Improving Security on Perth's Rail Network

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Executive Summary:

The PTA Urban Security Initiatives Project commenced in 2001 following a WA Government concern seeking to address increasing security fears amongst passengers when travelling on the Perth urban rail network.

The project gave rise to the introduction of a raft of innovative facilities and features culminating in the commissioning of a sophisticated central monitoring and CCTV control centre capable of detecting, recording and immediately responding via an integrated public address system to anti social behaviour, vandalism and duress calls at suburban stations.

The integrated CCTV design broke new grounds by considering human behaviour patterns, forensic needs of security authorities, effectiveness of the operators, technical capability and ongoing routine maintenance critical to ensuring the system remains effective in a harsh and public environment.

Innovative designs like the use of controlled views at all station entries that give positive forensic quality facial identification of all passengers as they enter each station on the network has more recently been endorsed by international agencies as a mandatory arrangement for anti terrorism measures for mass public transport venues.

Many other of the design philosophies have now also been adopted on a national scale through the soon to be released National Counter Terrorism CCTV Code of Practice. The PTA design and implementation pre-dated counter terrorism requirements by several years.

Recognising the large number of cameras and the practical limit of staffing for the proactive monitoring and response to antisocial behaviour, the design embraced an alarms driven approach to system operation where each station is monitored with up to 20 alarms designed to alert operators of possible security issues.

Technology limits were pushed with the project using extensive centralised digital storage of all images from 650 cameras, held 8 days online in a custom built, centralised secure environment. Incidents can be instantly retrieved and automatically archived for future investigations. The extensive use of Ethernet and IP based video streaming and coarse wave division multiplexed fibre interfaces was considered ambitious and was undertaken at a time when many of these technologies were in their infancy.

The Project included significant construction difficulties with both the extensive electrical and lighting work at stations and the installation of a new fibre optic network along 100 year old rail reserves and rail infrastructure. The network allowed widespread use of the 1GB ethernet communications for both operational and business requirements and now encompasses a network with over 5000 ethernet ports.

A major upgrade of station lighting and electrical infrastructure was required to ensure bright and safe environments existed at stations, and to ensure all video images captured provided useful forensic evidence. Although extensive disturbances to station platforms were required to install this infrastructure, this was undertaken during normal rail operations with minimal disturbances to rail patrons and no injuries to the travelling public

A new passenger information system was included to provide improved information to the travelling public and to better address the needs of disabled passengers.

The large increase in the amount of electronic equipment installed at stations necessitated the need to provide secure locations in a environmentally harsh environment and resulted in the design and construction of a Station Equipment Cubicle. The new enclosures consolidated a number of standalone passenger functions such as ticketing, passenger information and emergency phones into a new public face and provided a new "branding" of the Transperth image. The passenger interface was as a result of widespread community consultation with all stakeholders and disabled groups. It has survived the rigours of a public place without significant damage of disfigurement and provides environmental conditions acceptable to sensitive electronic equipment not normally installed in these environments.

The project is acknowledged within PTA and the passenger rail industry in Australia as being a huge success and one which has resulted in an almost 100% arrest rate for serious offences and the subsequent prosecution of offenders.

Wider community needs became additional benefits of the project with it serving as a model for other rail networks and current counter terrorism initiatives being undertaken by State and Commonwealth agencies in other states including Customs, and NSW Police. It has also recently received interest from overseas including Great Britain

The project involved $27,000,000 of capital expenditure and was carried out over a 4 year timeframe. Despite many uncertainties and risks at the time of conception the project was completed on time, on budget, allowed for growth of the Perth rail network and caters for future adoption of intelligent CCTV software technologies such as automatic facial recognition. It has exceeded all expectations of its success and placed the PTA and Western Australia at the forefront of the use of this technology in a worldwide sense.

Categorisation Statement

The Urban Security Initiatives Project has been entered in the category of Electronics, Telecommunications and Information Technology as the key aspects of the project delivered to PTA are firmly based in all three areas covered by this category.

The large component of civil and electrical and lighting also covered in the project are tightly related to the overall benefits and success of the key objectives and are also outlined in this submission.

