An Advanced Command, Control and Communication (C3) Solution for Transit Systems

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Abstract

This paper presents an Advanced Command, Control and Communication（C3）Solution designed for modern railway applications.

It briefly describes the advances in the control room solution for the transit applications, and compares the conventional Supervisory Control And Data Acquisition（SCADA）type solution deployed in older transit system's Control Rooms with the Operation-Centric focus in the integrated C3 solution, and its adoption of state-of-the-art multimedia IP communication infrastructure as its converged backbone, and IP（IP）-enabled devices.

It also explains the proposed system configuration, system functionality and the benefits of such an integrated approach.

Key Words：GUI, IP, IT, CCTV, PA

現代化捷運及軌道系統所需之指揮、控制及通訊的 C3 解決方案

摘　要

本文提供設計現代化捷運及軌道系統所需之先進的「指揮、控制及通訊（Command、Control and Communication）」的 C3 解決方案。

本文主要是討論應用在捷運控制中心的解決對策，並比較舊式 SCADA（Supervisory Control And Data Acquisition，監督、控制及資料收集系統）系統的行控中心與以中央營運爲設計核心的 C3 整合式行控中心的優劣點。C3 整合式行控中心的整合式傳輸骨幹及 IP 設備（IP-enabled devices）是採用先進的網際網路通訊協定 IP（Internet Protocol）多媒體通訊技術架構。

文中亦將提到此一解決方案的系統架構、系統功能和其效益。

關鍵詞：圖形操作介面、網際網路通訊協定、資訊技術、閉路電視系統、廣播系統

1、Introduction

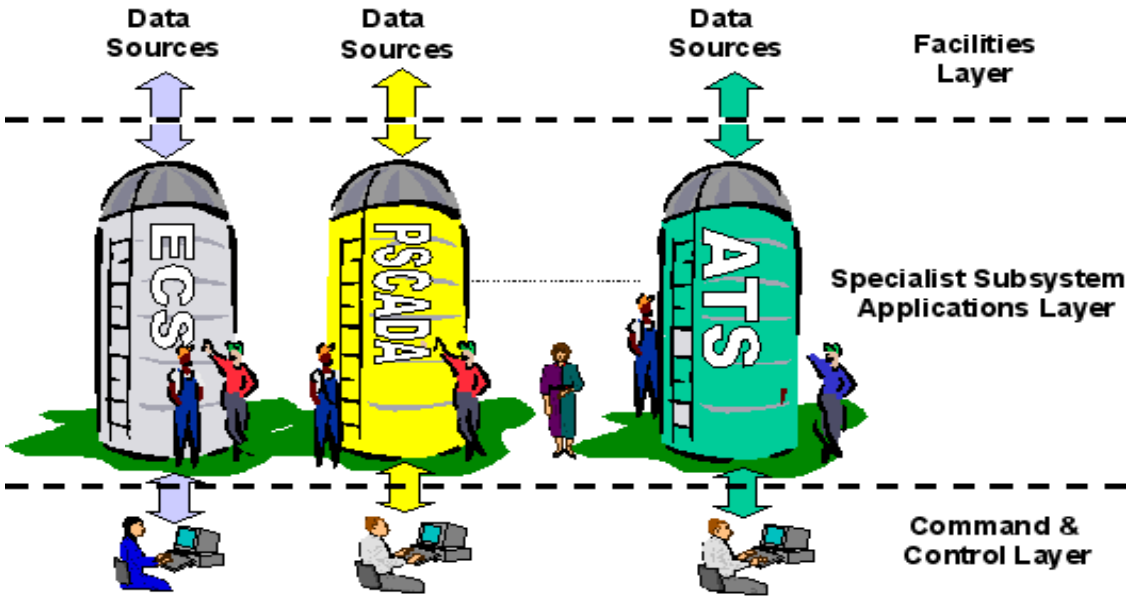
Since the advent of the railway and in line with its traffic growth, devices, systems and processes had been continually developed to allow efficient, cost-effective and safe railway operation. This ranges from the early adoption of hand signaling mechanism, morse codes, signalling equipment, to the fully computerized and automated metro systems of today.

A common thread running through all these developments is the need to gather and disseminate accurate and real-time information for the efficient and safe operation of the railway network. With the rapid advancement of Information Technology（IT）over the last 30 years, the centralized gathering and analysis of information and remote control became a reality.

