# CMS RESEARCH UPDATES
## JULY 2013

**RESEARCH HIGHLIGHT 1: NUS WINS GRAND PRIZE FOR NEXT GENERATION PORT CHALLENGE**
**-- CMS PROUD TO BE A KEY PARTY IN THE WINNING NUS TEAM**

### SUSTAINABLE INTEGRATED NEXT GENERATION PORT (SINGA-PORT)

- Four Research Track Leaders from the Centre for Maritime Studies (CMS) are the leading members in the NUS Team that has clinched the Grand Prize for the Next Generation Container Port (NGCP) Challenge. The prize was awarded on 11 April 2013.

- The winning team, consisting of researchers from NUS, Shanghai Maritime University and engineers from Shanghai Zhenhua Port Machinery Company, outdid 56 competitors worldwide from 25 countries to win the monetary prize award, valued at S$1.24 million. The team's winning design, SINGA Port (Sustainable Integrated Next Generation Advanced Port), proposes a radical container yard design that breaks away from the standard "flat" yard designs.

- Boasting a double-storey stacking yard design, SINGA Port addresses the challenges of land scarcity in Singapore, and reduces transportation time of containers by employing innovative container handling equipment and processes. Through incorporating highly efficient and sophisticated multi-hoist cranes that serve upper and lower levels of the stacking yard, SINGA Port occupies only 80 percent of land space allocated.

- CMS Research Track Leaders, A/Prof Chew Ek Peng, A/Prof Lee Loo Hay, A/Prof Tan Kok Choon, and A/Prof Chang Che Sau are the leading members of the NUS Team, together with CMS Researchers Dr Lee Byung Kwon and Dr Sun Zhuo.



### ABOUT THE NEXT GENERATION CONTAINER PORT CHALLENGE

The NGCP challenge is an international competition, launched by the Maritime and Port Authority of Singapore and the Singapore Maritime Institute in April 2012. This competition challenges international participants to think beyond existing conventions of port design and to submit radically new proposals for a future container port. It aims to raise awareness and foster innovation within the maritime industry. An international judging panel, comprising representatives from the Singapore government and the maritime industry and academic institutions, evaluated participants of the competition.

## RESEARCH HIGHLIGHT 2: STUDY ON GRID-FRAME BASED AUTOMATED CONTAINER TERMINALS (GF-ACT) (TRACK LEADER: A/PROF LEE LOO HAY, A/PROF CHEW EK PENG; RESEARCHER: DR LEE BYUNG KWON)

### OBJECTIVE OF STUDY

- Port automation is a potential way to improve efficiency, reduce cost and increase throughput capacity.

- This project studies the productivity and cost effectiveness of a new promising ACT design, which is potentially efficient and green, when this design concept is implemented in a transshipment hub port.
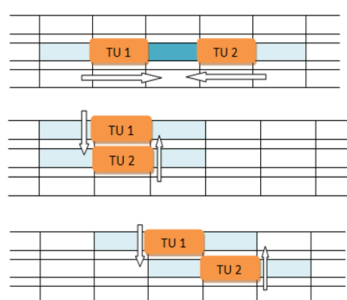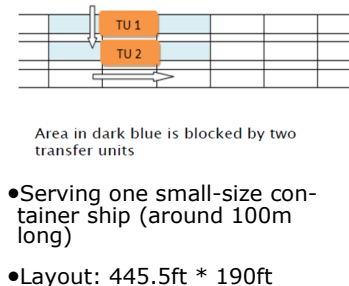
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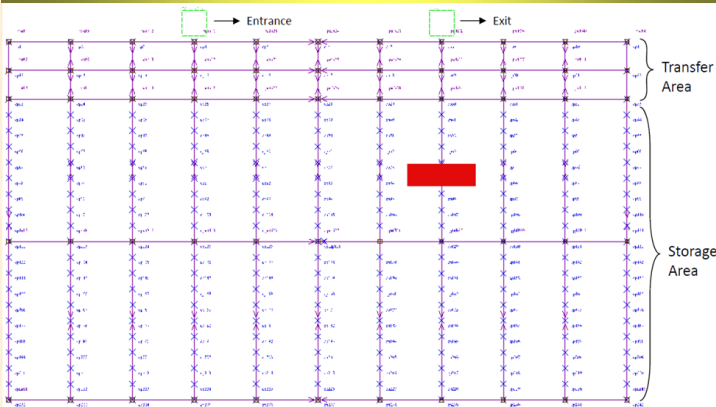


