捷運機電系統資產狀況評估 - 方法與程序
Asset Condition Assessment of MRT E&M Systems – Methodology & Process

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Key Direction Limited

成立於**2008**年，本公司擁有經驗豐富之捷運及鐵路系統專家和營運和維護專家，與鐵路相關之重點服務包括：

Formed in 2008 with a pool of experienced experts in rail systems and operations & maintenance with key aspects of railway related service include:

- 鐵路營運與維護規劃 **Railway Operations and Maintenance Planning**
- 鐵路項目投標業務支援 **Railway Tendering Support**
- 鐵路項目成本、項目外加成本和融資方案之獨立評估 / 審查 **Independent Railway Project Cost, Project On-cost and Funding Arrangement Assessment / Review**
- 鐵路項目管理 **Railway Project Management**
- 獨立鐵路安全評估 **Independent Railway Safety Assessment**
- 鐵路系統設計與管理 **Railway System Design and Management**
- 鐵路資產狀況評估 **Railway Asset Condition Assessment**

簡報大綱 Outline of the Presentation

➢ 資產狀況評估簡介
Introduction to Asset Condition Assessment (ACA)

➢ 資產狀況評估之方法綱領
Methodological Framework of Asset Condition Assessment

➢ 資產狀況評估程序
Asset Condition Assessment Process

➢ 個案分析
Case Study

➢ 結論及發展路向
Conclusion and Way Forward

資產管理
Asset Management (AM)

資產管理包括一系列經相互協調之流程及作業，旨在以最少之生命週期成本與最低之運營風險從而達至資產績效之優化。

資產管理涉及資產之總體生命週期，從設計，建造，運營和維護，翻修，更新，以至退役處置。

Asset management consists of a set of coordinated activities and tasks that are designed to optimize the asset performance with minimum life-cycle costs and lowest operational risks.

Asset management involves the asset's whole life-cycle, from design, construction, operation and maintenance, refurbishment, renewal and disposal.

資產狀況評估
Asset Condition Assessment (ACA)

資產狀況評估旨在檢視資產之狀況，並揭示適當之維護及更新措施，以便將資產恢復至與其已使用年期相若之基線狀態。

The asset condition assessment (ACA) is aimed to inspect the condition of the assets, and reveal appropriate maintenance and renewal intervention measures for reinstating the assets to an acceptable baseline condition relative to its age.

- **Different management, methods and managers target the same asset:**

OEE: Overall Equipment Effectiveness
TPM: Total Productive Maintenance

資產狀況評估之介紹
Introduction to Asset Condition Assessment

資產管理

Asset Management

資產狀況評估
Asset Condition Assessment

資產狀況評估之介紹
Introduction to Asset Condition Assessment

資產狀況評估與資產管理之聯係
Linkage of Asset Condition Assessment (ACA) and Asset Management (AM)

資產狀況評估
Asset Condition Assessment:

- "快照" 式資產狀況評估。
  Assessing asset condition at a "Snap shot" in time.

- 了解資產，系統表現及流程對正確決策至關重要 (並為實踐優良資產管理之守則)。
  Understanding the performance of the assets, the systems and processes is essential for proper decision making (part of good AM practice).

資產管理及資產狀況評估之聯係

Linkage of Asset Condition Assessment (ACA) and Asset Management (AM)

資產狀況評估
Asset Condition Assessment:

- 參考因素：
  Factors to consider:
  - 趨勢 Trends;
  - 絕對測度 (高於門檻) Absolute measures (above threshold);
  - 支持預測及相關決策之領先指標 Leading indicators to support forecasting and related decision.

- 專注於重點領域上之有關測量，從而有助於風險管理 。
  Focus on critical areas where measurement can help managing risk.

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資產狀況評估之介紹
Introduction to Asset Condition Assessment

資產管理及資產狀況評估之聯係
Linkage of Asset Condition Assessment (ACA) and Asset Management (AM)

資產狀況評估之優點 (部份為實踐優良資產管理之守則)：
Benefits of asset condition assessment : (some are part of AM practice):

- 能規劃及管理已承諾之服務。
  Ability to plan for and manage the delivery of the committed level of service.

- 避免過早出現資產故障，並提供具經濟效益之裝修/翻新選擇。
  Avoidance of premature asset failure, leaving open the option of cost effective renovation/ refurbishment.

資產狀況評估之介紹
Introduction to Asset Condition Assessment

資產管理及資產狀況評估之聯係
Linkage of Asset Condition Assessment (ACA) and Asset Management (AM)

資產狀況評估之優點 (部份為實踐優良資產管理之守則)：
Benefits of asset condition assessment (some are part of AM practice):

- 與資產故障相關之風險管理，以減輕故障後果。
  Risk management associated with asset failures, and mitigation of the consequences of failure.

- 通過瞭解剩餘資產壽命與資本投入需求，更好地預測未來所需支出。
  Better prediction of future expenditure requirements through understanding remaining asset life and capital investment needs.

- 改善維護及修復策略。
  Refinement of maintenance and rehabilitation strategies.