Nowadays, modern railway control rooms are generally equipped with an integrated supervisory control system for real-time supervision, information gathering analysis and planning. Currently, various solution vendors offer a variety of design and technologies to meet the demands of the market.

2、Trends in Railway Control System Applications

The earliest form of application of IT technology was the deployment of SCADA systems for the supervision of devices and subsystems critical for railway operation; for instance the Power SCADA system, Environmental Control system and the Automatic Train Supervision system. Traditional, these systems are built around specific functional requirements that correspond to the organization divisions typically set up to run the various railway functions. This results in 'silos-type' relationship between the functions and subsystems, where each function is supported by its own system and applications, and forming 'islands of automation' with limited inter-systems communication. Complex administrative and operational processes had to be set up to handle cross-functional issues.



'Silos-like' Unconnected Specialise Subsystems/Applications

As organizations gained experience, and with the constant drive for cost and operational efficiencies, additional demands are placed on IT system for solution. In response, the first generation of Integrated Supervisory Control System（ISCS）was developed to allow the supervision of Electrical and Mechanical facilities from a centralized Control Room, with limited localized supervisory capability at the station level. The Automatic Train Supervision（ATS）System remains a specialized stand-alone system. The typical ISCS c/s configuration would include hot-standby central servers with distributed functional operators' workstations, retrieving and sending data through Remote Terminal Units（RTUs）using slow serial transmission lines. This allows a certain level of information sharing, and automated/semi-automated cross-functional applications. For example, a fire alarm received from a zone can be a trigger to release the emergency escape doors and activation of signages for the rapid evacuation of passengers.

The next generation of ISCS design was developed to meet the challenges and needs of the World's first fully automated, lightly-manned and driverless heavy MRT system. Automation of routine functions, especially in the real-time dissemination of information to, and the interactions with passengers anywhere in the system, becomes crucial. For this, a new multi-media approach needs to be considered. As the demand for information available to the operator increases, the scope of the ISCS expands to include the integration of communication and ATS functions. This, to a large extend, removes the 'silos' effect of earlier generation of design and allows effective sharing and use of information, and certain level of decision support. For instance, a traveling passenger could initiate a multi-media conversation with the operator at the Operation Control Centre（OCC）via the train-borne intercom and the Closed Circuit Television（CCTV）subsystem.

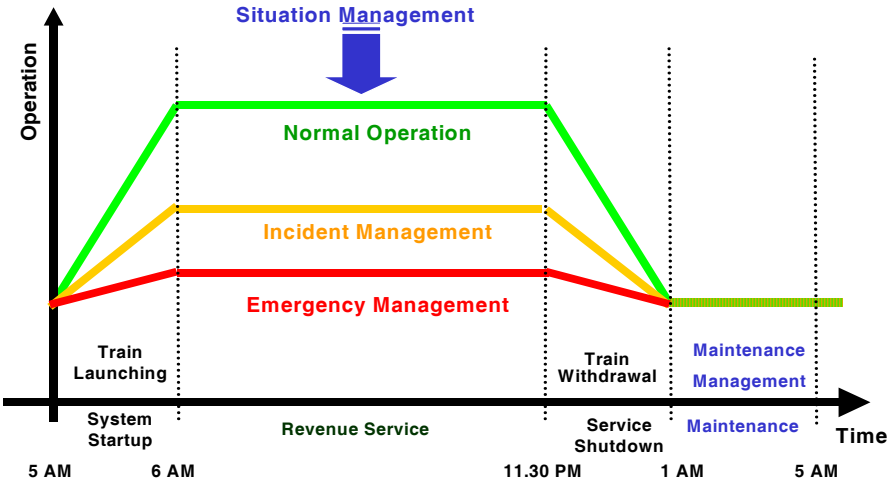
The latest generation of Control Room solution, more accurately termed the 'Command, Control and Communication（C3）System', not only draws on the experiences gained from previous control systems' projects, from both technical and commercial perspectives, but also the re-focusing of railway operational requirements as the primary enabler of the solution. In this respect, more advanced tools are required to provide operation assistance in the control rooms, especially in the management of abnormal incidents.

Recent technological advances in IP communication technology, and IP-enabled devices are incorporated into the design to provide a cost-effective, operation-enabled 'one-stop' solution to meet the command, control and communication, and maintenance requirements of modern railways.

In a nutshell, the C3 integrated system concept provides the framework for the unrestricted sharing of data, and business processes among any connected systems and applications, and various data sources in a typical railway operation. It also provides a standardized and unified product approach for efficient and cost-effective implementation of a comprehensive command, control and communication solution for railway systems. Within this framework, Singapore Technologies Electronics is able to offer an advanced solution named OASYS C3 Solution to cater to the demands of modern railway operators.