### FINDINGS

- Conflict-free routing rules can work well for the grid system

- The performance depends on layout design of the grid system

- To further improve the performance of the grid system, it is recommended to:
  - Increase TU speed
  - Decrease pick-up/set-down time
  - Add more horizontal paths

### CONFLICT SCENARIO ANALYSIS

▸ Opposite directions

- Orthogonal directions



Area in dark blue is blocked by two transfer units

- Serving one small-size container ship (around 100m long)
- Layout: 445.5ft * 190ft

### CHALLENGES IN PORT OPERATIONS

- High throughput requirement

- Limited space for expansion

- High manpower cost

- High fuel energy consumption

- Increasing container traffic
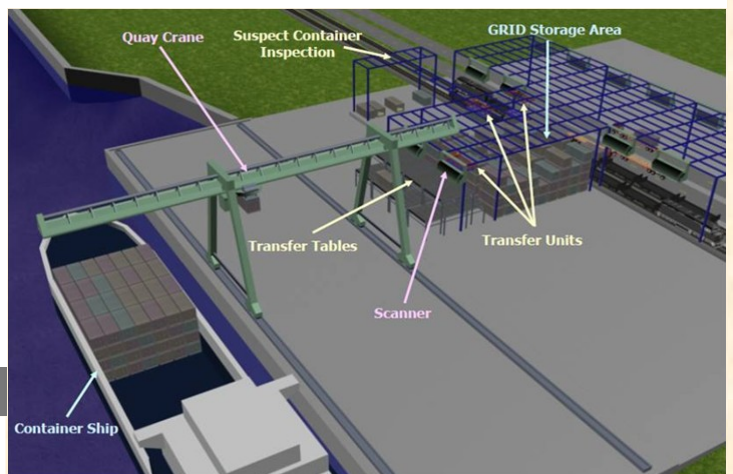


### PRACTICAL RELEVANCE TO INDUSTRY

- This project is important for port operators who are considering automation of their processes.

- This project helps port operators to better understand its advantages and disadvantages and prepare them for adopting this new design concept, including understanding the resource requirements and the reliability.

## RESEARCH ACHIEVEMENT

**WCTR Society Prize**, awarded by the World Conference on Transportation Research, at the 13th triennial WCTR held in Rio de Janeiro, Brazil on 15-18 July 2013, for the following Conference paper:

Boundary Estimation of Probabilistic Port Hinterland for Intermodal Freight Transportation Operation, by A/Prof Meng Qiang, Prof Lixin Miao (Tsinghua University) and Dr Wang Xinchang.

### About the WCTR Society

The WCTR Society is an organisation whose purpose is to provide a forum for the interchange of ideas among transportation researchers, managers, policy makers, and educators from all over the world, from a perspective which is multi-modal, multi-disciplinary, and multi-sectoral. The Society has become a primary forum for such international exchanges in transportation. Its World Conferences are the place where leading transportation professionals from all countries convene to learn from one another.

The WCTR is the most prestigious conference on Traffic Engineering, and is attended by leading researchers in the world.

## PUBLISHED TECHNICAL PAPERS (WITH ABSTRACTS)

**1. Zhuo SUN, Kok Choon TAN, Loo Hay LEE and Ek Peng CHEW, (2013), Design and Evaluation of Mega Container Terminal Configurations: An Integrated Simulation Framework, Simulation: Transactions of the Society for Modeling and Simulation International**

**Abstract:**

Operators of busy container terminals need to periodically evaluate options for capacity expansion in order to meet the increasing demands for container handling at their terminals. When planning such capital intensive investments, it is important to find an efficient and effective way to design and evaluate various possible terminal layout and equipment configurations. The issue is further complicated for mega-sized container terminals which consist of multiple berths and yards due to pre-existing geological conditions. This paper proposes an integrated simulation framework to facilitate the design and evaluation of mega container terminal configurations with integrated multiple berths and yards. There are two major components in this framework: a geographical information system (GIS) and a multi-agent system (MAS). The former is used to design specific terminal configurations which can be then simulated and evaluated by the latter. An application of the framework to a real container terminal expansion problem demonstrates the validity of the framework. Results obtained from simulation models generated efficiently by the framework are used to help terminal planners make reasonable decisions.

