منتدى دبي العالمي لإدارة المشاريع
DUBAI INTERNATIONAL PROJECT MANAGEMENT FORUM

RTA

Rail Infrastructure Maintenance Management System (RIMMS)

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Introduction

Dubai Metro and Tram systems are critical infrastructure to the Dubai civil society, carrying around 650,000 passengers on an average day. The long-term sustainability of Dubai is closely aligned with a well-functioning transportation infrastructure.

The safe functioning of each of these structural systems in an efficient manner using industry best practices is core to the efficient and sustainable performance of the Metro and Tram systems and the City of Dubai. The sustainable performance solidifies the foundation for continued growth of Dubai as a leading world financial and commercial centre. As the expected lifespan of each of these structural systems extends into multiple decades, the inspection and maintenance activities today have the potential to establish sustainable long-term financial and operational capabilities of the Metro and Tram systems for decades to come.

This sustainability can only be achieved by inspecting, quantifying and predicting the near-term and long-term maintenance needs of these core assets. For this purpose, RTA Rail Agency initiated the project of "Rail Infrastructure Maintenance Management System **(RIMMS)**" aiming to establish and deploy a new maintenance management system that would support RTA in actively managing the long-term sustainability of the civil and track infrastructure of the Metro and Tram to ensure these assets can continue to deliver high, safe and efficient services.

The project started in June 2016 and successfully delivered and deployed in June 2019. This included a trial operation period of 1-year focusing on verification of the system functionalities, training RTA Staff on how to use the system, feeding the system with the rail assets information as well as realization of the system implementation benefits.

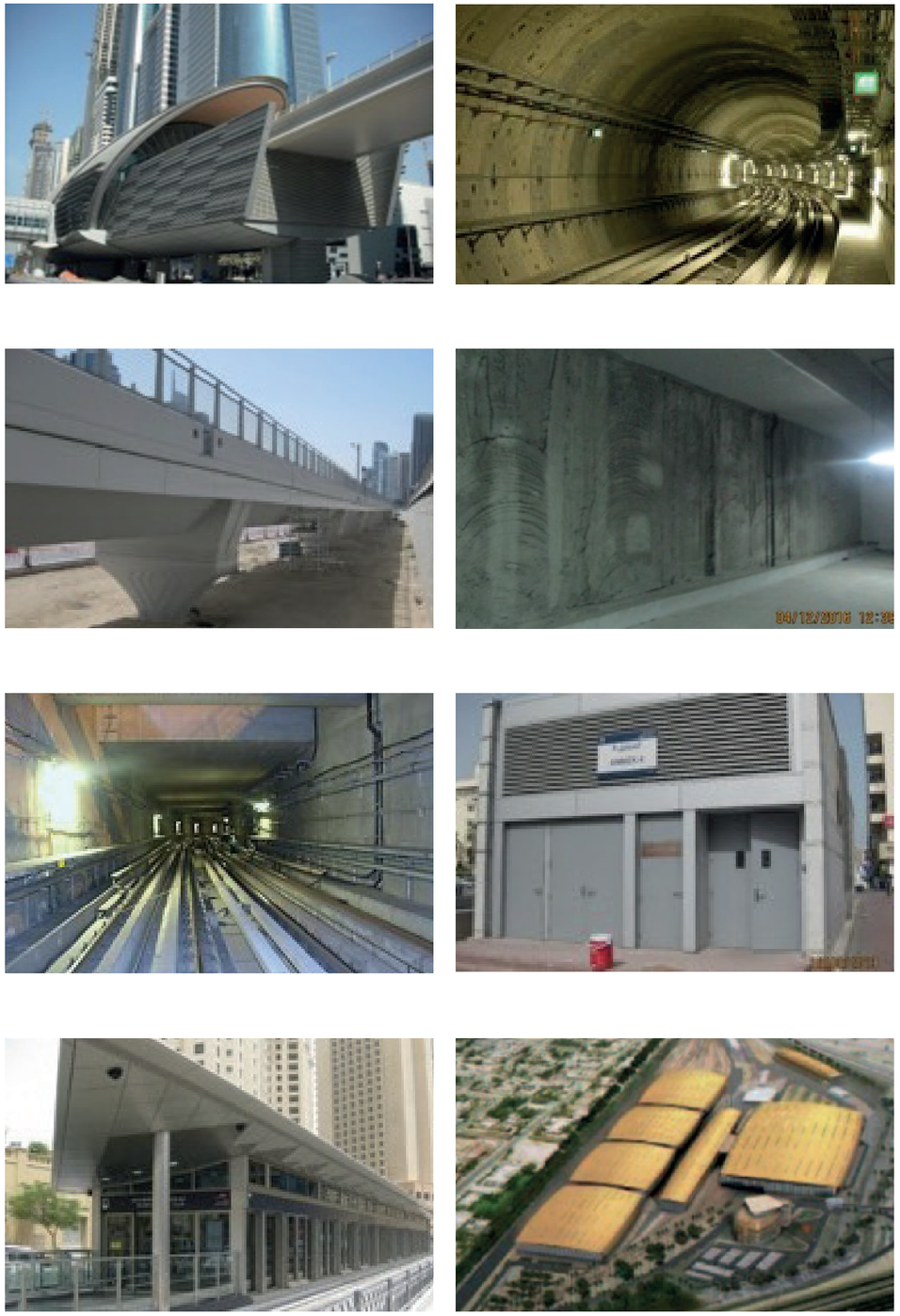

Figure 1: Different Types of Rail Civil and Track Assets included in the RIMMS Scope

02

Challenges in the Previous Maintenance Regime

RTA set an ambitious group of goals and objectives based on a clear and determined vision to be “The world leader in seamless and Sustainable mobility”. These objectives include a continuous endeavour to achieve pioneering in digital transformation, advance RTA optimize the asset life cycle utilization. In line with these objectives, RTA future trends include delivery of digital transformation, 4th industrial revolution, automation and future skills.

As part of this endeavour, RTA carried out a comprehensive and thorough study of the maintenance regimes implemented for Dubai Metro and Tram Systems assessing the effectiveness and efficiency of these regimes based on the best international practices and considering the current and future asset maintenance needs. This exercise included reviewing and evaluating the inspection and maintenance processes and procedures in order to identify the technical and business gaps in these regimes. In addition, a benchmarking with the international asset management practices was carried out through a case study included site visits to the metro systems in Washington DC and New York City in USA.

Although the original maintenance regimes were implemented successfully over the past years (since 2009 for Dubai Metro and 2014 for Dubai Tram) satisfying the asset maintenance needs at the time of the study in 2016, RTA identified a genuine and essential opportunity to enhance these regimes through utilizing the new digital technologies that became available in the market.

