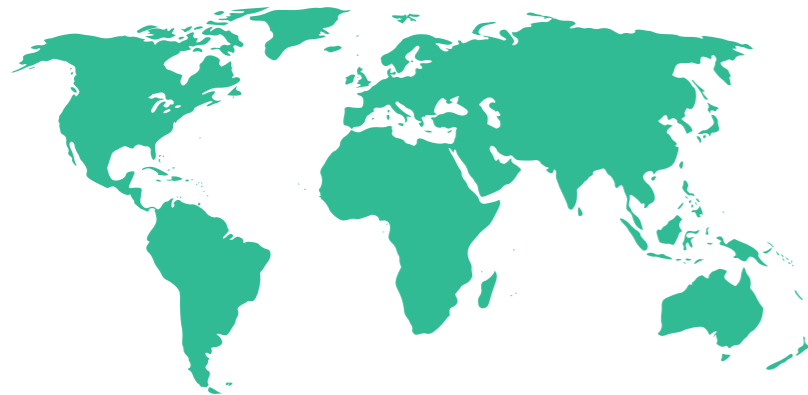
Inclusive Principles

Following the principles set out in the United Nations Convention on the Rights of Persons with Disabilities (CRPD)³⁶, many nations have enshrined statutory requirements for public infrastructure to meet specific standards of accessibility.

The UK sets out its accessibility requirements for public services in the Equality Act 2010³⁷. The Americans with Disabilities Act Amendments Act (ADAAA) of 2008³⁸ plays a similar role in the United States. Equally, Canada's Accessible Canada Act of 2019³⁹ has enabled the Canadian Accessibility Standards Development Organization (CASDO) to develop a roadmap towards a fully accessible Canada by 2040, by targeting priority areas such as employment, built environments and, of course, transportation⁴⁰.

For EU member states, the European Accessibility Act (2019) and the subsequent European Disability Strategy 2021-2030 have defined targets for the mobility of people with special requirements by removing barriers created through divergent legislation. With the Act set to be fully implemented by all member states by 2025, Europe has seen many initiatives to set a new bar for passenger transport accessibility through technological innovation. Luxembourg City, for example, won the 2022 Access City Award for implementing wide-reaching improvements after consulting citizens with accessibility needs.

Defining Accessibility Standards for Public Services Around the Globe...



ADAAA
(2008)



Accessible Canada Act
(2019)



The Equality Act
(2010)



European Accessibility Act
(2019)

Digital Technologies will be a Critical Factor in Creating Accessible Transport Systems of the Future

Keeping an accessible-focused mindset when designing passenger transport experiences leads to a better, fairer, more personalized journey experience for everyone.

Human needs are diverse and, as we've seen in recent years, will change with circumstances and time. Universal and inclusive design principles can help guide the way forward. Pairing purpose-designed digital technology with real-time information will enable transport operators to cater for as many user needs as possible and provide an empowering experience for all.



PART TWO

Creating a Safe Environment That Minimizes the Spread of Disease, and Guards Against Physical and Cyber Threats to the Individual and to Wider Infrastructure

Utilizing Real-time Video Surveillance & Analytics to Maintain Safer, More Reliable Transport Networks

AUTHOR: ANTHONY SPADARO

In his role as a Product Manager at Icomera's headquarters, **Anthony Spadaro** leverages over two decades worth of industry experience to oversee the development and deployment of our digital video surveillance and video management software solution.

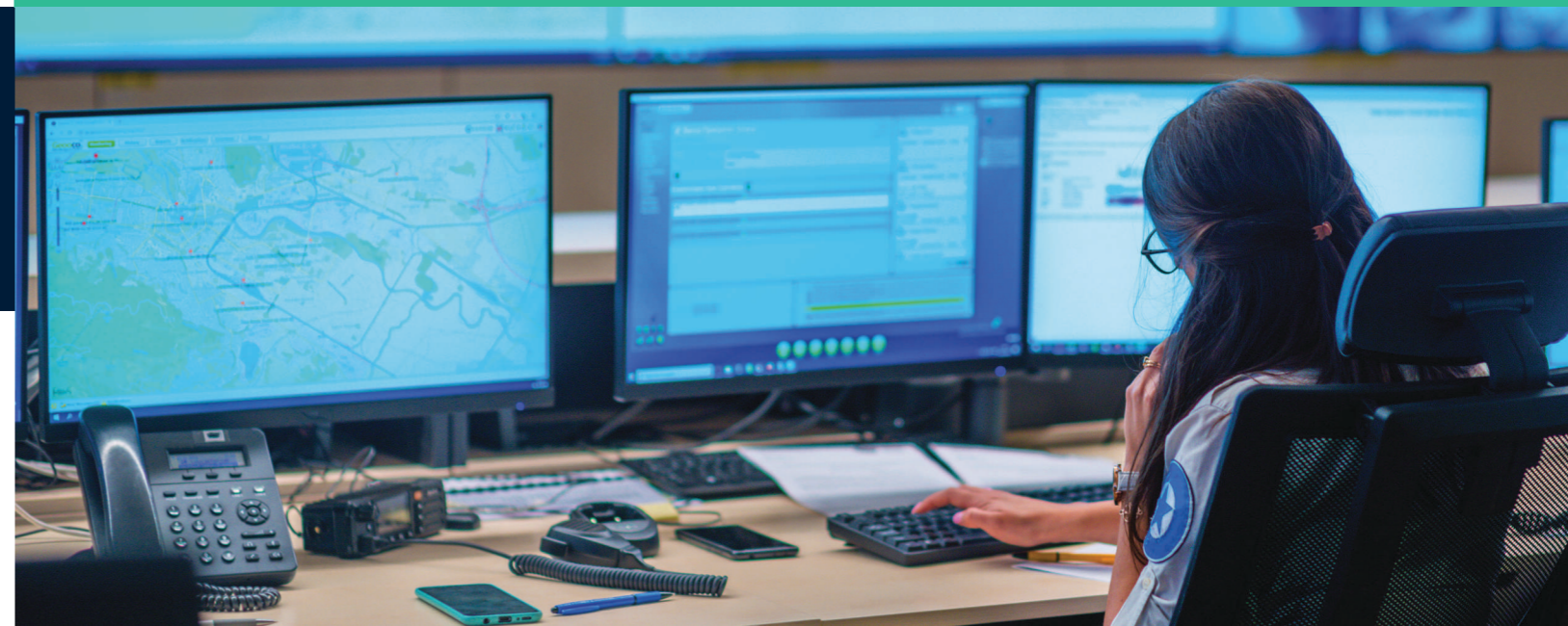


Despite research demonstrating the low risk of COVID-19 transmission through the use of public transit, especially where safeguards such as the use of face masks and increased frequency of surface cleaning have been put in place⁴¹, the perception of the safety of passenger transport is more important than ever, and the industry must work hard to restore full rider confidence as it bounces back from the pandemic. What's more, operators are increasingly expected to do more with less, delivering additional safety-focused services with the limited budget and resources that they have available.

