Intelligent highways

**BR-040 - Brazil**

The BR-040 is the highway from Rio de Janeiro to Juiz de Fora with an overall length of approximately 180 km (112 miles). The BR-040 has three toll booths (PCOs) from which a particular part of the highway is controlled.

The main toll booth, i.e., the Central Control Office (CCO), is furthermore in control of the complete highway.

Communication systems implemented on the BR-040:
- Emergency telephones;
- Variable message signs (VMS);
- Video cameras (full motion);
- Fog detectors;
- Height detectors;
- Traffic sensors (road loops);
- Administrative LAN (Ethernet).

The total capacity of all communication justifies the implementation of an OTN-600 network, in which video is the main application with 48 high quality video channels.

**AutoBAn - Brazil**

AutoBAn is the concession holder for the highways Anhangüera (SP-330) and Bandeirantes (SP-354) north of São Paulo. Each highway is approximately 160 km.

An OTN-2500 system is installed along both highways supporting a myriad of applications including:
- Emergency telephones;
- Variable message signs (VMS);
- Video cameras (full motion);
- Fog detectors;
- Height detectors;
- Traffic sensors (road loops);
- Administrative LAN (Ethernet).

The total capacity of all communication justifies the implementation of an OTN-600 network, in which video is the main application with 48 high quality video channels.

**M5 Budapest - Hungary**

Length: 70 km (44 miles)

OTN: OTN-38

Configuration: Daisy Chain

Applications:
- Ethernet 10 Mbps
- Analog telephones on Hicom 130 PBX (analogue voice)
- RS232 meteorological systems
- RS22 PTZ control of video cameras
- RS485 Serial 55/95 PLCs for SCADA system

**HIGHLIGHTS**

- OTN for implementing an "Intelligent Highway" connecting all roadside communication/surveillance equipment in one system
- All communication using only two (daisy chain) or four optical fibers (redundant ring)
- Video switching integrated in OTN-150/600/2500/X3M for control of all cameras by operators in different control centers

**Reference projects:**
- BR-040 (OTN-600) & AutoBAn (OTN-2500) - Brazil, M5 - Hungary

**Introduction**

Infrastructure (highways, railroads, airports and harbours) is the backbone of every economy. For many years investments stalled in several countries. Privatization and BOT (Build-Own-Transfer) concessions are now being used to support the modernization of a lot of these infrastructural works.

Due to budget restrictions maintenance and service extensions of highways and expressroads have been neglected for many years. A lot of effort and investments are needed now to improve the overall condition of the roads, including the road surface, crash barriers, street lighting and intelligent traffic signs. Also the increased traffic makes road safety (e.g., video surveillance) a major concern to governments and as such one of the key issues in the privatization/concession process.

The privatization/concession programs involve the economical and technical specifications of operating highways for a period of at least 20 years. In the economical contract the toll tariffs to be collected by the operator are specified. However, they are forced to invest in the necessary road reconstruction and modern communication means for two reasons: better services to the public and increased road safety.

The transformation of the old roads to the "Intelligent Highways of tomorrow" is stimulated in this way and investments are covered by toll earnings.
In this project two fiber optic cables run in parallel via separate ducts. The OTN-600 nodes are alternatively connected to one of the cables (called: Hopping). The network is fully redundant and a cable break will never cause the system to fail.

Daisy chain (only 2 fibers used)
In the M5 project, only 2 fibers are available to the OTN system. The system forms a single ring. In case of a failure, the network will only temporarily split up in two separate networks still with full functionality.

Applications

Ethernet (administrative LAN)
The BR-040 and the M5 both use Ethernet LAN to transfer all toll collection information to the central database. The toll booths are connected to the central office (CCO) based on 10 Mbps Ethernet. Normally, Ethernet is used within an office environment with distances of up to 100 meters (0.06 miles) over twisted pair. However, especially in stretched networks like highways, distances can be up to hundreds of kilometers. The OTN Ethernet card offers a 10 Mbps capacity throughout the whole network. The Ethernet card is fully transparent to all protocols such as Novell, TCP/IP, NetBliss or OSI. The Ethernet card acts as a 'buffered repeater' on the physical layer of OSI. Local LANs are connected to OTN without any additional routers or bridges.