Further, RTA identified that the original maintenance regimes provide RTA with insufficient support to address civil and track assets with long deterioration times jeopardizing comprehensive asset condition documentation, live-cycle analysis and capital planning activities.

Gap Analysis of the Original Inspection Methodology and Maintenance Business Process.

Through this analysis, it was observed that the original inspection approach focuses almost exclusively on identifying asset deficiencies which require condition-based maintenance, but without addressing the asset conditions and expected service life. Further, it was identified that there is a loose association between the asset types and the respective inspection needs, between thev inspection needs and associated individual faults and between the individual faults and associated individual maintenance action. This reduces the quality of data collected, the transparency of the inspection process, the repeatability of inspection findings and the ability to support additional asset, condition, maintenance cost or life-cycle cost analyses. In addition, the quality and quantity of the collected data during the original inspection methodology do not support performing asset condition analysis and Life Cycle Cost Analysis (LCCA).

Furthermore, the original inspection approach does not support a real time reporting on the asset deficiencies. Also, the maintenance process allows for a limited evaluation of the maintainer’s performanc and compliance.

Therefore, the inspection process needs to be expanded and further structured to provide more systematic inspection data collection laying the foundation for comprehensive asset maintenance management analysis.

GAP Analysis of the Original RTA Maintenance Management Systems

When the RIMMS project initiated, RTA was using two electronic systems for asset maintenance management as shown below:

- MMS IBM Maximo- deployed in 2010 for Dubai Metro Assets and it is used for scheduling the preventive maintenance (PM) tasks based on the asset maintenance plan table given within the assets O&M Manual and managing the related PM Work Orders. It is used also for management of the corrective maintenance service requests and work orders. The system is fully administrated by the O&M Concessionaire/Maintainer. A separate Maximo System is used for the Tram Assets and it was deployed in 2015.

- sTafteesh which is used to record the site observers and report the same. The system was being used by Rail of Way to report on the site issues related to the assets.

The business process and capabilities of the above systems were analysed. It was found that the main items that can be leveraged from these systems are unfortunately not their IT technical capabilities, as these are already deployed and configured, but the data they contain and the business processes they support. This includes Initial asset data configurations, the maintenance planning tables and the workflow completion statistics from ongoing maintenance activities which are used to generate targeted KPIs.

Further, the above-mentioned original MMS systems which are deployed for Metro and Tram facilities, do not provide the functionalities of mobile data collection, detailed digital documentation of asset condition, automated and integrated reporting, integration and cross system support, and ready ability for further customization and configuration.

In addition, the original inspection and maintenance management systems constrict the RTA's business processes. Also, they significantly limit the overall level of configuration. Furthermore, these systems do not support Integrated Life Cycle Cost Analysis (LCCA).

Required Improvements

Through the assessment process of the original maintenance regime, itwas determined that the effectiveness of the overall technical approaches to inspect and maintain the Dubai Metro Infrastructure Assets needs to be improved. Further, the business and technical practices, manuals and frameworks of the original maintenance regimes can be strengthened to achieve mid and long-term operational and financial sustainability. These improvements are elaborated below.

Technical Inspection Approach:

- Providing field inspectors with more detailed field inspection checklists to evaluat condition of the various asset deterioration modes.

- Digitally collecting field inspection data and employing integrated fault analysis, cost assessment and reporting capabilities to provide a near real-time reporting of inspection and maintenance needs.

- Specifying the location of needed corrective maintenance actions within a 10m accuracy.

- Developing cost estimates for asset deficiencies and future maintenance needs to identify the required level of maintenance financial support.

Inspection and Maintenance Business and Technical Practices and Frameworks

Clearly mapping the inspection needs and items into the specifi case inventory categories.

- Providing guidance for evaluating the condition of the asset inventory items per the specified inspection needs.

- Documenting not only asset condition requiring time-based or condition-based maintenance actions but also assets with active deterioration modes (based on a centralized qualitative condition rating scale from 9 to 1).

- Provide clear guidance for how condition rating factors are aggregated upwards through the asset inventory.

- Integrating a capability of generating digital inspection reports in a timely manner (within an RTA specified maximum time period) rather than over an extended period.

- Providing an independent assessment of the maintainer's performance.

- Documenting the asset's condition and its deterioration rates in order to evaluate the asset performance.

- Identifying if the performed preventative and corrective maintenance will meet or exceed the requirements of the asset design service life.

- Providing a life-cycle cost analysis capability to identify the required mid and long-term financial investment.

- Providing Key Performance Indicators (KPIs) and dashboards to support the maintenance plans and decision-making.

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The Proposed Solution

The results of the benchmarking and gap analysis of the original maintenance regime were leveraged to improve the RTA's overall inspection documentation, maintenance management and life-cycle cost analysis capabilities. It was concluded that RTA requires an integrated information management system that will provide four critical needs to the RTA and as follows:

- Implement a prescriptive and structured inspection protocols and maintenance initiation capabilities.
- Integrate inspection and asset management activities into maintenance management activities.
- Analyze maintenance costs over an asset's lifespan.
- Independently validates and verifies concessionaire activities and investment needs.

Therefore, RTA launched the RIMMS project to develop a new maintenance management system for the Rail Infrastructure Assets (Dubai Metro and Tram) that deals with the asset conditions, service life and integrated with the other RTA asset management systems (MMS Maximo, GIS, eB). The new system will provide RTA with the capability, transparency and structure to efficiently and effectively inspect and maintain the Metro and Tram systems, based on the practices of Reliability Cantered Maintenance (RCM) and Risk Based Maintenance (RBM) Also, it will generate asset health information and support maintenance plans and decision-making.

The project includes establishment of inspection and maintenance structure including asset database, inspection methodology, structured asset assessment process, and development of a rage of analytical modules integrated in a software package to support the assessment, quantification and long-term planning for the Rail Civil and Track infrastructures.

Concept

The life cycle management process, shown in Figure 2, provides the foundation for the asset management process. A typical rail infrastructure asset follows the standard five stage asset management from design through disposal. The rail assets included in RIMMS have an anticipated range of services lives from 10 years to 100 years. While in service, asset data (inputs) flow into RIMMS and provide useful assets performance (outputs) regarding asset condition and the closely related asset health. Asset condition is the primary metric that initiates maintenance, repair, or replacement activities. The budgetary analytics use various constraints including asset condition, asset risk, asset criticality, available funding, and the need for similar maintenance activities within the same facility as constraints to focus the budget prioritization process.