Key elements in this category addressed by this project are seen as:

Analysis

- Analysis of client surveillance needs, manning levels and resultant operating strategies
- Industry trends
- Camera placement and duties
- Work packages
- Equipment housing
- Maintenance procedures and resultant design inputs
- Change management
- Current technology issues
- Technology trends with regard to future proofing

Design

- Station equipment housing recognising environmental condition and maintenance issues
- CCTV at Stations
- Central Monitoring facility
- Fibre and Ethernet topology
- Station lighting levels
- Equipment rooms
- Passenger information
- Station monitoring and PLCs
- System operational concepts

Development and Operation of Computer Hardware

- Passenger information station controllers (in-house design and build)
- Passenger information central server (client – server)
- Storage array schema
- Topologies for redundancy and failover
- Public address station controllers

Software Engineering

- Passenger information station controllers
- Passenger information central server
- Interface to train control
- Programmable logic controller schema
- Maxpro macro based alarms switching
- Network management

Electronics and Communications and their Applications

- Passenger information network
- Layer-2/3 Gigabit Ethernet network
- Network management (SNMP)
- Quality of Service (QoS) and routing protocols
- Fibre optic network
- Public address network
- Programmable logic controller network
- Course wave division multiplexing of analogue CCTV
- Spread Spectrum Wireless Ethernet
- Voice over IP
- Digital CCTV transmission (station to central)
- Remote access to systems for maintenance and configuration management

Telephony

- Voice over IP
- Long line public address
- Passenger information transmissions

Optical Fibre

- Fibre optic rollout
- Fibre management systems
- Dark fibre allocation

- Fibre Coarse wave division multiplexing (CWDM)

Computer Systems

- Passenger information
- Public address
- Client server technologies
- Embedded systems
- Storage arrays and control
- Ethernet management
- Control room workstations

Cutting Edge Problem Solving

- Procurement methodology
- Use of Voice over IP
- M-JPEG versus MPEG-2/4.3 (latency)
- Metro IP/Ethernet network
- Extensive use of IP interface field equipment
- IT based storage arrays for CCTV management
- Extensive use of fibre
- Coarse division wave multiplexing over 21Km distances
- Extensive use of network management
- CCTV operating philosophy (alarms driven)
- Use of identification cameras and controlled entries

Overview of the work

The Urban Security Initiatives Project or 'Safer Stations' programme was initiated by the Western Australian Government to address public concerns over safety at PTA railway stations. Broadly, the project encompassed a raft of initiatives fashioned to improve safety and provide a more secure environment for rail patrons when travelling on PTA trains.

The project covered:

- CCTV at all stations.
- Central monitoring of CCTV and station alarms.
- Individually and group selectable line public address (LLPA) system for each station.
- Improved passenger information with facilities for the disabled.
- Integration of emergency and help telephones.
- Rationalisation and monitoring of station services.
- Improved lighting at all stations.
- Car park fencing and station barriers.
- Upgraded station communications (extensive fibre and 1GigE network), to facilitate the introduction of these features.

In essence, the project provides a level of integrated security services, designed to improve public safety, the public's perception of safety and provide general confidence that travelling on the urban passenger system is a safe activity.

The CCTV and central monitoring component of USIP includes the following main features:

- The provision of CCTV cameras at all stations, at station car parks and at other urban rail facilities.
- Local monitoring of CCTV camera views at manned stations on the network.
- Monitoring of all CTTV cameras at a centralised control and monitoring room (CMR) facility, including comprehensive incident and alarm monitoring and management functions
- A communications upgrade, by way of an optical fibre bearer system, to accommodate all of the Wide Area Network communications needs of the PTA, including the transmission and control requirements of the CCTV control system, alarms, monitoring and other functions including train control.
- The digital compression and transmission of all CCTV camera images back to the central digital storage and video management systems in the PTA Main Equipment Room at Public Transport Centre in East Perth.
- Digital storage onto hard drives in standard file space, of every CCTV camera view for at least 7 days.
- Connection of the digital compression, digital storage and video management systems to the PTA's Ethernet for access and viewing of digitised historical camera images at authorised workstations located anywhere on the PTAs network.
- Control of PTZ cameras at all stations and extensive switching and control of real-time (25 fps) analogue CCTV camera views for 48 concurrent video outputs in the CMR without significant latency to allow accurate position and monitoring of views in real time.
- Provision of a central along line public address (LLPA) central switch and associated equipment for Voice over IP (VoIP control).
- Integration of station PA with existing passenger information audio information and hearing-impaired audio amplifiers at stations.
- Development of operating procedures and practises to ensure legislative requirements are met.

Project Mobilisation and Design Issues

The project encompassed works across many disciplines including electrical and lighting, civil works, fibre installation, integrated communications design, IT, equipment housing, environmental, mechanical design, disabled access and CCTV and control room design and operation. In addition, by necessity the work was undertaken on a running railway and as such the safety planning was paramount both with regard to the works by contractors and the public interface.