**2. Qiang Meng, Zhiyuan Liu & Shuaian Wang, (2013), Asymmetric stochastic user equilibrium problem with elastic demand and link capacity constraints, Transportmetrica A: Transport Science,**

**Abstract:**

This paper focuses on model development and algorithm design for the general stochastic user equilibrium (SUE) problem with elastic demand, asymmetric link travel time functions and link capacity constraints. It first defines the generalised SUE conditions using generalised link travel time. An equivalent variational inequality (VI) model for these generalised SUE conditions is then developed and it is rigorously proven to be monotone and uniform Lipschitz-continuous. These two properties of the proposed VI model ensure the global convergence of the self-adaptive prediction–correction algorithm incorporating cost averaging method as a solution algorithm. Finally, a numerical example is utilised to assess the performance of the proposed VI model and solution algorithm.

## PUBLISHED TECHNICAL PAPERS (WITH ABSTRACTS)

3.  Ong, G. P., Farhan, J. and Chin, A. T. H. (2013). "Stochastic Imputation of Missing Physical Commodity Trade Information Using Monetary Trade Data." Accepted for publication by the Transportation Research Record: Journal of the Transportation Research Board.

**Abstract:**

International trade has conventionally been expressed in monetary values until the recommendations by United Nations Statistics Division. Since international trade in monetary terms alone is not entirely representative of global trade from a transportation and logistics perspective, the physical dimension of international trade is attaining increased importance. However, missing physical quantities in the trade flow databases, largely due to (1) non-compliance of reporter countries with the standard units of measurement or classification (2) confidentiality issues, or (3) erroneous collection and reporting of certain data, are observed. This paper, therefore, first presents the existing methods used in the literature to treat the issue of missing commodity weight information in international physical commodity trade databases, and then proposes a stochastic multivariate imputation model, utilizing auxiliary variables such as monetary trade data and price index, to impute missing physical quantities. Their relative performances in resolving the issue of incomplete physical commodity trade data are then evaluated and compared through a case study, and it is concluded that the proposed approach outper-forms the existing approaches for commodity flow data imputation.

4.  Xiaomin Sheng, Loo Hay Lee and Ek Peng Chew, (2013), Dynamic determination of vessel speed and selection of bunkering ports for liner shipping under stochastic environment, OR Spectrum.

**Abstract:**

In this work, we study a liner shipping operational problem which considers how to dynamically determine the vessel speed and refueling decisions, for a single vessel in one service route. Our model is a multi-stage dynamic model, where the stochastic nature of the bunker prices is represented by a scenario tree structure. Also, we explicitly incorporate the uncertainty of bunker consumption rates into our model. As the model is a large-scale mixed integer programming model, we adopt a modified rolling horizon method to tackle the problem. Numerical results show that our framework provides a lower overall cost and more reliable schedule compared with the stationary model of a related work.

5. Shuaian Wang, Qiang Meng, Zhuo Sun, (2013), Container routing in liner shipping, in Transportation Research Part E: Logistics and Transportation Review, 49:1, 1-7

**Abstract:**

Container paths play an important role in liner shipping services with container transshipment operations. In the literature, link-based multi-commodity flow formulations are widely used for container routing. However, they have two deficiencies: the level of service in terms of the origin-to-destination transit time is not incorporated and maritime cabotage may be violated. To overcome these deficiencies, we first present an operational network representation of a liner shipping network. Based on the network, an integer linear programming model is formulated to obtain container paths with minimum cost. Finally, we add constraints to the integer linear programming model, excluding those paths already obtained, so as to find all the container paths.

## CONFERENCE PAPERS (WITH ABSTRACTS)

1. **Shuaian Wang, Lauren Gardner and Waller, S. Travis, (2013), Global Optimization Method for Robust Pricing of Transportation Networks under Uncertain Demand. In: 92nd Annual Meeting of the Transportation Research Board, Washington DC, 13-17 January.**

**Abstract:**

We extend the existing toll pricing studies with fixed demand to stochastic demand. A new and practical second-best pricing problem with uncertain demand is proposed and formulated as a stochastic mathematical program with equilibrium constraints. In view of the problem structure, we develop a tailored global optimization algorithm. This algorithm incorporates a sample average approximation scheme, a relaxation-strengthening method, and a linearization approach. The proposed global optimization algorithm is applied to three networks: a two-link network, a seven-eleven network and the Sioux-Falls. The results demonstrate that using a single fixed estimation of future demand may overestimate the future system performance, which is consistent with previous studies. Moreover, the optimal toll obtained by using the mean demand value may not be optimal considering demand uncertainty. The proposed global optimization algorithm explicitly captures demand uncertainty and yields solutions that outperform those without considering demand uncertainty.