Thankfully, onboard security systems are becoming ever-more sophisticated, and enabling these systems to transmit images, audio and data wirelessly from the moving vehicle is helping lead to faster, more appropriate, and more proactive responses to incidents. In recent years, operators looking to remain competitive in the highly dynamic industry have embraced the switch from forensic to real-time digital video surveillance solutions, and transitioned from analogue to Internet Protocol (IP) based video sensors, to benefit from:

- **Better Legal & Regulatory Compliance** - As legislation continually evolves, it is no doubt beneficial for transport operators to invest in adaptive, future-proof technology which develops concurrently; delivering peace of mind that their transport systems will consistently remain compliant.
- **Reduced Expenditure & Insurance Premiums** - When incidents occur, the ability to access accurate, high-definition digital footage through reliable and easy-to-use video management systems allows operators to prevent and disprove fraudulent claims, avoid unnecessary claim pay-outs, and reduce their insurance premiums by having accurate and reliable evidence to hand.
- **Less Service Disruption & Maintenance Downtime** – By helping prevent vandalism, theft, and violence, and being able to react quickly in cases of medical emergency, operators can save money and reduce service disruption. Additionally, digital systems reduce the downtime sustained through needing to manually monitor asset health, and delayed repairs to any units which have stopped working as a result.

Technology has now also advanced to the stage where one system can often perform the functions of two or more others, and it's worth noting how **surveillance systems are increasingly being utilized in ways which go far beyond**



simply monitoring vehicles for threatening or dangerous passenger behavior. For example, nowadays there is really no need to have a separate digital video surveillance and traditional sensor-based Automatic Passenger Counting (APC) system installed on vehicles; with today's advanced analytics capabilities, surveillance systems can exceed APC systems in both function and accuracy [Learn more in our **South Western Railway Project Spotlight** on page 28].

Protecting Passengers While They Travel

While remaining the most efficient means of moving people across distances, the fact remains that passenger transport requires users to share confined spaces with total strangers, for predetermined lengths of time, with limited opportunities to remove themselves from uncomfortable situations. It is therefore important for transport operators to ease potential anxiety by giving passengers the peace of mind that their persons and property are fully secured as they travel.

Operators such as **RATP** in France are actively working to keep their passengers safe through innovative preventative means⁴². As part of a pilot project taking place on 30 buses operating on the '170 route' between St Denis RER station and Porte des Lilas in Paris, **live multi-view HD video feeds** are streamed from cameras installed on the vehicles back to RATP's security headquarters. The **real-time offload of footage** allows RATP's personnel to quickly access several video streams and switch from one to another across all equipped buses. With an optimal view of what's taking place on vehicles, and access to live sound transmitted from camera microphones, RATP staff can enact the appropriate response to any live situation, and its passengers have confirmed that they feel safer as a result of the technology's use. Importantly, as Didier Robidoux, Director of Safety at RATP explains: *"[The solution] doesn't replace security officers at all, because they are [still] responsible for intervening. So, there are no fewer security officers, but they can intervene more quickly."*

It should be noted that by helping ascertain how and why exactly an incident occurred, the collection of forensic evidence remains a vital component in any onboard surveillance system too; however, if the images retained do not meet the evidential standard required for prosecution, the solution is rendered ineffective. This is where high resolution digital footage makes all the difference, especially when combined with powerful compression technology and extensive storage capabilities.



South Western Railway

Case Study: South Western Railway Monitoring Train Occupancy Levels to Reassure Passengers Post-COVID

In 2021, Icomera undertook an exciting collaborative pilot with South Western Railway (SWR) in the UK, testing an industry-first solution in which existing onboard CCTV cameras and AI software technology are used to capture, analyze, and report occupancy data in real-time, in the form of a RAG (Red/Amber/Green) status. The trial was particularly timely, given that travel restrictions had only recently begun to ease after successive coronavirus lockdowns, and the industry maximized its efforts to reassure travelers.

The passenger counting software used runs natively on the same Icomera connectivity platform already used to support other systems, such as Passenger Wi-Fi. With no need for additional hardware to install, it could be deployed 'over the air' quickly and efficiently, offering considerable time and cost savings compared to similar solutions.

The ability to effectively gauge occupancy levels inside vehicles makes it far easier for passengers to find a free seat or quiet carriage, helping ensure that they can maintain social distancing throughout their journey. And, as SWR's Commercial Director Peter Williams explains, operators can look to "use this enhanced information to inform decision-making in [their] control room, and further improve the punctuality and reliability of [their] services".

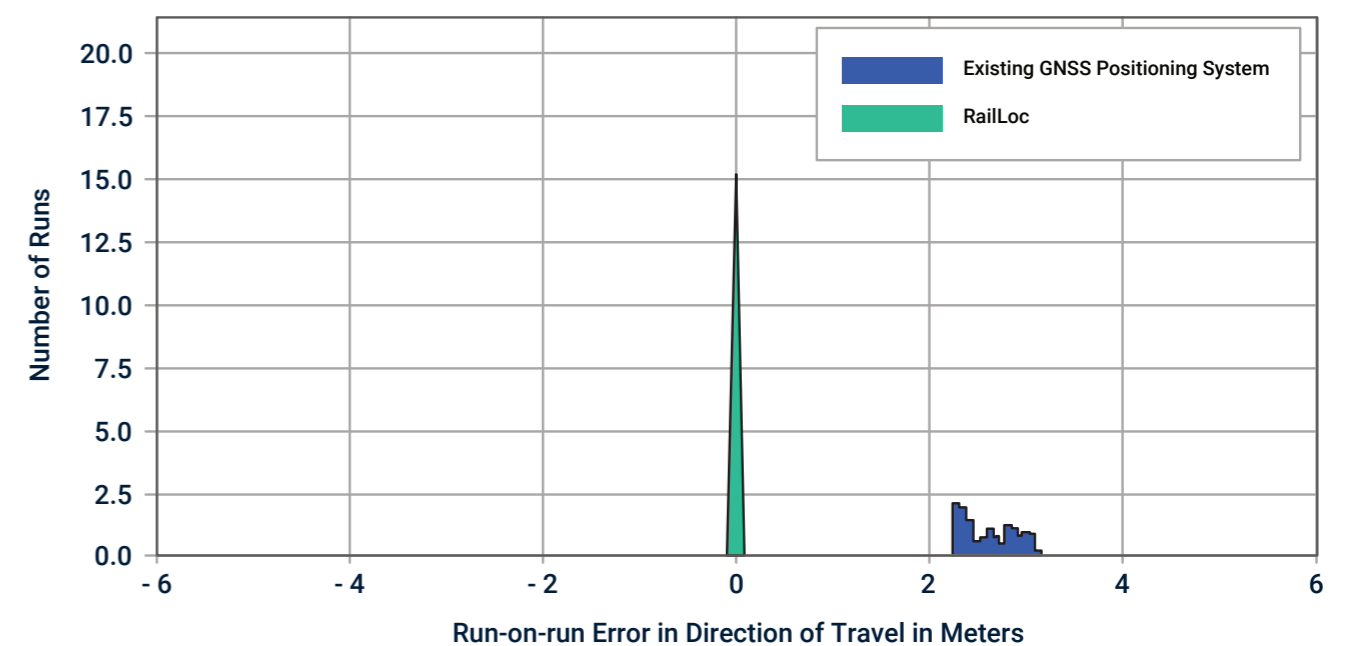


Case Study: Network Rail Improving Operational Efficiency using an Innovative Rail Positioning Solution

