Rail: Four Megatrends to Watch in 2030

Strategic and technological solutions to tackle the main railroad future challenges driven by megatrends such as technology, megacities, sustainability and globalization.

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Executive Summary

Over the last decades, there has been a spectacular development in the world's railroad sector. The introduction of the high-speed rail system, globalization, the development of new urban transport systems, and the latest technology and innovations have boosted the industry's network around the globe.

Global megatrends such as technology, sustainability and globalization will significantly impact the railroad industry in the following 10 years. Some industry leaders and stakeholders are aware of the stability and synergy between these major changing forces, which allows, to a certain extent, a likely medium- and long-term future to be envisioned with some level of confidence.

Global changes in transportation will be key when facing upcoming challenges. Yet while rail is among the most energy efficient modes of transport for freight and passengers, it carries unavoidable challenges such as cybersecurity, over population, mobility, global warming as well as social and political controversies. On the other hand, innovation, digital transformation, cultural changes, and operational management can provide strategic and technological solutions to these problems.

Getac has foreseen these megatrends and challenges. Hence, Getac's experts have built and constantly provide total railroad industry solutions that are easy to adopt and able to solve the upcoming challenges.

Likewise, the constant interaction with the global railroad companies leads Getac to gain extensive experience by developing tools and technological solutions to help industry management and operators tackle these challenges and maintain the rail system as a prioritized transportation alternative as we face global megatrends with a united front.

Introduction

Like other transport systems, the railroad can deliver huge value to society, with the ability to carry large volumes of passengers and freight safely, speedily and sustainably. In order to deliver value to its users, it must be organized and designed to deliver the highest levels of resilience and quality of service.

Based on current knowledge and understanding, megatrends are driving us to global challenges in the railroad industry. Therefore, there is a need to adjust certain practices and their developing routine so as to accommodate the current and future megatrends. Different technologies, sustainability regulations and globalization practices can cause critical impacts on cybersecurity, population, mobility and global warming.

The process of identifying megatrends affecting the future transport system is based on the review of existing literature dealing with such megatrends and their implications on transport. Therefore, our goal is to reach consensus on the key megatrends affecting both passenger and freight transportation systems.

World rail industry

Mobility is an activity that involves the movement of people, goods, or resources from one place to another, either through a locomotion mechanism or using some other type of transportation. It is an activity that responds to a population need but also a practice with a degree of responsibility given the fact that millions of trips occur daily in urban areas worldwide, which involves the consumption of natural resources on a large scale and consequently, the generation of pollutants into the atmosphere.

According to the World Bank, in 2020 there were 1,350 thousand kilometers of installed train lines globally (31% located in Europe, 32% in Asia/Oceania, 20% in America, and 7% in Africa). Even though Europe has the largest infrastructure, Asia accounts for 81% of the passengers-kilometer worldwide.

The global railroad industry market was valued at USD 295 billion in 2021 and is expected to expand at a compound annual growth rate of 4.4% from 2022 to 2030. The market is likely to be driven by continued investments in railroad expansion networks. A significant expansion is observed in Asia-Pacific, where projects are already approved and currently in design and construction stages.

Annually, the global railroad transportation system moves more than 4,000 billon passengers-kilometers. The US Department of Transportation has invested USD 8.8 billion every year over the last five years to modernize their railroad infrastructure while Europe renewed more than 10,000 locomotives between 2015 and 2022.

History, Present and Future

How the rail industry started?

The railway was one of the technological advances that came with the Industrial Revolution, when companies saw an increase in profits by reducing resources and human efforts.

At the beginning, the railway emerges as a way to transport material resources, which would initiate a stage of expansion towards new territories. With this new way of transportation, the concept of time also changed.

In the mid-nineteenth century, rail transport was practically limited to Western Europe and the United States, leading these regions to an era of industrial development.

Railways developed rapidly following the early successes of George Stephenson and other pioneers. This new technology was the result of the invention and subsequent development of the steam engine, which drove other applications of railways such as in mining, where they were ideal to bring coal and tin to the surface faster. This idea was transferred to the notion of pulling carts along rails, and eventually Stephenson took the idea one step further and built the steam engine on a cart.

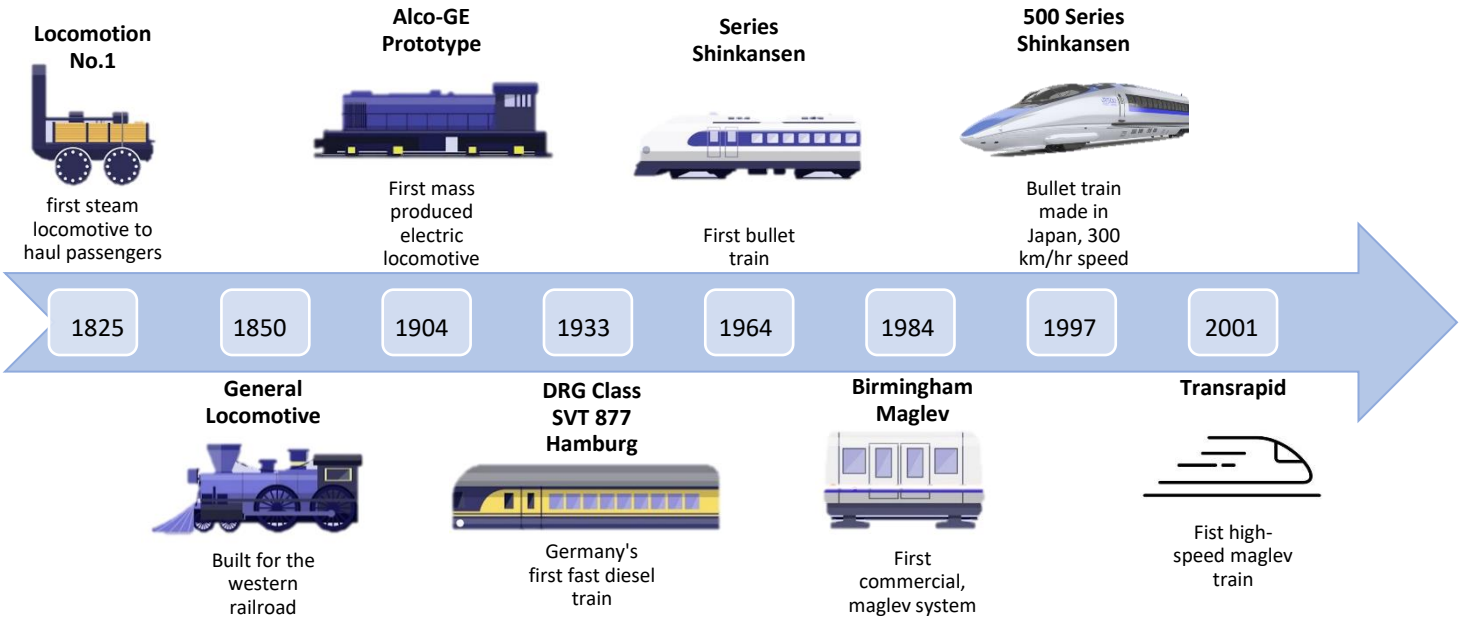

Figure 1 Timeline of commercial railroad industry

The current railroad industry

The rail industry is expected to grow over the coming years as the tourism industry increases thanks to inexpensive passenger train fares. Furthermore, investments in passenger railroad networks and the introduction of newer and faster trains are likely to impulse segment growth.

