Tunnel Traffic Control Solution

Safety is always the central theme for tunnel control systems, since tunnels provide a vital link for major roads and highways. Tunnels present a hazard to motorists by the fact that they often constrict traffic flow, and are difficult to widen as the amount of traffic increases over time. Compared to open routes, incidents in tunnels can result in disastrous consequences. The restrictive nature of tunnels makes it extremely hard to remove wrecked or broken down vehicles, and rescue accident victims. Congestion and incidents such as breakdowns, fire, or exceeding carbon monoxide limits must be detected and dealt with in a timely manner.

System Description

Tunnel control systems are managed from a centralized control room, and a comprehensive set of subsystems must be integrated into a consistent system for effective tunnel control. Comprehensive tunnel control subsystems consist of:

- Tunnel power control: substations and uninterrupted power supplies
- Traffic signal control (variable traffic signs using LED technology and traffic lights)
- Automatic ventilation control and illumination
- Emergency system and broadcasting system
- Height control system
- Fire detection and protection system: acquiring fire detector data and control of the fire fighting system. Water accumulation and distribution are also included.
- Pollution measurements: acquiring data on visibility and carbon monoxide concentration in the tunnel
- Video monitoring system

The Challenges

Today, tunnels handle large volumes of automobile traffic, sometimes moving at expressway speeds. In the narrow, confined environment of a tunnel, even minor incidents can cause deadly disasters, since critical, catastrophic incidents may occur even faster than on surface highways. Immediate response to traffic incidents is critical for maintaining a smooth traffic flow. For this reason, it must provide timely and vital information for operating personnel to advise motorists of the hazards in the tunnel. A second challenge is constant availability. Non-stop operation is a must to ensure maximum safety and reliability.
**Application Requirements**

Since tunnels are considered one of the most complex route sectors, safety, reliability, and real-time access are key factors in constructing an intelligent tunnel control infrastructure. A network that connects and communicates all sub-systems must meet the following requirements:

- **Ethernet-based Network Infrastructure**: For tunnel control systems, it is crucial to create an effective network infrastructure to connect and communicate with all sub-systems. In this day and age, IP networks have many advantages over traditional field buses. In addition to supporting the transmission of any kind of data, the other main advantage is the big increase in data throughput. This enables extensive use of video cameras in conjunction with the more common control equipment, with all devices connected to the same backbone ring through Industrial Ethernet ring switches.

- **Redundancy and High Availability**: Effective traffic management systems do not tolerate traffic downtime. As opposed to serial lines, Ethernet switches can be connected to a ring, with the ability of the system to detect a fiber or link failure and re-route data in the opposite direction. Such a process is very critical to ensure uninterrupted operation. The safety of motorists is ensured by the use of redundant Ethernet units.

- **Fast and Long Transmission**: The network capacity should be sufficient to handle the large amount of data that is transmitted. Ethernet switches and fiber optic cabling offer fast and cost-effective bandwidth, and the reliability to relay all information from field controllers, sensors, and detectors. Standard Ethernet bandwidth includes 10, 100, 1000 Mbps, and fiber optic cabling offers high speed and secure connectivity over the long distances required in traffic applications, including bridges and tunnels.

- **Real-time, Video over IP Surveillance System**: Modern tunnel management systems have benefited greatly from the use of video cameras, which provide real-time information for traffic controllers who are responsible for controlling and monitoring road signs, light signals, emergency situations, ventilation, and tunnel lighting. Newer and cost-effective cameras with the ability to send good quality compressed figure files require more bandwidth. Therefore, video over IP has become very important for surveillance and safety aspects. Moreover, operators can easily acquire video images over an IP network anytime, and from anywhere.

- **Rugged Design in Unpredictable, Harsh Environments**: The ability to monitor, detect, and recover immediately from system failure is mandatory for safety-critical tunnel applications. To further enhance system reliability, industrial-type products that have a rugged design, high MTBF (Mean Time Between Failures), and extended operating temperature range (e.g., -40 to 75°C) are required for ensuring the security of the tunnel communication system.