The disparate nature of the overall works required a high level of planning to ensure client expectations were met and to co-ordinate across different work packages. The total works included some 34 individual contracts and 16 consultancies and was co-ordinated by a small internal project team, overseen by a project steering group.

The main issued addressed during the planning phase included:

- Packaging of the work, including assessment of contractor capability
- Co-ordination and dependencies of each contract
- Minimising station disturbances (to avoid public inconvenience)
- Railway safety issues
- Public safety issues
- Contractor work practices
- Environmental hazards
- Development of technical standards
- Development of Network base drawings
- Strategic direction and value adding to the organisation
- Impact on disabled groups
- Determination of appropriate technologies
- Determination of overall system operational concepts

Initially the project group commenced the process by examining existing internal processes and technical standards and also examining typical practices utilised by other railways and non rail industries. A study tour of major installations in other states and industries was conducted, including Sydney Airport and Darling Harbour prior to the 2000 Olympics. The capability of local suppliers and contractors was also examined. This gave rise to the production of a number of new and revised technical standards and also a work break-up which reflected the capability of the local industry.

Early in the design, it was realised that the amount of equipment to be housed at each station would require a dedicated cubicle. A preference for a dedicated equipment room was soon overshadowed by the high costs and as a result a decision to install a Station Equipment Cubicle (SEC) was taken. The process for approval however required two prototypes, the inclusion of the stand-alone ticket machines (TVM), vandal treatment, environmental treatment and an extensive approval process for compliance with disabled groups, and all stakeholder groups. The resultant SEC is now used on all minor stations and selected major stations in the network and provided a 'branding' for the organisation as well as being a functional unit.

The urban rail corridor was not documented in any comprehensive way and an early task required the production of 'survey' drawings of the urban network. This resulted in a set of CAD bases which were used for all subsequent works and resulted in the 1st time the PTA had accurate as-built drawings of the network infrastructure. This information was also the source of base information for the PTA award winning Land & Transportation System (LATIS) GIS project.

The existing combined electrical and communications conduits at stations were almost all non-ACA compliant and required replacement. Budgets would not allow this and only the worst installations could be replaced. Others were modified using an innovative treatment to allow clear separation between LV and ELV circuits. At Perth station a new conduit system was installed to allow a complete traversing of the station from both North and South with three crossover points. This work required extensive under track bores and was done during normal train operations. Similar work was required on all lines at road and bridge crossings to allow the fibre backbone installation.

This planning was done at a very early stage and allowed the work packages to be coherent with little need to re-visit sites.

Centralised Monitoring and CCTV Alarm Management (CMR)

The centralised monitoring and CCTV alarms management system known as the CMR, included the management of all analogue CCTV images, the digitising of CCTV images and the storage and retrieval of CCTV images as well as the interface to the fibre transport system and Ethernet. It also includes the alarms monitoring and automatic keying of the LLPA.

The CMR is in essence the focus of the overall project. It was decided early in the documentation process to include a 'proof of concept' stage which required that following a short-listing process, each tenderer would be required to undertake a limited demonstration of their proposed system in operation on the rail network. This process resulted in reversing the order of preferred tenderer and greatly reduced the risk of non delivery,

The CMR works includes:

a) At Stations

- Station CCTV multiplexer and CODEC systems at all stations.
- Station fibre CWDM interfaces
- Public address amplifier and controller at all stations
- Audio loop amplifiers for the hearing impaired at all stations
- Network diagnostic and monitoring facilities for all station equipment

b) At the PTC Equipment Room

- Main CCTV multiplexer and video controller.
- Fibre interface for station CCTV
- CODEC digital video servers for control and management of digitised images
- Fibre interface for reticulation of CCTV to CMR and TCC
- Disk storage arrays for all cameras for 7 continuous days
- Long line public address controller and audio switcher unit
- Fibre interface for reticulation of CCTV to CMR

c) At the CMR and CMR Equipment Room

- Main video viewing wall
- 6 x monitoring desks complete with live and digitised viewing monitors, control workstation and PA and video control panels.
- CCTV front end multiplexer unit
- PA control equipment
- Duplicated servers for redundancy

The decision to centrally record and to digitise in the field was taken to avoid the need to install hard disks and other sensitive equipment in an environmentally poor location.

The system currently controls in the order of 650 CCTV cameras at some 60 Stations and this number will increase to approximately 900 with the new Southern Railway, and has the capacity to exceed 2000 cameras with expansion of the rail network and increased coverage in selected areas.

It provides a tightly integrated operating platform for surveillance officers and allows automatic public address zone selection at stations following an alarm and instant access and replay of recorded events. In this way, the CMR operator can quickly facilitate the management and control of an incident.