The rail freight segment has been witnessing steady growth due to the reliance on railroad routes for the transportation of goods and lower rates. Likewise, the railroad network's strong connection capacity facilitates the transportation of commodities to remote places that are otherwise hard to reach by air or other transportation technology. Even though global trade and cargo volumes were highly impacted by the pandemic, the industry is expected to recover over the next few years as freight and shipping volumes return to regular levels.

The passenger railroad in 2019 recorded total revenues of 3,500 million euros. 511 million passengers chose the train as their means of transport. Looking at the numbers by type of service, commercial services transported a total of 34.5 million passengers, representing a traffic of 62.3 million km-train. Although these services represented 37.2% of the total volume of traffic measured in train per km, they only transported 6.8% of the total number of passengers.

The US transportation company Union Pacific is the world's largest railroad organization by market value (approximately USD $147.2 billion as of May 2022). Canadian National Railway and CSX came in second and third, respectively.

World ranking of the largest railway companies according to market value as of May 2022. As shown in the following graph:

Figure 2 World Ranking of largest railroad companies per annual value in million US

Future investments per region

Political, commercial and environmental elements define each region's current situation and future investments on the railroad transportation industry. Europe has opted for passenger trains as one of their main transportation systems. United States and Canada have a strong freight and commercial infrastructure bringing steadiness into their economy. Pacific Asia is the region with the most development in the last decades. Africa, Oceania and South America try to catch up considering the importance of technological advances in the railroad transportation industry.

Europe

In terms of length of rail lines, Europe accounts for 31%, however only 14% of passenger-kilometer of usage worldwide. Currently, the rail network offers little advantage compared to air and road transport. Europe's decline on train as main transportation system began in the 1990s. Since then, the rail system has kept their operations and maintenance good practices with a natural growth in its infrastructure; however, not revolutionary or outstanding practices have been observed in Europe in the latest decades passing the lead in technological advances to other countries such as Japan and China.

In terms of clean mobility, the railway plays a key role as it continues to increase. Transport is currently responsible for 27% of total greenhouse gas emissions in Europe. The European Green Deal indicates that, in order to achieve climate neutrality in 2050, it is necessary to reduce emissions from this sector by 90%.

The European Commission's Communication on "A New Industrial Strategy for Europe" mentions that:

"There should be a special focus on sustainable and smart mobility industries. These have both the responsibility and the potential to drive the twin transitions, support Europe's industrial competitiveness and improve connectivity. This is notably the case for the automotive, aerospace, rail and ship building industries, as well as for alternative fuels and smart and connected mobility."

Likewise, their priorities to pursue its own way towards a digital transformation focus on three main objectives:

1. Technology that works for people
2. A fair and competitive economy
3. An open, democratic and sustainable society.

The Rail European Partnership has the potential and ambition to contribute to these priorities by boosting the rail sector through research & innovation activities and bringing together key stakeholders across Europe.

Europe's creation of mobility and transport solutions rely on a rail system capable to serve properly the evolving needs of customers and to meet the urgent needs of decarbonization answering them together with other modes, delivering societal cohesion, integrating socio-economic developments with a systemic, smart and sustainable concept of operations.

Digitalization is key in reaching the ambitions of the European Green Deal, and transport can benefit immensely from digital solutions in pursuing the ambitious sustainability objectives of the European Green Deal.

The European Commissioner for Cohesion and Reform recalled in 2021 that the EU has already invested in railways in recent years, expecting by 2025 to reach a total of about 580,000 kilometers of railway lines, as well as almost 6,000 kilometers of reconstruction of existing railway lines. Technology, communication systems and more sustainable practices are set to be incorporated into the existing railways to match the regional and international industry goals.

European strategic vision for an integrated transport system

According to a Europe's multi-annual masterplan for the Shift2Rail initiative, aligned to the sustainable and technological goals, passengers and freight rail system major actions are summarized in the following line items.

For Passenger Rail

- Triple the length of the existing highspeed rail network by 2030 so that, by 2050, the majority of medium-distance passenger transport should go by rail and high-speed rail.
- By 2050, connect all core network airports to the rail network, preferably high-speed.

- For the upcoming near future, establish the framework for a European multimodal transport information, management, and payment system

For Freight

- 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050
- Rail freight should be almost doubled adding 360-billion-ton km (+87%) compared to 2005
- By 2050, connect all seaports to the rail freight system
- Rail freight corridors as the backbone of the EU freight transport system

North America

The North American rail network is extremely extensive, connecting almost all major cities and most small ones. The United States, Canada, and Mexico have an interconnected system extending from West to East and North to South.

The United States Senate recently approved a new Infrastructure Plan for the new presidential period. This plan, among other things, redoubles investment efforts in transportation alternatives with less environmental impact, allocating up to USD $66 billion for the development of passenger and freight railways.

The Northeast Corridor project consists of an integrated system of approximately 457 miles (735 km) beginning in Washington, DC and ending in Boston, passing through the cities of Baltimore, Philadelphia and New York. In addition, it connects with other train lines to reach 1,446 km (899 miles) of coverage. Much of this corridor is owned and operated by Amtrak, probably the largest intercity passenger carrier in the United States.

Similarly, the Canadian government has initiated efforts to modernize the rail passenger transport network with the goal of promoting the integration and economic development of the large cities in the east of the country through high-frequency trains.

Via Rail's proposal for a high-frequency train service to connect Toronto, Ottawa, Montreal and Quebec City is one of the most important infrastructure projects in Canada.

South America

The railroad industry, like most of the industries of Latin America, has been determined by economic, social and political factors and challenges.

The history of guided transport systems in the region began with the construction of the first rail networks in the early nineteenth century and continued as metro systems were introduced in the region’s main growing cities in the early twentieth century.

Most Latin American cities experience structural problems and suffer from environmental pollution due to poor urban and land-use planning as well as a lack of regulatory procedures, causing recession on the transportation system development and its technological advances.

