Operating Control System for the Elbe Tunnel in Hamburg

by Wonderware Germany

"By using upward-compatible software from Wonderware, we were able to lay the foundations for later expansions even during the first phase of the project in 1996. The version upgrades of the InTouch application has never been expensive and time consuming."

Dipl.-Ing. Olaf Kolmer,
Project Manager, Cegelec AT GmbH

VALUE DRIVERS

Goals

• Monitor and control the 142,000 vehicles that cross the tunnel at peak times.

Challenges

• Control of the ventilation system in all bores and the monitoring of all the equipment;

• Develop and use a system that is not affected by changes in technology.

KEY METRICS

Wonderware Solutions

• InTouch HMI.

Results

• The modular design means that new systems can be integrated easily;

• System expansion is cheaper using the Wonderware software;

• Parts of the system are interchangeable without limiting function in any way.

Company Overview

Hanseatic City of Hamburg – Hamburg, Germany

The Elbe Tunnel in Hamburg was opened in 1975 and takes the north-south traffic through under the Elbe at a depth of 20 meters. From 56,000 vehicles per day initially, the rate of traffic flowing through the tunnel has risen to a current average of up to 142,000 vehicles at peak times today. The tunnel originally consisted of three bores, each with two lanes of traffic; a fourth bore was added in 2002. The Elbe Tunnel in Hamburg is one of the most highly used yet safest underwater tunnels in the world with no occurrence of major incident.

An efficient infrastructure is absolutely essential if Hamburg is to fulfill its role as an international traffic intersection. This was one of the main reasons for the construction of the New Elbe Tunnel connecting the two sides of the River Elbe.

Original design

Work on the construction of the New Elbe Tunnel started in 1968 and it was opened by Chancellor Helmut Schmidt on the 10th of January 1975. Out of a total length of 3,325 m, 1,056 m lies below the river bed, and at mid-tide, it is 28 m below the surface of the water. In the river area, the tunnel was built using caissons and a shield tunneling machine with compressed air was used under the slopes of the Elbhang.

Initially, the tunnel consisted of three bores with a total of six driving lanes which can be blocked off individually using around 450 dynamic traffic control systems. Depending on the traffic situation, the tunnel bores can be opened for one or both travel directions. The Elbe Tunnel is monitored by the tunnel operating unit above the North Gate, which is manned around the clock. The operator can not only observe the drivers via numerous cameras and can control the traffic with illuminated sign systems – he can also talk to them directly. All radio transmitters that can be received outside the tunnel are also broadcast in the tunnel with their own transmission systems and can be interrupted at any time if announcements have to be made.

Extensions

With the increase in traffic in the 1980s and 1990s, traffic jams began to be a common occurrence, especially for holiday traffic, since the Tunnel was regarded as the fastest way of crossing the Elbe in a north-south direction. Work started in 1995 on the expansion of the tunnel by the addition of a fourth bore, although the construction of the actual tunnel only started in 1997. The 3,096 m long bore was built over its whole length using a shield tunneling machine nicknamed "*TRUDE*," a short form of the name Gertrude and an acronym for Tief Runter Unter Die Elbe (deep down under the Elbe). The machine had a front plate diameter of 14.20 m, making it the largest shield tunneling machine in the world. The original cutting wheel is now on show at the Museum of Labor in Barmbek. The bores were constructed with a soil cover of 7 to 13 m and 70 cm thick reinforced concrete tubbing was used to support the cavity walling.

The new fourth bore, costing around Euro 550 million, with another 400 traffic signals, was opened on October 27, 2002. It is as close as 70 m to the existing bores and it comprises two driving lanes each 3.75 m wide, a breakdown lane 2 m wide plus three emergency exit tunnels leading into the adjacent bores.

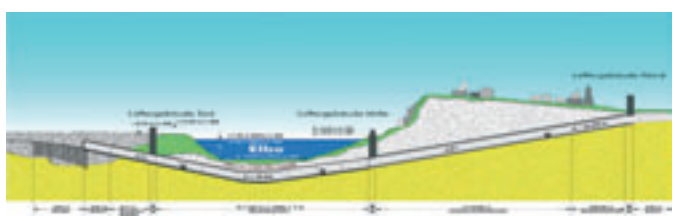
Challenge

Not only the tunnel construction but also the computer-aided control of the ventilation systems in all four bores and the monitoring of all the technical equipment had to be absolutely state of the art. The systems are distributed

Tunneling machine finishing the fourth bore

across the three ventilator structures (South, Central and North); the North structure also houses the central operating unit from which the entire system is monitored.

