# INTER-TERMINAL TRANSPORT AUTOMATION IN SEAPORTS: GLOBAL INSIGHTS, IMPLEMENTATION BARRIERS AND SYSTEM INTEGRATION APPROACHES

B.W.G.N.H. Gunaratne

(248040B)

Master of Science (Major Component Research)

Department of Transport Management and Logistics Engineering
Faculty of Engineering

University of Moratuwa
Sri Lanka

March 2026

# INTER-TERMINAL TRANSPORT AUTOMATION IN SEAPORTS: GLOBAL INSIGHTS, IMPLEMENTATION BARRIERS AND SYSTEM INTEGRATION APPROACHES

B.W.G.N.H. Gunaratne

(248040B)

Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science (Major Component Research)

Department of Transport Management and Logistics Engineering
Faculty of Engineering

University of Moratuwa
Sri Lanka

March 2026

## DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to the University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

13.03.2026

Signature of the candidate: Date:

The above candidate has carried out research for the Masters dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of the supervisor: Prof. H.N. Perera

Signature of the supervisor: Date: 13.03.2026

## ACKNOWLEDGMENTS

This research was supported by the University of Moratuwa through its SRC long-term research grant (SRC/LT/2025/16). The institutional support provided through this grant played a vital role in facilitating the successful completion of this study.

I would like to express my deepest and sincere gratitude to my research supervisor, Prof. H. Niles Perera, for giving me the opportunity to undertake this research and for his continuous guidance and support throughout the research process. His expertise, patience, motivation and insightful feedback have deeply inspired me. He taught me how to conduct research as well as present research work properly which significantly contributed to the successful completion of this thesis. It was a great pleasure and honor to be one of his research students.

I am also sincerely thankful to Mr. Buddhi Weerasinghe for his invaluable advice, encouragement and insights, which greatly strengthened the quality and relevance of this research. His support was invaluable in keeping me motivated and carry out the day-to-day research works.

I would like to extend my sincere appreciation to the academic and non-academic staff of the Department of Transport Management and Logistics Engineering for providing a supportive research environment and necessary facilities during the course of this study.

Finally, I am extending my heartfelt thanks to my beloved family including my father, mother, brother and sister. They are the reason behind my success and I am forever grateful to them for proving me a supportive environment to carry out my work. I would also like to thank my dear friend Dewmi, as well as Mr. Kusal Silva for their unwavering support, understanding, and motivation throughout this academic journey. Their encouragement and belief in me were a constant source of strength and inspiration.

## ABSTRACT

Container terminal automation has progressed notably in recent decades, especially in quay and yard operations. However, inter-terminal transport (ITT) remains largely manual, despite its vital role in the efficiency of multi-terminal ports where the transshipment incidence is high. This research addresses this gap by examining the current status, adoption dynamics, and operational integration of ITT automation in container ports. The study is structured around three research objectives. First, a global assessment is conducted to identify the level of transshipment activity, the presence of ITT systems, and the degree of automation across the top 100 container ports worldwide. The results confirm that, despite increasing terminal-level automation, ITT automation adoption remains limited and uneven. Second, a system dynamic modelling framework is developed to analyse the factors delaying ITT automation adoption. The model integrates Bass diffusion theory with an economic investment mechanism to capture behavioral, structural, and financial interactions. Sensitivity analysis reveals that behavioral and organisational factors such as resistance to change, limited imitation effects, and low internal automation readiness are the primary constraints on adoption, while economic investment variables play a secondary role. Third, the study develops scenario-based conceptual operational models for ITT automation by aligning feasible operational configurations with different levels of port automation maturity. By consolidating terminal automation levels into three representative scenarios, the study demonstrates that ITT automation requires staged and context-specific operational solutions rather than a single universal approach. The findings contribute a system-level understanding of ITT automation diffusion and provide practical guidance for port authorities and terminal operators seeking to plan effective and realistic ITT automation strategies in multi-terminal port environments. Future research should explore the governance frameworks, technological integration strategies, and coordinated port-wide approaches necessary to enable the transition toward automated ITT systems, which is a crucial step for achieving a sustainable port system.



**Keywords:** inter-terminal transportation, port automation, system dynamics, container terminal, maritime logistics

# TABLE OF CONTENT

## LIST OF FIGURES

# LIST OF TABLES

## LIST OF ABBREVIATIONS

ACT – Automated Container Terminal

AGV – Automated Guided Vehicle

ASC – Automated Stacking Crane

AT – Automated Trucks

CLD – Causal Loop Diagram

IT – Information Technology

ITT – Inter Terminal Transport

MTS – Multi-Trailer Systems

OCR – Optical Character Recognition

OM – Operational Model

RFID – Radio Frequency Identification

RMG – Rail Mounted Gantry cranes

RTG – Rubber Tiered Gantry cranes

SD – System Dynamics

SFD – Stock and Flow Diagram

STS – Ship to Shore

TEU – Twenty-foot Equivalent Unit

TOS – Terminal Operating System