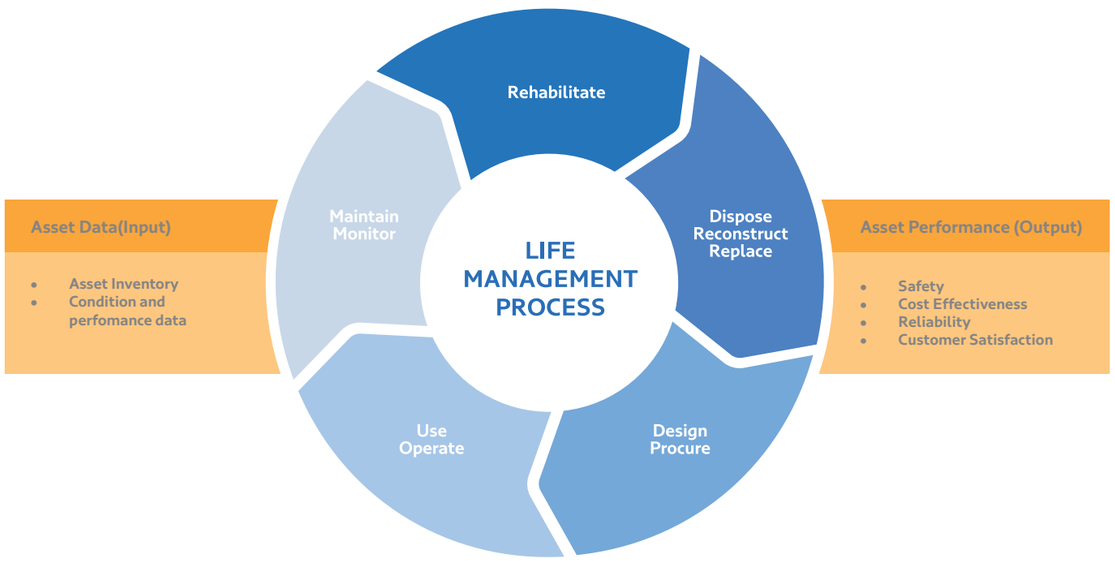


Figure 2: Life Cycle Management Process

Once placed into service, an asset's health (condition) decays over time. The decay may be gradual to follow the asset's intended design life or may accelerate or decelerate due to one or more factors such as level of maintenance, environmental factors (i.e. salt-water exposure), accident, or design / construction variances (i.e. fragile materials in high traffic areas). As shown in Figure 3, asset decay can accelerate and rapidly shorten an asset's useful life which will require higher capital investment to repair/replace the asset.

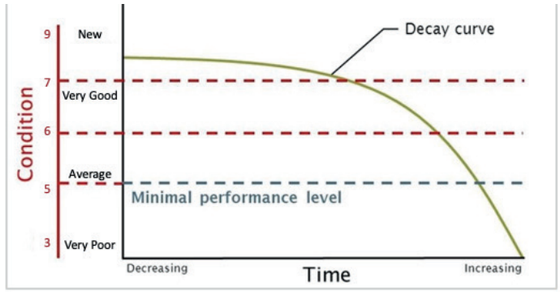


Figure 3: Typical Asset Decay/Curve.

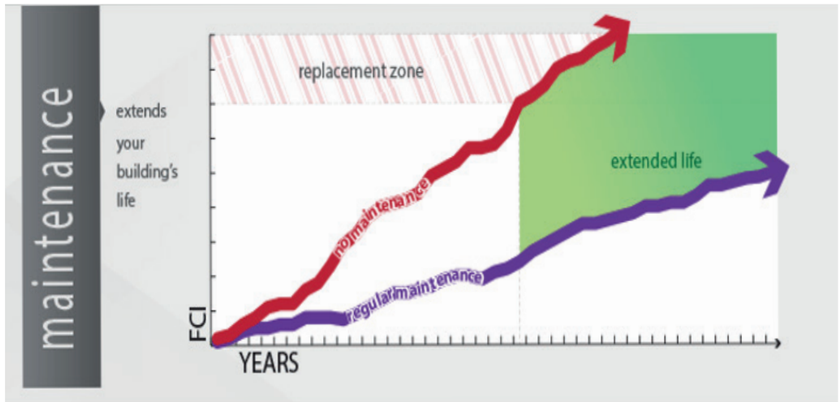


Figure 4: Extend Asset service life with reular maintenance

As shown in Figure 4, the aim of well deployed asset management activities is to delay, forestall or correct the deterioration of an asset's condition over time to extend the asset's overall service life. The RIMMS system is well structured with detailed identification of applicable inspection items and corresponding condition rating rubrics to effectively assess an asset's evolving condition throughout its service.

The core value of active asset management and preventative maintenance is that an asset's performance can be verified and confirmed, and the given asset's life can be extended through the active and moderate level investment in maintenance by extending an asset's life, the eventual asset replacement time is extended, and the replacement costs can be significantly deferred if not avoided all together. This time value of extending the life of these assets results in a significantly reduced present value of future maintenance and gives the system owner with additional information and control over when various maintenance and replacement actions are conducted.

RIMMS Value Proposition

In the original maintenance regimes of Dubai Metro and Tram, RTA deals with the Rail Assets through only the O&M Concessionaire who administrates the Maintenance Management System (MMS) as per the O&M Contract. Although RTA staff have access to this system; in both Dubai Metro and Tram, to view and follow up the maintenance plans, actions and related records, they cannot initiate or process any inspection or maintenance action through the MMS which is fully control by the concessionaire. Whilst, the new system (RIMMS) is fully administrated and controlled by RTA and it enables RTA staff to deal directly with the rail assets through recording the inspection observations, registering the asset faults and assessing the asset condition, providing a capability of independent verification of the asset maintenance needs as shown in Figure 5.