Accurately determining the location of any issues along a track helps reduce the time needed to resolve them, delivering a better performing railway at a lower cost, and ultimately helping offer the traveling public a more reliable service. In a recent UK trial, Network Rail - the owner and infrastructure manager of most of the British railway network - leveraged Icomera's centralized connectivity platform to test RailLoc, a highly accurate Rail positioning technology developed by Machines With Vision.

The RailLoc system works by using a pair of cameras mounted under the train to map thousands of Visual Waypoints per kilometer; these Visual Waypoints are then accurately geolocated over the entire railway network. Tests performed as part of the trial project, which was funded by the Rail Safety and Standards Board (RSSB), provide evidence that RailLoc improves repeatability, when compared to the existing Global Navigation Satellite System (GNSS) used for positioning, by a factor of 100; the RailLoc solution has an average error variance of 27mm, while the GNSS system has an average error variance of 2.7m.

Kevin Hope, Network Rail's Principal Engineer for Mobile Monitoring, commented: "The ability to locate asset data to the level of accuracy possible with RailLoc has the potential to significantly improve our current measurement and maintenance of the network."



Building Cybersecurity Best Practices into Network Architecture Design and Incident Response Planning

AUTHORS: MARK HOFFMAN & CHRIS BAKER

Mark Hoffman works as a Senior Business Continuity Consultant for Icomera. A co-founder of the Resilience Think Tank, he won the Global BCI Continuity & Resilience Consultant Award in 2021. In his role as Icomera's Global Cybersecurity Engineer, **Chris Baker** ensures that systems are designed with security front-of-mind and that best practices are followed.



Mark Hoffman



Chris Baker

Cybercrime continues to rise⁴³ and has been classified as the biggest threat businesses face today⁴⁴. It is little wonder that new laws are being proposed and passed in the EU⁴⁵, UK⁴⁶ and US⁴⁷ which will push organizations to further strengthen their resiliency.

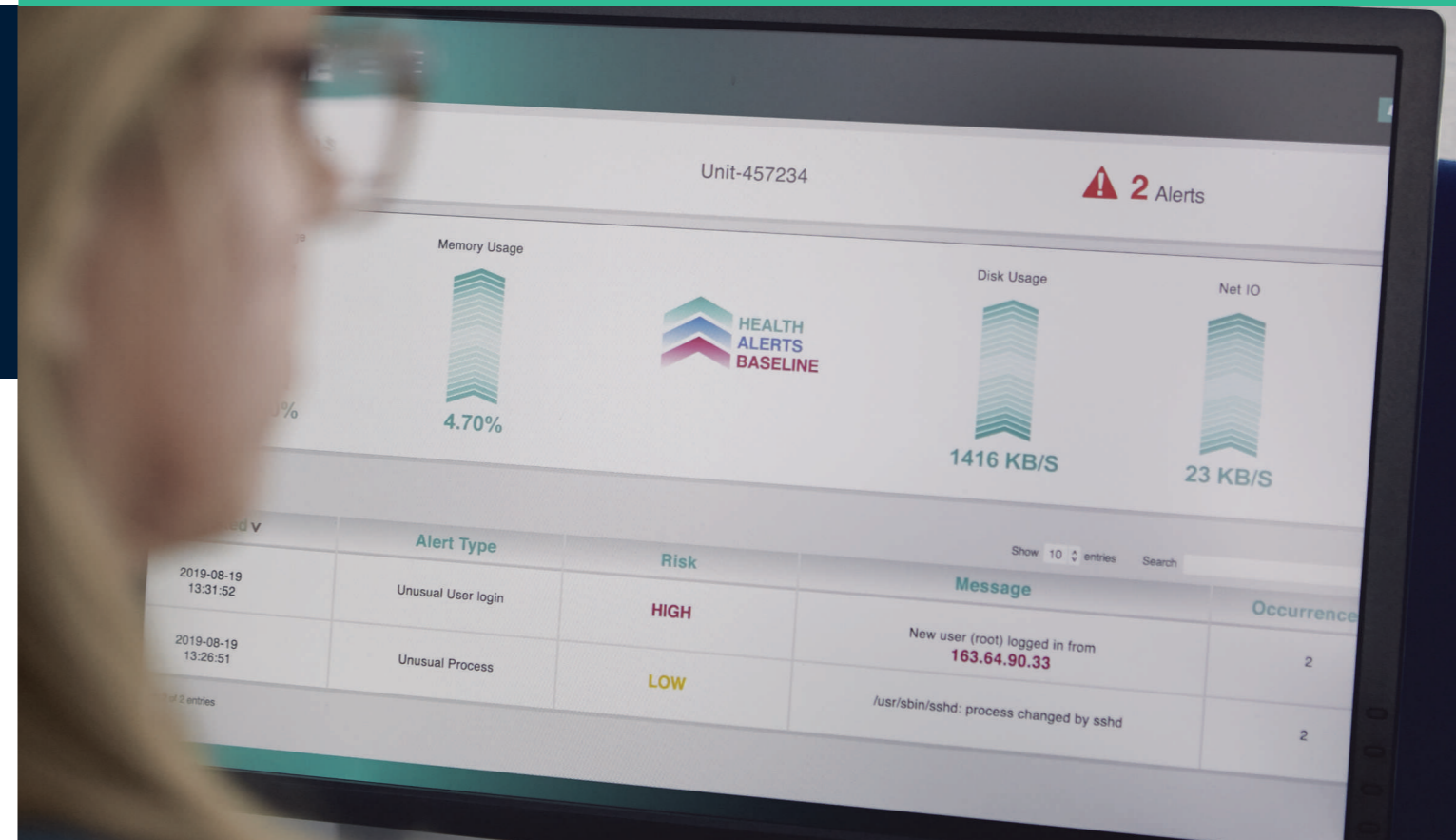
This upward trend is clearly disconcerting, and transport operators must continue to deploy new detection and response tools in order to establish robust protection systems. *However, these tools are simply one element in the overall arsenal of cyber-defenses that organizations should rely on.* There are also a range of frameworks, processes and methodologies that should be incorporated into a company's cybersecurity planning which are fundamental in helping ensure that they are well protected and prepared.