The CMR is the focus of the 'Safer Stations' project works and brings together the individual initiatives to provide a coherent security strategy for the PTA rail network.

The strategy for the CCTV and CMR was developed following a PTA review of other systems in Australia including other railways, airports and public gathering areas such as Darling Harbour in NSW.

CCTV cameras are located at strategic positions on all Station platforms and in car parks adjoining Stations.

Each CCTV camera at a Station or a car park has been assigned a specific duty, depending on its location and the view required to be obtained from that location. For example; CCTV cameras located at the entry points to Station platforms are configured as identification cameras (ID), to capture high resolution, close-up views of every person entering the station for forensic identification purposes. The design included selection of focus and depth of field under varying lighting conditions as well as the direction a person would be looking, height and angle of the camera and the like.

Controlled PTZ cameras are used extensively at each Station, to provide increased flexibility in the operation of the CCTV control system and allow tracking of offenders or other moving targets.

The CMR facility provides the main interface in the handling of rail security and crime and incident control. To this end, the management and control facilities provided needed to provide sufficient tools to ensure that this is achievable. The CMR includes a large video wall and a number of composite video screens for viewing up to 56 Real-Time (25 fps) composite video images, in either single or multi image format.

The facility also allows access to the digitised historical stored images and also the digitised live views of any camera.

In order to mitigate the risk of theft and vandalism, all Station equipment is monitored for alarm conditions and the CCTV control system programmed to respond to the alarms by automatically moving the controlled PTZ cameras to a known preset view and annunciating to CMR operators that an alarm has occurred. The alarms monitored by the system include:

- For all cameras:
  - Loss of video (loss of sync)
  - Low video (low signal level)
  - High video
- Equipment intruder alarm (door opened etc.)
- Equipment vandal alarm (microphonic switches)
- Emergency Telephone (ET) call request
- Information telephone request
- Ticketing alarms (e.g. cashbox alarm)
- Other cubicle alarms

Other alarms are also be used as operator alerts where available.

Once the system has logged an alarm, the CCTV Control System automatically selects and 'keys up' the associated Station public address (PA), or PA zone selection at larger stations. In this manner the CMR Operator is able to quickly determine the nature of the problem and communicate directly to the Station as required.

Manual control of all functionality is also available and all controlled PTZ cameras and PA functions can be controlled manually.

The CMR Operators can also select CCTV images to be viewed either via keyboard(s) or soft controls from any of six, three-screen workstations.

Access to digitised live video images and historical data (stored images) is also available through a Web client viewer to allow approved personnel anywhere on the PTA corporate network to also view live images as well as being able to retrieve footage for investigative purposes.

A key design philosophy utilised is the use of controlled entries to all stations to ensure that one or more of the ID cameras capture images of all rail patrons coming onto Stations. These ID cameras have a tightly controlled field of view to ensure each person entering the network can be identified. Other cameras include controlled PTZ and general views.

Operators generally work with the 25 fps real-time analogue images, but also have access to the digitised and historical stored images. These are available at 6fps via the image storage system.

Digital Compression and Storage Facility

All camera images are compressed and digitised and stored for 7 days at a secure central location.

As one of the systems primary uses is to allow historical footage to be reviewed to allow the identification of suspects, image quality of all stored and streamed images needed to approach the optical performance of the installed cameras. This was deemed as a demonstrable and fundamental term of the CMR contract works. The quality of images stored has been proven to be excellent and footage is regularly used in Police investigations and for evidence and prosecutions.

The system provides watermarking on individual images and also image streams to verify historical video images have not been tampered with.

The system is fully network managed to allow prompt response to equipment failure and system problems.

Long Line Public Adress System (LLPA)

The LLPA system is a key component to the management of incidents and is available to the CMR operators, to the PTA train controllers and to PTA customer service assistants at Stations distributed along the urban railway lines

The LLPA system is based around a central audio switch matrix and utilises Voice over IP technology and has been tightly coupled to the main alarms management system to ensure coherent operation.

The PA can be manually controlled to select a station, a zone on a station, a line or the whole network and parts thereof. The main operation however, is controlled by the station alarms, whereby once an operator has selected an alarm, the station PA and zone are automatically selected and keyed up allowing the operator to talk to the station using a push to talk microphone. The LLPA also allows

multiple operators to concurrently annunciate to different stations.

The public address system is also integrated with the passenger information system and selected messages are announced through the PA. A programmable input switcher characterises each input and output. The PA switcher also controls the loop amplifier used to provide audio through a wire ground loops system for the hearing impaired.

