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Tech Brief

NATIONAL HIGHWAYS UNITED KINGDOM – DIGITAL PRODUCTS CATALOGUE (DPC) AND RAPID ENGINEERING MODEL (REM)

Abstract

The United Kingdom (U.K.) National Highways (NH), Digital Products Catalogue (DPC) and the Rapid Engineering Modeling (REM) systems are cutting-edge technologies used by the organization, its suppliers, and contractors to enhance the management and visualization of highway infrastructure data and construction projects. National Highways is a government-owned company responsible for operating M-designated motorways and major A-roads in England. The DPC serves as a centralized repository for standardized digital assets related to highways, while the REM system enables rapid and accurate 3D modeling of transportation projects. This technical brief provides an overview of the purpose, architecture, and key features of both systems. Additionally, it explores the potential adaptation of these systems for use by State Departments of Transportation (DOTs) in the United States.

Introduction

The DPC and REM systems are part of a broader initiative by the U.K. Department for Transport (DfT) to modernize their highway infrastructure management practices. These systems leverage advanced technologies such as Geographic Information Systems (GIS), Building Information Modeling (BIM), and Cloud Computing to streamline data management, collaboration, and project visualization. By digitizing and centralizing highway-related information, the use of DPC and REM has significantly improved decision-making, planning, project execution, information sharing throughout the supply chain, and stakeholder/community engagement processes. The use of DPC and REM has resulted in significant cost and time savings in the project design phase, allowing subject matter experts to focus on high-risk or unusual issues.

Digital Products Catalogue (DPC)

Purpose

The DPC's primary purpose is to provide a comprehensive and standardized repository of digital assets related to the UK highway network. This includes data on road geometry, bridges, tunnels, signage, drainage systems, and more. This information is consolidated into a single catalog that contains accurate and up-to-date data and is readily available to all stakeholders involved in highway infrastructure projects.

Architecture

The DPC's architecture is based on a cloud-based infrastructure, which offers scalability, accessibility, and security. The system uses a combination of databases, file storage, and application servers to store and manage various types of data. The DPC employs modern APIs (Application Programming Interfaces) to enable seamless integration with other applications and systems used within the transportation sector. The architecture can be broken down into the following components:

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- Data Ingestion Layer: This layer is responsible for collecting and validating data from various sources, such as field surveys, satellite imagery, LiDAR, and other remote sensing technologies. Data undergoes quality checks before being ingested into the system.
- Data Storage Layer: The DPC uses a combination of relational and MSSQL databases to store structured and unstructured data. This allows for efficient storage and retrieval of large volumes of data, including road geometry, bridges, signage, drainage systems, and more.
- Data Management Layer: This layer handles data indexing, version control, and metadata management. It ensures that digital assets are properly organized, versioned, and linked to relevant project information.
- Data Access Layer: The DPC provides multiple interfaces for accessing data. It includes web-based portals, APIs, and integration with Geographic Information Systems (GIS) to allow easy access and visualization of highway-related information.

Key Features of DPC

- Standards: The source information used to develop the attributes and objects is derived from National Highways standards that are found in a document called Asset Data Management Manual. This document defines how assets are to be managed and sets out the requirements for how asset attributes are to be represented in a digital form.
- Standardization: The DPC enforces standardized data formats and metadata, ensuring consistency across all digital assets. This improves data interoperability and reduces data conversion efforts during project collaboration.
- Version Control: The system maintains version control for each asset, enabling users to access historical revisions and track changes made to digital products over time. This feature aids in auditing and ensures data accuracy.
- Accessibility: Stakeholders can access relevant data through user-friendly web interfaces or APIs, promoting transparency and collaboration among various entities involved in highway infrastructure projects.
- Data Governance: The DPC incorporates robust data governance mechanisms to manage access rights, data integrity, and data sharing agreements, safeguarding sensitive information, and adhering to data privacy regulations. This is called the moderator function which effectively allows assets to be uploaded into DPC and held in a ‘holding pen’ while the asset is being validated as compliant, endorsed, or supported by National Highways Safety, Engineering and Standards Directorate.

Figure 1 shows a construction product’s 3D model in DPC. Figure 2 shows the construction product’s standardized metadata in DPC. Both images are reproduced from NH presentation materials.

Figure 1. Example of a Construction Product’s 3D Model in DPC (Image Courtesy: NH)

Parameter	Value
Wall Height	1.80 m
Concrete Grade	C40/50
Easting	317234.983
Northing	194693.839
Rebar Spacing	200 mm c/c
Rebar Diameter	16 mm
Material Cost	£16765.56
Date of Arrival to Site	20th April 2020
Construction Date	15th May 2020
Test Result	63.2 N/mm^2
Last Inspection Date	6th December 2022
List of Defects	Spalled concrete

Figure 2. Example of a Construction Product's Standardized Metadata in DPC (Image Courtesy: NH)

Rapid Engineering Modeling (REM) System

Purpose

The REM system is a cutting-edge technology designed to facilitate rapid 3D modeling and visualization of highway infrastructure projects. By offering a virtual environment to explore proposed changes, assess potential impacts, and optimize designs, the REM system streamlines the project planning process and enhances stakeholder engagement.

