Building safer, less congested and sustainable highways
The digitalization of our highways

Our highways and roads are the lifeblood of most societies. With over 1.2 billion vehicles on the world’s roadways, they are also a source of concern. We need to make highways safer, reduce congestion and lower emissions. The ultimate goal of highway operators and authorities — “vision zero” — is to eliminate all three. Digital technologies will be key to achieving these audacious goals by making highways and vehicles more intelligent. Communications networks, advanced analytics and IoT will play a big role by supporting the various systems and applications that will be required to achieve vision zero.

The first generation of intelligent transportation systems (ITS) included applications such as traffic detection, advanced traveler information systems (ATIS) and electronic toll collection. In the second generation, operators integrated these applications with more data and video. They installed multi-purpose systems that supported infrastructure monitoring, road safety and traffic management, and they laid the foundation for connected vehicle technology in the future. To take ITS to the next level, however, they will have to upgrade the communications and IT systems that support it. They need to converge their many siloed sub-systems onto a single network platform that can handle increased data, voice and video, accommodate new capabilities, such as IoT, AI and machine learning, and provide support for automated, connected vehicles as they evolve.

**Nokia and highways**

At Nokia we are a global leader innovating the technologies at the heart of our connected world. We understand that smart, dynamic networks will be the foundation for the digital transformation of society, including our highways. The Nokia Bell Labs Future X Network architecture is of a connected, digital platform that supports and fosters new applications and services for greater productivity and innovation, richer experiences and enhanced quality of life.

As a leader in highway communications, we believe that building this dynamic, connected ITS architecture is the best starting point for achieving operational efficiencies and a safer, more efficient and sustainable highway system. We call this the Future X Network vision for highways. We are committed to helping highway operators to build this smart foundation and realize vision zero by digitally transforming highway infrastructure, operations, and the driving experience.

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Over 1.25 million fatalities occur each year on the world’s highways. Congestion results in trillions of dollars in lost productivity. The transportation sector was identified by NASA in 2010 as the single largest contributor to climate change. It is no wonder, then, that road and highway administrators have embraced vision zero: zero fatalities, zero congestion and zero emissions.

These issues are complex and some go beyond highways alone. On the emissions front, it will have to be a multi-pronged approach. A rapid upshift in the production of hydrogen/electric automobiles will be required to reduce emissions meaningfully. Ride sharing is expected to account for one of every three kilometers driven by 2030. European targets for 2050 include a 50 percent shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport. And, according to PWC, all of this is expected to reduce the number of vehicles on the road, worldwide, by 138 million in 2030, with over 50 percent of the remaining inventory being electric.

On the safety and congestion front, many are looking to automated driving technologies to reduce accident rates due to human error. Cooperative ITS (C-ITS) will use vehicle-to-everything (V2X) communications to improve traffic flow using techniques such as Cooperative Adaptive Cruise Control. V2X communications will be used for advanced traffic management systems (ATMS).

ATMS is the next-generation of intelligent transport solutions (ITS). The first-generation ITS systems used variable speed limit (VSL) signs and dynamic message signs (DMS) to convey information on traffic conditions to drivers. The next-generation ATMS systems will communicate directly with drivers or, in the case of automated vehicles, directly with the cars themselves. They will combine data from sensors, cameras and in-vehicle systems to optimally manage traffic flow and decrease congestion. These systems should have beneficial effects with regards to safety and emissions, as well.

In order to accommodate these many and, still-emerging applications, the highway communications network of the future will need to be highly flexible. It will migrate individual networks, often with serial interfaces and legacy protocols that were created for the first generation of technologies. And, it will have to support new broadband, low latency applications, as well. Some ITS functions will be able to be handled directly by cellular networks, especially as we move from LTE to 5G. Most other technologies will be backhauled by IP/MPLS over Ethernet, including

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1 According to the INRIX “2017 Global Traffic Scorecard” $305 billion dollars was lost in the US alone from time spent in traffic jams. This leaves out costs due to shipping delays for trucking, which lost 1.2 billion hours globally in 2017 [https://roadscholar.com/blog/trucking-industry-loses-12-billion-hours-annually-due-to-congestion].

2 For electric cars to have an impact on emissions, there will also have to be a concurrent shift to non-carbon producing electrical generation.
sensor networks, dedicated short-range communications (DSRC, and cellular vehicle to everything (C-V2X) communications.

Many of the next-generation applications touched on above will require extremely low latency response times between roadside cameras and equipment and in-vehicle sensor and control systems. Powerful edge computing at the roadside is required to host ultra-responsive traffic applications. Supported by multi-access edge computing (MEC) technology, we are calling this roadside cloud. The network will also have to be highly scalable and dynamic with ultra-high reliability and security. Network equipment will need to be compact and hardened for harsh roadside conditions. This flexible, dynamic, edge-computing-based network will be the platform for delivering vision zero: safer, less congested and sustainable highways.

1 PWC, “Five trends transforming the automotive industry 2017-2018.”

The Nokia Bell Labs Future X Network architecture for highways

Highways are complex with multiple sub-systems for roadside monitoring, signaling and signage, traffic detection, electronic tolling, maintenance and, in the future, in-vehicle systems. All of these diverse applications have requirements for connectivity, data storage and processing, and many will benefit from analytics and machine learning. The Future X Network architecture for highways is to provide an intelligent, dynamic communications and cloud-based platform to support all of the individual systems, processes and activities associated with tomorrow’s highways. It will enable consolidation of many existing systems and provide a launch pad for innovative new applications and services.