Fibre Optic Cable Rollout

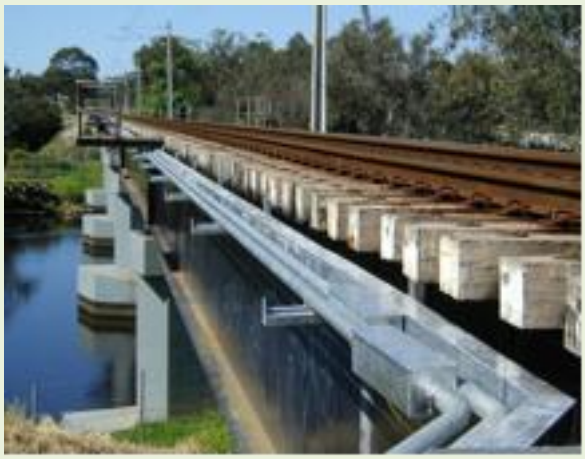
To allow the CCTV to be centrally monitored, the project included a new fibre optic cable rollout to all stations in the network excluding the Northern line which already had installed fibre.

The work required extensive surveys of the terrain to determine the best locations for access, under road and track crossing and river crossing.

The tender process included a mandatory tour of each line to ensure all tenderers were fully aware of difficult areas and client expectations.

The work was undertaken on the operating rail and significant attention was applied to the rail safety aspects of the work and personnel safety, including contaminated sites, asbestos testing, needle-stick awareness and vehicle access to the rail reserve.

The PTA rail network is an old network and many unknown services run underground both across and along the reserve.



Much of the work included extensive civil works and was undertaken in difficult terrain often with poor access and working space. The works were undertaken and completed during normal train running with the minimum of disturbance to rail operations.

The work had to recognise areas of asbestos, limestone and buried services.

The fibre was arranged such that each station became a spur from nominated hubs to ensure that local vandalism or faults would not impact the overall fibre availability.

In all, 60km of fibre was installed in ducting through the urban rail corridor.

Ethernet Rollout

The PTA Gigabit Ethernet network was required to deliver project communications, but it was apparent from the start that an extended Ethernet could be used for both operational systems and corporate IT and that the network should be designed to accommodate these areas. As such, reliability and resilience was a major factor in the topology design. The other major factor was cost and the design was undertaken to a budget but with a future view of adding further resilience as funding became available and organisational needs changed.

By the completion of the work, the traffic traversing this network included:

- CCTV video streams

- LLPA Voice over IP announcements
- Passenger Information System
- Train Control RTU's
- SmartRider ticketing systems
- Voice over IP PABX system
- Network management
- Ethernet enabled field equipment (PLC's, UPS's etc.)
- Corporate PC's

Many of these systems require time critical data transmission.

The network was split into separate virtual local areas or VLAN's by classifying traffic type. Categorised traffic allowed isolation in the event of equipment error and the following categories were provided for:

- General Use (PC's)
- Voice over IP
- Wireless
- SmartRider
- Station Services (CCTV, LLPA, PLC's etc.)
- Train Control
- Network device administration

The network design mandated a partial 3-tier design as follows:

a) Access/Edge (~100 nodes) with the following attributes:

- A minimum of one 24-port switch exists at each station or relay room
- L2 switch, L2 defence (port-security, STP defence etc.)
- High port density
- Separate VLANs for separate applications
- QoS (classification and marking)

b) Distribution (~20 nodes) with the following attributes:

- Connects 3 to 7 Access/Edge nodes
- Located at fibre aggregation points
- Performs inter-VLAN routing
- Secures VLANs via Access Control Lists; multiple redundant paths to other distribution or core nodes
- QoS (queuing and scheduling) to address traffic bottleneck under high-load.