The distance between the outer toll booths is 116 km for the BR-040 and 130 km for the M5 respectively.

Emergency telephones (call boxes)
Safety is crucial for operating toll roads and measurements are taken by the operators to assure a rapid response to emergency calls and assistance to broken-down cars. Especially locating cars in densely populated or dangerous areas is essential. Therefore, emergency telephones are located along both sides of the road at 1 km distances. The central operator can respond to incoming calls using on screen information about the caller's position and dispatch the emergency services (ambulance, police and/or low car).

Many of these emergency telephone systems are based on 4-wire circuits, balanced pairs used on twisted pair segments. Copper cables are installed along the road and telephones are connected in parallel. Regenerators are used every 20 km to regenerate the signal and to supply the necessary 48 V to the telephones.

The OTN 4-wire voice card (4WVOI-S) can connect the individual copper segments to the central office without regenerators, without loss of the signal quality or long stretched copper networks. The 4WVOI-S card is transparent to all voice signals in the standard voice band of 340-3400 Hz.

The connections over OTN are far more protected from cable breaks, high voltage (e.g. from nearby power lines), radiation and atmospheric influences (radio, lightning, etc.).

RS485 bus applications

Many systems use the RS485 protocol (bus) for implementing a master-slave protocol. A central system needs to access individual slaves and transfer asynchronous data. Examples are VMS (Variable Message Signs), traffic sensors and PTZ (Pan/Tilt/Zoom) control of cameras. The OTN RS485 interface card supports 3 independent buses for system subareas and a maximum transmission rate of 2 Mbps per bus.

Variable Message Signs (VMS)
The VMS signs are used to display dedicated information to the public. The RS485 bus can take care of all weather conditions (rain, icy roads, etc.) and automatically enters the text for a particular VMS or one of the information systems generated automatically for a particular VMS.

An OTN RS485 card is installed in each roadside cabinet of the BR-040. The VMS signs (sometimes more than one) are connected to one bus.

The traffic sensor systems (sensitive road loops) are connected to the second bus. The speed of each bus is set at 9600 bps, occupying only 96 kbps on OTN.

For more information on the RS485 interface card refer to specification sheet: A31003-Z3931-S246-*.765.

Video switching over OTN

The key application on the BR-040 is video transmission with integrated video switching.

In view of the dangerous curves and crossings, video is essential for good traffic and safety management. Approximately 70 cameras are installed along the BR-040.

In each of the three toll booths (PCOs) eight monitors are used to control a specific part of the highway. The CCO has another 12 monitors to monitor the entire tollway. This means that each toll booth selects cameras from its part of the road, whereas the CCO should be able to select any combination of cameras of all the cameras along the BR-040.

Furthermore, an advanced video detection and recognition system is used for detecting hazardous situations and accidents. A total of 48 high quality video busses of 12-16 Mbps each are programmed on OTN:

- 12 video busses for the CCOs;
- 8 video busses for each PCO;
- 12 video busses for the advanced digital recognition system.

Video switching on OTN provides each operator with full access to all cameras without the burden of designing a fixed video network of matrices and switches.

Each video bus is associated with a video output of a VIDEO-OUT card. The operator can dynamically select any camera to any video output. This video switching is an integral part of the Video Control Center (VCC).

In the BR-040 project all video images are high resolution, full color and full motion (i.e. 60 fields/NTSC). The bandwidth needed per video bus depends on the following parameters:

- color depth;
- horizontal resolution;
- vertical resolution;
- frames per second.

Depending on the above setting the bandwidth ranges between 2 - 36 Mbps.

The VIDEO-IN card automatically adapts to the PAL/BG or the NTSC-M standard.

For more information on the VIDEO-IN and -OUT cards refer to specification sheet: A31003-Z3931-S239-*.765.

OTN - the connection on roads

The diversity of signals and applications make OTN an ideal backbone transmission network for the 'Intelligent Highway'.

OTN offers connectivity to all applications, over almost unlimited distances, without the least timing constraints and also over just two fibers, if necessary.

The backbone for the 'Intelligent Highway of tomorrow' can be implemented today. Future proof...