3、Transit Operation Model

A typical rapid transit railway 24/7 operation can be illustrated below:



Typical Railway Operational Model

Generally, over the 24/7 period, the railway operation goes through various phases; from line start-up, train launching, revenue service, train withdrawal, to maintenance management. Each of these phases requires specific operating procedures and supporting systems/applications to ensure a safe and efficient outcome.

In particular, the control operator will need to react promptly, effectively and accurately to various operational situations（incidents or emergencies）to minimise adverse impact on service availability and inconvenience to commuters. These incidents could be any situation ranging from equipment failures, 'brown-outs', 'track intrusion', to 'train on fire' situations.

In a well-designed and managed railway system, the frequency of such situations is normally low, and regular simulated drills are conducted to familiarize operators managing them. Drills generally are unable replicate all the possible scenarios, and the tense control room environment during such situations. The possibility of catastrophic human failures in managing such situation could not be ruled out.

Operation-enabled advanced control systems are required to meet these challenges. New tools have to be developed to provide operation-assistance to the operator, in addition to its basic supervisory functions.

The advanced integrated C3 solution proposed here is designed with these operational needs taken into consideration, particularly in emergency situation management. A situation management tool is developed to allow the railway operator to configure pre-defined situation management scenarios unique to its operation as a real-time operational aid. As mentioned above, with this integrated C3 concept, it is possible to design complex cross-functional business processes between interconnected systems to handle a broad range of situations in a consistent and controlled manner. This is especially useful in handling situations that are non-routine in nature and very infrequent. Traditional 'silos-like' control system would not be sufficient in this respect.

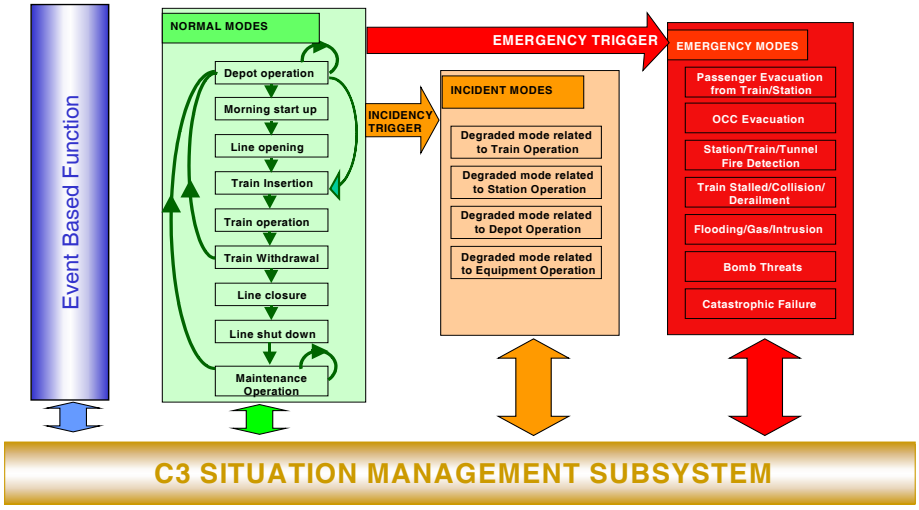
The OASYS C3 Solution is designed to support the following situations：

Normal Mode：　Normal service startup, revenue operation and service shutdown with no major disruption.

Incident Mode：　Occurrence of incident that does not result in major service delay or injuries. For example, train-stalled in tunnel.

Emergency Mode：　Occurrence of an emergency situation that causes major service delay or serious injuries. For example, 'train-on-fire' in tunnel.

This is illustrated in the following diagram:



Situation Management Support

The Event-based function of the OASYS C3 System provides basic real-time basic supervisory control functions like alarm/event management, basic controls, trending, data management etc. In addition, it also supports multi-media functionality through its IP-enabled communication platform.

Operation assistance function is provided during various modes of operation; Normal, Incident and Emergency management.

4、System Configuration

4.1　System Overview

The OASYS C3 solution is designed to operate from the Operation Control Centre（OCC）, the Depot Control Centre（DCC）and the Passenger Stations（STN）; a typical requirement for railway system. In addition, other supporting subsystems（Testing and Training Systems etc.,）can be set up.