By following the best practices which we outline here, companies can lay the most solid foundation possible when it comes to (i) designing and building resilient onboard networks and (ii) ensuring an effective response to an attack.

Becoming Secure by Design

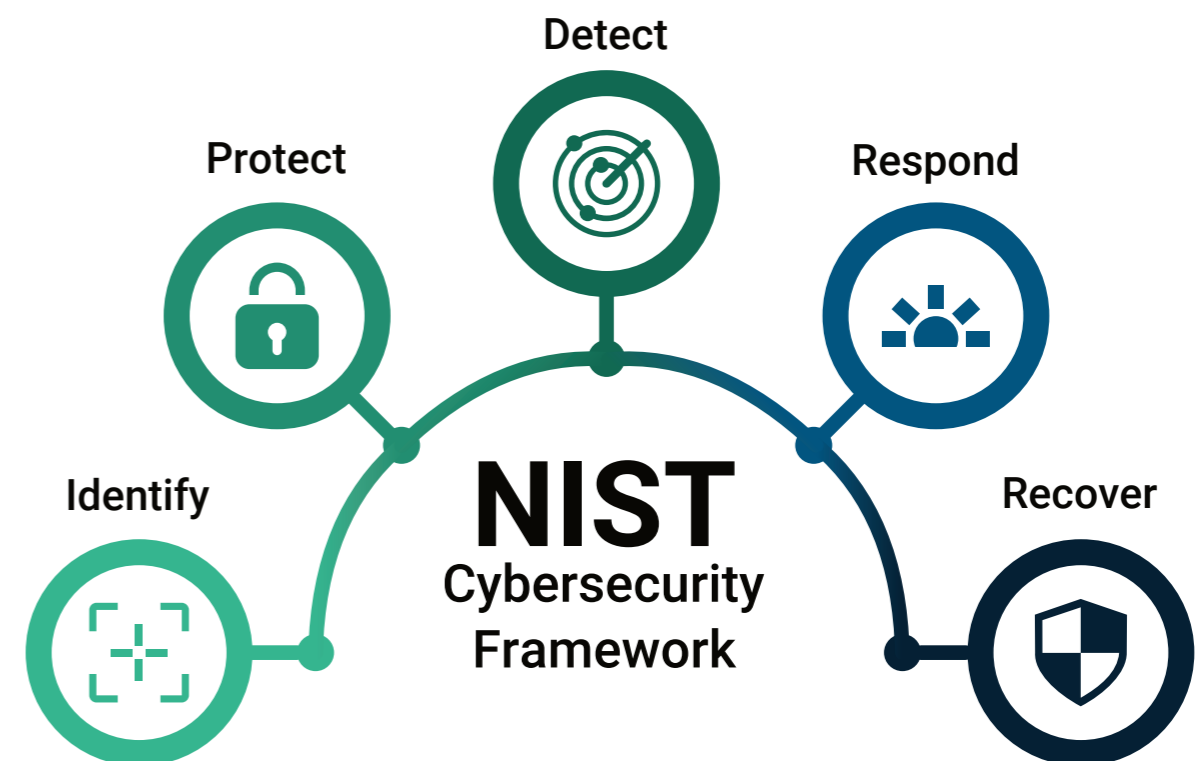
The transport industry's move towards digitalization offers significant advantages in terms of simplifying network architecture and facilitating communication between different onboard components. However, greater connectivity can also increase the number of potential entry points that can be targeted in a cyber attack. Without the right design in place, a single vulnerability in one system can be exploited to put other networked systems at risk. Similarly, the fact that more and more systems can be accessed remotely brings new challenges that must be considered.

This is why it's imperative that security is prioritized right from the outset when planning an onboard network, rather than as an additional consideration to be investigated down the line. Indeed, one simply cannot think of digitalizing the components on a vehicle, without keeping security front of mind from the initial design phase.



The system architecture must be designed in a way which effectively deters and prevents against breaches, following best practice standards in line with established protocols such as ISO 27001⁴⁸, IEC 62443⁴⁹, and the National Institute of Standards and Technology (NIST) framework for cybersecurity⁵⁰.

As the NIST framework outlines, the starting point in a robust cybersecurity approach involves being able to identify and protect against threats; these are key to then being ready to detect, respond and recover from an attack appropriately.



Designing and Maintaining an Onboard Network: Three Key Security Considerations

1

System Architecture Design

It is common for legacy onboard systems to connect to one another over a flat network with no segmentation. The problem with this approach is that penetration in one area of the network can result in access throughout the system. The use of network segmentation isolates any penetration to a single area, significantly reducing the overall exposure and risk.

2

Access Control and Monitoring

Intelligently managing and monitoring access to a network helps ensure that only those that require access can gain entry. Access can be controlled by means including establishing a robust password policy, allowing access only to authorized devices, and implementing automatic account lockouts after multiple unsuccessful login attempts. Additionally, change logs should be actively monitored to verify that no potentially malicious updates are made to the system.

3

Continuous Improvement

An effective cybersecurity approach must acknowledge that protection is an ongoing and evolving process. No-one can afford to become complacent in thinking that a system is ever fully protected; a defensive measure which was robust at the initial design phase may not be tomorrow. Regular penetration tests should be carried out to discover and react to any potential new / existing vulnerabilities, and multi-layered lines of defense should be deployed to help form the strongest possible protective web around a network.



Responding Effectively to a Cyber Attack

Unfortunately, even with an optimal system architecture design, and with the best possible detection / defense processes and tools in place, operators will still be susceptible to a breach at some point, and they must be ready to respond quickly and appropriately when one occurs.

It should go without saying that an organization's IT department will play an integral role in any response playbook; technical experts will need to carry out forensics, work to contain and eradicate the threat, and take steps to get systems back online as soon as possible.

However, there is an equally important parallel work-stream that often gets overlooked, and this involves establishing a robust crisis management response. This component involves many other stakeholders within a company and relies on good planning across a range of different departmental areas...

Business Impact Planning

Before any attack occurs, a detailed assessment should be carried out into which systems are used by the company, what role these different systems play, which departments rely on these systems, and what the business impact would be if a system were to be taken offline. From this analysis, it will be possible to form a clearer understanding of where a breach would incur the least / most damage, and for the crisis management team to gauge an appropriate level of response.

Insurance and Legal Planning

Operators cannot afford to wait until an attack occurs to determine their cyber-insurance coverage. They should research the scope and limitations of their policy, as well as confirming the process for how they must engage with a breach coach during a crisis. Additionally, it's essential to pay attention to legal considerations, ascertaining ahead of time what must be done to meet any obligations, especially when it comes to privacy-related matters (e.g. in the event of a data breach).

Crisis Decision Planning

When a cyber attack happens, some extremely tough decisions will need to be made under considerable time pressure. Thankfully, it's possible to plan ahead. Conversations can take place between relevant stakeholders based on possible attack scenarios, and default positions can be built into an organization's incident response plan. These default positions must be based on an operator's core values and principles, and its appetite for dealing with risk. However, companies must also be willing to deviate from this default based on likely accentuating circumstances; for example, stakeholders can discuss together whether they would be more or less likely to pay a ransom demand in a live incident if the ransom were extremely low, or in a case where there was the additional threat of data exposure.

