Centre for Maritime Studies

# CMS RESEARCH UPDATES JULY 2017

March 2017 – June 2017

## Research Highlight 1: Two-phase Decomposition Method for the Last Train Departure Time Choice in Subway Networks, by Dr. Kang Liujiang (Track Leader: Professor MENG Qiang)

### Objective

An urban subway network with a number of service lines forms the backbone of the public transport system for a large city of high population, such as Singapore, Hong Kong and Beijing. Passengers in these large cities heavily rely on urban subway networks for their daily life. The departure times of the last trains running on different lines of an urban subway network should be well coordinated in order to serve more passengers who can successfully transfer from one line to another, which is referred to as the last train departure time choice problem. This study aims to develop a global optimization method that can solve the last train departure time choice problem for large-scale urban subway networks. To do so, it first formulates a mixed-integer linear programming (MILP) model by introducing auxiliary binary and integer decision variables. For the real-life and large-scale instances, however, the formulated MILP model cannot be solved directly by the global optimization methods such as branch-and-bound algorithm invoked by CPLEX – one of the powerful optimization solvers because of the instance sizes. An effective two-phase decomposition method is thus proposed to globally solve the large-scale problems by decomposing the original MILP into two MILP models with small sizes. Finally, a real case study from the Beijing subway network is conducted to assess the efficiency and applicability of the two-phase decomposition method.

### MILP model for the problem

The last train departure time choice problem aims to determine the last train departure time vector $\mathbf{t}^R$ by minimizing the total connection time subject to the necessary operational constraints. Let us further illustrate the last train connection issue caused by the departure time pattern of last trains via a spatial-and-temporal analysis of train services. A three-dimensional time-space diagram shown in Figure 1 is created to represent the train timetables of line $l$ and line $l'$ as well as the time dimension. Sets $\{k, k+1, k+2, \cdots\}$ and $\{k', k'+1, k'+2, \cdots\}$ denote the series of stations standing on lines $l$ and $l'$, respectively. $k'(k)$ denotes an element of the intersection of sets $\{k, k+1, k+2, \cdots\}$ and $\{k', k'+1, k'+2, \cdots\}$, which gives the transfer station between lines $l$ and $l'$. The last train (solid lines) and non-last trains (dotted lines), as shown in Figure 1, serve lines $l$ and $l'$ by calling at each station. It can be seen that the passengers of the non-last trains can transfer to connecting trains successfully. As for the last train transfers, lines $l$ to $l'$ at transfer station $k$ is successfully connected. However, the last train connection from lines $l'$ to $l$ fails.

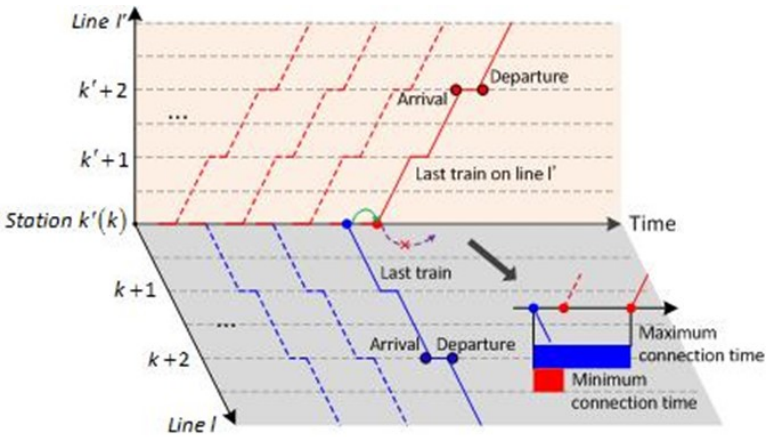


Figure 1 Illustration of the last train connection

 

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### MILP model for the problem

The last train departure time choice problem can be formulated by the following MILP model.

**[MILP-0]:**

subject to:

$$\text{Min} \sum_{\forall l\in L}\sum_{\forall l'\in L}\sum_{k\in S(l)\cap S(l')}\left[p_{ll'}^{k}\times w_{ll'}^{k}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)\right] \tag{1}$$

$$w_{ll'}^{k}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)=t_{kll'}^{R}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)-y_{ll'}^{k}\times H_{l'}+\left(1-x_{ll'}^{k}\right)\times M \quad \forall k\in S(l)\cap S(l'),\forall l,l'\in L \tag{2}$$

$$M\times\left(x_{ll'}^{k}-1\right)\le t_{kll'}^{R}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)\le M\times x_{ll'}^{k} \quad \forall k\in S(l)\cap S(l'),\forall l,l'\in L \tag{3}$$

$$\left[t_{kll'}^{R}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)\Big/H_{l'}\right]-1\le y_{ll'}^{k}\le t_{kll'}^{R}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)\Big/H_{l'} \quad \forall k\in S(l)\cap S(l'),\forall l,l'\in L \tag{4}$$

$$x_{ll'}^{k}\in\{0,1\} \quad \forall k\in S(l)\cap S(l'),\forall l,l'\in L \tag{5}$$

$$y_{ll'}^{k}\in\square^{+} \quad \forall k\in S(l)\cap S(l'),\forall l,l'\in L \tag{6}$$

$$Dep_{\min}^{l}\le Dep_{k}^{l}\left(t_l^{R}\right)\le Dep_{\max}^{l} \quad \forall k\in S(l),\forall l\in L \tag{7}$$

$$Arr_{\min}^{l}\le Arr_{k}^{l}\left(t_l^{R}\right)\le Arr_{\max}^{l} \quad \forall k\in S(l),\forall l\in L \tag{8}$$