資產狀況評估之介紹
Introduction to Asset Condition Assessment

一般機電系統資產
Common Types of E&M Assets

- 車輛 Rolling Stock (RS)
- 供電設備 Power Supply Equipment
- 號誌系統 Signalling System (SIG)
- 通訊系統 Communications (COMMS)
- 監控系統 Supervisory Control Systems (SCS)
- 自動收費系統 Automatic Fare Collection (AFC)
- 月台門 Platform Screen Doors (PSD)
- 環境控制系統 Environmental Control System (ECS)
- 升降機及電扶梯 Lift & Escalators
- 電器設備 Electrical Equipment

資產狀況評估之方法綱領
Methodological Framework of ACA

方法綱領
Methodological Framework

硬體狀況評估
Physical Condition Assessment (PCA)

功能狀況評估
Functional Condition Assessment (FCA)

記錄，配置管控及維護組織狀況評估
Records, Configuration Control & Maintenance Regime Assessment (RCMCA)

硬體狀況評估

Physical Condition Assessment (PCA)

對資產之硬體作目視檢測。 目的是從維護需求或一般維護實踐守則內之量化或質量準則來確定關注領域。

To physically and visually inspect the conditions of each asset. The aim is to identify the areas of concerns, using quantitative measurements or qualitative criteria specified in associated maintenance requirements or common maintenance practice.

功能狀況評估

Functional Condition Assessment (FCA)

通過進行功能，系統和操作性能檢測來評估每項資產之功能狀況。目的為確定資產狀況能滿足其所需運作要求。

To assess the functional conditions of each asset by conducting functional, system and operational performance checks. The aim is to identify the asset's conditions with respect to its intended that need to be performed.

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資產狀況評估之方法綱領
Methodological Framework of ACA

記錄，配置管控及維護組織狀況評估

Records, Configuration Control and Maintenance Regime Condition Assessment (RCMCA)

評估維護組織並將過去之維護記錄文檔（例如，過去1年或過去3個維護週期）並與設備供應商提供之操作及維護手冊內之要求進行比較；並評估資產配置是否為最新版本。其目為評估過去維護工作在保護資產狀況方面之影響（正面或負面）。

To assess the maintenance regime and compare the past documentation of maintenance records (for example, past 1 year or past 3 maintenance cycles) with those documented in the O&M Manuals specified by the OEM; also to assess whether the configurations of assets are up-to-date. The aim is to evaluate the impact (positive or negative) of past maintenance actions in preserving the condition of the assets.

