iESM 2013
Integrated System Assurance Approach for Railway Design, Construction and Operations

Nelson Ng
General Manager – Safety & Quality
MTR Corporation
11 April 2013
We carry 4.9 million passengers every weekday in Hong Kong.
Business Overview of MTR

**Heavy Rail**
- 11 lines
- 84 stations
- 182 KM length

**Light Rail**
- 12 routes
- 68 stops
- 36 KM length

**Bus**
- 17 routes
- 84 stations
- 182 KM length
Our rush hours… …
Business Overview of MTR

Five New Rail Projects are progressing well, which will add 56 km to our network in Hong Kong.

- Guangzhou-Shenzhen-Hong Kong Express Rail Link
- West Island Line
- South Island Line (East)
- Shatin to Central Link
- Kwun Tong Line Extension
Our Vision

“We aim to be a leading multi-national company that connects and grows communities with caring service”
Safety Management Framework

Corporate Safety Policy

Safety of our customers, the public, contractors and employees is an absolute pre-requisite. MTR Corporation is committed to consistently meeting statutory requirements, maintaining a safety-first culture employing management systems to achieve MTR Corporation's safety goals for continuous improvement in safety performance in all aspects of the business.

Safety demands active involvement by all. It is the responsibility and duty of everyone and should be foremost at all times in everything we do. Safety management is the responsibility of each director, manager and supervisor. All employees have a duty to protect our customers, the public, contractors, colleagues and themselves.

Corporate Safety Governance Framework
Our Safety performance is amongst the very best in the world

2 Safety Aspirations

To be amongst the very best in safety performance globally

To be the safest mode of public transport in every place where we operate

Graph: Total Fatalities / Billion Passenger Journeys

Source: CoMET 2000-2010 Data
Only metros with data are listed (* 2009 result)
Hong Kong Safety & Health Regulations

- Mass Transit Railway Ordinance Cap. 556 and Operating Agreement
- Factory & Industrial Undertakings Ordinance (occupational safety & health)
- No local prescriptive railway safety standards
- Adopt UK and other international safety and risk management principles and good practices

ALARP Principle
As Low As Reasonably Practicable

Driving for Continuous Improvement
“Risk Management” & “System Assurance” are fundamental elements of our SMS to drive continuous improvement.
MTR System Assurance Framework

Project Phase
- New Railway Lines
- Interfacing Works

Day-1 Operation
- Operating

Operations Phase
- Maintenance
- Asset Modification
- Asset Replacement

Building & Maintaining
Fit-for-purpose Assets

Reducing Risks to
ALARP

ASSET LIFECYCLE
- Design
- Construction
- Commissioning
- Handover to Operations

RISK CONTROL
- Identify & Evaluate Risks
- Register Risk
- Propose controls
- Implement Controls
- Update and review
MTR System Assurance Process

Organizations

Key Processes

System Assurance Plan & Specification
- SA / RAMS Analysis (HAZOP, PHA, FMECA, FTA, ETA, QRA, DSA, CCF, SIL, MRA, DSC, Human Factors, PHL)
- Design Control (SCS)
- System Safety Report

Risk Identification & Control (ASRISK)
- Risk Identification (R1 to R4)
- Maintenance Control of SCI
- Risk Control Performance
- Risk Scenarios Review
- Operational Control of SCO
- Precursor Monitoring
- Operations System Safety Assurance (OSSA)

Operations System Assurance
- Integrated SA
- HAZOP
- RCM
- PHL
- Risk Assessment
- Value Assessment V1 to V4
- Design Control SCS
- Technical Safety Assurance
- Independent Safety Assessment
- System Reliability Modelling
- Software & Integrity Assurance

Project Phase
- New Railway Lines
- Interfacing Works
- Asset Replacement
- Value Assessment V1 to V4
- Design Control SCS
- Technical Safety Assurance

Day-1 Operation
- Operating
- Operations System Assurance

Operational Phase
- Maintenance
- Asset Modification
- Operations System Assurance

Enterprise Risk Management (ERM)
Corporate-wide Risk Knowledgebase

Over 3,000 Risk Records, ~60 Precursors and ~600 Safety Critical items (SCI) Used by Operations, New Projects and C&R Works
Project System Assurance Framework (Life Cycle)

Particular Specifications
Definition / Specification

Contract Award
Tendering

Design Completion
Design

Construction / Installation

System Validation
T & C

Revenue Service
Trial Running

Operation / Maintenance

Requirement analysis and specification

Project Hazard Log

Safety Analysis (if needed)

Validation and Verification

System Safety Report

Operations Hazard Log
Risk Identification (Project Phase)

Reference hazard log sent to contractor for review

Contractor to:
- review the reference hazard log
- conduct hazard identification exercises e.g. HAZOP, PHA, etc.