Architecture

The REM system's architecture is built on advanced 3D modeling software integrated with Building Information Modeling (BIM) principles. It harnesses high-resolution geospatial data, LiDAR, and photogrammetry to create accurate representations of existing terrain and assets. These models are then integrated with proposed designs, allowing stakeholders to visualize and analyze the project's impact in real-time. The architecture can be divided into the following components:

- Data Acquisition and Processing: This component focuses on acquiring geospatial data, such as high-resolution imagery, LiDAR point clouds, and aerial photographs. The data undergoes processing to create detailed 3D models of existing highway assets.

- BIM Integration: The REM system integrates BIM principles, allowing engineers and planners to import proposed design models and link them with existing infrastructure data. This integration enables better coordination and visualization of the project.
- 3D Visualization and Simulation: The REM system renders 3D visualizations of proposed designs overlaid on existing infrastructure. It also enables real-time simulations, such as traffic flow analysis, environmental impact assessments, and safety evaluations.
- Collaboration and Sharing: The REM system supports multi-user collaboration, enabling stakeholders to work together in real-time, regardless of their physical locations. It also provides sharing capabilities to facilitate communication and feedback.

Key Features of REM

- Standards – The rules developed within REM are based on the content of the Design Manual for Roads and Bridges (DMRB). This is the infrastructure owners set of requirements and performance specifications that highways are to be design and built to meet.
- Realistic Visualizations: The REM system generates detailed 3D renderings of highway infrastructure, allowing stakeholders to visualize projects from different perspectives and make informed decisions.
- System Agnostic – REM is built on the principles being as license free and system agnostic as is reasonably possible.
- Pareto Rule – The philosophy of REM is 20% of the effort gives 80% of the value, based on repeatable common elements of standards as part of production line style of program delivery.
- Performance Analysis: Engineers can run simulations and analyze the impact of proposed projects on traffic safety, traffic flow, environmental factors, and other critical parameters. This analysis aids in optimizing designs for better outcomes.
- Intelligent Client – REM allows the client to make better informed decisions with lower levels of dependency on supply chain.
- Collaboration Capabilities: The REM system enables efficient collaboration among various stakeholders, fostering transparency and facilitating informed decision-making throughout the project lifecycle.
- Hosted in National Highways Azure tenancy and is made freely accessible by Tier 1 supply chain design and delivery partners. Levels of authorization are clearly defined, and users need to be security cleared to access and use it. This is standard practice and procedure for Tier 1.

Figure 3 shows a construction project's 3D model in REM – which includes the construction site environment, 3D model of the existing roads, engineering constraints, potential hazards identified through REM's analysis, and the 3D model of a gantry inserted into the construction site. Figure 4 shows analysis and evaluation of the construction site environment and the construction project in REM.

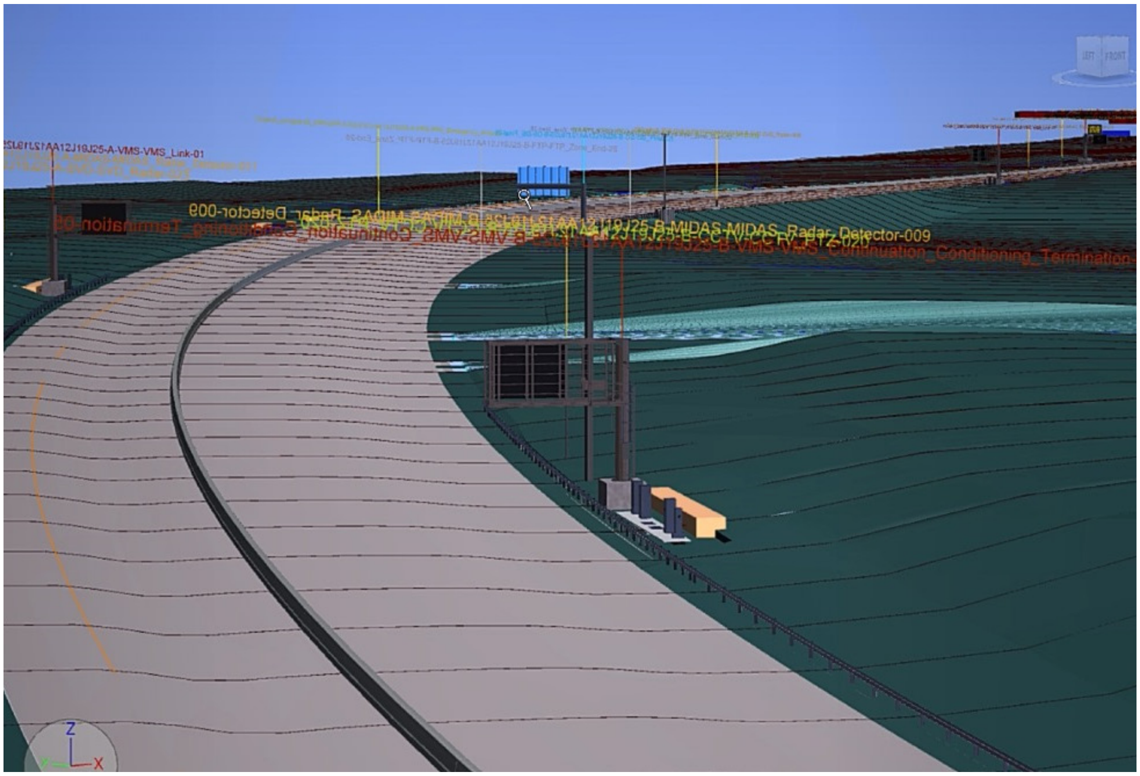

Figure 3. Example of a Construction Project's 3D Model in REM (Image Courtesy: NH)