總體整合狀況評分

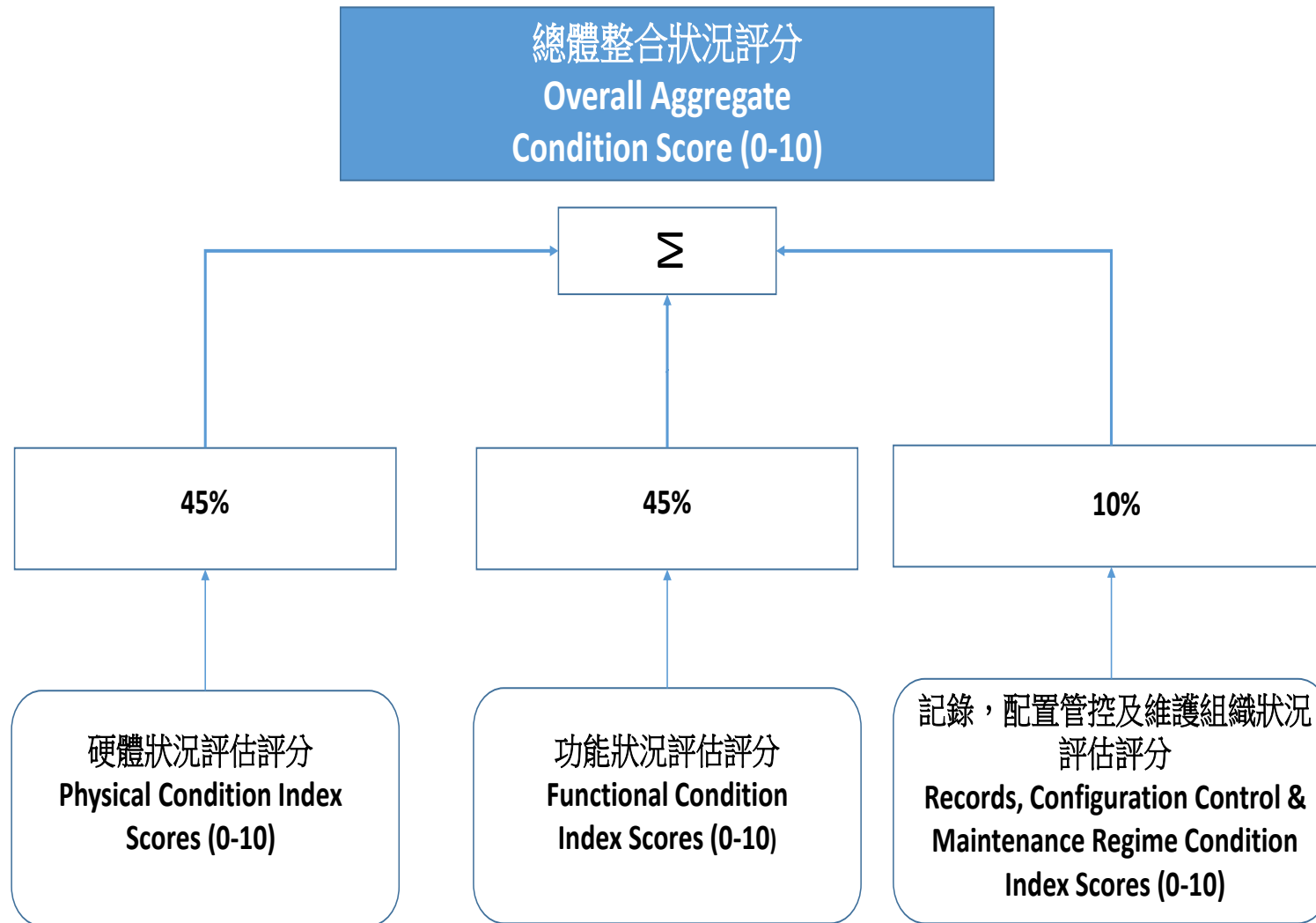**Overall Aggregate Condition Score**

方法綱領中使用之個別評估標準將以零（0）分到十（10）分，對資產進行定量和定性評分，零是最佳分數，10是最差分數。

The individual assessment criteria used in the Methodological Framework shall be quantitatively and qualitatively represented by their respective index scores from zero (0) to ten (10), with zero being the best score and ten being the worst score.

總體整合狀況評分
Overall Aggregate Condition Score

總體整合狀況評分
**Overall Aggregate
Condition Score (0-10)**

∑

| 45% | 45% | 10% |

硬體狀況評估評分
**Physical Condition Index
Scores (0-10)**

功能狀況評估評分
**Functional Condition
Index Scores (0-10)**

記錄，配置管控及維護組織狀況評估評分
**Records, Configuration Control &
Maintenance Regime Condition
Index Scores (0-10)**

總體整合狀況評分
Overall Aggregate Condition Score

Summary Rating	Description	Detail Rating	Condition Index
0	New Asset	0	A new asset or an asset recently rehabilitated back to new condition.
1	Very Good Condition	1	A near new asset with no visible signs of deterioration often moved to condition 1 based upon the time since construction rather than observed condition decline.
2	Minor Defect Only	2	An asset in excellent overall condition. There would be only very slight condition decline but it would be obvious that the asset was no longer in new condition.
		3	An asset in very good overall condition but with some early stages of deterioration evident, but the deterioration still minor in nature and causing no serviceability problems.
		4	An asset in good overall condition but with some obvious deterioration evident, serviceability would be impaired very slightly.
		5	An asset in fair overall condition deterioration in condition would be obvious and there would be some serviceability loss.

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總體整合狀況評分
Overall Aggregate Condition Score

Summary Rating	Description	Detail Rating	Condition Index
3	Maintenance required to return to acceptable level of service	6	An asset in Fair to poor overall condition. The condition deterioration would be quite obvious. Asset serviceability would now be affected and maintenance cost would be rising.
		7	An asset in poor overall condition deterioration would be quite severe and would be starting to limit the serviceability of the asset. Maintenance cost would be high.
4	Required Renewal	8	An asset in very poor overall condition with serviceability now being heavily impacted upon by the poor condition. Maintenance cost would be very high and the asset would be at a point where it needed to be rehabilitated.
		9	An asset in extremely poor condition with severe serviceability problems and needing rehabilitation immediately, which could also be a risk to remain in service.
5	Assets Unserviceable	10	An asset that is no longer serviceable and should not remain in service. There would be an extreme risk in leaving the asset in service.

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總體整合狀況評分
Overall Aggregate Condition Score

例如，通訊系統之比例設定為：硬體狀況評估佔45%，功能狀況評估佔45%，記錄，配置管控及維護組織狀況評估佔其餘10%。

For example, the weightages of COMMS for **Physical Condition Assessment (PCA), Functional Condition Assessment (FCA) and Records, Configuration Control and Maintenance Regime Condition Assessment (RCMCA)** are assigned respectively as **45%, 45% and 10%.**

比例設定是基於資產在捷運營運環境中之硬體狀況，功能狀況和維護表現之相對重要性。

The weightage apportionment is based on the relative importance of an asset with respect to it physical condition, functional condition and maintenance performance within the railway operation environment.

比例設定
Weightage Assignment

硬體狀況評估和功能狀況評估應具備相同重量，基於它們對捷運營運提供同樣至關重要之所需功能。
The PCA and FCA should possess equal weight as both of them are equally critical to deliver the required functions to the railway operations.

記錄，配置管控及維護組織狀況評估必須確保執行適當之維護作業，以便按照資產製造商之要求維護資產狀況。
The RCMCA is required to ensure that proper maintenance activities are performed in order to maintain the asset condition as required by the asset's manufacture.

基線狀況
Baseline Condition

基線狀況
Baseline Condition

基線狀況是與資產已使用年期相對應之"應有狀況",並假設在其生命週期內已進行適當之維護,而該資產亦在其設計條件下運行。

The baseline condition is the 'should be' condition range corresponding to the asset's age, assuming that appropriate maintenance has been carried out during its lifecycle and the asset had been operated within its design condition.