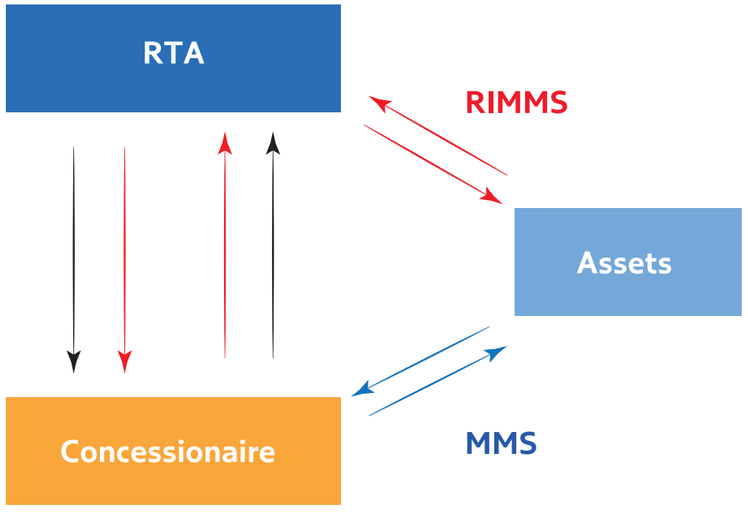


Figure 5: Independent Verification of O&M Needs

The new system (RIMMS) is aimed at using the technology to empower and maximize the following:

- Asset performance and long-term value.
- Concessionaire contract value through improvement of the RTA Operation and Maintenance (O&M) Management and by enabling independent verification of the O&M Needs; Figure 5.
- Long-term capital planning capabilities.
- Achieving Infrastructure sustainability.
- Digitization of the Rail Inspections and support paperless process.

In addition, the new system will improve the rail concessionaire management through the following:

- Integrated prescriptive inspection
- Off-line mobile APPS for field data collection
- Field GPS, image, data review and capture
- Predictive asset condition models
- Configurable workflows and dashboards
- Integrated condition, LCCA, reporting capabilitie

04

Project Execution Plan

Execution Milestones, Schedule and Budget

RTA employed an International Consultant to develop the RIMMS Software and deliver the Project. A budget of AED 18.42 Million was allocated for the project execution and delivery.

The project execution commenced on 09 June 2016 and it has been structured into 5 sequential stages which represent the project milestones as shown in the table below. All the project stages were completed and successfully delivered by June 2019. Further, One-Year Trial Operation of the RIMMS Software was implemented from July 2018 until June 2019 at both Dubai Metro and Tram.

Project Stage	Completion Date
Stage 1 - Development of a Comprehensive Database	27/10/2016
Stage 2 - Field Inspection and Testing	05/04/2017
Stage 3 - Development of Critical Modules	19/11/2017
Stage 4 - Softwares Package Development	30/06/2018
Stage 5 - Integration with the RTA Assets Management Systems	30/06/2019
Trail Operation	30/06/2019

Asset Data Structure

Within the RIMMS system, the rail civil and track asset data is structured in systematic asset, inspection and maintenance perspectives as detailed within Figure 6. This data structure and associated business rules deployed and refined within Stage 2 of the RIMMS project, to assist the RIMMS system in collecting a portion of the required data to effectively run the Stage 3 modules. These ranges of data structure and activities include:

- Segmenting the assets by system, asset type and location.
- Identifying the expected service lives for the various asset types.
- Structuring and providing actionable guidance on the inspection and rating of the various asset types to rate the asset's general condition state and to identify individual faults.
- Recommending focused maintenance activities for identified faults by identifying the various repair types, the unit repair costs, the localized repair quantities to derive an associated repair cost.

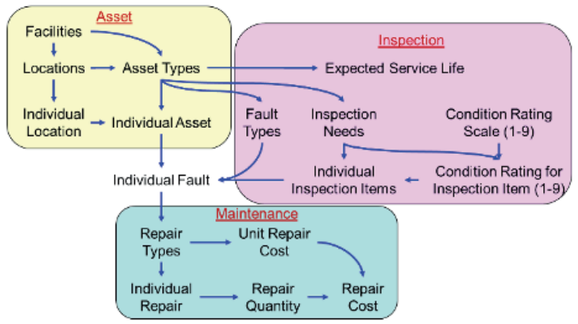
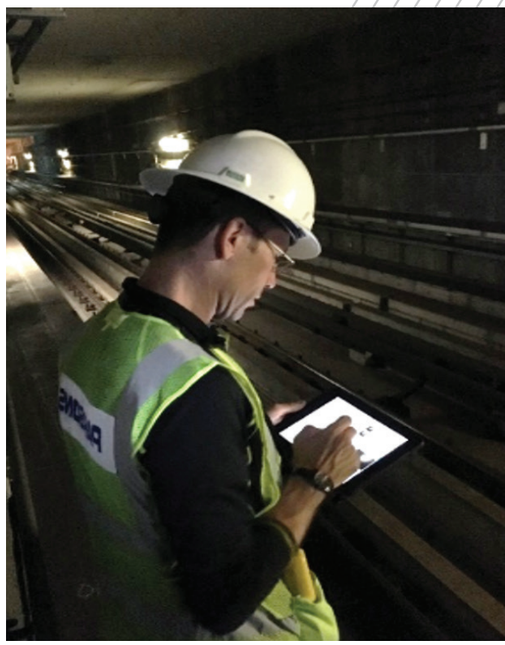


Figure 6: RIMMS Asset Data Structure

Structured Asset Assessment



The inspection and maintenance methodology were refined, and the RIMMS software frameworks were established. The RIMMS Asset Work Breakdown Structure (WBS) segments metro and tram facilities into 17 facility types which are segmented into 322 asset types and customized inspection form was generated for each asset type. Further, the system inspection framework identifies 125 civil and track inspection items incorporated in the inspection forms for different civil and track asset types. A condition rating scale (9 to 1) was defined and provided within each inspection item to provide the field inspectors and data analysts alike with a consistent and uniform asset condition data structure. This has resulted in 5,845 asset type/inspection item combinations and more than 50,000 asset type/inspection item combinations across entire rail systems. Also, the RIMMS set the foundation for tracking future deterioration modes and deficiencies documented at the room or chainage level.

REFERENCE ID	INSPECTION ITEM	9 NEW	8 EXCELLENT	7 VERY GOOD	6 GOOD	5 AVERAGE	4 POOR	3 VERY POOR	2 CRITICAL	1 FAILED
Material – Concrete (01-09)										
Civil-01	Concrete Spalling	New	No Defects	Minor Signs	Minor Isolated Defects	Minor Repairs Required	Moderate Repairs Required	Major Repairs Required	Immediate Closure	Failed
Civil-01	Concrete Spalling	New	No Defects	<1 cm diameter local spall	1 cm diameter spalls	1-2 cm diameter spalls covering >5% of structure	> 1.5 cm diameter spalls covering >10% of structure	> 2 cm diameter spalls covering >20% of structure	Immediate Closure	Failed
Civil-02	Concrete Cracking	New	<0.8 mm wide cracks	< 1.6mm wide cracks	1.6 mm wide cracks @ 2m spacing	>1.6 mm wide cracks impacting 2-50% of structure	>1.6 mm wide cracks impacting >15% of structure	>1.6 cm wide cracks impacting >30% of structure	>1.6 wide cracks impacting majority of structure	Failed
Civil-03	Concrete Rebar Corrosion	No Concrete Rebar Corrosion	Single occurrence of localized corrosion rust stain	Light localized corrosion rust stains	Local corrosion rust stains	Corrosion product emanating from concrete	Rebar corrosion causing cracking of concrete	Rebar corrosion causing spalling of concrete	Corrosion causing measureable rebar loss of section	Corrosion causing >25% loss of rebar section

Figure 7: Asset Inspection Items & Condition Rating Thresholds

Critical Analytical Modules

Five key critical analytical modules were developed within the RIMMS System in line with the RTA Business process and requirements. These modules are:

- Asset Condition Data and Analytics Modul.
- Risk-Based Inspection and Maintenance Analytics Module.
- Life Cycle Cost Analysis (LCCA) Module.
- Risk and Criticality Analytics Module.
- Asset Health Indicator.