Buenos Aires pioneered the implementation of the first underground metro system in Latin America, but over the years, Mexico City, Caracas, Santiago, São Paulo and Rio de Janeiro followed this trend with their own passenger transportation systems.

Among the 50 countries with the largest railway network in the world, we find 5 in Latin America, in this order: Argentina in 8th with 36,928 km of railway lines, Brazil in 10th with 29,850 km, Mexico in 11th with 26,914 km, Chile 30th with 7,282 km and Cuba 35th with 8,367 km.

Asia

Rail transportation services of goods between China and Europe have expanded rapidly, positively affecting the Middle East region. In 2013, 80 trains ran between China and Europe, rising to 800 in 2015 and 6,300 in 2018. An increment in traffic volume between these routes is observed as well, which rose from 114 thousand tons in 2013 to 511 thousand tons in 2016.

In September 2013, the One Belt project was announced, which included two megaprojects: the Silk Road Economic Belt (SREB), and the Maritime Silk Road (MSR). China is the major investor supporting the Asian Infrastructure Investment Bank with a capital of USD $100 billion, and the Silk Road Fund with a capital of USD $40 billion.

Although some specialists considered the development of freight rail services between China and Europe not feasible, we note a rapid expansion on the railroad system, all accompanied by the construction of new rail infrastructure in Russia, China, Southeast Asia, Iran, and Pakistan. The development of these rail links favors the creation of new markets and the development of trade, strengthening the economic relationships that China hopes to fortify not only with its nearest foreign neighbors, but also with European partners.

The lines that are currently in operation represent more than 80,600 km and are distributed as follows: Southeast Asian Line with 12,600 km, Northeast Asia Line 32,500 km, Caucasus and Central Asia Line with 13,200 km and the Southeast Asia Line 22,600 km.

The International Union of Railways has estimated the potential for growth at 15% per annum in the following years. Kazakhstan Railways expects 2 million containers by 2020. Commercial links have also been established with Russia and Iran; while China also hopes to develop rail services to Southeast Asia.

Oceania

In Oceania, the countries with main railway systems are: Australia with a track extension of 33,000 km, New Zealand with 4,128 km and Fiji with 600 km.

In Australia, the sector has an estimated annual revenue of USD $22 billion, adding USD $8.7 billion to the Australian economy in 2020. More than 50,000 people are employed in the sector across around 950 companies supporting the industry directly and indirectly with private and public staff.

There's a lot happening in the rail infrastructure industry across Australia. From expansions and new metros, to rail linking suburbs and new stations, the rail sector is continuing to boom. With the number of projects running concurrently, Australia is going through the largest rail projects expansion across the continent. If the forecast becomes a reality, in the next five years Australia will drive more than double the annual construction activity that we saw at the peak of the mining boom.

Africa

The total railroad system in Africa covers 90,000 km of train tracks.

The current condition of railways infrastructure and the performance of most rail systems are generally poor in Africa. However, rail transport has an important role to play in the growth and sustainable development of the African continent over the next decades. In comparison to other means of transportation, railways are particularly necessary for the conveyance of freight and passengers in urban and inter-city areas.

Africa may be the continent with the most development opportunities in the coming decades. Therefore, and despite all the difficulties, a strong interest in railways can be perceived in most of its countries. A variety of projects have been prepared for many purposes and with different levels of ambition. Some of these projects are integrated in a comprehensive masterplan at national level. Typically, projects begin through the initiative of mining corporations, investors, or as stand-alone government projects.

Global Megatrends

Megatrends are large-scale social, economic, political, environmental or technological changes that once taken root, could drive a profound and lasting influence on many human practices and ways of thinking. A relative stability in the trends of these major changing forces allows, to a certain extent, a likely medium- to long-term future to be envisioned with some level of confidence. The global megatrends that might impact the railroad industry in the next years cover three thematic areas: technology, megacities, sustainability and globalization.

1. Technology

The growing maturity of digital technologies is likely to have an important impact on productivity, manufacturing, lifestyle and environment. By 2030, most consolidated firms will be predominantly digitalized, delivering highly integrated and efficient processes. Transportation and more specifically train systems will be influenced by IoT (Internet of Things), big data analytics, artificial intelligence and machine learning tools to emerge through sensor technologies, cheap computing power and the real-time use of collected data.

2. Megacities and an ageing society

The current world population by 2022 is 7.9 billion people according to the most recent estimates from the United Nations. The world population is projected to reach 8.5 billion in 2030 and 9.7 billion in 2050. Nowadays, more than half of the world's population now lives in major cities; however, this percentage will increase to 80% by 2050.

On the other hand, the number of people aged 80 and over is estimated to triple, from 143 million in 2019 to 426 million in 2050.

In terms of mobility, never before have so many people emigrated. In 1990, 154 million people left their home countries in search of new opportunities, whereas that figure rose to 232 million by 2013.

India’s population will see the biggest growth. New Delhi will overtake Tokyo as the world’s most populous city, growing to 39 million people by 2030. China will gain two more megacities, with Chengdu and Nanjing adding to the six already topping the 10 million people. Bangladesh’s capital, Dhaka, is predicted to be the fourth biggest city in the world by 2030. Karachi and Lahore in Pakistan will rise up the rankings, while Manila and Jakarta will see big population booms. The new megacities will include Seoul and Ho Chi Minh City. With the most rural population, Africa has the biggest scope for change. Cairo will remain the continent’s biggest city, but Kinshasa and Lagos are on track to break into the world’s top 10.

No new megacities are predicted at all for the Americas. Sao Paulo and Mexico City are currently the 4th and 5th largest in the world. But by 2030 they will have dropped to 9th and 8th respectively.

The challenges facing the world’s megacities are vast, as millions of people migrate into areas that are often struggling to support their massive population. Housing, pollution, transportation, infrastructure, inequality and social cohesion are all seeking creative and technological solutions.

3. Sustainability

Sustainability is defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The United Nations' Sustainable Development Goals were adopted in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.

The 17 Sustainable Development Goals (SDG) are integrated, recognizing that action in one area will affect outcomes in others; hence development must balance social, economic, and environmental sustainability.

The creativity, knowhow, technology, and financial resources from society will be necessary to achieve the SDGs in every context.

According to the International Union of Railways (UIC), Sustainable development is considered one of the main global challenges facing the world today and is an important aspect of transport development.

The rail industry, as the cleanest and greener high-volume transport (representing only 2% of the transport sector's emissions and the 8% of global passenger and freight transport activity), has a key role in creating sustainable lifestyles and economies.

Transport demand is expected to double in the same time we have to decarbonize, before 2050. It is clear that today's challenges can only be met with sustainable mobility systems. According to mobility experts, railroads are the fastest and most cost-efficient way to decarbonize mobility and logistics practices.