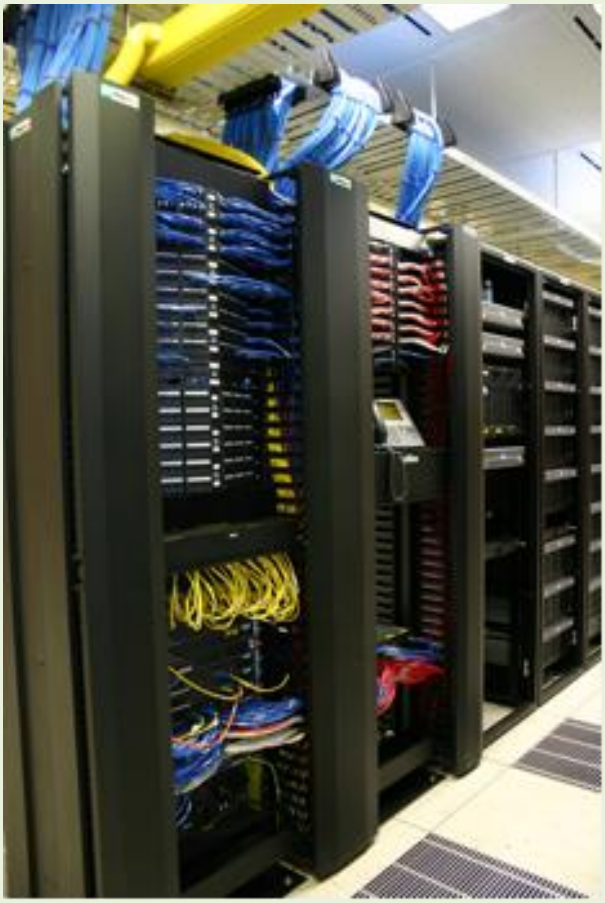
c) Core (2 nodes) – with the following attributes:

- Connects multiple distribution nodes
- No single point of failure, one core must be available for network to function
- Interconnected by 2 x 10GigE links over diverse paths
- L3 routing, all other network tasks (Multicast RP etc.)

The design uses a semi 3-tier approach as the Core switches perform distribution and edge roles for the CCTV, LLPA, IT servers and switches within the PTA's two main buildings: PTC and City Station.

Following the decision to install a highly available Ethernet, it was decided to install equipment which could be either managed through the network or provided a web based interface for management. As a result, equipment that is centrally managed includes:

- CCTV video streamers (CODECS)
- CCTV storage arrays
- LLPA station server
- Passenger Information System (PINS)
- SmartRider smartcard reader and ticketing systems
- Voice over IP PABX system
- Programmable logic controllers at each station
- Uninterruptible Power supply at each station



- All Ethernet equipment
- Remote Corporate PC's

Station Equipment Cubicles (SEC)

Early in the project, it was identified that the quantity of equipment required at each station was significant and that it would not be appropriate to house the new equipment in wayside location cases both due to the size and environmental requirements due to equipment operating temperatures.

While some stations did have a suitable communication rooms some 36 did not and the SECs were designed to meet these needs. During the design it became apparent that the unit was also tidying up the disparate cubicles at the stations such as ticketing and passenger information and also providing a level of PTA 'branding', where a similar look and feel was available at all station independent of the station.

The SEC houses the following equipment:

- Uninterruptible power supply
- Site Main Switchboard
- Ticket Vending Machine
- Programmable logic controller
- CCTV coax patch panel and PTZ control panel
- CCTV surge diverters
- CCTV matrix switch
- CCTV Codecs (blade server)
- CCTV CWDM fibre interface
- LLPA controller

- PA amplifier
- Audio loop amplifier (for hearing impaired)
- EWIS and line monitor for PA
- Passenger Information Controller
- Audio switcher and prioritiser
- Passenger displays
- Emergency telephone
- Help telephone
- Fibre FOBOT
- Ethernet switch (1GE)
- RJ45 structured cabling panel
- Telecommunication cable and krone frame
- Intruder sensors (2 off)
- In-attendance switch
- Microwave motion detector
- Audible alarm unit
- Writing desk (pull out drawers x 2)
- Test GPO blocks
- Power distribution (per bay)
- Fan and cooling assemblies (by 2)
- Air filters (by 2)
- Internal lighting bank
- External lighting system for illuminated hoods

The SEC design was undertaken as a series of two prototypes and a final production unit. This allowed many of the design and presentation issues to be addressed.

The main design issues taken into account were;

- Easy maintainable and access to equipment
- ACA compliance
- Cable management
- Lighting levels on façade
- Environmental and Temperature control internally
- Tolerance to vandalism and intruder resistant
- Tolerance to power fluctuations

These issues were addressed as follows:

a) Maintenance:

- All devices IP connected and supporting network management and IP based diagnostic tools
- Consistent layout across all units
- Labelling of all cables and equipment
- Patch panels as break-out interfaces (between contractors) to allow testing and monitoring upstream and downstream
- Document drawers and pull out writing tables
- Spare IP connections for test equipment IP phones
- PLC and IP based monitoring of all equipment
- Test GPOs
- Internal lighting
- OH&S

b) ACA compliance and Cable Management:

- Separate comprehensive cable tray system for power and communications cables
- Central bays for communications and outer for power

c) Environmental and Temperature Control

- 2 banks of quad fan assemblies
- PLC control of fans from 25 deg C upwards
- Designed air flows for a max 8 deg internal temperature rise at 40 deg C ambient (external)

- Removable filter assemblies to reduce dust and other contaminants
- Fibre cement backing board insulation
- Temperature monitoring

d) Tolerance to Vandal Attacks:

- Use of checker plate aluminium at kick plate level
- Doors and lower sections reinforced with fibre cement backing board
- Powder coated sections with scratch resistant finish
- Intruder alarms acoustic switches with vandal settings (2 off)
- Microwave motion detector gated with PLC timer to

identify motion out of normal running hours

- Centrally monitored PLC alarms system
- Audible alarm
- Key switches on all doors
- In-attendance key switch
- Use of poly-carbonate signage panels

e) UPS:

- UPS with approximately 20 minute capacity at full rated loads

At locations where a SEC was not installed and on marginal platforms, the existing Passenger Information Module was reworked to provide the same functionality as a SEC and comply with ACA and AS-3000 regulations.

Passenger Information System

The existing PTA passenger information system was dated and prone to poor availability and difficult maintenance, and as a result the replacement of the system was included as part of the works. The decision to undertake this work in-house was taken following a prototyping exercise which confirmed that a simple process of comparing the train timetable to current train locations and annunciating the difference at station platforms was reliable.

The prototype was put into production and rolled out on the complete network. This resulted in a significant improvement in availability, accuracy of information and, reporting on operational performance and maintainability.

The system was enhanced to include an automatic announcement system (AMS) to allow operational staff to preset announcements and profiles for annunciation. The profiles allow announcement to be scheduled by time of day, by run type, by external stimulus (such as train lateness exceeding a threshold), and the like. The AMS was used extensively during the network outages for the new Mandurah railway and the introduction of the Thornlie spur which changed the platform usage at key stations. It allowed the operator to keep the travelling public informed about service availability, platform use and changes as they occurred.

The passenger information system is integrated with the LLPA and the station audio loops for the hearing impaired and operators can direct messages to only one output, all outputs and combinations thereof.

Electrical and Lighting

The original PTA station lighting technologies were largely sodium and mercury vapour lighting which provide a low colour temperature (yellow) and these are generally unsuitable for CCTV. As such, the project included a major electrical and lighting upgrade for the majority of the network. In many instances, the existing electrical installation was life expired and the project was required to both upgrade the lighting and the electrical services to the station.

A lighting design guideline was formulated based on the Australian Standards, Disabled Access Standards and project requirements. PTA standardised on a colour temperature of 4000°K (white) and 'type' approved a number of fittings based on suitability, product life, ease of maintenance and cost.

The lighting works largely undertaken to ensure good CCTV coverage and quality at night, also provides a level of comfort for waiting passengers due to the improved levels and even coverage.

Station works required new conduit system in most cases and this involved extensive civil works at platforms. The work was done during normal train operations and significant effort was put into ensuring safety for rail operations contractor personnel and the travelling public. In general most stations were completed in 2 halves where one half was closed, barrier'ed and excavated at a time. This involved daily co-ordination with train operations to ensure the longer trains were stopped at the correct locations to avoid passenger alighting in the construction area.

Due to the level of disturbance to platforms, the project team ensured that all such work was included in a single work programme at each station. This included:

- Electrical and communication conduits and pits
- Remedial works on shared pits
- SmartRider ticketing conduits and footings
- SEC and PIM footing
- Audio loop conduits around shelters
- CCTV footings
- New lighting columns
- New switchboards and transformers

CCTV Installation

At the commencement of the project PTA had limited CCTV cameras installed. The philosophy at that time was to provide general views only and this was common across most rail companies in Australia as well as other industries. In the initial planning, it was determined that general views would not meet the overall objective of the project and as such, it was decided to use controlled PTZ cameras extensively and also to provide an alarms driven system to allow a small number of CMR operator to effectively monitor a large number of cameras. At that time, PTA was actively co-ordinating with the WA Police and it was decided that the philosophy would use fixed narrow views of all entrances to effect an 'ident' view of all persons entering the rail network. In this way, post event analysis could provide WA Police with evidence of place and time.

This philosophy has more recently been endorsed by security agencies following the London bombings and other major acts of terrorism, but was introduced by PTA before these events.