基線狀況應在進行資產狀況評估前確定,以便評估後之資產總體整合狀況評分可與基線值作比較。

Baseline should be defined before conducting an Asset Condition Assessment, so that an asset's Overall Aggregate Condition Score in the assessment can be used to compare the baseline value.
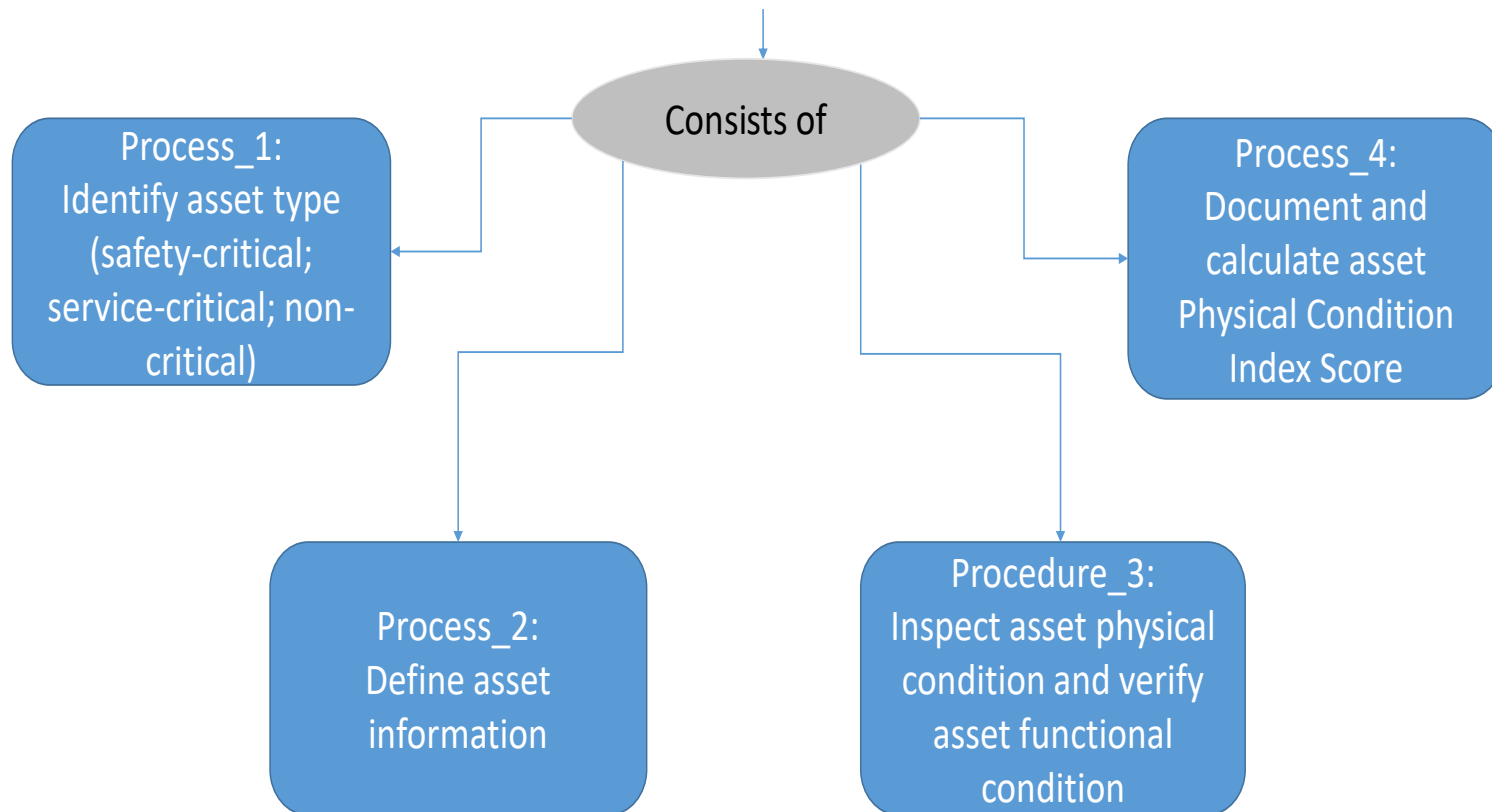
資產狀況評估之程序
Asset Condition Assessment Process

資產狀況評估 (硬體狀況及功能狀況)
Asset Condition Assessment Process (Physical & Functional)

Consists of

Process_1: Identify asset type (safety-critical; service-critical; non-critical)

Process_4: Document and calculate asset Physical Condition Index Score

Process_2: Define asset information

Procedure_3: Inspect asset physical condition and verify asset functional condition

資產狀況評估之程序_1
Asset Condition Assessment: Process_1

程序_1
Process_1:

識別資產類型
Identify asset type
(safety-critical; service-critical; non-critical)

根據其對捷運營運的重要性，識別和分類每種資產的類型。例如：
- 安全攸關
- 服務攸關
- 非攸關

To identify and categorize the type of each asset, in term of its criticality to the railway operations.
For example, each asset can be categorized into:
- Safety-critical
- Service-critical
- Non-critical