UIC and its members work together on the Sustainability Platform, focusing on 5 main environmental sustainability topics, which are Air Quality, Circular Economy, Energy and CO2, Noise and Vibration, and Sustainable land use.

4. Globalization

Globalization has impacted people and communities around the world and has a significant influence on sustainable development. Influenced by technology and the increased mobility of goods, services and other resources over the past decades, globalization has changed economies and societies making our world more interconnected than ever before.

Globalization presents vast opportunities, helping world GDP grow from around 50 trillion USD in 2000 to 75 trillion USD in 2016. On the other hand, globalization has also manifested significant challenges, including an uneven distribution of its benefits, costs, and wealth.

Globalization may also benefit those working on solving global challenges, which need to be solved on a global scale with global collaboration. The more globalized we become, the easier we can develop solutions, implement and spread them.

These big opportunities generated from globalization require international alignment in order to work towards equality. Otherwise, the risk of international conflict increases because the socio-economic differences will be highlighted to a greater extent the closer our global connection becomes.

Additionally, not only ideas, goods, and people can move around easier and quicker, since that also applies to challenges such as financial crisis, infectious diseases and the ripples of climate change.

Technological globalization

Technological globalization is a phenomenon based on the continuous increase in the development and use of technology across the world, helping create greater cultural, economic and social interconnection. In this way, the borders between countries dissolve more and more, and what was previously thought impossible due to distance is now within the reach of a click.

Successful companies understand the importance of technological globalization as it helps processes to become more efficient. Stakeholders in the railroad industry are not the exception and constantly develop practices around this principle.

Below, some advantages and disadvantages of technological globalization during the digitization processes in the railroad industry. Among the main advantages of technological globalization, we can find:

- Access to advanced technologies and its applications in the industry.
- Being able to share knowledge and products from anywhere in the world in a more accessible, more secure and less costly way.
- Companies could be based in different parts of the world in order to reduce production and shipping costs.

On the other hand, the mishandling of corporate and operations data is a sensitive issue. Investments in cybersecurity and data protection is highly relevant to control and mitigate potential risks and cost overruns. Another issue is the lack of ability to access to certain technology, which can create gaps between a business' goals and its operations.

Facing upcoming challenges

Global railroad transport is growing fast, in part because of megatrends. Passenger and freight activity will double by 2050. Such growth carries challenges related to cybersecurity, population mobility and global warming.

Global changes in transportation are fundamental to facing upcoming challenges. Yet while rail is among the most energy efficient modes of transport for freight and passengers, it carries challenges that cannot be avoided.

1. Cybersecurity

In 2008 a teenager in Poland demonstrated just how vulnerable a rail network can be. He altered a television remote control and took control of the industrial control systems managing light-rail track points in the city.

Safety in the railroad industry has never been more important as risks from cyber threats increase. The World Economic Forum cites cyberattacks on critical infrastructure, including transportation, as the world's fifth highest risk in 2020.

Intelligent Transportation Systems (ITS) are becoming more digitized, connected and complex, increasing the need for enhanced network and asset visibility across operational technology (OT), Internet of Things (IoT) and information technology (IT) environments. Fortunately, real-time OT/IoT visibility technology can be used to improve both availability and cyber resilience, helping ensure the safety of transportation systems as they transform.

More and more components used in transportation and logistics systems are digitized and connected. From traffic signaling systems with road sensors and Lidar (Light detection and ranging), to tunnel lighting and ventilation systems, to railway power and control systems; the complexity of networks and the number of assets in ITS is rapidly growing. With this increasing connectivity comes an expanded attack surface with many vulnerabilities. For example, NotPetya ransomware was used to attack a global shipping and logistics leader. The outcome was anything but incidental: a two-week disruption of operations, a shutdown of the Port of Los Angeles' largest cargo terminal, and a loss of USD $300 million.

Manager and railroad leaders are under pressure to reduce risks for the entire organization, which involves going beyond the enterprise's IT systems to include ITS. As a result, initiatives for improving the visibility and cybersecurity of OT/IoT networks are now being embraced.

Rail Infrastructure

Rail systems are considered critical infrastructure, vital to the functioning of societies and economies. If traffic or rail signaling control systems are disrupted, an entire city or region could be thrown into chaos.

Today, many municipalities are re-imagining their mobility systems. They're leveraging technology, sensors, and connectivity to change the way transportation infrastructure is used and improve passengers' experience.

It is critical to have visibility and to monitor actions for threats. They need to know when a cyber incident impacts or has the potential to impact. In addition to malicious attacks, an incident could be unintentional.

For instance, it can be caused by the misconfiguration of an asset by poorly written software that leads to failing equipment. Early warning of such situations allows operators to act before downtime occurs or safety is threatened.

Transit authorities around the world are conducting audits that unfortunately demonstrate a lack of visibility into their ITS cyber and operational risks. With the added concerns over safety and the need to maintain revenue, it becomes clear why many public and private transit organizations are investing in ITS visibility and security solutions.

2. Population and mobility

Migration is the movement or displacement of an individual across a geographical boundary, from a place of origin to a destination place, with the intention of adopting a new residence.

Changes in daily mobility patterns, specifically in movements between places of residence, work and education, are another consequence of the impact on the growth of cities, hence it is important to know the characteristics of this mobility, as well as those of the population.

On the subject, these are the top 5 most populated cities in the world:

1. Tokyo (Japan): 39.4 million inhabitants

2. Guangzhou (China): 32.6 million inhabitants

3. Shanghai (China): 29.6 million inhabitants

4. Jakarta (Indonesia): 27 million inhabitants

5. Delhi (India): 25.3 million inhabitants

Challenges of megacities:

Besides the mobility challenges in the megacities, where transportation planning and systems have to achieve a high level of efficiency, here are some other important considerations to keep in mind in the next years:

- Depletion of natural resources.

Every year the deficit of natural resources increases since these are limited and the planet cannot regenerate them at the same rate in which they are consumed.

- Environmental degradation.

The enormous consumption of natural resources leads to the destruction of ecosystems.

- Unemployment.

Industrialization, the automation of certain jobs or overpopulation in cities lead to a lack of job offers. Likewise, the job demand and availability is not always balanced to satisfy all the population.

- Rising cost of living.

The sum of all of the above (few resources and population increase) causes an increase in the prices of basic necessities to which only part of the population has access.

High density cities drive multi diverse challenges that have to be tackled as a whole integrated system. Strategic and technological solutions in transportation systems will facilitate future mobility in the highly populated urban areas.

3. Global Warming and Sustainable regulations

Extreme weather and climate change have impacts on both the cost and reputation of the rail sector. The failure of a critical piece of infrastructure can cost millions of dollars to replace during an emergency. The economic and reputational costs to the industry and companies could have irreparable damage.