These analytical processes and corresponding business processes established the foundation of the required technical procedures, required data flow, and corresponding dashboards and reporting capabilities. Figure 8 shows the RIMMS critical modules and process hierarchy.

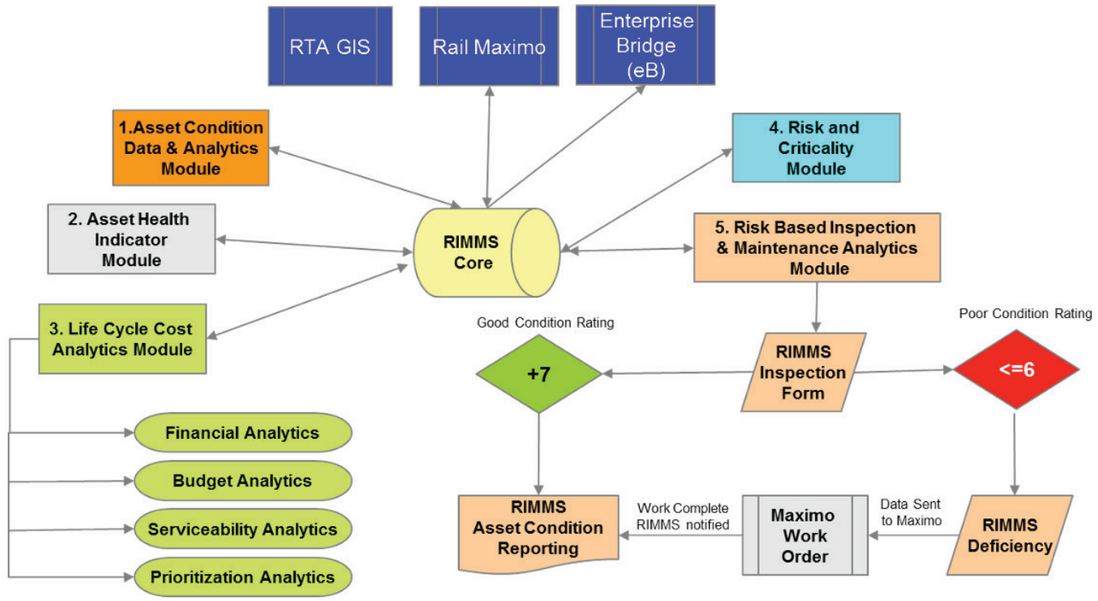


Figure 8: RIMMS Process Hierarchy

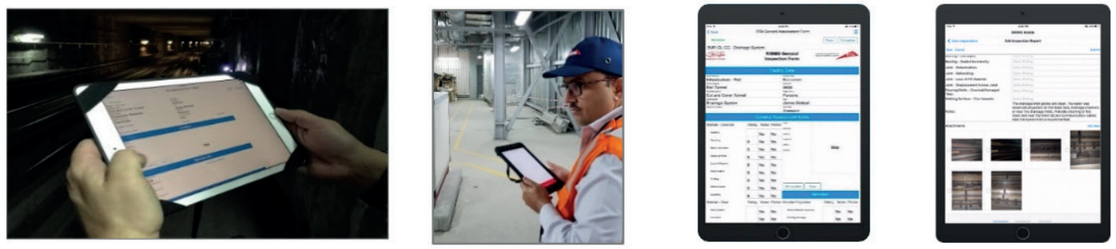
RIMMS Software Package

The RIMMS system is comprised of two separate key tools; a Mobile Application that is used for conducting off-line field inspections, and a Web Application used for administrative setup, reviewing, editing, approving, tracking, analyzing and reporting upon asset condition, maintenance needs, RIMMS identified maintenance actions and broader life cycle cost needs.

RIMMS Mobile Application

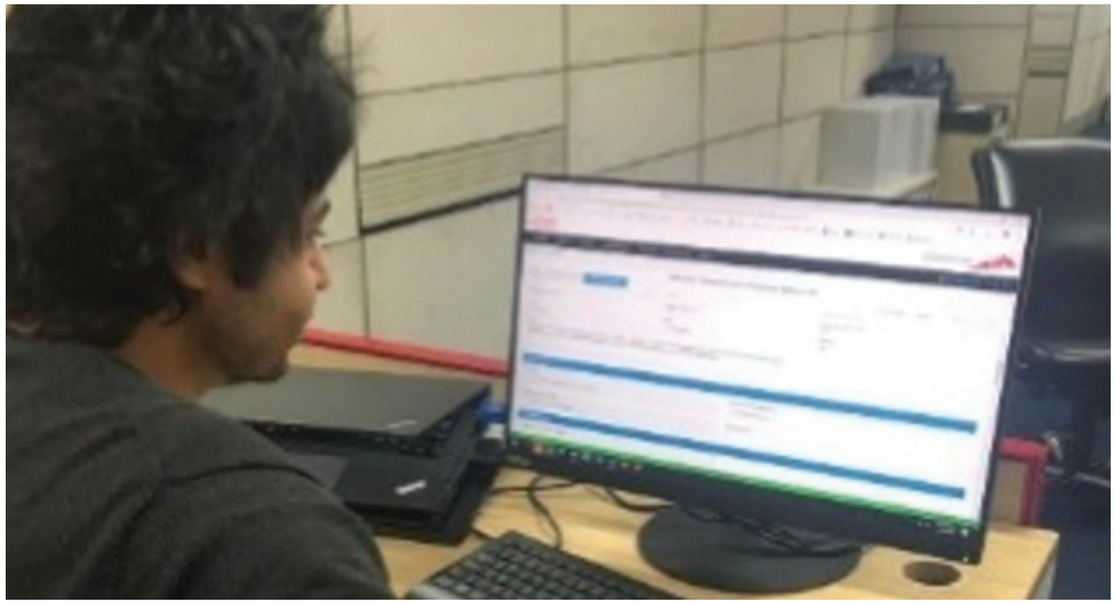
The Mobile Application can be deployed within both an iOS and Android mobile platforms. It provides the field inspector with the ability to:

- Select a facility to inspect.
- Retrieve and display the facility's recently and open deficiencies.
- Retrieve and display the facility's asset structure and asset type general inspection and asset type specific inspection forms.
- Conduct offline data review, editing, capturing and documenting activities focused on evaluating the existing condition of the selected facility and identifying needed repairs in the form of RIMMS deficiencies.
- Synchronize the offline collected data back up to the RIMMS web environment.
- Remove the RIMMS data stored on the mobile device to limit the potential unintentional release of data beyond the immediate RIMMS user.