資產架構
Asset Hierarchy

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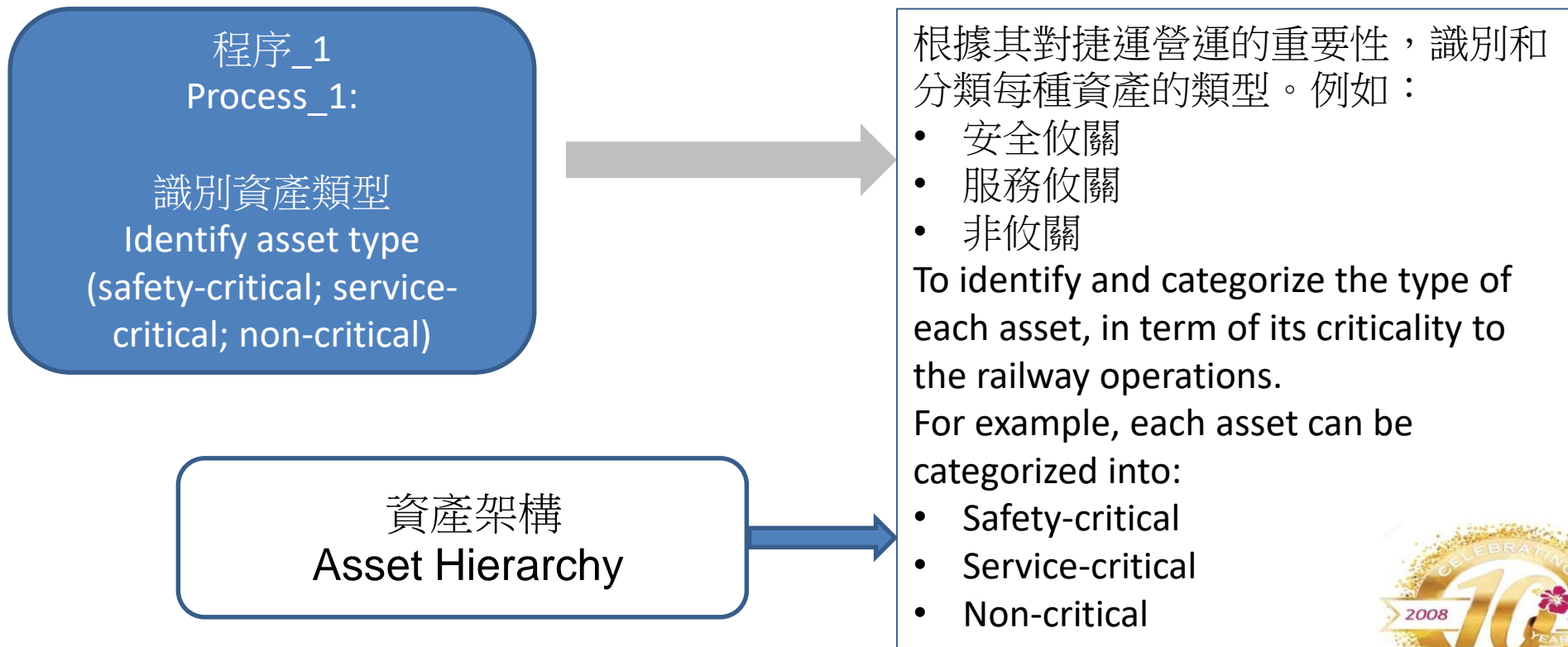
資產狀況評估之程序_2
Asset Condition Assessment: Process_2

程序_2
Process_2:

制定資產資料
Define asset information

制定ACA所需之資料，例如：設備製造商之技術規範，資產生命周期等 To define the asset information needed for condition assessment, e.g. technical specifications from asset's OEM, asset usage life etc.

資料也包括由捷運營運者提供之資料，例如資產編號，資產號型及所在位置等。
Asset information also includes those information generated by the railway operator, such as asset identifier, asset model information and location information.

評估清單
Checklist

資產狀況評估之程序
Asset Condition Assessment Process

資產狀況評估之程序_3
Asset Condition Assessment: Process_3

評估清單
Checklist

目視檢測資產外部／內部狀況，安裝及環境狀況，並檢測資產之功能狀況。
To visually inspect the asset external / internal condition, installation, environmental; and verify the functional condition of the asset.

