

Barcelona Underground Railway

Barcelona, Spain's second largest city, is widely regarded as one of the most forward thinking cities in Europe. The city has demonstrated its visionary nature by constantly undertaking new challenges, including a successful bid to host the 1992 Summer Olympic Games. With this type of philosophy, and ever aware of the latest technological improvements in transport services, Barcelona long ago recognized the social and economic importance of creating, maintaining, and improving a public underground rail network.

In 1924, Barcelona's first underground railway line was built between the stations of Lesseps and Catalunya. Since then, this urban transport system has

been continuously upgraded and improved to incorporate the latest available technologies. With the suspension of the last regular tramlines in 1971, the Barcelona underground railway system became the primary means of transportation in the city.

Today, the Barcelona Metro, as it's commonly referred to, is comprised of five main underground lines, with 115 stations and more than 500 trains. Each day, over 1.1 million passengers use this rail network. A single five car train can carry over 1000 commuters and during the daily rush hours, when trains run every three minutes, the system has a throughput of over 60,000 passengers per hour. In total, the Barcelona Metro transports over 310 million passengers annually.



The Barcelona Metro Rail Network

In efforts to improve both rail operations and safety conditions, and simultaneously increase the comfort of its passengers, the Barcelona Metro has implemented many technological improvements to both its fleet and facilities. One of the most beneficial of these improvements has been the integration of Ethernet TCP/IP industrial technology into the Barcelona Metro's existing IT network infrastructure for the purposes of automation, control, and remote monitoring. This integration has improved operations in the areas of network reliability, communications and video surveillance, among others.

Agecontrol: The Technology Consultants

The company responsible for the integration of these new technologies in the Barcelona Metro is Agecontrol. Founded in 1976 as part of the AGE Corporation, a major Spanish engineering contractor, Agecontrol specializes in designing and deploying control and telecommunications technology solutions. The company has designed and built control systems based on PLC, SCADA, and DCS technology for customers in such diverse industries as oil and gas, water treatment, environmental control, and energy. Agecontrol also specializes in networking and infrastructure of wiring cabling systems for voice, data and image transmission. They also provide strategic planning and network architecture design, diagnostics and auditory services for communications systems.

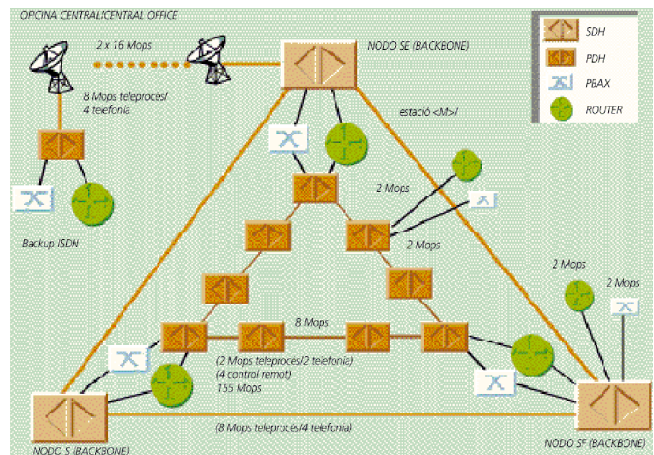
Developing the Best Solution

Agecontrol understood that although PLCs solve many of the basic control requirements of industrial automation, they have severely limited data acquisition capabilities. More importantly, however, PLCs are not easily attached to a traditional IT network and to adapt them for that purpose would be costly, inefficient, and would require the addition of middleware components that require extensive programming and support. Agecontrol knew that the Barcelona Metro required quality industrial devices that could *simply and directly* bring their proprietary equipment onto their existing TCP/IP network, deliver data from this equipment directly to management software applications, and accomplish this transparently, without disrupting existing systems or processes.

Agecontrol searched the marketplace for a system that met these requirements. The answer was Opto 22 SNAP Ethernet I/O™.

Opto 22 SNAP Ethernet I/O

The SNAP Ethernet I/O systems designed for the Barcelona Metro consist of a collection of up to 16 modules on an industrial rack, with each module offering two to four inputs. Contacts or switches are wired to the digital modules, while sensors and variable controls are wired to analog modules. Serial modules supply two independent bidirectional data communications ports. Deployed throughout the railway's many stations and tunnels, these SNAP Ethernet I/O systems act as standard IP nodes within the Barcelona Metro's existing network infrastructure. The systems transmit critical operational data from the connected devices and systems through the Barcelona Metro's Ethernet network to management consoles in the Metro Control Centre.



The Telecommunications Network

The Telecommunications Network

The Barcelona Metro's telecommunications network is responsible for supporting all activities related to telemetry control, remote data connections, voice communication, and video. This network is built on a fiber optic backbone that extends through 81 kilometers of railway tunnels. In remote locations and other areas where it has not been possible to install this fiber optic cable, communications signals are delivered through the use of Ethernet radio links.