This application has the following technical capabilities and features.

- Offline compatible
- Operates in tunnels
- Structured inspection process
- Asset Condition Rating
- Photos/GIS
- Uploads digital data directly into application Automated data integration
- Paperless process



RIMMS Web Application

The Web Application is a three-tiered, .NET, SQL database asset management system which can be accessed by a range of browsers including Internet Explorer 10 or Google Chrome. The application is accessed by both RTA and the Concessionaire, and it provides the RIMMS user with the ability to:

- Review collected inspection and asset information.
- Leverage defined RIMMS User (RTA, Concessionaire) work flows to manage the review, editing and approval of identified deficiencies for correction, and automatically generate maintenance service requests through integration with the Maintenance Management System (MMS Maximo) of Dubai Metro and Tram Systems, which are used by the O&M Contractors to schedule the Corrective and Preventive Maintenance Plans and manage the related Work Orders.
- Review and verify completed maintenance activities.
- Leverage integrated condition modelling and asset health analytics to model future asset deterioration, summarize asset type and facility condition, and quantify the estimated remaining service life of the given asset type.
- Leverage the life cycle cost analytics to determine the cost impact of various maintenance approaches and quantify the corresponding required funding for targeted to programmatic maintenance activities.
- Conduct reporting activities on deficiency, asset condition, asset risks, maintenance performance and life cycle cost.

The RIMMS Web Application generates automatically asset inspection and deficiency reports and present the asset and maintenance data in dashboards including the following:

- Asset Deterioration Curves showing the impacts of the maintenance actions on the asset service life.
- Performance KPIs (Mean Time between Failure and Mean Time to Repair.)
- Asset Health Indicators at system/facility levels.
- Annual Capital Expenditure.
- Risk associated with each deficiency, and each asset type within a facility.

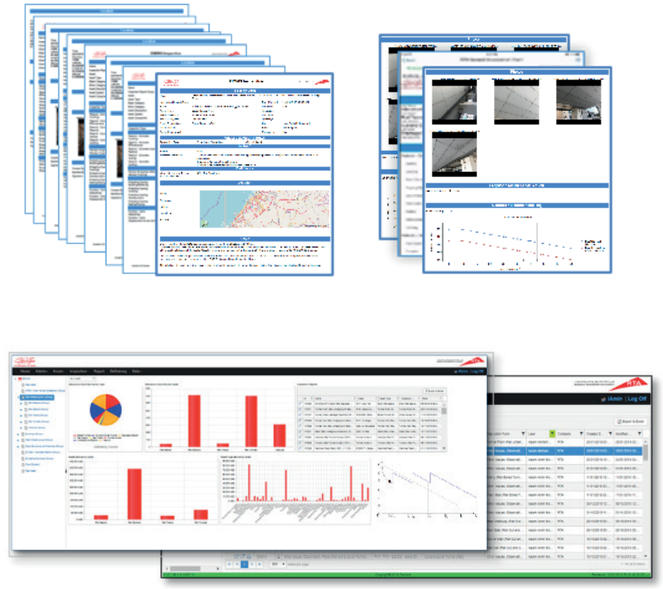


Figure 09: RIMMS Web Application Reports and dashboards

05

The Results

The RIMMS standalone software was deployed in Apr 2018. The system with all the necessary hardware equipment was installed at RTA environment and operated. Subsequently, the system was successfully integrated with the RTA management and information systems shown below:

- Metro Maintenance Management System (Rail MMS Maximo).
- Tram Maintenance Management System (Tram MMS Maximo).
- Geographical Information System (GIS).
- RTA Identity and Access Management System (IAM).
- RTA Electronic Document Management System (EDMS).
- RTA Email Gateway (Email).
- RTA SMS Gateway (SMS).

In addition, RIMMS Integration with the RTA AssetWise System (which is used for management of the Rail Assets and Projects Documents) is planned to be delivered in 2024.

The RIMMS Network Architecture is shown in Figure 10.