Contractor to prepare the contract specific hazard log

Contract Specific Hazard Log

System Assurance (SA) Team to conduct risk assessments on specific issues, as raised by designers, construction team, or Operations

Contractor to review the hazard log at various project phases
Risk Identification (Project Phase)

Bottom-up Approach

Top-down Approach

High Level Hazard Records

Project Specific Issues

• Interface with operating railway
• Software cut-in
• Unattended Train Operation
Risk Identification (Project Phase)

- Top Events (Major Hazards)
  - Collision
  - Derailment
  - Fire
  - External Factors
  - Others....
A1. Suspension system failure
A2. Bogie structure failure
A3. Broken axle
A4. Underframe equipment drops onto track – **xxx equipment failure**
A5. Wheel failure (e.g. excessive wear beyond limit)
A6. Braking system fails to reduce train speed

B1. ATP Wrong Side Failure cause train overspeeding
B2. Wrong Side Failure of speed indication
B3. ATP failure to detect correct point position
B4. Point moves when train berthing above the point

C1. Defective switch or crossing
C2. Undetected broken rail
C3. Broken clips or mounting failure
C4. Track twist
C5. Incorrect track profile
C6. Materials left or object fallen from OLE on track
C7. Equipment installation (including OLE, TECS, trackside auxiliary, ...etc.) inside tunnel infringe KE

D1. Signalling Passing at Danger under RM mode
D2. Tunnel structure failure (e.g. concrete spalling from ceiling)
D3. Differential settlement of WIL stations

E1. Advertising panel detached from wall
E2. PSD detached
E3. Equipment installation at platform infringe KE

MTR Corporation
Interfacing Works Risk Management

Works at SHW
Uptrack Temporary Refuge Siding

Works at SHW
Downtrack New Temporary Refuge Siding
Project System Assurance
System Safety Report

• Overview of the operational safety of the new railway system prior to handover to Operations

• Outline the operational safety management tasks undertaken at project phase and planned downstream for future operations

• Provide a summary of the key operational safety issues, that complement the risks to be transferred to Operating Railway
Operations System Assurance

- 5 million people a day
- 99.9 % train reliability
- Any changes could have an effect on its people, organisation, procedure and equipment and overall system performance
Operations Assurance Process

Assure assets are able to perform to the required **Reliability, Availability, Maintainability and Safety** requirements

- Technical Safety Assurance Framework
- Integrated System Assurance Framework
- Software Assurance Framework
- Integrity Assurance Framework
- New Business Safety Assurance Framework

Management and Engineering Assurance Tasks
Risk Management, Independent Check, QRA, FMECA, RAM analysis, Interface requirement, Reliability Centered Maintenance, Cost Benefit Analysis, software V-model, technical audit
Technical Safety Assurance
To assure a safe railway operation

Tasks for assuring safety of O&M activities and modification of asset involving Safety Critical System

- Independent Check
- Incident Review
- Technical Investigation
- Fit-To-Test and Fit-To-Run Certification
- Quantitative Risk Assessment

Tasks for seeking continuous safety improvement

- Safety Alert from other Railways
- Review on International Standard

Operating Railway

Technical Safety Assurance

Benchmarking
Integrated System Assurance

To assure seamless transition with the introduction of new assets and modifications of existing assets

- Life cycle SA - from concept stage through to handover and future O&M

- Tailoring SA activities – based on risk of individual project
Software Assurance

To assure critical software changes are properly done for Safety / Service Critical Systems, e.g. Signalling / AFC
Integrity Assurance

To assure assets are fit for the purpose after years of service

- Technical Audits
- System Reliability Monitoring
- Asset Condition Surveys
Managing Safety Critical Systems and Tasks

**Design Control**

Safety Critical Systems (SCS)
- e.g. Train Wheel & Axle, Emergency Brake and Door System, Signalling ATP / interlocking system

- Competent design staff
- Design and functions verified and validated
- Independent design checks
- Technical audit

**Maintenance Control**

Safety Critical Item (SCI)
- e.g. Train underframe equipment, door control unit, Escalator safety switches, Platform Screen Door detection relays (600 items)

- Maintenance by certified staff
- Safety Independent Check
- Full maintenance records
- Period audits
- Incoming goods inspection control

**Operational Control**

Safety Critical Operations (SCO)
- e.g. Door Isolation, Train Manual Mode operation, Manual operations of points, operation of tunnel emergency ventilation

- Operations by qualified staff
- Safety Independent Check
- Full log book/ records of actions and system affected
- Periodic review/audits
Evolution of Safety Toolkits