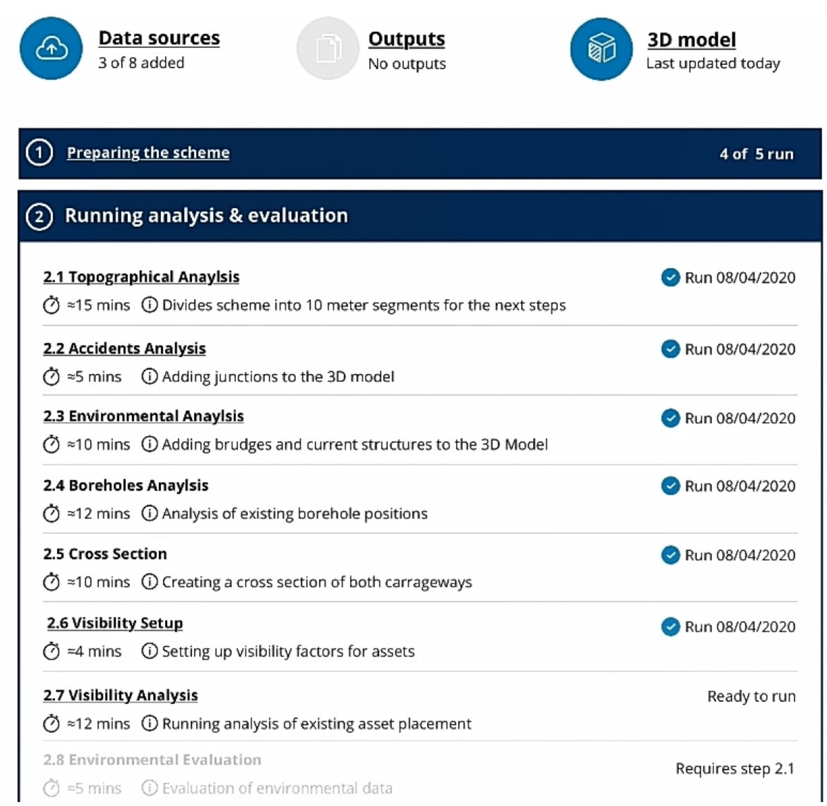

Figure 4. Analysis and Evaluation of a Construction Project in REM (Image Courtesy: NH)

Adaptation for Use by State DOTs in the United States

The success of the UK DPC and REM systems has attracted interest from transportation authorities worldwide, including State DOTs such as Caltrans in the United States. Adapting these systems for use in the U.S. context offers numerous potential benefits, but it also poses specific challenges that need to be addressed.

Data Standardization and Interoperability

To facilitate seamless data exchange and collaboration across State DOTs, it is crucial to establish common data standards and metadata frameworks. The adapted systems should support industry-standard data formats, allowing easy integration with existing State-level databases and applications.

Scalability and Performance

State DOTs manage vast highway networks with varying complexities and data volumes. The adapted systems should be scalable, capable of handling large datasets, and ensure optimal performance even during peak usage periods.

Integration with Existing Systems

To promote user adoption and minimize disruptions, the adapted systems should integrate seamlessly with the State DOTs' existing databases, asset management systems, project management tools, and GIS platforms.

Legal and Security Considerations

Adapted systems must comply with relevant data protection laws and regulations, ensuring data privacy and security. Robust access controls and data governance mechanisms should be implemented to safeguard sensitive information.

Training and User Adoption

State DOT personnel may require training to effectively use the adapted systems. A comprehensive user adoption strategy, including training programs and user support, is essential for the successful implementation and utilization of these technologies.

Conclusion

The United Kingdom National Highways DPC and Rapid Engineering Modeling (REM) systems have revolutionized highway infrastructure management, offering standardized data access and real-time visualization capabilities. Adapting these systems for use by State DOTs in the United States presents an exciting opportunity to transform transportation infrastructure planning, collaboration, and decision-making processes. However, successful adaptation would necessitate addressing specific challenges related to data standardization, scalability, integration, security, and user adoption. By leveraging the expertise and experience gained from the UK implementations, State DOTs can potentially enhance the efficiency and cost-effectiveness of transportation infrastructure development in the United States.

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Distribution and Availability—This Tech Brief can be found at https://www.fhwa.dot.gov/construction/technologies.

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Notice

Quality Assurance Statement

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