At the deepest level of the Future X Network architecture lies dedicated universal broadband connectivity, both wireless and wired, making every kind of communication and information exchange possible. Built with a dynamic mesh fabric around a high performing IP/optical/microwave core, it uses wired or wireless access to connect with people, sensors, vehicles, video monitors and...
signage, all securely and with the highest reliability.

Cloud technology is essential to the Future X Network architecture, ensuring the flexibility, scalability and universal availability of both data and intelligence. Placed throughout the network fabric, local and roadside clouds ensure the ultra-low latencies required by video analytics and V2X applications for safety and traffic control. Cloud-native, software-defined networks dynamically allocate capacity when and wherever it’s needed.

Built into the Future X Network architecture are data processing capabilities and analytics, including machine learning and artificial intelligence systems. These ensure that, out of the ocean of data about assets, processes, environment and vehicles, relevant and actionable insights can enable greater efficiencies and new services. Analytics, operational systems and automation provide open, digital value platforms that can be harnessed by any kind of highway application.

Our Future X Network architecture will help highways to launch their digital transformation. They will be able to create new levels of intelligence, responsiveness and efficiency. With it, they will better be able to address their many challenges and help to realize vision zero and a new role for highways in a more sustainable world.

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Traffic management and tolling
Current systems for traffic detection, video surveillance and electronic toll collection often use a mix of older, legacy ITS systems based on voice, video and data networks. They usually operate in network silos with limited interconnectivity. Highway agencies need a single, simplified and optimized communications infrastructure that is able to support the unique set of network requirements of each ITS application. This includes support for a variety of legacy serial communications technologies, such as SDH, SONET or TDM, as well as new ITS services based on IP. The Nokia mission-critical solution for intelligent highways meets all the communications needs of an advanced ITS with a single, intelligent, multiservice and ultra-broadband network architecture. It reduces operational costs while improving safety. Highway agencies benefit from real-time, multimedia communications between traffic management systems and roadside sensors and cameras, vehicles, travelers, and all highway stakeholders.

Cooperative traffic systems
Highway agencies are looking to improve highway safety and keep traffic moving smoothly with cooperative traffic systems and roadside services that use vehicle-to-everything (V2X) communications. These systems will require extremely low latency, below 100ms. The Nokia roadside cloud solution combines multi-access edge computing (MEC) with today’s 3GPP-based cellular networks, such as LTE, V2X communications and static roadside equipment, such as surveillance cameras. The Nokia MEC platform provides roadside storage and data processing to support ultra-responsive roadside services for V2X and safety-critical highway communications applications, such as electronic break light and vulnerable road user warnings. It also supports distributed analytics for applications like hazardous road condition warning and new mobility and convenience services such as infotainment. By adding edge computing to roadside networks, operators will be prepared for the rise of connected and autonomous vehicles.

Operations, maintenance intelligence and security
Highway operators are no different than any major infrastructure manager. They are heavily asset-based, and the majority of their operational expenses relate to managing and maintaining the physical road infrastructure. This includes bridges, tunnels and rest areas — with budgets that are always under pressure. They are also expected to ensure anytime availability, security and safety to the travelling public. Nokia’s IoT for roadways solution addresses some of the key operational concerns of operators with remote asset management, predictive maintenance analytics, video analytics and a framework for managing and deploying IoT devices.
The communications infrastructure of Highways England was a patchwork of many voice, video and data networks — the legacy of 40 years of first-generation ITS systems. They needed to converge these systems onto a single network infrastructure that was more efficient to operate and provided “safe roads, reliable journeys and informed travelers”.

The National Roads Telecommunications System (NRTS) project included a Nokia end-to-end communications solution built on an IP/MPLS network and a WDM transport network. The broadband network supports a nationwide system of roadside CCTV cameras, VoIP roadside phone network and a number of legacy applications such as weather station systems. The network will also provide a highly scalable, low-latency and secure platform for building smart highway solutions in the future.
Highway service stations are often used as rest stops by long-haul drivers. They are also the site of vandalism, theft and coordinated drug and human traffic. Unfortunately, the cost of 24/7 video and audio monitoring, either by personnel directly or using software processing, is prohibitively expensive because 99 percent of video, audio and sensor data records normal behavior. In order to focus resources only on incident footage, many security solutions are pre-programmed to recognize specific security scenarios. Their accuracy, however, depends on how well the programmers anticipate what might actually happen, which is hit and miss, at best.

Nokia worked closely with Room 40 and VIAS, the Belgian knowledge center for road safety and security, to jointly tackle this safety and security issue on Belgian highways. The Nokia Scene Analytics solution uses machine learning (ML) to “learn” what is “normal”, enabling it to track and record only anomalous behavior that might be connected to safety or security incidents. This non-scenario-based solution reduces the amount of data needing to be processed and more quickly and efficiently alerts personnel to incidents. It is also capable of extracting information from older, low-resolution CCTV cameras, as well as audio and other IoT sensors, again, lowering the cost of the solution.

Customer case story:

Public safety at rest stops in Belgium
As a leader in highway communications, we believe that the Future X Network architecture is the best starting point for achieving greater safety, less congestion and improved sustainability. From ultra-broadband, low latency IP/MPLS networks to the roadside cloud, IoT/analytics and V2X, Nokia is well placed to support highway authorities with the most complete portfolio of products and services to support your advanced ITS solutions.

Our Nokia Bell Labs consulting services team will help you with planning for the future and understanding the business case benefits of new technologies using a structured methodology for establishing quantifiable outcomes for your highway operations. Nokia also contributes its professional services to help you leverage your technology platforms while accelerating your transformation and mitigating risk.

“We chose Nokia because of their technology, their approach, and their commitment to deliver this contract.”

Ron Davison, Managing Director of GeneSYS.