- PHA
- HAZOP
- ETA
- QRA
- FTA

System Diagram
Operational Flow Diagram
Risk Model (Scenarios)

Output of OSSA Framework - Example

Key defenses for preventing hazardous event:
- Controls to eliminate/minimize the gap

Key defenses for reducing consequences:
- Controls to warn pax of gap
- Controls to detect pax in gap
- Controls to interrupt Train Movement
- Passenger injury/ fatality

Train stalled in a Tunnel

PAX on incident train
- Acknowledge incident
- PAX inform Tcap of incident thru PAD

TC1
- Acknowledge incident
- Saloon on fire?
  - Yes
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Risk Tree and Safety Critical Items/Precursor Trend

Major Risk Scenarios

Risk Tree

- Derailment
  - Object on / near track
  - Track Failure
  - Staff Behaviour
  - Train Failure

Root Cause

- Coil Spring (Safety Critical Item)

High Consequence Risks

ASRISK

High Frequency Risks

MTR Corporation
A new tool to review adequacy and robustness of key control measures for high consequence scenarios

Review existing, rejected and potential controls

Use traffic light to focus on strengths & weaknesses

Provide an increased level of assurance that risk controls are reducing risk ALARP
Integrating Human Factors with SMS

Incident Review / Safety Process
- Accident Reports (Staff / Contractor)
- Incident / Investigation Reports
- Hazard & Near Miss Reporting
- Change Management
- Job Hazards
- Behavioural Safety Observation (BAPP)

Human Factors Process

Human Factors Issue Register

Recommendations
- Human Factors Reports
- Human Factor Studies

Human Performance Issues & Control Measures

Risk Register (ASRISK)

Human Factors Wheel
(Error Traps Analysis)

Equipment / Environment

People

Procedure

Organisation
Integrating all Risks under Enterprise Risk Management (ERM) Framework

**Top 10**
+ hot spots

**Top 30**

**Enterprise Risks**
E1, E2, E3, E4

**Business Risks**

**Divisional Risks**

**Project Risks**

**Railway Operations Safety Risks**

The Board (Annually)
Executive Committee (6 monthly)

Enterprise Risk Committee (3 monthly)

Business Units (Hong Kong, Mainland China and Overseas)

*Railway Operations Safety Risk is an integral part of Enterprise Risk Management*
Competence Management of Railway System Safety and Reliability Specialist

E1 Qualification Criteria

<table>
<thead>
<tr>
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<th>RCM Facilitator</th>
<th>SA Practitioner</th>
<th>Human Factors Specialist</th>
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Railway System Safety and Reliability Specialist Qualifications Scheme

E3 Log Sheet of Job Practices for Initial Registration / Renewal of Qualification - RCM Facilitator / System Assurance Practitioner / Human Factors Specialist

Name of Staff:

Name of Mentor (if applicable):

Qualification: RCM Facilitator / HAZOP Facilitator / Risk Assessment Specialist / HF Specialist

<table>
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<tr>
<th>Name of study</th>
<th>Duration (MM/YYYY)</th>
<th>Give a brief of study supporting the initial registration / renewal of qualification</th>
<th>Name of immediate Supervisor and Signature (initial registration / renewal of qualification)</th>
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MTR Corporation

4/17/2013

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Enhancing Platform/Train Interface Safety

- Enhanced monitoring at platform
- Trial of different types of gap fillers
- Additional Platform Emergency Plungers
- Minimising Train/Platform Screen Door Gap and Detecting Trapping
- Bridging the Gaps Standardisation

Reducing Platform Gap
Building Better and consistent HMI

Different Trains
Different Cab HMI

Standardised HMI
- Grouping / Color / Logic
Operating a Safety Critical Task

Environmental System Controller

Passengers will evacuate towards LOF. I will switch on modes KOT 23, LOF 22...

Traffic Controller

Mode Table

Checked OK!

Independent Verification

Computer-aided Decision Support (standalone)

Fully Integrated Decision Support System

Press press Confirm Button to operate selected modes

Prompting by Decision Support System

MDR

DSS (Emergency Smoke Extraction)

KOT-LOF D/T goto LOF

SKM

KOT

LOF

WTS

Note: Exhaust Mode should be operated before Intake Mode

4/17/2013
Integrated System Assurance Approach

I - Integrated & holistic

S - Systematic

A - Asset Lifecycle

ASSET LIFECYCLE

Handover to Operations
Commissioning
Construction
Design

RISK CONTROL

Identify & Evaluate Risks
Register Risk
Propose controls
Implement Controls
Update and review

Equipment/ Environment
People
Organisation
Procedure
Thank you
Have a safe journey