程序_3
Process_3:

審視資產硬體狀況及檢測資產功能狀況
Inspect asset Physical condition and verify asset functional condition

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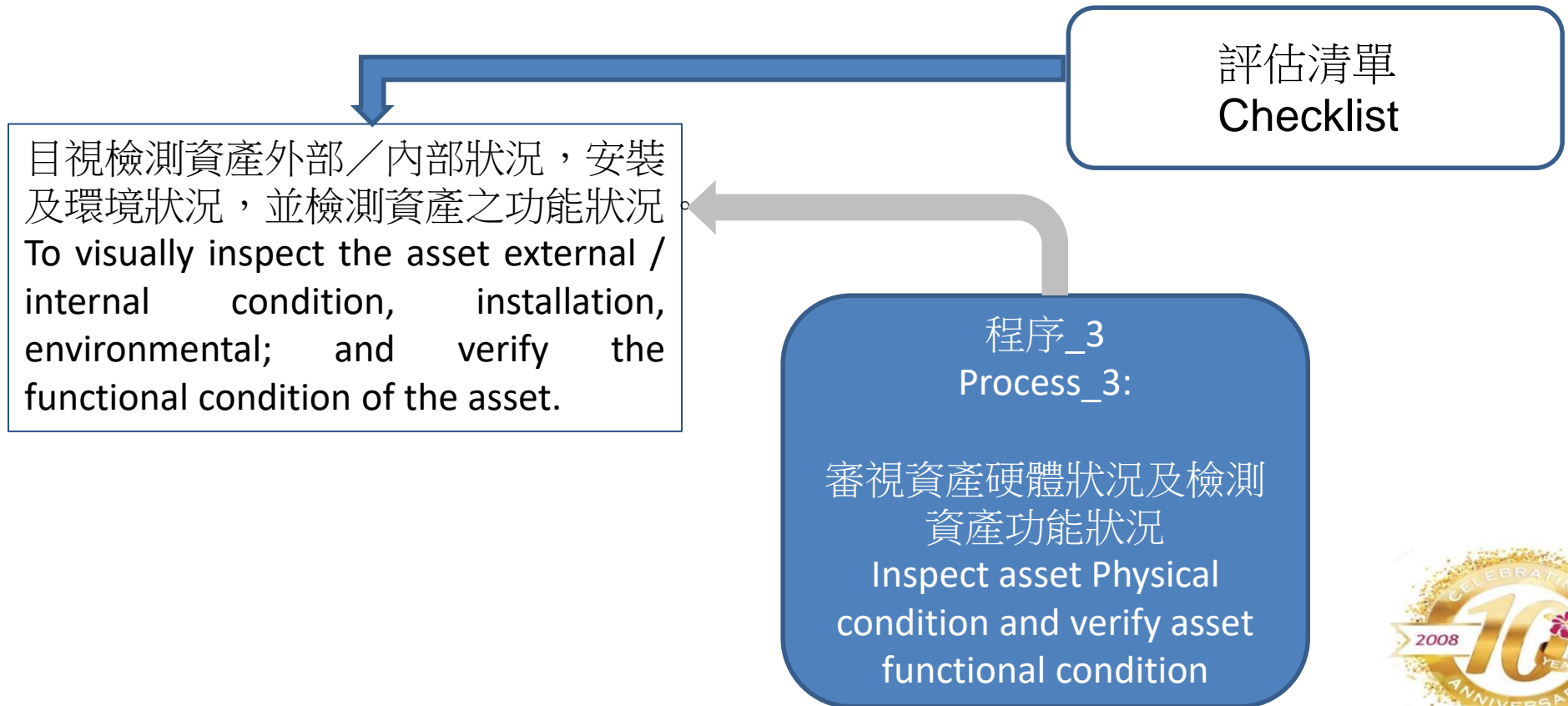
資產狀況評估之程序_4
Asset Condition Assessment: Process_4
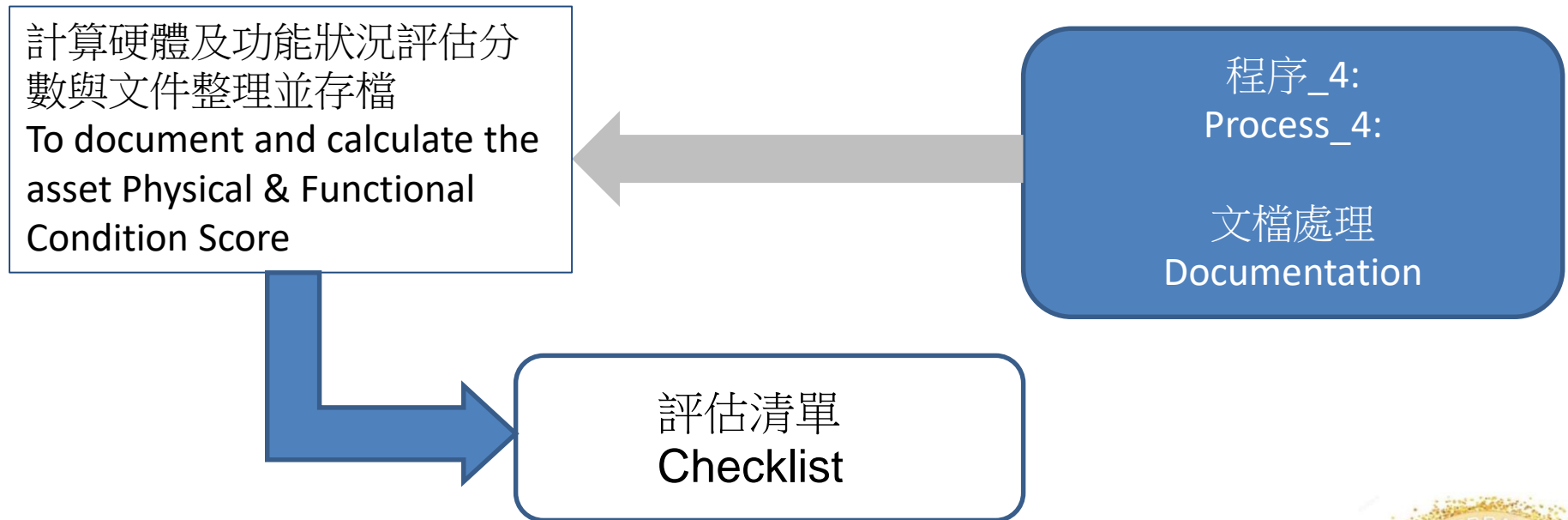
計算硬體及功能狀況評估分數與文件整理並存檔
To document and calculate the asset Physical & Functional Condition Score