At the OCC, the C3 solution provides the control room operators with real-time command, control and operation support functions over the entire railway line through the multi-functional Operator Workstations（OWS）and the Overview Display System（ODS）. The Graphical User Interface（GUI）on the OWS and ODS provides the operator with animated symbols, icons, schematics, textual and adjustable annunciation for efficient and effective operation. All supporting communication functions（data, voice and video）are available to the

operator.

At the Depot, the C3 provides similar functionality within the confine of the depot area.

At the Passenger Station, the C3 has the same functionality of OCC within the confine of the station and adjacent sections.

These logical entities operate as an integrated whole through the high speed IP Communication network that serves as a multi-media platform for voice, video and data transmission through the railway system.

4.2 System Components

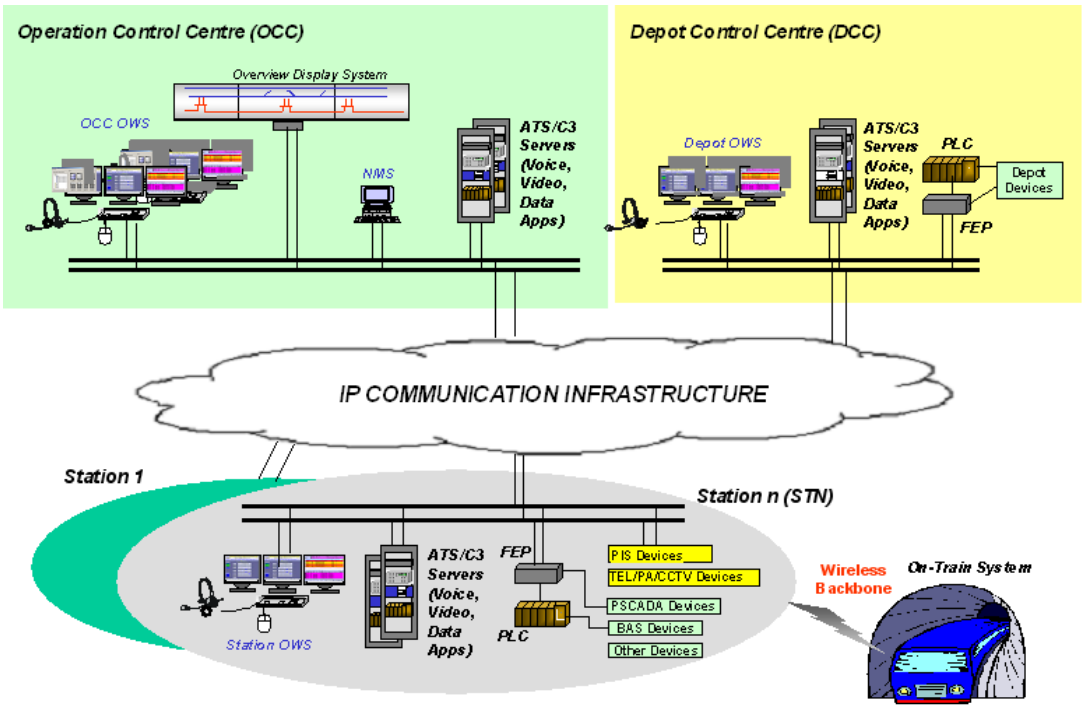
The OASYS C3 solution comprises the following primary components necessary to perform the C3 functions:

- Application/Database Servers
- Operator Workstations
- Overview Display system
- Printers & Peripherals
- Front-End Control & Data Acquisition Equipment for facilities management（Power, Environmental & other services）
- IP Railway Communication Infrastructure
- IP Video（CCTV）subsystem for CCTV function
- IP Voice PA（Public Address）subsystem for PA & Telephony functions
- Radio/Wireless subsystem
- IP Traveler Information subsystem
- IP Access Management subsystem
- Integrated On-Train subsystem
- Integrated Maintenance Management Subsystem（MMS）

In addition, the ATS functions are also integrated operational within the common OASYS C3 framework for a unified Graphical User Interface（GUI）experience.

All these components integrated through the IP backbone provide a comprehensive set of functionality for railway operation. As may be noted, functions like power scada（PSCADA）, building automation system（BAS）and communication subsystems（CCTV, PA, Telephony etc.）traditional provided by different vendors are now part of the OASYS C3 solution to allow overall optimization of the design from a operational perspective, and minimize cross-functional barriers thus enabling complex operational support functions to be implemented within a common platform.