With the completion of the fourth bore, the old ventilation control system was also replaced by an open system based on industry standards. At the same time the existing remote transmission lines between the ventilator buildings were to be replaced by a powerful process bus system.
The operating systems previously controlled via a conventional mosaic diagram such as medium- and low-voltage switching systems, tunnel ventilation controls, tunnel lighting, hydrants, pump plants and building services, plus the monitoring of the many recess doors and emergency call facilities were to be integrated into this system.



Section through 4th bore

Operating computer

In 1996, the Elbe Tunnel process computer, originally installed by AEG in 1976 was replaced. The new operating technology incorporated, for example, the ventilator controls and building monitoring of Bores 1 to 3.
At this time (1996), a future-proof system had to be developed which would be capable of expansion for the construction of the 4th bore in 2002. This was achieved by using a system design based on a strictly modular structure using only standard components.
In 2001, the operating computer was expanded by the addition of the elements from the 4th bore. The data capacity of the system also doubled because of the imposition of new safety requirements.
The Elbe Tunnel thus has an ultra-modern control and monitoring system that can also be expanded in the future.

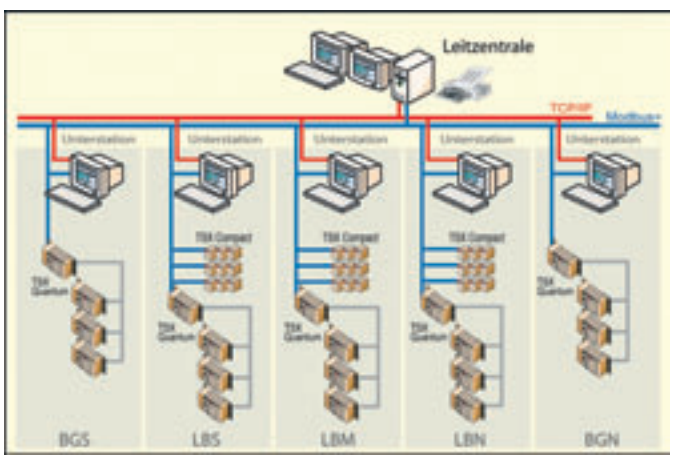
Central control unit

The solution

The concept developed by the Technical Services Department of Cegelec AT GmbH Anlagen- und Automatisierungstechnik GmbH & Co. KG, Hamburg was granted approval since the special system and operating expertise that had been built up during the long support phase meant that it was possible to submit the best possible solution.

The solution that was implemented using Wonderware's InTouch HMI software and Quantum PLCs goes beyond the original ventilator control system.
The operating control system now allows:
• Ventilator control in automatic mode, by individual bore according to CO content and visibility conditions;
• Ventilator control on the basis of editable weekly timetables;
• Manual ventilator control;
• Ventilator control in the event of a disaster (fire);
• Monitoring and control of 10 kV system;
• Monitoring and control of 0.4 kV system;
• Monitoring and control of 0.5 kV system;
• Load monitoring and control;
• Hydrant monitoring and control (extinguisher water);
• Pump monitoring and control (tunnel drainage);
• Recess door monitoring with indicator boxes;
• Building services and building ventilation monitoring;
• Monitoring and control of tunnel and ventilation duct lighting;
• Monitoring of carriageway temperature.

All computers are linked with each other via a redundant exclusive network. The special feature of the design is that the operating stations are designed as Multimasters with redundant data storage. Each computer works independently with its own process connection and own database. If a computer fails, the system can still be operated without restrictions from one of the remaining computers. After the computer that has failed is restarted, it updates its own data stocks itself, from the other computers.
PLCs are connected via Modbus-Plus. In this way, all the control computers receive the process data in synchronization with the process.
The process images are a further development of the operating and monitoring concept previously handled via switching panels. The consistent uniform screen design provides the operator clearly with just the information needed in each case and for each situation; he can select any of the 40 images here directly. Any alarms, whether acknowledged or not, can be seen at a glance.
Cegelec also developed a number of special functions for this project. To link external peripherals, various drivers make use of InTouch interfaces. If certain faults or events occur, for example, a signal is sent to the video system to tell it which camera should be swiveled into precisely the right position and which monitor should be selected in the control centre.



Configuration of operating computers

Future-proof

Traffic in the Elbe Tunnel along the federal autobahn BAB 7 has grown from the original figure of around 70,000 vehicles a day to over 120,000 vehicles now. The construction of the 4th tunnel bore was completed in 2004. It has equipped Hamburg to face the traffic flows of the future. The modular design means that new systems can be integrated and because standard software has been used, it will be possible to expand the system at a low cost. Parts of the system are interchangeable without limiting function in any way.

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