Climate change is not the only global sustainability issue that rail can help solve. The railway sector indeed plays an important societal role in relation to the ecosystem and biodiversity, both in urban and rural areas.

According to international rail organizations, by 2050, railway infrastructure should be an integral part of the natural landscape and therefore should become a sustainable network. UIC is working on other key issues, such as promoting the sustainable use of resources (ballast, concrete, steel, water etc.), the reduction of external costs by means of careful monitoring and controlling noise and vibration, sustainable land use, and of airborne particulate matter, all in order to help the railways contribute towards the achievement of the United Nations Sustainable Development Goals.

Many railroad companies and organizations plan strategic actions to align to the highest sustainable and green standards.

4. Scarcity of Resources

If current trends continue, human demand on the Earth's ecosystem is projected to exceed nature's ability to regenerate by 2030. Humanity is currently using resources at a rate 50% faster than nature’s capacity to regenerate them.

Global demand for materials has increased tenfold since the beginning of the 20th century and is projected to double again by 2030, compared to 2010.

The global extraction of materials has multiplied by 14 from 1900 to 2015 (from 6 billion tons in 1990 to about 84 billion tons in 2015) and is projected to continue increasing by 119% by 2050.

The global transition to a low-carbon economy, for example through a large deployment of wind turbines, electric vehicles and data centers will require global production of some metals to increase at least 12 times by 2050 compared to current production.

Even if increasing demand and technology for railroad systems will drive social, political and environmental benefits, a massive production demand will also drive scarcity on certain resources.

5. Social and political

Because of the effective reduction in distance, established organizations were able to spread more easily to neighboring municipalities. The railway expansion, therefore, helped the spatial diffusion process of social movements.

Political and social influence impulse infrastructure development. For instance, United States President Biden on 2021 approved USD $66 billion in funding for passenger and freight rail infrastructure, which was accompanied by a new law imposing rail safety measures to be supervised by the US Department of Transportation acting through the Federal Railroad Administration.

Strategic and technological solutions

1. Innovation and vision

Nowadays, innovation and technology have a presence in almost every industry. For instance, in the railroad systems, “smart plastic” components are implemented in trains to provide real time information and advance failure prediction. Acoustic monitoring is another innovation in which acoustic signals coming from train axles on tracks are measured to identify defects before they occur.

The industry is focused on improving customers’ experience, which is a key focus area in the Smart Rail Route Map. Customers expect flexibility, real-time travel information, omnichannel ticketing options, and transparency from rail operators. Leveraging data and digital technologies can inform decision-making practices and help the industry develop a deep understanding of customer behavior and expectations.

Eventually, a wide range of industries and jobs will be impacted by automation and technology. For now, this means performing tasks faster, safer, cheaper and more accurately.

Strategic solutions for a high-density urban area

Any solution for high density cities mobility issues has to be based on an integral strategy that facilitates the displacement of people. Apart from the different railroad technologies mentioned above, there are other mobility mechanisms that must be interconnected and synchronized with the flux of resources and people. The right usage of IoT, Big Data and Circular Economy are some steps to start exploring worldwide solutions.

Cybersecurity

In the last year, over 59,000 cybercrimes have been reported in Australia, equal to one cybercrime every ten minutes. Investment in the development of strategies and digital skills to combat cyber threats is integral to business continuity and to enable digital transformation. The Australian government has made significant investments to develop a skilled workforce with technical and cyber security skills in partnership with the private industry. The development of cybersecurity skills can also encourage workers to become more engaged with other digital technologies, benefiting both organizations and the whole country’s economy.

A robust cybersecurity system should provide ITS visibility, threat detection, and insight into the railroad system no matter the number of sites around the world. The usage of AI facilitates the task of inventorying, visualizing and monitoring ITS control networks. Asset’s stakeholders benefit from the real-time visibility and threat detection needed to ensure high cyber resilience and reliability.

Energy Efficiency

Rail is a central pillar to transformative climate action in transport. It is the fastest and most cost-efficient way to decarbonize people’s daily mobility and logistics chains. Unleashing the full benefits of rail for decarbonization will be key to significantly cut emissions from the transport sector in line with international sustainability agreements.

Solar, wind and other energy saving actions

The increase in environmental sustainability has been growing in rail transport with the incorporation of various elements such as autonomous poles and streetlights powered by the sun to illuminate stations.

In addition, photovoltaic panels for power generation in tunnels, roofs and other points already feed the operation of many trains. Some trains are powered by energy from solar plants.

The wind also joins the sustainable future in transport. In Spain, for example, very innovative systems have been implemented, such as vertical axis wind turbines in several stations to power the facilities with wind energy technology. In European networks and in subways in South America, many of their systems run on 100% wind power.

Among the latest innovations in the industry are some prototypes being tested for generating energy from the train braking mechanism, significantly increasing the system's efficiency.

2. Digital Transformation

AI, Big Data and Cloud IoT

Digital technologies such as AI, Big Data and Cloud IoT are appearing at a rapid rate, promising innovation across the industry's operations, safety and passenger's experience. Digital transformation has enhanced asset condition monitoring and provides analytical insights to better inform decisions.

For instance, digitalization of signaling systems improves network reliability by decreasing the likelihood of signaling faults and unplanned service disruptions. Likewise, this technology enables the installation of sensors and acoustic monitoring devices mounted under train carriages or on rail tracks which measure and record acceleration, vibration, and sound. The collected data allows the industry to transition from preventive maintenance to predictive maintenance by identifying the presence of future potential damage in the system.

The introduction of autonomous systems has increased the volume and complexity of information. These increases will significantly change the role of the remote operator. Automated driverless trains, Advanced Train Management System (ATMS), and Automation of roll by inspections are already operating in Australia. ATMS brings train control into the digital age by precisely locating trains on the network and managing their relative position to other rail traffic. Automation has extensive benefits such as removing the risk of human error, increasing service punctuality and reliability, and reducing energy usage and operating costs.

A current challenge the industry is facing is the integration of all these technological applications, which can be solved with rugged hardware devices such as Getac's high-performance laptops and tablets. These devices can integrate several software and accessories such as docking systems or additional battery or rugged cases, being ideal for specific and unique working environments.

Using Lux sensors for safety

Lighting is an essential part of staying safe and is particularly important at train stations for obvious reasons (hint: incoming speeding trains). By integrating IoT into the lighting system, sensors can control the general ambience of the station, making sure that they stay at an ideal level of illumination.

At unmanned stations, this really comes into its own, as it can react to changes in station usage, ambient lighting, or even malfunctions. If a light breaks, someone can be automatically called to fix it and other lights can compensate if available.

Actions that come from the rail management software have to be agile and integrated with other teams and organizations. Getac's hardware enforces constant communication and visibility across the teams to make faster and smarter decisions to avoid material and asset losses.