This is illustrated in the following figure：



OASYS C3 Solution Architecture

5、System Functionality

5.1 Overview

The OASYS C3 Solution is an integrated command, control and communication platform developed for the transport industry. It provides easy to use graphical user front ends, and reliable server back ends to communicate with, and monitor, hardware in the field.

Additionally, it provides a central repository for system wide alarms and events, planned response mechanisms to streamline activities in the event of an incident, and collection of statistical data for later analysis.

It is made up of 3 primary types of software components:

◆Graphical User Interfaces（GUIs）

◆Application Specific Agents

◆Core Components

Graphical User Interface（GUI）

GUIs are run on operator workstations and provide an operator with a audio-visual view of the

railway system. They can include standardized screens or custom GUIs for project specific components.

Application Specific Agents

Agents are server side processes that integrate various subsystems and devices into the OASYS C3 solution. All Agents implement a interface that allows other applications to query the state of devices that the agent has access to and make requests for state changes on those devices. Agents implements the business logic and conversion to the particular protocol required to communicate with other subsystems.

Standard Core Components

At the core of the OASYS C3 solution are the standard components necessary for the implementation of the basic functionality. These core components are responsible for:

- launching GUIs
- the data configuration
- the archive function
- the basic and group remote control general mechanisms
- the alarm management function.
- the event management functions
- the severity levels
- the time schedule programs
- the trend logging functions
- the system security
- the avalanche filtering function

5.2 Operational Functionality

The following briefly describes some of the basic functionality necessary for the control room operation.

5.2.1 Alarm Manager

The Alarm Manager is the primary user tool for viewing the detailed status of the system. It displays all the alarms currently active in the system, giving the user a number of options for dealing with the alarm condition.

5.2.2 Event Viewer

The Event Viewer provides the user with an overview of system activities. The list of events can be filtered and sorted to only display events of interest.

5.2.3 Schematic Viewer

This system is responsible for the monitoring and control of various devices present in the system. Data received from devices allows the system to determine that state of a given device, while control information can also be sent to devices.

5.2.4 Trend Viewer

The Trend Viewer is used to generate graphical plots of statistical data that has been collected by the system.

5.2.5 Network Status Viewer

The Network Status Viewer is a graphical representation of the systems being monitored by the system. It uses a colour-coded display to indicate when systems are or are not contactable.

5.2.6 Configuration Editor

The Configuration Editor is the central point of configuration for the system. It provides a graphical representation of the configuration database, allowing the engineer to configure the system without knowledge of the database schema.

5.2.7 Archive & Backup Manager

The Archive & Backup Manager is a single location from which all backup and archive activities can be carried out. It provides scheduling capabilities for both backup and archive, selective archive and restore, and manually initiated backup and archive.

5.2.8 Report Manager

The Report Manager is used to select and run operator's reports using pre-defined templates.

5.2.9 Incident Viewer

The Incident Viewer is used to manage and track the progress of given incidents. It allows operators to group alarms and events with their corresponding incidents, as well as record further details for each incident.

5.2.10 Passenger Information System（PIS）Manager

The PIS manager controls the display of message to the appropriate display units in both stations and trains. Messages can be free text or selected from a pre-defined message library.

5.2.11 Display Manager

The Display Manager is used to control the switching of CCTV images to the available video monitors, to select video wall layouts, and to change the applications displayed in application display areas.

5.2.12 Telephony Manager

The Telephony Manager provides the operator software control of the telephony subsystem. It includes the ability to access the telephone directory, monitor telephony resources and operator activity, and access common call controls, such as hold and forward.

5.2.13 Radio Manager

The Radio Manager provides the operator software control of the Radio system. It includes the ability to access and modify the online radio directory, as well as the ability to monitor and manage the radio system, and to also communicate using the radio system.

5.2.14 Public Address Manager

The Public Address Manager provides the operator software control of the Public Address system. It includes the ability to configure the system, as well as the ability to monitor and manage the system resources. The operator is able to broadcast music, pre-recorded, or live messages, there is also the ability to record new messages for broadcast.

5.2.15 Automatic Train Supervision Function

The Automatic Train Supervision（ATS）Agent provides access to the ATS system. Through this interface, the ATS functionality is embedded within the C3 system to allow a common HMI（Human Machine Interface）to be used.

5.2.16 Maintenance Management System Agent

The Maintenance Management System（MMS）Agent is responsible for monitoring the status of equipment and interfaces, and generating job requests.