2. **Miao, Lixin, Meng, Qiang, Ruan, Qingfang, (2013), Vehicle Routing Problem with Pickups, Deliveries, and Handling Costs. In: *92nd Annual Meeting of the Transportation Research Board*, Washington DC, 13-17 January.**

**Abstract:**

This paper proposes a novel and practical vehicle routing problem with pickups, deliveries and handling costs (VRPPD-H). The VRPPD-H extends the conventional vehicle routing problem with pickups and deliveries (VRPPD) by taking into account additional handling costs caused by loading and unloading operations for cargo rearrangement. Four mixed integer linear programming models are first built for the VRPPD-H under the four different cargo storage and handling policies. Two types of branch-and-cut exact algorithms are subsequently used to solve each of these four models. Finally, numerical experiments are carried out to assess the models and algorithms proposed in this study.

3. **Ticy Veluvellel Thomas, (2013), The Legal Regime of Maritime Piracy: Problems and Progresses. In: *The Legal Experts Meeting to commemorate the 30th Anniversary of the United Nations Conventions on the Law of the Sea (UNCLOS),* New Delhi, 5 March.**

**Abstract:**

As a speaker in the Session dealing with Maritime Security and Piracy, my presentation titled "The Legal Regime of Maritime Piracy: Problems and Progresses" provided an overview of the maritime piracy regime, examined the evolving developments in the regime and evaluated the progresses. The presentation elicited positive response for its singular research quality and comprehensiveness and stimulated interesting discussion from the floor in the light of the ongoing Enrica Lexie case.

## C M S  R E S E A R C H  S E M I N A R S

### 1. Effect of Trade Data Aggregation on International Commodity Mode Choice, by Researcher Ms Maggie Sou (Track Leader: Dr Raymond Ong)

**Seminar Abstract:**

Different widely accepted principles in the strategic planning level are used to determine the transport mode in which particular commodity is to be carried. One major rule is the use of commodity value-weight ratio as a means to estimate the amount of goods carried by certain mode. Discrete choice model is being employed in this study using available macroscopic commodity trade information. Besides, the selection of appropriate data aggregation level for analysis is also being investigated and its corresponding impacts are presented. By examining international commodity flows between territories, modal split between air and sea transport can be compared by the proposed discrete choice models in this study. This study aims to address the potential impact of trade data aggregation on commodity mode choices derived from discrete choice models.

### 2. Alliance in liner shipping , by Visiting Researcher Dr Xu Zui (Track Leader: A/Prof Meng Qiang)

**Seminar Abstract:**

The formation of liner shipping strategic alliances has been a dominant form of inter-organizational cooperation in liner shipping, particular since the early 1990s. The cooperation helps carriers to improve asset utilization, share capital cost, gain economics of scale and explore new markets. In this presentation, we will review the history, trends, types and objectives of alliances. Then, we will talk about the liner alliance stability and alliance success especially with the view of game theory.

### 3. The Shipping Industry and its impact on the Environment, by Researcher Ms Remani Chinchu Balaji (Track Leader: Prof Bernard Tan)

**Seminar Abstract:**

Pollution has been on the rise with the increase and developments in shipping activities. As a result of this, there has been a hoard of steps taken worldwide at both the international and state levels to address and combat the same. This seminar is an attempt to explore the ways in which shipping activities adversely impact the environment and identify and analyse the legal  and policy framework that have been set up at the international level to address these adverse impacts.

### 4. Computer Vision Applications in Transportation Engineering - A Review, by Researcher Ms Lakshmi Rajasekhar (Track Leader: Dr Raymond Ong)

**Seminar Abstract:**

Computer Vision can be described as a technology which tries to emulate the capabilities of biological vision (esp. human brain and eyes). Computer vision has a wide range of applications of which I would like to concentrate on the applications specific to transportation engineering like pedestrian movement detection and analysis, vehicle count and classification etc. This talk will give a brief overview of the research in computer vision for transportation engineering applications.