Monitoring ambient conditions

Ambient conditions are another huge part of the customer experience providing comfort and safety. When all fans, heaters, and air conditioning units are connected to sensors, they can all work together to ensure perfect temperature and humidity levels. These applications are seen in wagons, train stations and waiting areas within the rail system. This dynamic data generates visuals that could be modular with Getac's rugged tablets for quicker, data driven decisions, leaving behind the centralized control and visualization rooms.

These conditions have a great impact on how long people stay in the station, which in turn can impact whether they will decide to buy a coffee, hang out or stand outside while waiting for their train to come. Comfort equals revenue.

Monitoring air quality

As anyone who has used any busy subway line, air quality can greatly impact the customer experience, as well as their long-term health. Trains throw particulates and dust into the air, which can have a harmful effect on users and operators. The PM2.5 (particles that have a diameter less than 2.5 micrometers) are particularly harmful and need to be carefully monitored and mitigated.

IoT means the possibility of alerting someone or do something if such particles reach a certain level. When doing this for long enough, patterns emerge.

Smart cleaning

This one might not seem suited to a seemingly revolutionary fourth-generation technology, however, IoT can massively improve the cleanliness of a building, bathroom or train terminal. 'Smart-cleaning' ensures that cleaning activities are done when needed, so time isn't wasted when other stations or places could be cleaned.

For customers, this can be one of the most poignant factors impacting their view of their rail experience, a customer satisfaction parameter hard to observe and quantify in the short term.

Long-term utilization of IoT cannot just react, but pre-act before an event takes place, making sure it is dealt with appropriately.

Blockchain technology

As the name indicates, a blockchain comprises a series of data blocks, each linked to the previous data block by a series of numbers and letters that represent all the text that comes before it, known as cryptographic hash. Any alteration of the information of the data block will not match the cryptographic hash. That makes unauthorized alterations of a single block of data difficult. The benefit is that because all computers that registered the transaction have a record of the nearly unique hash sequence, the database of transactions is resistant to fraud or manipulation.

Blockchain technology may be the way of the future for railroads looking to minimize costs and streamline operations. More than 230 transportation and freight companies — including BNSF Railway, Union Pacific,

and Canadian National — have joined the Blockchain in Transportation Alliance, known as BiTA, an organization seeking to develop blockchain standards for the freight industry.

For railroads, and freight carriers in general, blockchain technology offers some exciting advantages. First and foremost, fast and accurate record keeping where everyone involved in the transaction has the same information generated from a single source. According to its website, BiTA officials say the technology can free up capital, reduce transaction costs, expedite processing, and increase security with fewer chances for error.

Hard as it may be to believe, certain international intermodal shipments are still governed by paper documents that need to be mailed between shipping companies and presented by truckers to intermodal ramp managers before making final deliveries.

The current system is also open to corruption and abuse, for instance, where bribes can be made to distribute cargo without complete paperwork or fulfilled contract terms, such as a letter of credit from a local bank.

Blockchain shipping documents or passenger's ticket information would permit operators, truckers, airlines, banks, and customs officials to read and understand the extent and context of a transaction quickly and make preparations or corrections before the train even arrives at its destination.

Shipping documents are only a beginning for blockchain's potential in railroading. With radio frequency tracking devices, or future variations, every move a shipment takes on a railroad (from loading to local switching, yard switching, long-distance hauling, or delivery) could be recorded as a separate transaction or as steps in a transaction.

Permanent record could inform the railroad and shippers about crew handling, weather disturbances, equipment performance, and locomotive reliability.

Blockchain remains an emerging technology and implementing the technology even at just the railroad level would require industry-wide reformation replete with standardization reaching deep into company operations.

Metaverse

A metaverse of HS2, England's upcoming high-speed rail line, will allow engineers to put on a virtual reality (VR) headset to fix faults. HS2 plans to fill railway tracks, overhead power lines and bridges with sensors, like those used in Formula One and aviation, the sensors will detect problems and transmit data to a 3D digital replica at a nearby control center.

According to experts, around 50,000 sensors will be incorporated into the HS2 infrastructure when the construction of the first high-speed rail line is completed.

The way they envision it to work is by an antenna that will receive data from sensors on tracks, bridges and power lines. The data is transmitted to the signaling mast and sent to the control center, at which point, flaws on the real track will appear on the digital replica so the workers can detect faults and dispatch repair teams. In addition, there will be cameras on top of the trains that monitor the status of the railway line.

3. Cultural Changes

Until the beginning of the 21st century, railway management has been oriented to achieve what could be called “technical perfection” based on safety, punctuality, and capacity maximization.

All these objectives have changed in the last years provoking a massive cultural change in the workforce of the rail industry. In 2021, the rail company HS2 Ltd recently published its annual Equality, Diversity and Inclusion report stating the key for the industry’s future success: productivity and people. Both drive the industry’s cost and image and could help secure the railways as the world’s long-term green and affordable mass transit solution.

In order to properly implement the solutions for the railroads near future challenges, organizations, companies and stakeholders have to understand the needs, desires and incentives of todays and future workforce which, according to Deloitte, rely majorly on communication, collaboration and connectivity. Additionally, working conditions will shift into more mobile, team-oriented, project-based, collaborative and fluid processes.

4. Operation management

Operations management in the rail industry is a big topic that has a vast number of branches, which lead into very specific challenges, for instance, accurately tracking the location and repair status of individual trains or freight cars.

There are certain beneficial actions to be taken against these challenges that could be supported by Getac’s technology:

1. Full visibility, which minimizes disruption by re-planning with a complete view of the network.
2. Digital asset tracking to receive precise locations of stock and crew for efficient task allocation.
3. Enabling business intelligence by delivering historic, real-time and predictive insights for smarter decisions.
4. Expediting and clarifying communication by delivery of instructions and receiving feedback via Getac’s crew application.
5. Interfacing dynamically through APIs which share data with third-party systems for multi-layered insight.

Safety operations

Safety of rail workers, operators, and passengers is one of the industry’s priorities. Regulations and technologies play an important role in improving safety. Harmonization of safety standards and new methods of improving capabilities (technical and behavioral) of those workers in control of rail track protection are key to improving rail safety. Wireless technologies such as GPS enable real-time tracking of trains on the network, improve operational flexibility, safety, and reliability. The tech industry constantly implements advanced solutions dedicated to the monitoring and management of critical systems such as Getac’s integrated solutions, which provides a greater level of control and oversight of the rail networks and contributes to the overall safety of the industry.