Crisis Communication Planning

One of the most important aspects of a cybersecurity response will be in working to protect an organization's reputation, and effective communication is key to securing this aim. Again, it's possible to anticipate and prepare on this front. Based on likely attack scenarios, choices can be taken in advance on what internal / external communications would need to be published. Pre-drafted templates can be created which form the foundation for what these communications might state, allowing teams opportunity for internal discussion on the tonality and messaging, and helping ease pressure when it comes time to deal with a live incident itself.

The bottom line here is that operators who rely solely on their technical IT teams to deal with an attack are only considering half the equation. Without the right crisis management planning, it's impossible to properly understand what the business impact of any breach would be, and therefore also impossible to make good decisions around how to deal most effectively with it.

In contrast, with the right preparation in place, teams will be far better placed to make good business decisions during a cyber attack, leading to a far higher likelihood of them gaining the best possible result for the organization.

Importantly, a well-formed crisis management plan is not only an expectation that operators should place on themselves; it should also be a requirement they place on each of their partners and suppliers.



PART THREE

Responding to Rapidly Changing Environmental, Societal, and Economic Needs in a Cost-Effective, Resilient Way

Time Travel

Taking Older Rolling Stock into the Future

AUTHORS: MIKE MORTIMER & MARK HOPTRUFF

Mike Mortimer and Mark Hoptruff are the directors of DG8, Icomera's in-house design and engineering professional services business unit. A creative and versatile team, DG8 has extensive experience in delivering projects from concept through to implementation.



Mike Mortimer



Mark Hoptruff

While introducing more new vehicles into service will contribute to the technological advancement of the transport industry over the next decade, it is the life-enhancing, life-extending upgrades of older vehicles that will have a greater, more immediate impact on supporting the transport industry's overarching goals in a sustainable and cost-effective way.

Playing Catch-up

Ten years is not a long time in Rail, with limited valuable windows of opportunity to modernize rolling stock - realistically only one or two at most per vehicle - and equip them to meet challenges that are already very present.

Vehicles are always playing catch-up with new technologies, even before they have entered service for the first time. It starts with the long train procurement process, where manufacturers are building vehicles to specifications that were defined 4-5 years earlier and trying to incorporate technologies - particularly in the cases of those that are digital - that refresh every 5-7 years.

If the hardware required to support that technology is not installed during vehicle construction, it can face a five-year wait for the next opportunity, and the difficulties will only ever increase each time the window opens again. Eventually there will come a point where the train design pre-dates even the conceptual stage of a new technology. This is something Icomera encountered when first installing its connectivity hardware on older rolling stock, trying to find the best way to route fibre optic cable through a train that was designed long before manufacturers understood that fibre optics was ever coming to the railways.

We will encounter this more frequently over the next decade as global events dictate the need for the faster adoption of a wider range of new technologies, from multiple vendors, across multiple vehicle classes. In the UK, for example, the average age of passenger Rail rolling stock over the last 10 years has been between 17 and 21 years⁵¹. This is a

huge number of vehicles that pre-date the wider understanding of concepts like the Internet of Things, or emissions targets. But they will all be expected to play an equal role to their newer counterparts in terms of delivering a smarter, safer, and greener travel experience.



DG8 worked to convert two British Rail Class 153 passenger units into Visual Inspection units for Network Rail

Intelligent, Space-Efficient Design: The Blueprint for Success

The projects that most successfully blend new technologies with older assets are those that keep the passenger's engagement with their journey in focus: Design-led, from concept through to implementation, working across all tiers of the supply chain.

DG8 Design and Engineering was formed in 2008. In our early years, retrofitting vehicles with known third-party systems made up the largest percentage of our work. Now, with the increasing interest and availability of innovation funding (such as the UK government's First of a Kind competition), retrofitting new and advancing technologies accounts for at least 60% of our active projects at any given time. This will only increase.

When (re)designing and delivering the onboard networks of devices and systems that will support the digital and energy transitions, the main challenges are (1) limited space and (2) the need for integration with current on-board systems.

The rapid installation of safe and reliable modular systems across a wide variety of vehicle types therefore requires innovative **engineering design** work. When DG8 was tasked with adding Icomera's 5G connectivity solution to a West Midlands Metro (WMM) tram - **the country's first 5G enabled tram project** - the limited space available on the vehicle required a compact design solution. Collaborating with multiple partners, we worked to neatly package the new connectivity solutions around the existing equipment, and to ensure the deployment met all industry standards; once designed, installation was completed over the course of a day, with the support of WMM's depot team [Read the full **West Midlands Metro Project Spotlight** on page 19].

Similarly, design challenges must be overcome when it comes to **electrical engineering**. DG8 recently led the installation design and engineering, approvals (RIS-2700-RST), material supply and installation work on **Network Rail's** project to convert two British Rail Class 153 passenger units into Visual Inspection units.

The unit conversion was based around three complex digital solutions: 1) A track condition and geometry monitoring system, 2) a camera system recording images of the track and uploading the footage back to the Network Rail viewing platform, and 3) a positioning system that accurately tags the data from the other systems with the location on the network. These systems required a hybrid power source with multi-mode controls to support recording while in service, and post-processing while in sidings. DG8's solution was to install an internal generator and supporting lithium batteries working in tandem - The systems were split into critical and non-critical, with critical systems receiving constant power, maintaining communication with the vehicle for data transfer on-demand. [Read the full **Network Rail Project Spotlight** on page 29].

These examples help demonstrate the potential of what can be achieved in the near-term when partners with the required competency and capacity are engaged at the earliest stages of a project.



DG8 designed the interior meeting and social areas for HydroFLEX, the UK's first hydrogen-powered train



HYDROFLEX

Case Study: HydroFLEX Supporting The UK's First Hydrogen-powered Train

The HydroFLEX project, led by rolling stock asset manager Porterbrook, involved the conversion of a 30+ year-old British Rail Class 319 train, fitted with hydrogen fuel cells, giving it the ability to run autonomously on hydrogen power on non-electrified routes. HydroFLEX is expected to play a key role in decarbonizing the British railway network, by helping to replace diesel-only trains by 2040.

DG8 was responsible for the train's mechanical installation design, including how best to integrate key components such as the hydrogen fuel tanks, fuel cell and battery module, and the interior design of the train's 'onboard boardroom' conversion, giving passengers the chance to work with Icomera's 5G Passenger Wi-Fi while traveling on the train.

In addition, DG8 supported the electrical installation design, working to ensure that it conformed to the railway industry's specifications and best practices; performed structural calculations to verify that the items installed on HydroFLEX met structural compliance requirements; and provided support to validate the wider approvals process.