程序_4:
Process_4:

文檔處理
Documentation

評估清單
Checklist

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資產狀況評估之程序
Asset Condition Assessment Process

記錄，配置管控及維護組織狀況評估
Records, Configuration Control & Maintenance Regime Condition Assessment

RCMCA

預防及故障維護記錄

Preventive & Corrective Maintenance Records

故障率及故障趨勢分析

Failure Rate and Trend Analysis

維護工作指南

Maintenance Work Instructions

營運及維護手冊

O&M Manuals

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資產狀況評估之程序
Asset Condition Assessment Process

記錄，配置管控及維護組織狀況評估

Records, Configuration Control & Maintenance Regime Condition Assessment

RCMCA

峻工圖

As-built Drawings

維護計劃書

Maintenance Plan

設備報廢

Equipment Obsolescence

培訓計劃及記錄

Training Plan & Records

配置管控

Configuration Control & Management

資產狀況評估之程序
Asset Condition Assessment Process

方法及評估清單制定方案
Development of Methodology & Checklist

審閱方法與評估清單之研討會
Review workshop for Methodology & Checklist

業主審批
Approval granted by the Authority

試點作業
Pilot station(s)

檢討試點作業之後勤安排
Review of the logistic arrangement for Pilot Station

全面執行評估作業
Full-scale implementation

新加坡地鐵及輕軌之資產狀況評估個案

Asset Condition Assessment for Singapore MRT & LRT Network

地鐵及輕軌線路包括：

MRT/LRT Lines involved:

- 東西南北線 North South East West Line (NSEWL)
- 環狀線 Circle Line (CCL)
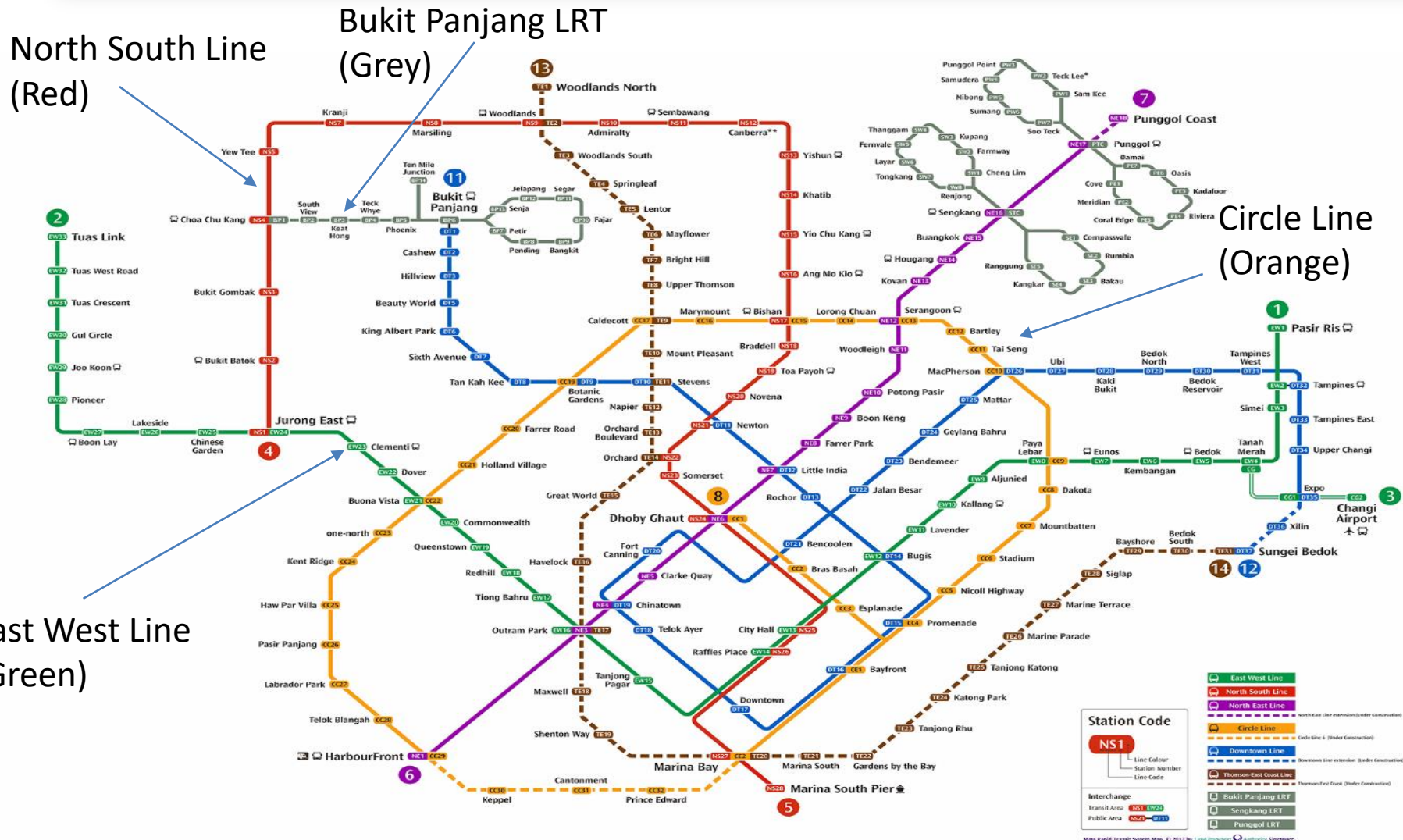- 班吉武讓輕鐵線 Bukit Panjang Light Rail Transit (BPLRT)