Automated operations

Advancements in new technologies and automation have significantly changed rail industry operations. New train management systems are being developed and implemented to improve rail network capacity,

operational flexibility, train service availability, and rail safety. The advent of autonomous systems and trains increases the volume and complexity of information (i.e. data, train telematics, diagnostics of vehicle health), changing the role of remote operators significantly. Remote operators require higher-order skills in data analytics, problem-solving, and an understanding of autonomous systems.

Rail operations are Digital

According to Boston Consulting Group, by embracing a digital transformation in the rail industry, operators can reduce costs, improve service quality and reliability, and maximize use of their physical assets. By not adapting to this mega trend, operators could put many rail systems at a competitive disadvantage to road-bound cargo and passenger services.

The digital future of rail consists of three main components: driverless trains, real-time operations centers, and fully automated planning and scheduling.

Getac as a solution

The railroad management solutions for the 2030 challenges have to be supported by hardware and software tools that facilitate the tasks executed by the operators, managers, and business decision makers in order to succeed in such a complex and technological environment.

Since 1989, Getac has been providing rugged computing solutions for demanding professionals in extreme environments and around the globe. As one of the leading rugged computer providers, Getac offers extensive rugged computing product lines including laptops and tablets for a wide range of vertical markets including transportation, military & defense, public safety, emergency services, utility, natural resources, oil and gas, telecommunications, and industrial manufacturing. Also, they have made several technological breakthroughs that improve the performance and safety of using computers in dangerous environments.

Hardware

Getac tablets and portable computers are built to be rugged and withstand extreme weather conditions, shocks, high vibrations, high and low temperatures, humidity, dust, and falls of up to six feet. All Getac devices have international third-party certification MIL-STD 810H and up to IP67 protection.

Software

Getac devices can connect to your existing systems, either through a wired or wireless connection. Getac has a variety of devices to suit your needs, with a number of RS232, LAN, RFID, BCR com port options and software alternatives:

- **Getac Virtual GPS Tool**, which replicates the GPS data to multiple virtual COM ports, allowing the functionality of different software applications running simultaneously on your Getac device.
- **Getac Device Monitoring Systems**, a software solution that tracks and monitors deployed devices, spotting potential issues before they impact on field-based personnel. Ideal to maintain operational efficiencies.
- **Getac Key Wedge Barcode Scanning Tool**, that provides single and multiple barcodes scanning features, expanding the capability of any Getac

Getac complements its solutions with third party software listed in the Total Solutions section of this document.

Total Solutions

The world is becoming more urbanized and the population is growing, driving the need for more efficient and optimal railroads – to achieve this you need a railroad management system that is up to the task. Getac's solutions for railroad applications provide solid support for professionals that keep railroads working efficiently and safely.

Getac devices come equipped with the latest connection and network technology including 4G/5G, Wi-Fi 6 and GPS. These technologies allow operators to access remote experts, stream video in the field, work in tandem with technologies such as Lifi, track assets in real-time and gain more operational efficiency.

Getac's accessories complement hardware and software to provide the users with the flexibility to perform their tasks. Accessories ranges from additional battery to carrying devices such as shoulder harness and carry bags. Also, portable chargers and detachable keyboards are part of the solutions.

Hardware, software and accessories and glued together with professional and warranty service, providing the proper guidance from Getac's professionals and technicians to help achieve the industry's technological and commercial demands through high performance technology.

Getac Select it's inspired by the customer's challenges. The outcome is a combination of rugged computing devices, software, accessories and professional services in a purposeful range of specifically tailored solutions. With Getac solution a partner that understands needs and challenges innovate to provide the most effective solution.

Getac Select

Getac Select is inspired by industry leaders and operators and the challenges they face. The solutions combine rugged computing devices, software, accessories and professional services in order to address specific tailored solutions. This integration focuses on a reliable and high-quality solution for the toughest and unique challenges on the industry.

Enabling Partners

Getac works together with several partners to provide potential solutions for the rail industry challenges. These partners support technological areas such as communications, data, device security, mobility solutions and docking and mounting accessories.

Absolute Software

With its partnerships, Getac delivers a unique security platform that unites the power of self-healing devices, applications, and network connectivity. The application connection on your Getac device allows switching between cell towers or wireless access points seamless to the end user on a secure connection.

Airgain Inc.

Airgain Inc is a leading provider of advanced antenna and embedded connectivity technologies that enable high-performance wireless networking across a wide range of devices and markets, including consumer, enterprise and automotive.

Airgain antennas attach to nearly any Getac platform, providing an ideal balance of performance and durability. The solution provides connectivity and optimization for wireless solutions.

Lind Electronics, Inc

This solution provides power adapters and battery chargers designed specifically for Getac's devices; they ensure that you can continue working in even the harshest of environments.

Gamber-Johnson LLC and Havis, Inc

These two partnerships manufacture mounting solutions, docking stations and motion attachments. Their ergonomically designed solutions maximize productivity and comfort without sacrificing quality, reliability, or durability for the type of needed application or environment.

Additional partner solutions complement Getac's portfolio, making Getac a great allied for the rail industry unique working and operating conditions.

InfoCase, Inc

InfoCase has been an industry leader in the design and manufacturing of cases, harnesses, and other mobile accessories for mobile devices. When working in the field and harsh operating environments, InfoCase understand that Getac end users need their hands to utilize other tools and equipment.

InfoCase provides accessories designed for enhanced mobility, hands-free use, and reduced end user fatigue. They are performance tested and approved in-house, and selectively tested via third party engineering. This diverse range of mobile accessories include hand straps, shoulder straps, and screen covers with easel functionality and 4-point user harness compatibility.

Final insights

The intention of this document is to encourage railway stakeholders and industry decision makers to devote attention to the industry's future.

Normally, the intense operational work required by this industry prevents us from devoting time to prepare for upcoming challenges, keeping us oblivious to these trends without taking actions that guarantee results for the coming years.

Evidence clearly suggests that future mega trends and challenges for the railway industry are very likely to happen. We have described the characteristics and possible consequences of each one, as well as the importance of each trend and the key role of adequate planning by industry leaders.

Although not the only one, digital transformation will be essential to face these challenges. Until now, existing computational devices have covered the industry's needs and, in many cases, set the pace for growth; but as IoT, artificial intelligence, and cloud capacity evolve, hardware and software will experience sporadic and much more dynamic changes to suit specific needs and tasks.

To facilitate this work for industry leaders, we recommend the implementation of a plan using the following chart. The plan allows to identify threats, opportunities and actions within the organization, which in turn will make it possible to assess the set of variables that will constitute the immediate future in the industry and also to develop the skills and abilities necessary to face them.