Working collaboratively with a number of skilled partners, we were proud to have been involved in this ambitious project to make the vision of the hydrogen powered train a reality in the UK, successfully creating the UK's first hydrogen-rail supply chain in the process.

The Fast-Track to Future-Proof Connectivity

AUTHOR: MATS KARLSSON

Mats Karlsson is Icomera's Chief Technology Officer and co-founded the company in 1999. The original inventor of Icomera's link aggregation technology, Mats established the Rail Passenger Wi-Fi business segment, creating a new industry in the process.



With passengers demanding constant connections while they travel, and transport operators looking to leverage real-time operational data to and from their vehicles, there are an ever-increasing number of onboard devices and systems requiring connectivity. And, as the other authors in this report have already demonstrated, ensuring that this connectivity is **fast, reliable, robust and secure is key** to assuring that the industry will be able to cater for the evolving needs of business and leisure commuters, as well as maintaining their safety.

What's more, we've explored how the industry must deliver all this connectivity in a way which is **both cost-efficient and resilient, and that allows it to adapt quickly** based on shifting environmental, societal, and economic needs. It's no good for the connectivity on offer to simply meet the requirements of today, only to become technologically redundant tomorrow (or in a year or two!) when necessities shift; undoubtedly, that would be a waste of time, budget, effort and resources, in a period when all of these must be treated with greater importance than ever.

"Rather, any investment in connectivity now must confidently offer compatibility with future communication technologies as and when they arrive."

In doing so, transport operators will be able to take advantage of these new technologies while utilizing their existing assets, future-proofing their connectivity over the long-term.

Traditionally, addressing the growing data-demands of the transport industry have raised two principal challenges:

- (1) Passengers and onboard systems share the same finite bandwidth of the onboard Internet connectivity
- (2) Connectivity needs to be available for the entire journey through rural and / or urban environments

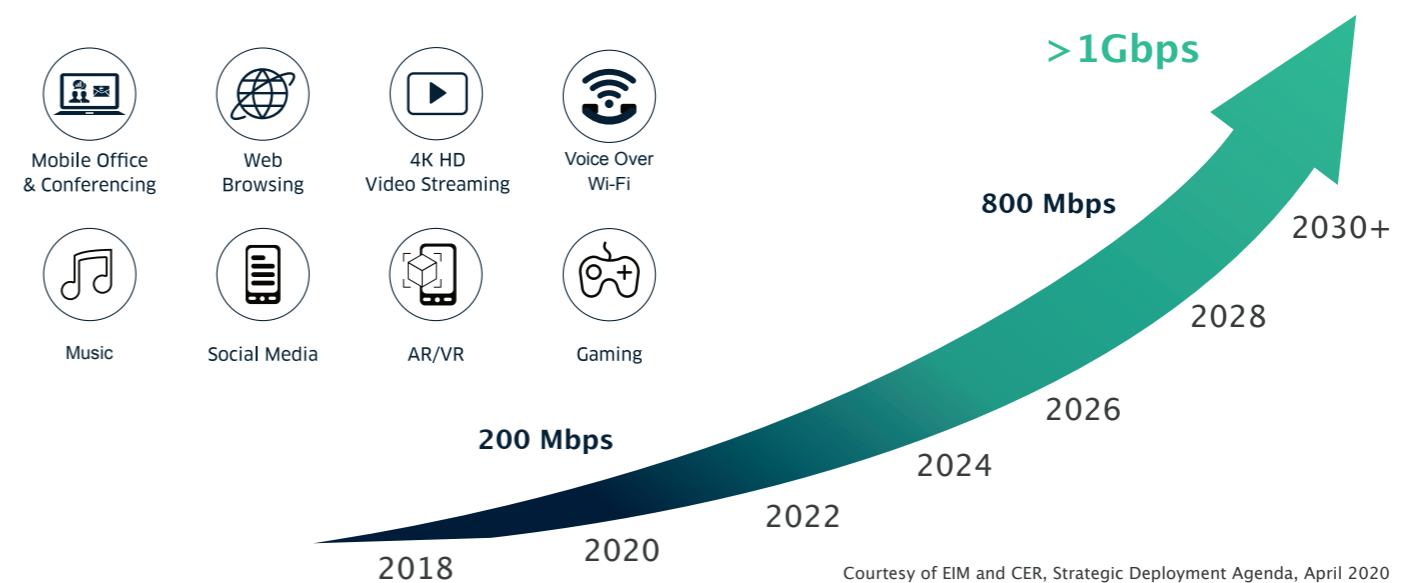
But how can these connectivity challenges be overcome in the timescales required, and with the appropriate sense of urgency? In this article, I will examine two approaches which transport operators would be diligent to consider - Link aggregation and trackside networks - But first let's talk about cellular technology...

Maximizing Value from Cellular Connectivity

Today, personal and commercial Internet connectivity on the move is largely delivered through cellular networks; however, in most countries, geographical patches of poor coverage and capacity mean that the stability and throughput of the Internet connection varies along a vehicle's route, causing data packets to be delayed or lost. In real-world terms, for passengers this means slow webpage load times, video buffering, broken VPN tunnels and dropped conference calls; and, for transport operators, unreliable connectivity is a significant concern at a time when many onboard systems are becoming increasingly business critical.

With its promise of higher capacity, lower latency, and greater throughput than 4G networks, 5G is often touted as the cure-all. Indeed, 5G does provide several great opportunities for increasing data capacity on passenger transport; with more available spectrum, more advanced antenna technology, and more efficient routing from Mobile Network Operators (MNOs), 5G is able to deliver faster, more cost-efficient communications and increased network capacity and availability than was previously possible solely with 4G LTE networks.

Forecast of Future Data Demand...



Courtesy of EIM and CER, Strategic Deployment Agenda, April 2020

However, it is far more fitting to think of 5G as being an upgrade rather than a total overhaul, or an “*evolution, not a revolution*”. Despite the advantages it brings, 5G is nonetheless *still a cellular network*, and therefore has the same challenges associated with previous generations of wireless communications technologies:

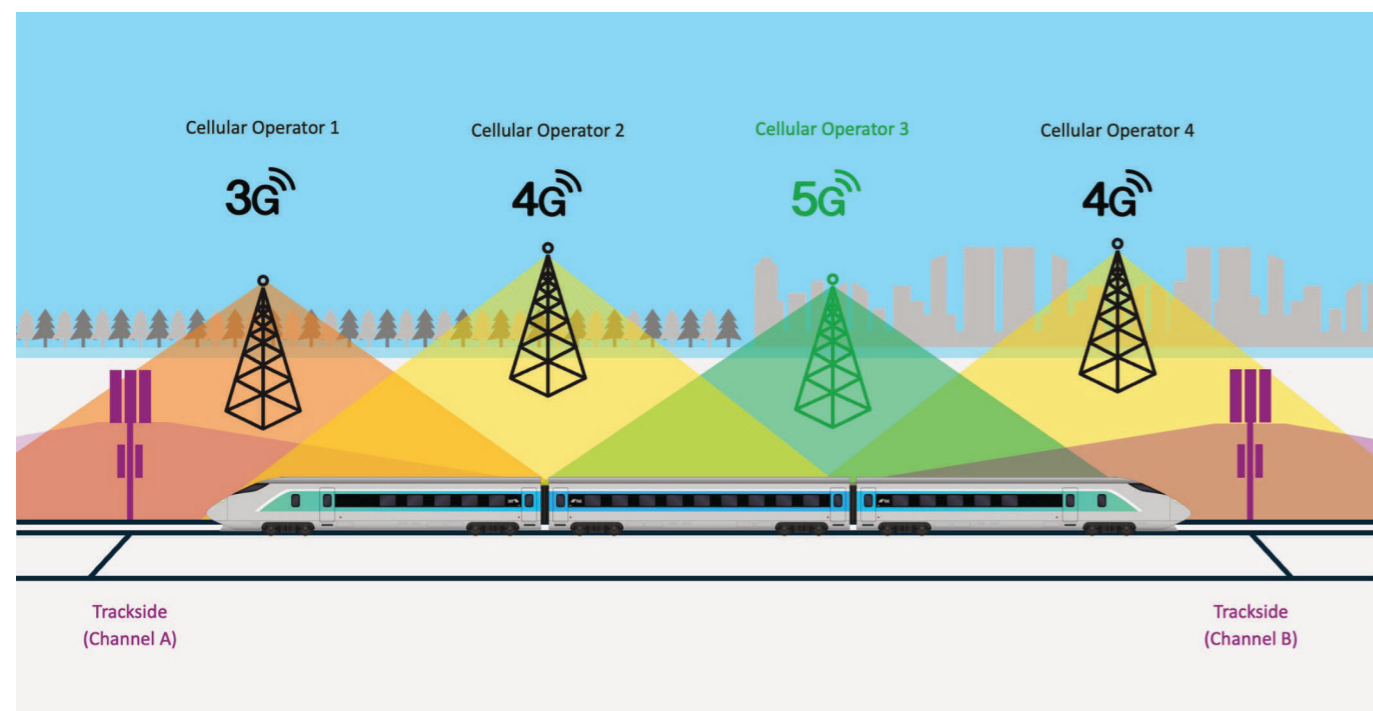
- Firstly, frequency limitations with 5G mean that coverage challenges will remain, when 5G alone is relied upon. The technology’s higher frequency RF bands, such as mmWave, are more designed for stationary environments and are thus generally not the best choice for most passenger transport connectivity use-cases (particularly where long, rural routes are concerned); 5G and 4G’s “Sub-2 GHz” frequencies will remain the most versatile options for delivering consistent connectivity along entire routes.
- Secondly, due to the CAPEX-constrained nature of cellular network development, it is likely that the full 5G rollout will still take quite some time, at least in some countries. Rural areas that some train routes pass through will be some of the last places to receive 5G.

Because 5G suffers from these limitations where passenger transport is concerned, transport operators should therefore adopt a wider connectivity strategy, selecting the right technologies that will make the most of 5G’s eventual benefits, while continuing to resolve the existing challenges of working with cellular technology.

The Efficiency of Link Aggregation

When it comes to cellular connectivity, using a “5G / LTE-hybrid” approach will remain the best way to maximize the effectiveness of existing coverage and capacity, plugging any gaps along the line, and delivering more consistent performance across both rural and urban environments in a cost-efficient manner.

To deliver this hybrid solution, transport operators can take advantage of existing link aggregation technologies, such as Icomera’s SureWAN™ solution, phasing in the next generations of connectivity as they become available along a route.



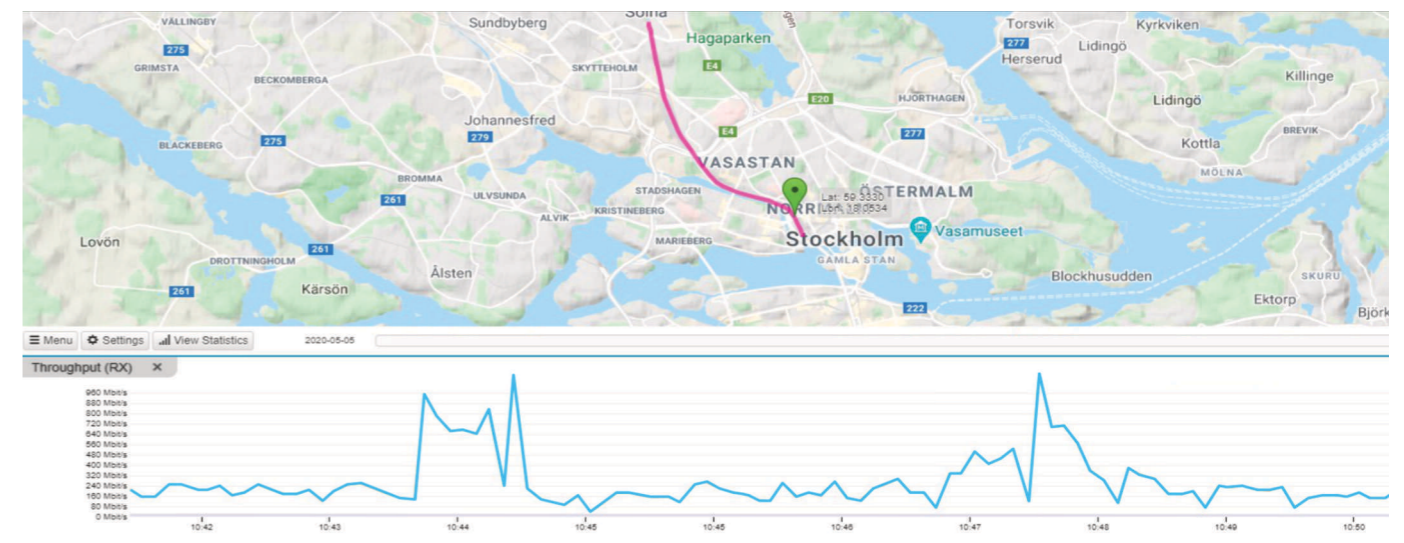
Optimizing aggregation helps deliver the fastest, most reliable connection possible and can involve various levels:

- **Carrier Aggregation:** Each modem in a router can aggregate all available radio frequencies from a single MNO along the route
- **Dual-Connectivity:** This feature allows each modem to utilize both 4G and 5G to improve network coverage and data rate
- **MNO Aggregation:** Each router can contain multiple carrier-aggregating modems, capturing all available capacity provided by all MNOs in the coverage area
- **Multiple-router Aggregation:** Multiple routers can be distributed along a vehicle (e.g. across train carriages), aggregating capacity across different coverage areas
- **MIMO Technology:** Routers use “MIMO” (Multiple Input / Multiple Output) antenna technology. “Multiplexing MIMO” makes it possible to send and receive multiple signals along the same radio channel by using (typically) two or four antennas, increasing the capacity even further

Additionally, SD-WAN solutions such as SureWAN allow network traffic to be intelligently prioritized, throttled and / or blocked, as required; using this technology, transport operators can better manage their cellular data costs through efficient bandwidth usage, and prioritize their business-critical applications that need Internet access most (e.g. video surveillance systems or staff Wi-Fi over e.g. Passenger Wi-Fi).

