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# قسم

## نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
## علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

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# بالرسالة صفحات

# لم ترد بالأصل

# Maintenance Planning of Subway Operating Systems using BIM

By

**Omar Amr Saad El-Din El-Hamshary**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
**INTERDISCIPLINARY-MASTER OF SCIENCE**
**in**
**Integrated Engineering Design in Construction Projects**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Approved by the Examining Committee

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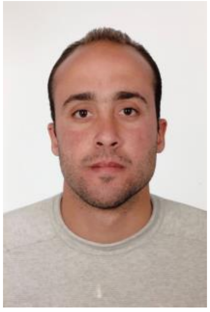

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**Title of Thesis:**

Maintenance Planning of Subway Operating Systems Using BIM

**Key Words:**

Subways systems, Maintenance planning, Building Information Modeling, Multi-Objective Optimization, Quality Function Deployment

**Summary:**

This research presents a framework for condition assessment and budget allocation optimization for subways operating systems. The proposed framework utilizes BIM as an openly shareable information platform for maintenance planning of subways operating systems. The research framework encounters five main modules that are designated for performing different functions. These modules are: Reliability Centered Maintenance Database, Deterioration Modelling, Multi-objective Optimization, Decision Making, and BIM-based Model. Reliability Centered Maintenance Database module where subway operating systems are decomposed to components levels showing their functions, operational failures, failure causes, failure effects, estimating failure consequences using Quality Function Deployment (QFD) technique, responsive maintenance actions, and the hourly maintenance costs. Deterioration Modeling module is used to analyze operational failures using deterministic and artificial intelligence models to estimate future conditions of subway components. Multi-objective Optimization module, which uses gradient descent technique to decide the optimal maintenance frequencies that derive lowest maintenance costs and lowest risk of failure for each operational failure. Decision Making module that utilizes AHP/TOPSIS multi-criteria decision-making techniques to conduct comparative analysis between subway operating systems to derive the criticality index for each of them. Lastly, BIM-based model is used to link the optimized maintenance plans with the corresponding subway components. As such, maintenance information can be easily recognized, shared and monitored among subway asset managers. A case study of Cairo Metro line 1 is presented to demonstrate the main features of the proposed framework.

# Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Omar Amr Saad El-Din El-Hamshary Date: 15/10/20

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