Monitoring locations at each CSA office and at selected centralised locations such as the PTA Train Control Centre and the Security offices were included to ensure that the maximum number of 'eyes' were looking at the coverage

General Concepts

Cameras installed have duties as follows:

- Platform and entrance exit cameras – to monitor the general areas on platforms
- Platform PTZ cameras – at selected platforms and locations to allow the security staff to better view the area
- Driver assisted video cameras – to view the perimeter of the platforms and for the vehicle drivers to confirm passenger clearance
- Car park cameras to view the general car park areas

All cameras are streamed to a centralised storage location and are available for viewing in both real-time and historical mode.

The station design ensured that there are sufficient controllable cameras to allow operator to track suspected offender and to explore all areas of the stations.

The cameras are arranged such that each camera can be viewed by a minimum of one other controlled PTZ or fixedc camera to allow vandal attacks and theft to be observed and responded to. As the system is largely alarms driven, the controlled PTZ cameras also respond to the camera and cubicle alarms and the emergency help point around the station.

Platform controlled PTZ cameras

PTZ cameras are installed at all bus interchange and terminal stations and at other selected strategic locations where good platform coverage is deemed as required.

Platform Indent cameras

Platform ident cameras have a controlled field of view to, typically 1,8m wide at the point of interest. This allows views with a high level of detail of head and torso for all persons entering a railway station.

Some 600 plus cameras are currently available on the system distributed as follows:

Line CCTV Totals	Total Camera Count	PTZ Count	Fixed Duty Camera Count	Identification Camera Count
Midland	107	42	38	27
Fremantle	132	46	35	51
Armadale	180	69	52	59
NSR	154	48	62	44
City Area	66	22	24	20
Totals	**639**	**227**	**211**	**201**

The analogue CCTV transport utilises a dark fibre interfaced. For the fibre rich areas the system is a point to point connection. For the fibre poor areas, CWDM multiplexing technology is used in an add/drop arrangement.

Digitisation is done by field mounted Codecs utilising MJPEG compression to avoid the latency and interframe dependencies of the MPEG-2 or MPEG-4.3 standards. All digitised images are transported across the Gigabit Ethernet network and recorded centrally.

Analogue switching is done by a distributed CCTV matrix switch which handles 384 inputs switched to 64 outputs. This is currently being examined for an upgrade. The inputs are arranged such that 8 channels are assigned to larger stations and 4 to smaller.

Case Studies

There have been approximately 1000 arrests arsing from the CMR footage and these include many serious incidents. These are held in secure storage with privacy and legal issues preventing the viewing of incidents unless they are in the in public domain

Because of these reasons incident footage cannot generally be released. One incident however was released to the media and this is included on the CD (incident (a) below) as an example of the capability and effectiveness of the system.

Other recent examples are described below.

a) Carlisle bashing of Asian students

A group of youths attacked two Asian students in an unprovoked attack during the evening of 8th April 2005 The youths were picked up on the Station CCTV and the CMR operators responded by calling the Railway Police. All offenders were arrested and charged by police the following day. One of the attackers handed himself in following the televised footage of the incident on the local news; citing that he seen himself on TV. A grandmother of one of the youths wrote to the local papers after seeing her grandson on TV.

b) Kelmscott small axe attack

A man waiting for a train was attacked by two youths brandishing a machete or small axe during the evening of 18th March 2006. CMR operators observed the incident and responded by using the PA. The victim cited the prompt action of the control room operator as the major reason why he lived.

Conclusions

The project involved $27 million of capital expenditure and was carried out over a 4 year timeframe. Despite many uncertainties and risks at the time of conception the project was completed on time, on budget, allowed for growth of the Perth rail network and caters for future adoption of intelligent CCTV software technologies such as automatic facial recognition. It has exceeded all expectations of its success and placed the PTA and Western Australia at the forefront of the use of this technology in a worldwide sense.

The recent COAG CCTV Working Group National CCTV Code of Practice draft is modelled on the work of this project and is to be adopted Australia wide by the mass transit industry. It is also being adopted by other federal agencies such as Customs for use at airports and other customs locations.

The success of the project has had a significant impact on the safety on the public transport systems and has halted the declining perceptions of feeling unsafe while travelling on the system. Further work is planned with integration of the system with bus ports, and caters for real time images from within the trains when the communications technologies make this an economic and reliable.

The system has contributed to the significant increases of patronage on the rail network with consequent benefits to the wider community.

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Cisco Systems – Ethernet network equipment
AXIS – Digital CCTV Codecs
NKF – Analogue CCTV fibre transport
Jacques Electronics – LLPA equipment
Dell – CCTV Servers
IBM – LLPA Servers
Infotrend – CCTV Storage Arrays
Powerware – UPS systems
MGE – UPS Systems
Modicon / Schneider Electronics – PLC systems