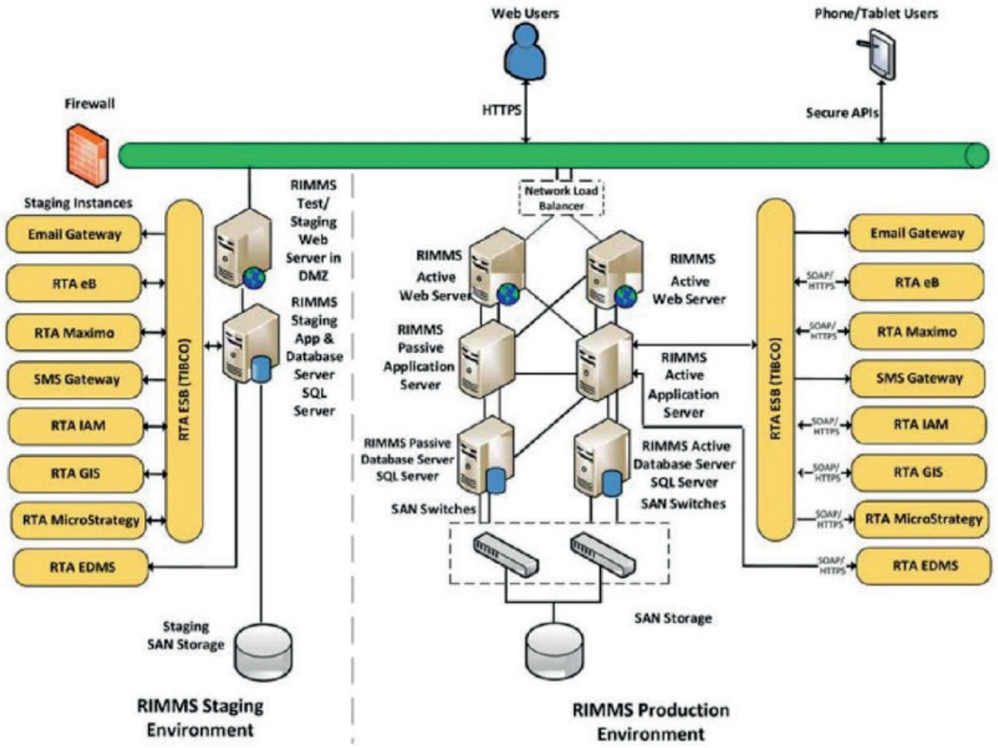


Figure 10: RIMMS Network Architecture

Trial Operation

In order to verify the new system functionalities, one-year trial operation was carried out from 01 July 2018 until 30 June 2019. Several training sessions and workshops were conducted for the RIMMS users on how to use and administrate the system. Further, large number of asset field inspections were conducted by the RTA and Rail Maintainers, and more than 2000 deficiencies were captured and recorded in the new system and addressed to the rail maintainers.

Results and Added-Value

During the RIMMS implementation, the following benefits were realized:

- The system provides an effective platform for RTA staff as well as Maintainer's Staff to digitize their inspection and maintenance activities, register the asset conditions and deficiencies data and access and manage the data effectively and efficiently.
- The system improves significantly the quality of the collected inspection data.
- The system automates the maintenance activities processes and allow RTA staff to immediately access and on site the asset maintenance data to follow up the maintenance activities and verify them effectively on site.
- The system analyses the inspection and maintenance data to evaluate the asset conditions, maintainer performance and to support the maintenance plans and decision-making.
- It reduces the time durations between inspection and rectification.
- It is a key step for transitioning to a paperless environment.

The following figure shows the achieved improvements in the efficiencies of the inspection processes after application of the RIMMS digital processes in comparison with the old paper processes.

Paper		RIMMS App
70%	Fault Evaluation Accuracy	99%
1-7 Days	Fault Reporting Timeliness	30 to 120 Min
0%	Digital GIS Photos	100%
30%	Structured for Data Analytics	100%
5%	Field Maintenance Verificaiton	90%
0%	Integrated Reporting	90%

Figure 11: Improvement of the Inspection Process Efficiency after implementation of the RIMMS

Benefits and Impacts

06

Impact on the Community

The RIMMS system enables RTA and the O&M Contractor to develop effective maintenance plans for the rail assets (Dubai Metro and Tram Systems) and support maintenance decisions in order to improve the asset performance, maintain asset health, prolong asset life and maximize the asset long-term values.

Considering the large numbers of the rail assets in Dubai and their impacts on the city environment, the RIMMS will play an important role to support the asset sustainability.

Moreover, RIMMS is an important step towards fully digitizing the asset maintenance and management processes, which will support transferring this business to a paperless environment.

Benefits for the RTA

The RIMMS uses technology to deliver the following benefits to RTA:

- Empowering the rail asset performance and long-term value.
- Maximizing the concessionaire contract value through improvement of the RTA Operation and Maintenance (O&M) Management, and by enabling independent verification of the O&M Needs.
- Providing Long-term capital planning capabilities.
- Reducing the asset maintenance costs.
- Achieving infrastructure sustainability.
- Digitizing the Rail Inspections and support paperless process.

Benefits for Rall Systems O&M Service Providers

- Providing a digital platform for the rail operators and maintainers to facilitate and support their maintenance activities and increase the efficiencies of these activities.
- Supporting asset performance monitoring and enabling for decision-making.
- Saving time and money in generating maintenance reports.
- Knowledge transfer to the staff of the rail operators and maintainers.
- Supporting staff training on asset maintenance and management towards a sustainable asset culture and environment

Benefits for Customers

- Supporting availability of a continuous rail service to the Metro and Tram Dubai Passengers.
- Improving the asset performance and quality, which would raise the customer satisfaction.
- Reducing/mitigating the risks associated with the rail assets which would improve the safety to the rail passengers.

Environmental Impact

The RIMMS uses the technology to empower and maximize the following:

- Rail Asset Sustainability.
- Digital paperless environment.

07

Transferability

As per the Contract of the RIMMS Project, RTA fully owns the system and its brand name and software source code. This will enable RTA to develop further the system by adding more functionalities and features. Further, RTA is currently evaluating expansion of the system usage beyond the rail civil and track systems to include other types of the Rail Assets such as Rolling Stocks, Electrical and Mechanical Systems. Also, RTA is studying to expand this system to make it a platform for all RTA Assets Inspections.

Further, the system was designed to allow for further configuration by the system administrator to modify and update the inspection forms, add new inspection items or attributes, add new asset facilities and systems, configure the generated reports information, and update the asset database.

Roadmap for a Holistic Asset Management System

In addition to the RIMMS project, RTA is implementing currently a plan to develop several integrated software systems that will enable RTA to actively manage the long-term sustainability of the Rail Assets to ensure these assets can continue to deliver high, safe and efficient services. RIMMS will be one of the key systems in this plan. Figure 12 shows the concept of this plan.

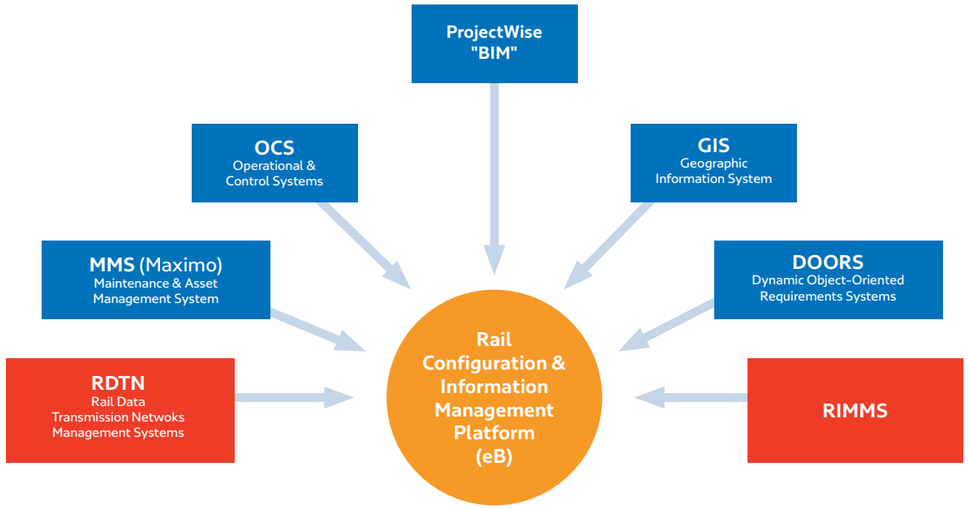


Figure 12: Rail Configuration & Information Management Integration

08

Project Challenges

RIMMS project is unique in terms of the research and inductive nature of the project, delving into new technical areas, developing new approaches for handling and analyzing asset data, satisfying the business requirements of multiple stakeholders, and building and managing a project team of disparate disciplines that include civil engineering, railway engineering, statistical and stochastic analyses, asset management, processes governance, data handling and analysis, information technology, and electronic systems integration. The main challenges of the project can be summarized as follows:

- Building a team of professionals from different backgrounds to work on the same task requires additional efforts to establish a common understanding across the team members and create the environment that enables all of them to actively interact with each other to deliver the project objectives. For this purpose, a proactive approach was adopted by RTA to handle the project and manage the team with full support by the RTA management.

- Engaging the stakeholders at early stage of the project represents a challenge due to their resistance to the proposed changes with an attempt to question the outcomes and benefits of the project. This has required additional efforts and management support to educate the stakeholders on the project benefits engaging them as partners in the project success story.

- Testing and Acceptance of the developed software represents a real challenge due to high technicality of the software. This has mandated long testing sessions to review all the system features and functionalities, document the testing observations and follow up closure of the same.

- Training the new system users and providing them with the necessary technical support was one of the challenges that have been addressed during the RIMMS Trial Operation Phase. This needs to be considered within the project plan.

- Project documentation was one the key challenges as the project team has exerted considerable efforts to document the technical specifications and details of the proposed system, approaching the stakeholder seeking their approvals.

09

Lessons Learned

Several lessons learned have been driven from the RIMMS Project which can be summarized as follows:

- RIMMS project is an important step towards **digitising the inspection and maintenance regime** for the entire rail assets utilizing the technology to improve the asset inspection efficiency, empower and maximize the asset performance and maintenance contract values. The RIMMS system can be **expanded** to handle the other types of the rail assets such as electro-mechanical and rolling stock systems.

- Building a comprehensive **asset database** including a full and **detailed asset inventory** is a preliminary and crucial step to develop an effective asset maintenance management system. This needs to start during the construction phase of the assets levering the BIM technology.

- **Engagement of the stakeholders** and prospective end users of the proposed system at early stage of the project is very important and it represents a challenge to the project team who need to ensure that the stakeholder requirements are addressed, and their expectations are satisfied.

- Prior to starting the electronic system development, it is very important to develop **detailed business processes,** visualise and present the same to all the stakeholders and end users to get their feedback on the same. This is to include designing all interfaces and screens of the proposed system in coordination with stakeholders.

- It is highly advisable to develop any electronic system in **multiple phases** starting with the basic modules of the system, then expanding the system after successful delivery and implementation of the basic phases. This will allow the system developer to receive the users feedback and address the same within the subsequent phases. **Agile project management style** would provide an efficient solution to handle and deliver such projects.

- **Integration** of the Asset Maintenance Management Systems with the **Remote Condition Monitoring Systems** of the assets levering the current digital smart technologies represents an opportunity to promote the asset maintenance business and enhance the efficiencies of the business processes.

- **Integration** of the RIMMS with the other RTA Information and Maintenance Management Systems **took longer time duration** that originally planned due to the different stakeholder's requirements, integration testing and verifications, documentation and approval process. **Educating the stakeholders** on the new project scope, requirements and expected benefits at early stage of the project in parallel with the identification of the stakeholder requirements and commencement with the documentation are necessary steps for effective project management and to ensure delivery of the project on time as planned.

- The **Transfer from the original maintenance regime** which is based on paper inspection process **to the new regime of RIMMS** implementing a digital process represents a challenge in terms of training the maintenance teams who need to have a minimum level of skills and competencies that enable them to utilize the system efficiently to ensure smooth transfer to the new regime. Identification of the training requirements and planning for the training activities need to be done as part of the project and in line with the project deployment phases.

- Trial Operation of the system needs to be considered within the project plan for development of such platform in order to:

- Test the system features and functionalities and collect the user's feedback. This is including the Proof of Concept duration.

- Examine and verify the system business processes by the users and stakeholder and identify any gaps in order to address the same under the same project.

- Build the asset condition database to allow for effective testing of the system and realizing its benefits.

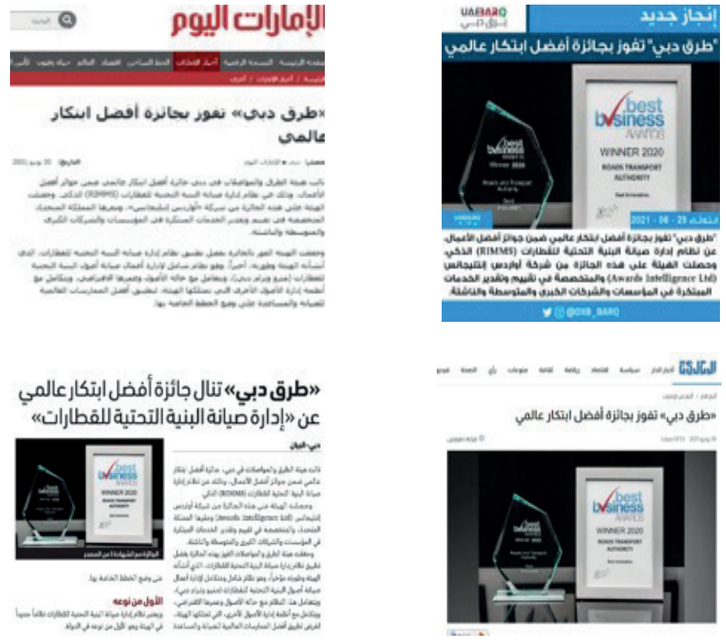


Figure 12: Media coverage of RTA winning the UK's Best Business Award for the RIMMS for the Year of 2020

10 Awards

In Dec 2020, RTA won UK's Best Business Award under Category of Best Innovation for the RIMMS System. RTA received this award from Awards Intelligence Ltd which is a UK-based firm specialized in evaluating innovative services in large, medium and emerging companies and establishments.

This award is considered one of the best awards in the United Kingdom, and winning it reflects the extent of excellence, leadership and pioneering of the participating firms and companies. This award reflects the global interest in having a smart engineering solution for management of the asset maintenance as the RIMMS offers.