Tunnels: Integrated Safety and Security for Integrated Transport Networks

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In recent years, the issue of safety and security in tunnels has come to prominence following a series of serious incidents in Europe. These incidents have resulted not only in major structural damage and lengthy disruption of the transport networks but also casualties and loss of human life. They have highlighted the central role that tunnels play in the modern economy, with thousands of people and tons of goods passing through them every day. Any interruption in operation can have significant consequences. Maintaining a safe and secure environment is therefore of paramount importance.

The world’s population is constantly growing. In 2007, it reached a historic point when, for the first time in history, more than half of the earth’s population was living in cities. Urban conglomerations are the undoubted growth engines of the future. Globalization – the ongoing process by which regional economies, societies, and cultures have become integrated through a worldwide network of communication, trade and travel – has shown a tremendous acceleration over the past few decades too. Global trade has increased nearly thirty-fold since 1950. The impact of this growth on transport networks is also set to continue, with freight transport worldwide forecast to increase over 60% by 2030. Climate change is also a generally accepted fact. Greenhouse gas emissions have risen dramatically since industrialization and we now have higher levels of CO2 concentration in the atmosphere than we have had for 350,000 years.

Tunnels – critical infrastructures for the future

In the face of these ‘megatrends’ – urbanization, globalization, demographic and climate change – the need for enhanced, environmentally friendly transport systems and the difficulty in obtaining open space for these inter-urban systems such as road, rail and MRT (Mass Rapid Transport) networks will only become more challenging.
Mass transit and traffic are amongst the most serious challenges for cities in the 21st century. So the need to build underground facilities and tunnels will continue to grow, as will the road and rail traffic that uses them. In 2012 there were over 1000 tunnels longer than 500 metres in the European Union. With a further 200 tunnels in Switzerland and 300 in Norway, that makes a total of over 1500 tunnels. Tunnels are also getting longer all around the world: lengths of over five kilometers are no longer exceptional.

A healthy road, rail and mass-transit transport network is essential to the economic health of entire regions and even countries. Tunnels have an important role to play. They keep areas accessible and thereby competitive and attractive to industries and investors, as they carry people to their workplace and companies to their suppliers and markets. For cities, tunnels are also an effective opportunity not just to facilitate transport-dependent economic activities but also to reduce traffic congestion in their centers.

So the importance of making road and rail tunnels safer and more secure will only grow exponentially, requiring innovative, integrated systems to achieve the vital levels of dependability needed to cope with such numbers.

**Video surveillance: automation through algorithms**

In tunnel applications, safety and security are inextricably linked. The limited escape options which characterize a tunnel mean that identifying a problem at the earliest opportunity is critical. Whether it is protection from potential attack, identifying an issue in the traffic flow, or detecting a fire, at the heart of it all is detection and management. Fundamental to this is the need to have visibility from the tunnel entrance to the exit. Quite naturally, video surveillance is therefore commonly employed.

The video surveillance increasingly being adopted in tunnels features algorithms which identify potential sources of incidents. Since the early 1970s, a variety of incident algorithms has been developed based on traffic flow theory, pattern recognition, statistical techniques and, more recently, using artificial intelligence and fuzzy logic.

This technology takes the onus away from the human observer and automates the identification of the incident, an important point when you consider the limitations of the human part of the process. Research has shown that an observer viewing two monitors with automatic image switchover will miss up to 45 percent of all activity in scenes after only 12 minutes. After 22 minutes, this increases to up to 95 percent. Information overload is often seen as a particular problem of modern times and in terms of monitoring the output from video surveillance cameras, it has led to extensive research into how its effects can be minimized.

CCTV technology can now automatically detect a range of events which could have serious repercussions in a tunnel: stopped vehicles, traffic queues, vehicles driving against the traffic, fire, smoke, dropped or lost loads. By automatically generating an alarm through the use of policy zones and virtual barriers, if such an event is spotted by the cameras, it allows an immediate
response which can prevent the incident from escalating. The cameras, placed at strategic points to provide a full view of the tunnel, not only monitor but also evaluate the scene. If one of the pre-defined activities is detected, it generates an alarm, also recording the activities via a digital video recorder. The video recording speed can automatically increase to full frame rate during an alarm, providing invaluable information to review during the event itself or post-event in any analysis of an incident. Filters are used to minimize false alarms, e.g. smoke is detected by the algorithms but vehicle exhaust fumes are ignored.

In both road and rail tunnels, such algorithms can also be used in a video motion detection application – a useful tool to spot people on tunnel roads or rails which could lead to accidents and casualties. It is a case of using analytics to do the monitoring and to highlight potential threats, thereby removing much of the boredom factor which can seriously impact on the effectiveness of the operator. With such intelligent video surveillance solutions, tunnel operators are relieved of much of the observation workload and can fully concentrate on any incident flagged and make the appropriate and correct response decisions. These systems also have an important role to play in incident management: A tunnel operator can reduce the detection times, initiate corrective action – e.g. halting of traffic, dispatch of emergency services – and possibly prevent any escalation of the situation.