## CMS RESEARCH SEMINARS

### 5. Overview of Traffic Micro-Simulation Modeling , by Researcher Mr Yang Jiasheng (Track Leader: Prof Fwa)

**Seminar Abstract:**

Micro-simulation models have become widely used tools in transportation engineering because they are able to reproduce queues, traveling time, throughput, actuated traffic signals, and many other traffic characteristics observed in real life. Testing road design and traffic control systems, analysis of intelligent transportation systems, evaluating traffic management schemes, and calibrating adaptive control systems are important applications of micro simulation models that requirement a well calibrated model to produce satisfactory results. The focus of the talk will be on the overview of the micro-simulation model development. The seminar concludes with useful information for traffic micro-simulation modeling application.

### 6. Empty Container Repositioning Management, by Visiting Researcher Dr Xu Zui (Track Leader: A/Prof Meng Qiang)

**Seminar Abstract:**

Empty container repositioning has been an on-going issue since the beginning of containerization. But it has become more prominent in recent decades. This seminar will review the literature related to empty container repositioning from both the internal and external managerial points of view, and analyze how the Major Shipping Company, CSAV, to solve this problem.

### 7. Piracy and Armed Robbery against Ships , by Researcher Ms Remani Chinchu Balaji (Track Leader: Prof Bernard Tan)

**Seminar Abstract:**

The issue of piracy against ships poses a significant threat to world shipping. Acts of piracy and armed robbery against ships are of tremendous concern to shipping in general. The fight to prevent and suppress these acts has been a cause for major concern for the shipping industry in particular and the international community in general. The IMO has come up with various initiatives to counter piracy and armed robbery at sea. IMO has been working on implementing an anti-piracy project, a long-term project which began in 1998. This seminar is an attempt to look at the objectives of the anti-piracy project envisaged by the IMO and the effectiveness of the same.

### 8. Port State Control in Maritime Law, by Researcher Ms Ticy Thomas (Track Leader: Prof Bernard Tan)

**Seminar Abstract:**

Maritime law is among the oldest branches of law. Although initially concerned with maritime commerce, it has expanded to address contemporary issues such as those involving the environment and the use of cruise vessels. One of the most pressing issues confronting the International Maritime Organization relating to maritime safety and marine environmental protection is port State control (PSC). The seminar proposes to trace the development of the concept of PSC and analyze its increasing role in the current maritime regulatory landscape.

## CMS RESEARCH SEMINARS

### 9. Publishing Trajectories with Differential Privacy: Sampling Mechanisms, by Researcher Dr Jiang Kaifeng (Track Leader: A/Prof Stephane Bressan)

**Seminar Abstract:**

It is now possible to collect and share trajectory data for any ship in the world by various means such as satellite and VHF systems. However, the publication of such data also creates new risks for privacy breach with consequences on the security and liability of the stakeholders. Thus, there is an urgent need to develop methods for preserving the privacy of published trajectory data. In this paper, we propose and comparatively investigate two mechanisms for the publication of the trajectory of individual ships under differential privacy guarantees. Traditionally, privacy and differential privacy is achieved by perturbation of the result or the data according to the sensitivity of the query. Our approach, instead, combines sampling and interpolation. We present and compare two techniques in which we sample and interpolate (a priori) and interpolate and sample (a posteriori), respectively. We show that both techniques achieve a $(0, delta)$ form of differential privacy. We analytically and empirically, with real ship trajectories, study the privacy guarantee and utility of the methods.

### 10. Overview of Global Material Flows of Traded Commodities Using United Nations Commodity Trade Statistics Database, by Researcher Dr. Farhan Javed (Track Leader: Dr Raymond Ong)

**Seminar Abstract:**

Global physical trade volume has been increasing since 1962, and reached more than 19 billion tonnes in 2005 as reported in the United Nations Commodity Trade Statistics Database (UN Comtrade). As the trade volume per definition accounts for the sum of both imports and exports, the real trade flow equals half of the reported trade volume. Thus, in 2005 nearly 10 billion - tonnes passed an international border. The dominant traded commodity in physical units was fossil fuels, mainly oil. This presentation describes material flows for dominant resource suppliers and demanders which report their trade, in terms of physical terms, to United Nations Statistics Division. United States, having the world's largest economy and leading importer, has an important influence on global sustainable development through the trade of primary commodities. Using the UN Comtrade database, an overview of material flows of the traded primary commodities by the United States is analyzed.

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