These provide the Barcelona Metro with a very high level of reliability. The entire system is reinforced by redundant connections to public digital ISDN telephone links, which are activated in the event of internal failure but can also be used simply to add more bandwidth should a particular network segment experience an increase in demand.

The Metro Control Centre

All of the Barcelona Metro's key equipment and systems report back to the Metro Control Centre. These systems include the escalators and hydraulic passenger lifts; communication links such as telephone and two-way radios; video surveillance; vibration monitors; smoke, gas, and fire detection equipment; lighting; and security.

How the Opto 22 SNAP Ethernet System Works

Network Monitoring

The Opto 22 SNAP Ethernet I/O system is used to monitor Barcelona Metro's entire communications network including the radio links used for voice and data transmission throughout the stations, two-way communication between the trains and the station, and driver communication with maintenance personnel. Having the Opto system perform this function allows for the detection of multiple faults or communication disruptions. In general, the network can handle single faults, but these must be detected and fixed before a second fault occurs. Through comprehensive network monitoring, the SNAP Ethernet I/O system is able to verify that communication is intact and also acquire and deliver data from all the connected systems back to the Metro Control Centre thereby ensuring that the network is up and running and operating optimally.

Equipment Monitoring and Management, Data Acquisition

As described earlier, the SNAP I/O modules are connected via sensor technology to many of the Barcelona Metro's key systems and equipment. When alarm conditions occur for any of these

systems, the SNAP Ethernet I/O system is preconfigured to transmit SNMP traps containing details of the alarm and the associated device to predesignated IP nodes acting as management consoles on the network. Through their enterprise management system (Hewlett Packard's Openview running on a UNIX platform), operators at the Metro Control Centre are notified immediately as the incoming SNMP traps activate diagnostic programs and begin procedures such as event logging, incident reporting, network reconfiguration, and email generation to maintenance staff.

Remote Control

Each of the 115 stations in the Barcelona Metro has a closed-circuit television (CCTV) system installed. Each such system incorporates a large number of cameras installed in stairways, passages, and train platforms. These cameras are connected to a panel of monitors and video recording equipment usually installed in the ticket offices. A video matrix system is used to switch the multiple video channels and sequentially display them on the monitor panel.

Also installed throughout these stations is a system of public intercom phones that allow passengers to communicate with the station manager. Each intercom is, in reality, an extension of a local PABX switchboard in each station, a unit that includes an RS232 serial communication device using V.24 protocol.



The Barcelona Metro requires that when a passenger activates a particular intercom to request information or report an incident, the camera that provides the best coverage of that zone be immediately switched into the video matrix system and maintained on one of the monitors, where it can be monitored from the ticket office during the entire period of the conversation. During this time, the video stream and conversation is also recorded. In other words, the act of picking up a phone sends a message to the video matrix instructing it to reposition the closest camera.

To facilitate all this, SNAP Ethernet I/O has been installed with a serial module connected to the V.24 output of the switchboard. Digital output modules are being used to control the switching contacts of the video matrix system. When any serial module receives a message from the switchboard, the SNAP Ethernet I/O brain processes the information, determines which camera should be switched into the matrix and activates the corresponding digital output. At the same time, the video and voice-recording systems are activated to capture the communication between the passenger and the station manager.

Benefits of the Implementation

While less forward thinking organizations may consider the introduction of network-based technology an unjustified cost, the Barcelona Metro's use of Ethernet TCP/IP industrial technology has proven to be a wise investment. While cabling and installation costs have been negligible, benefits have included the improvement of operational safety as well as a reduction in maintenance costs, despite the fact that the number of Ethernet I/O system installations on the network continues to increase.

Barcelona Metro's adoption of SNAP Ethernet I/O, and its seamless integration by Agecontrol, has significantly improved the railway's operations and contributed to its reputation as an exemplary organization whose management and facilities are used as a benchmark for other large transportation companies not only within Spain, but all over Europe.

About Opto 22

Opto 22 manufactures and develops hardware and software products for applications in industrial automation, remote monitoring, and enterprise data acquisition. Using standard, commercially available Internet, networking, and computer technologies, Opto 22's SNAP systems allow customers to monitor, control, and acquire data from all of the mechanical, electrical, or electronic assets that are key to their business operations. Opto 22's products and services support automation end users, OEMs, and information technology and operations personnel. Founded in 1974 and with over 85 million Opto 22-connected devices deployed worldwide, the company has an established reputation for quality and reliability. Opto 22 products are sold through a worldwide network of distributors, partners, and system integrators. For more information, contact Opto 22 headquarters at 800-321-OPTO or visit our Web site at www.opto22.com.