In late 2020, the power of link aggregation technology was demonstrated in a real-world trial of Icomera’s 5G-enabled X5 router traveling on an **SJ train on the Stockholm–Gothenburg route**. In the trial, the X5 achieved a record-breaking throughput level, delivering over one gigabit of data per second, surpassing the benchmark referred to in the transport industry as “the Gigabit Train.”

Importantly, the X5’s backwards-compatible 5G modems also yield gigabit speeds when using only 4G LTE networks, thanks to “LTE CAT 20” technology, which allows for faster data transfer by aggregating up to seven “frequency carriers” at once. This means that transport operators can see substantial increases in throughput from existing networks, even before the rollout of 5G has been completed.



In trials, Icomera’s X5 router achieved over 1 Gbps throughput using commercially available 4G and 5G networks

Designing and Implementing Dedicated Trainside Networks

Longer-term, transport infrastructure owners and operators looking to take greater control of their connectivity strategy will invest in dedicated broadband radio networks installed along the track. Trainside networks solve the existing connectivity challenges presented by cellular networks by ensuring high-bandwidth coverage along an entire route: Overground, underground, and in stations. Significantly, trainside solutions also offer several cost-efficiencies when compared to cellular-only solutions:

1. The presence of pre-existing infrastructure, fibre, and power along the track can be used to reduce costs during the installation process
2. Once constructed, these private networks offer greater capacity and better security at a lower cost when compared to purchasing data directly from MNOs
3. Those who invest in private trainside networks will have the opportunity to create new revenue streams by licensing access to these dedicated networks to other transport operators wishing to share access
4. Trainside solutions offer further cost savings using the “unlicensed” 5 GHz spectrum, delivering stable, high-bandwidth connectivity, with no need for additional licensing overheads

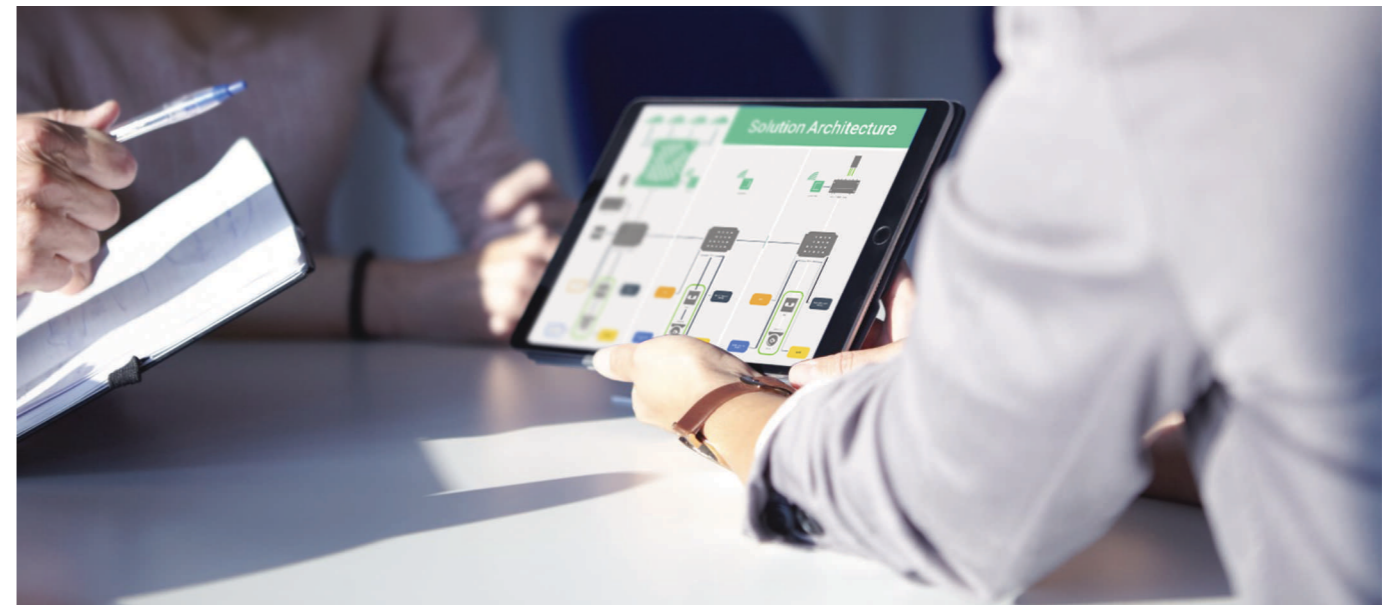
Conclusion:

Combining Tools & Technologies to Deliver Optimal Performance

Looking ahead, with control and reliability remaining key measures of any good connectivity solution, well-integrated monitoring and management software tools will play a vital role too. Transport operators seeking to attain maximum value from their investment will take advantage of these tools to gain deep insights across multiple data streams simultaneously, proactively analyze and optimize their network performance, and mitigate against any potential issues at the earliest possible point.

Finally, despite the significant benefits that trainside technology offers, it should be noted that link aggregation will remain important in order to (i) manage the seamless handover in connectivity between trainside radios along a route, (ii) aggregate both trainside and cellular and / or satellite connectivity along stretches where both / all are available, (iii) offer fall-back to cellular networks / satellite connectivity if parts of the trainside network fail, or in areas where trainside networks have not yet been deployed for some reason.

By taking a hybrid approach as documented here and intelligently utilizing a range of different connectivity technologies together in tandem, transport operators will be best placed to gain maximum value well into the future: Efficient link aggregation will continue to provide the means by which the full power of 5G and / or trainside technologies can be achieved where possible, while the next best available cellular or satellite connectivity can be achieved in those areas in which 5G and / or trainside networks are unavailable.



ABOUT ICOMERA

Icomera is the world's leading provider of integrated connectivity solutions for trains, trams, buses and coaches, serving millions of passengers and tens of thousands of onboard systems on a daily basis.

We deliver the fastest, most reliable and secure Internet connection available to a moving vehicle, supporting a wide range of digital applications which increase passenger satisfaction, enhance operational efficiency, and improve safety and security.

We work in partnership with clients to build long-term relationships, listening to your needs and advising you on the solutions that fit your requirements, with room to grow in the future. We are with you through the installation process and over the entirety of a solution's service life. We can point to our proven track record of successful projects, providing relevant case studies on request.

Our solutions make transport more attractive for passengers and part of a smarter, safer, greener future for everyone, accelerating the transition towards a carbon-neutral world.

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