**Continuous improvement**

As in any traffic or transport management related topic, data mining is as important for reviewing adequacy of safety measures and systems as ensuring a reliable and optimal flow. Such systems can also be used for continuous improvement of safety measures or to highlight trends in traffic which could possibly cause problems for tunnel availability and safety. These intelligent video systems are capable of gathering and collecting traffic data, e.g. number of detected vehicles per lane within a defined period, vehicle classification, number of trucks per lane, distance control, speed control or average speed detection per lane, average truck speed per lane.

**Integration supports holistic approach**

The European directive EN 2004/54/EC requires that an automatic incident detection (AID) system and/or a fire detection system be installed in tunnels over 3000 meters. Studies show that where aging tunnels must cope with changed traffic patterns and volumes, and where ever-longer tunnels are built in increasingly challenging urban or geological environments, effective prevention and mitigation of incidents and fire risks and their far-reaching consequences requires a holistic approach to safety and security. They should be an integral part of incident management processes as much as of day-to-day operations. This is why security and safety technologies are increasingly being integrated.
It is not uncommon for the video surveillance system to be integrated with, for example, a linear heat detection system. This allows the precise location of a fire, with automatic extinguishing activated even when smoke obscures visibility.

**Safe and secure in design and operation**

Minimizing accidents has long been a priority for tunnel designers. Tunnel layout has evolved over the years drawing experience from past incidents – twin tubes now being favored to flow traffic in only one direction being a prime example – and improvements in emergency call stations, road signals, critical systems maintenance such as lighting and ventilation and speed-limiting practices have also taken place. Automatic detection of extra-large commercial vehicles is also now linked to electronic signage systems to stop over-height vehicles before they enter the tunnel.

This focus on safety and security in the design stage also needs to be followed through to the operational procedures once the tunnel is open. Through an integrated approach, whereby all potential incidents are monitored and automatically highlighted on a single screen, the ability to intervene and prevent escalation is provided, as well as the opportunity to ensure a more effective coordinated response in the event of a major incident.

**References:**

**City Tunnel, Bregenz (Austria)**

Siemens equipped the 1,300 meters long, bi-directional "City Tunnel" in the Austrian town of Bregenz with its Siveillance SiteIQ Tunnel solution. The City Tunnel system of video sensors with intelligent camera surveillance comprises seventeen fixed and five, swivel-tilt cameras that deliver their data to a control center in Weidach, Austria. There the analog signal is converted to digital format and saved as compressed, MPEG-4 files. At the same time, the data is delivered to the Siveillance system for analysis. If a critical event is detected, an alarm is automatically triggered at the monitoring center in Hohenems, which is staffed around the clock. Potentially dangerous situations are automatically highlighted for the operators.

**Berlin Autotunnel (Germany)**

The Tiergarten Spreebogen Tunnel (TTS) is a road tunnel in the German capital of Berlin running between Heidestrasse to the north and the Landwehr canal to the south. The 2,400 meters inner-city directional traffic tunnel – with two separate tubes – carries up to 50,000 vehicles per day and is one of the first to be served by a complete safety concept comprising video monitoring, event-controlled video detection, fire alarm and ventilation systems combined with building automation. For continuous surveillance of traffic in the tunnel and at the entrances, 87 fixed and 25 remotely controlled cameras are used evaluating and comparing images using stored algorithms.
as smoke, stationary traffic, vehicles in the wrong lane or pedestrians in the emergency lane are detected, an alarm is triggered.

**Bolaman Persembe Tunnels Project (Turkey)**
The approximately 28 km long Bolaman-Persembe four-lane highway with 40 bridges and 5 tunnels with a total length of 4,600 meters is an important connection along the Black Sea Coast. Siemens provided all the electrical equipment on a turnkey basis with the integrated tunnel management system and the products and services of different Siemens groups. The solution allows the highly-efficient, secure and safe operation of these tunnels, which includes the Nefise Akcelik, the longest tunnel in Turkey with 3,800 meters.
The 350 km of 4-lane road along the Black Sea coast from Espiye to Sarp close to the Georgian border are equipped with a state-of-the-art operations management and traffic control system. The project encompasses a control center and seven sub-centers for a total of 29 tunnels as well as the related high-tech infrastructure, including traffic control, fire alarm with Fibrolaser linear heat detection and firefighting systems, power supply, lighting, ventilation, communication and camera monitoring technology with integrated automatic incident detection.
Emergency generators and uninterruptible power supply equipment will ensure nonstop operation. In more than twenty of the longer tunnels, an automated video monitoring system is installed for the detection of potential obstructions. The system can also identify foreign objects on the road as well as smoke and trigger the corresponding alarms. In addition, the system will acquire a wide variety of data to identify potentially hazardous conditions.

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