5.2.17 Access Management Subsystem Manager

The AMS Manager provides the operator software control and the ability to configure the system, encode the access smart cards, generate 'blacklist', 'access-list' as well as the management of system resources.

5.2.18 Situation Management Subsystem

This subsystem is responsible for the creating and executing pre-defined plans corresponding to various scenarios in support of operation.

5.2.18.1 Plan Viewer

The Plan Viewer provides the user interface to allow the general system control and management of incident plans. Plans provide the capability of pre-defining operator responses to common or expected system occurrences, as well as automating day-to-day tasks.

5.2.18.2 Plan Agent

The Plan Agent is responsible for the control and running of plans. It performs the plans that are shown in the plan viewer, and is also capable of running plans (manual, semi, fully automated) in response to certain situations in support of railway operation.

6、OASYS C3 Solution Benefits

The OASYS C3 solution not only departs radically from the traditional 'silos-type' approach taken in the earliest generations of railway control room design, it is also 'operation-centric', and deploys 'state-of-the-art' IP technology down to the primary equipment control layer.

We believe this solution offers the following benefits:

• Better Operation Support

With the integrated concept offered by this solution, cross-functional operation support plans can be pre-defined and implemented in the system for all likely scenarios, including emergencies. For example, in the event of multiple terrorist strikes in metro stations, it would have been possible to manage the situation, through pre-defined plans as it unfolds.

Each of these plans would have pre-determined decision steps to be taken in response to the real-time events that is occurring. This may include contacting relevant government agencies, emergency services etc.

• Uniform Operation User Interface

Unlike older design where different set of hardware and software applications are typically

required in the control room to perform various functions, the integrated operator workstations of the C3 platform allows the use of a common set of hardware and client applications to be installed. Operational function at each workstation is controlled by the rights and privileges accorded to the staff logging in.

This not only facilitates the training and deployment of control room operators, it also simplifies the maintenance process.

• Optimised System Architecture

The lowest layer in the system control hierarchy forms part of the OASYS C3 solution. It would be possible to optimize the design and the use of hardware/application（typically third party Programable Logical Controller（PLCs）etc.,）at this layer in each station. Different functions typically provided by various vendors can now the implemented through a common set of front-end equipment with the removal of the contractual boundaries.

• Lower Operational Cost

With the integrated C3 concept, the reduction in operational costs is both quantitative and qualitative. The measurable cost savings would be in the form of lowered carrying costs of spares, simplified maintenance process and flexibility in the training and deployment of staffs.

With the situation management capability of the OASYS C3 solution, service reliability and safety level are improved. Service disruptions, and its inconvenience to the traveling public, due to incidents or emergencies can be better managed and resolved.

• Lower Project Implementation Cost

The OASYS C3 offers the user a ‘one-stop’ common, control and communication multi-functional solution which removes the contractual boundaries associated with the conventional control system model.

Besides allowing the optimization of system design as mentioned earlier, the solution also simplifies the project implementation process significantly, leading to a reduction in the total project costs.

Instead of multiple teams managing each aspect of the control room subsystems and associated applications along the artificial contractual lines, a multi-disciplinary team can be set up to manage the OASYS C3 solution from a overall design and operational perspective. This not only reduces the level of manpower needed to be deployed by the owner and the contractor, it also lower the risk of subsystems’ incompatibilities, and minimizes the number of contractual disputes associated with large multi-disciplinary projects. Overall the quality of design is also improved.

• Updated Technologies

Besides the operation-centric focus of the OASYS C3 Solution, it also deploys ‘state-of-the-art’ technologies currently deployed on other applications.

The rail system communication requirements of the solution are supported by a IP communication IPC infrastructure that supports multi-media applications. This IPC structure is increasingly used in enterprise network to support voice, video and data transmission. It can not only support the enterprise data processing application functions, it also provides the necessary bandwidth for telephony and video applications support services（video-on-demand, video conferencing, etc.,）required by the employees.

This integrated concept is incorporated in the OASYS C3 solution.

7、Conclusion

Rail transportation is an effective and efficient means of moving large number of passengers between destinations. It is an important mode of transportation in major cities of the world. It is necessary than to ensure that this service can be provided cost-effectively, reliably and safely, and if disruptions or emergency situation do arise, it can be dealt with promptly and efficiently.

The deployment of IT technology in meeting these challenges is therefore one crucial aspect of railway operation. The OASYS C3 Solution draws on the design and experiences of earlier generations of railway control systems, and its modern integrated and operation-centric approach is well placed to meet these challenges.