Global industry trends and challenges	**Threads and opportunities**	**Actions**	**Responsible**
Technology			
Megacities			
Sustainability			
Globalization			

Figure 3 Strategic tool to determine actions and responsible for railroad future threads and opportunities

Business cases

Lithuanian Railways

The national railway company of Lithuania, provides freight services for half of all the goods transported in the country. It needs a digital solution that can provide live video surveillance to enhance operational safety, and act as a supplement to traditional communication and record- keeping tools to improve efficiency. The solution must be rugged enough to accommodate the round-the-clock work schedule of a busy freight train.

Getac worked closely with Latvia-based partner ELKO Group and Lithuanian system integrator FIMA to create a rugged computing solution that provided real-time video monitoring. Together with FIMA, they seamlessly combined a video package with Getac F110, the 11.6" fully rugged tablet.

Getac F110 hardware capacity allows us to process information from all four cameras at the same time. The 11.6" display is large enough to show the video feeds clearly, and the brilliant sunlight readable screen enables operators to see the images even under bright daylight. The F110 is also used to write and transmit official documents such as cargo manifests via 4G. Its resistance to water and wide operating temperature range between -21°C and 60°C are crucial features for the extreme climate near the Baltic Sea. The F110 is also completely protected against the dust and constant vibration of railroad travel. Its powerful dual batteries have no trouble keeping up with round-the-clock work on busy freight trains, and the fully rugged chassis protects against bumps, drops, and spills. Even if accidental damage puts the F110 out of commission, Getac's Bumper-to-Bumper warranty service guarantees the unit will be returned within days, keeping disruption to operations to a minimum.

Lithuanian Railways is very satisfied with the results. They see digitalization as the optimal way to improve efficiency and safety throughout the railway network. The tablet complements traditional tools such as pen, paper, and radio transceivers to further boost productivity. Lithuanian Railways has over a century of history, but it is already adopting the latest technology for a new era of prosperity.

Rail IQ

Founded in 2001 as IIRX LP, Rail IQ is a software and business intelligence service provider, focused on utilizing their industry knowledge, experience and track record to provide an innovative solution to solve common challenges in the freight rail industry. Rail IQ provides a full life cycle management system for car repair billing for both private shops, running repair agents, and railroads.

The traditional way of determining replacement interventions on a car involves staff writing down on a clipboard the car number and its potential diagnosis. With this methodology, and in an industry where maximizing equipment utilization rates is a priority; cost, logistics and operations' performance are impacted due to the complexity of the railroad system.

Now, using external reader, hooked up to a Getac F110 running RailIQ's proprietary system and robust barcode reader, allows repair technicians to scan Automatic Equipment Identification (AEI) tag, loading specific car data in a matter of moments. This solution delivers increased ROI, shop productivity & car availability.

Bombardier

Bombardier Transportation offers one of the broadest rail vehicle portfolios in the world. Their highly-skilled technicians are responsible for the safety and reliability of the fleet, which often involves critical maintenance activities in challenging work environments.

Getac's notebooks are specially designed to carry out diagnostic tests and maintenance tasks on trains in all types of conditions, which has allowed Bombardier Transportation to increase the reliability and sustainability of its trains and, at the same time, generate economic benefits, including reduced maintenance time and increased efficiency.

Communication Technology

Getac's devices provide specific features such as the resistance to saline fog and has the QuadraClear technology, which allows reading screen with sunlight and night vision technology, characteristics that solve the problem of its outdoor use. In addition, Getac incorporates the Modem Gobi 2000, which guarantees continuous communication at any time and place.

The key compliance applications compatible with Getac's notebooks include patented fingerprint software, which is used together with the fingerprint scanner, the Microsoft Office program, as well as Microsoft Mappoint 2009, Google Earth and police applications available on the FWC (FCIC/NCIC/David) network.

SMARTMCT and MOBILE FORMS are programs developed by CTS America that allow users to have access to CAD information, consult the NCIC and FCIC databases, use the RVA system (automated vehicle tracking) to obtain information about cartography and logistics in the region, and write or emit alerts and fines for infraction.

Baidu's Vehicle Internet Security Equipment

As a globally recognized brand of rugged notebooks and tablets, Baidu chose Getac as their computer equipment provided due to its robust, durable and resistant flagship 15.6" screen with exceptional performance and ideal for the demanding workshop environment. Getac's equipment is fully adapted to the harsh working environment of a railroad operational or manufacturing process. Its expansion function makes it suitable for intelligent vehicle safety information detection. Its excellent performance includes the following aspects:

It comes with an optional expansion slot, an unparalleled advantage that most rugged laptops don't offer. It has an installed docking station that can be connected to the vehicle's CAN interface to facilitate the detection of security information. Certain Getac hardware has the capacity to add two optional slots for PCI or PCI Express 3.0, combining the power of desktop expansion with the portability of a rugged mobile device. Using the docking station, staff are able to scan for BCM, PEPS, gateway, ABS, and EMS security vulnerabilities on vehicles to ensure information security.

On the other hand, there may be a need to use the test vehicle in the workshop or laboratory, where there is a lot of equipment and cables, so the equipment is likely to experience collision or accidental fall. Getac provides rugged and durable hardware solutions in compliance with MIL-STD 810G, IP65 and MIL-

STD-461G standards. Even in case of accidents such as impacts, liquid splashes, vibrations and falls, the operation of the equipment will not be affected.

The way Getac is supporting Baidu's operations and businesses is an example of Getac's potential solution and equipment support. These applications are easily translated to other industries including the railroad by providing visibility, control and connectivity in their operations.

Client's testimonials have validated Getac's tablet and laptop models, such as S410, V110, X600, to be ideal for the operations and working conditions of the railway industry.

Bibliography

Agency, I. E. (2019). The Future of Rail: Opportunities for energy and the environment.

Arup. (2019, May). Future of Rail 2050.

Board, I. R. (2015). A GLOBAL VISION FOR RAILWAY DEVELOPMENT. Paris.

Canada, R. A. (2019). Rail Trends 2020.

Canadian Pacific's Bid for Norfolk Southern, 9-216-057 (Harvard Business School September 2017).

Group, A. D. (2015). Rail Infrastructure in Africa: Financing Policy Options. Côte d'Ivoire.

National Railroad Passenger Corporation (AMTRAK), UV0093 (Darden Business School 2002).

Railways, I. U. (2018, February). SUSTAINABLE DEVELOPMENT: Making railways greener, quieter and more energy efficient.

Railways, I. U. (2022). Railista: Railway Statistics Synopsis.

Railways, I. U. (2022, June 28). Traffic trends among UIC member companies in 2021.

Taiwan's High-Speed Rail: A Public Private Partnership Hits a Speed Bump, 1910.0 (Harvard Kennedy School 2009).

The Coming of the Railroads, 9-391-120 (March 14, 1995).

Vladislav Maraš, M. B. (2020, August 24). Megatrends – a Way to Identify the Future Transport . Belgrade, Serbia.