執行期

Duration:

- 18個月
  18 month programme

個案分析
Case Studies

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新加坡地鐵及輕軌之資產狀況評估個案
Asset Condition Assessment for Singapore MRT & LRT Network

主要目標：
Key Objectives:

- 達至更高之資產可靠度及可維護度。
  To achieve a better asset reliability and maintainability.

- 應用適當之維護及翻修措施，從而使資產恢復至其已使用年期相若之基線條件 。
  To apply appropriate maintenance and renewal intervention measures for reinstating the assets to an acceptable baseline condition relative to its age.

新加坡地鐵及輕軌之資產狀況評估
Asset Condition Assessment for Singapore MRT & LRT Network

地鐵及輕軌資產包括：
MRT/LRT Asset Groups involved:

- 車輛 Rolling Stock (RS)
- 供電設備 Power Supply Equipment
- 號誌系統 Signalling System (SIG)
- 通訊系統 Communications (COMMS)
- 監控系統 Supervisory Control Systems (SCS)
- 自動收費系統 Automatic Fare Collection (AFC)
- 月台門 Platform Screen Doors (PSD)
- 環境控制系統 Environmental Control System (ECS)
- 升降機及電扶梯 Lift & Escalators
- 電器設備 Electrical Equipment

新加坡地鐵及輕軌之資產狀況評估

Asset Condition Assessment for Singapore MRT & LRT Network

重點挑戰：

Key Challenges:

➢ 路段安排 Track Possession for assets assessment.

➢ 工程及技術資源 Engineering resources.

➢ 資產之基線訂定 Determination of Baseline value for each Asset Group.

➢ 電子記錄表 Electronic Log Sheet

➢ 啟用久遠之資產文檔資料（如峻工圖等）Documentation (e.g. As-built drawings) for legacy assets.

結論
Conclusion

資產狀況評估
Asset Condition Assessment (ACA)

主要目的
Main Objective

資產狀況評估旨在檢視資產之狀況，並揭示適當之維護及更新干預措施，以便將資產恢復至其已使用年期之可接受基線狀態 。

The asset condition assessment (ACA) is aimed to discover the condition of the assets, and reveal appropriate maintenance and renewal intervention measures for reinstating the assets to an acceptable baseline condition relative to its age.

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結論
Conclusion

資產狀況評估
Asset Condition Assessment (ACA)

方法與程序
Methodology and Process

建立資產狀況評估方法前應考量個別捷運系統之屬性及特質，並在評估作業前訂定相關程序，否則，資源定必浪費。

The methodology of ACA must be established and customized according to the nature and characteristics of each MRT system; and processes must be determined before implementing the assessment, otherwise, significant engineering resources will be abortive.

結論
Conclusion

資產狀況評估
Asset Condition Assessment (ACA)

方法與程序
Methodology and Process

開展評估作業前可考慮進行試點評估，已觀效用，並對有關評估程序與文件作微調處理。

Pilot assessment is worth to try, before full-scale implementation. During pilot assessment, processes and documentation (e.g. checklists etc.) can be fine-tuned.

資產狀況評估

Asset Condition Assessment (ACA)

- 資產擁有者要認識資產狀况評估及其重要性。

  Importance of Asset Conditions Assessment must be fully appreciated by the asset owners.

- 推動資產狀况評估概念並強調此概念乃超越傳统維護守則。

  Promotion of the concept of Asset Conditions that is beyond the conventional maintenance practice.

資產狀況評估

Asset Condition Assessment (ACA)

- 利用最新科技並開發輔助工具從而令資產狀況評估作業更有效率。

  Making use of latest technology to develop more advance tools for Asset Condition Assessment, so that it can be done more effectively.

- 把資產狀況評估完全整合至資產管理架構內。

  Fully integration of Asset Condition Assessment into the Asset Management framework.

資產狀況評估
Asset Condition Assessment

簡報完畢

< End of Presentation >

多謝參與！

Thank you for your attention

答問及討論

Q&A and Discussion

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