$$T_l^{\min}\le t_l^{\mathrm{R}}\le T_l^{\max} \quad \forall l\in L \tag{9}$$

The objective function expressed by Eq. minimizes the total transfer connection time for last train passengers, in which $p_{ll'}^{k}$ is the number of passengers from line $l$ to line $l'$ at transfer station $k\in S(l)\bigcap S(l')$. Constraint is the equivalent linear expression of the minimum connection time using auxiliary binary variables $x_{ll'}^{k}$ and integer variables $y_{ll'}^{k}$. Constraint completely expresses the logical relationship between auxiliary variable $x_{ll'}^{k}$ and the maximum connection time $t_{kll'}^{R}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)$, namely: $x_{ll'}^{k}=1$ if the maximum connection time $t_{kll'}^{R}\left(t_l^{\mathrm{R}},t_{l'}^{\mathrm{R}}\right)\ge 0$ and $x_{ll'}^{k}=0$, otherwise. Constraint linearly reformulates $h_{ll'}^{k}=floor\left(t_{kll'}^{R}/H_{l'}\right)$ using the auxiliary integer variables $y_{ll'}^{k}$. Constraints and define the domains of the decision variables $x_{ll'}^{k}$ and $y_{ll'}^{k}$, respectively.

The departure, arrival and service times of a train at each station should be restricted within the lower and upper

 

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### MILP model for the problem

bounds shown in constraints -, where $Dep^{l}_{\min}$ represents the earliest train departure time from stations on line $l$, $Dep^{l}_{\max}$ denotes the latest train departure time from stations on line $l$, $Arr^{l}_{\min}$ indicates the earliest train arrival $Arr^{l}_{\max}$ represents the latest train arrival time at stations on line $l$, $T^{\min}_{l}$ is the acceptable earliest off service time of line $l$, and $T^{\max}_{l}$ provides the acceptable latest off service time of line $l$.

### Two-phase decomposition method

It can be easily observed that half of the total possible transfer activities at a transfer station should fail in practice, elaborating by

**Observation 1**: Connection conflicting in a cross pair of transfer directions (e.g., $l$ to $l'$ and $l'$ to $l$) is unavoidable, and only one last train transfer direction at most can be connected by the last trains when the transfer time is strictly greater than the train dwell time.

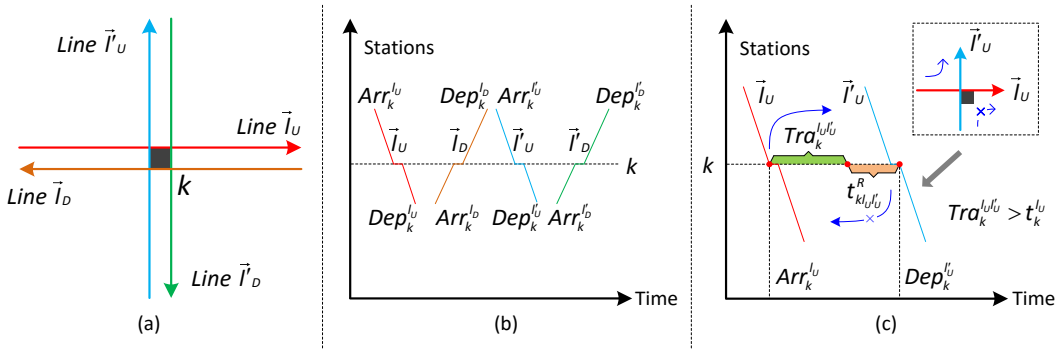


**Figure 2 Illustration of transfer contradiction**

Figure 2(a) is an illustration of the observation by taking transfer station $k$ with four directional lines ($\vec{l}_U$, $\vec{l}_D$, $\vec{l}'_U$ and $\vec{l}'_D$) for instance. Letters "U" and "D" represent the up-train and down-train directions, respectively. Figure 2(b) shows a timetable for the last trains at station $k$, especially indicating the arrival and departure times of four last trains, in which the x-axis represents the time dimension and the y-axis shows station indexes. We use Figure 2(c) to illustrate the last train connection contradiction of lines $\vec{l}_U$ and $\vec{l}'_U$, which indicates that the last train connection of lines $\vec{l}'_U$ to $\vec{l}_U$ fails when the connection of $\vec{l}_U$ to $\vec{l}'_U$ succeeds. In other words, Observation 1 does hold. Based on Observation 1, a two-phase decomposition method is proposed to reduce the size of model MILP-0. In the first phase, the small-size MILP model is developed to maximize the number of passengers being connected by last trains:

 

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### Two-phase decomposition method

**[MILP-1]:**

$$\text{Max} \sum_{\forall l \in L} \sum_{\forall l' \in L} \sum_{k \in S(l) \cap S(l')} \left[ p_{ll'}^{k} \times x_{ll'}^{k} \right] \tag{10}$$

subject to constraints (3), (5), and (7) - (9).

The second phase minimizes connection times for those successful transfer passengers in the first phase (without taking into account missed connections so that the MILP model size reduces significantly), which can be formulated by the MILP model:

**[MILP-2]:**

$$\text{Min} \sum_{\forall l \in L} \sum_{\forall l' \in L} \sum_{k \in S(l) \cap S(l')} \left\{ p_{ll'}^{k} \times \left[ t_{kll'}^{R}\left(t_{l}^{R}, t_{l'}^{R}\right) - y_{ll'}^{k} \times H_{l'} + \left(1 - \bar{x}_{ll'}^{k}\right) \times M \right] \right\} \tag{11}$$

subject to constraints (4), and (6) - (9).

where the optimal $\bar{x}_{ll'}^{k} \quad \left(k \in S(l) \bigcap S(l'), l \neq l' \in L\right)$ are given by model MILP-1.

### Performance of the two-phase decomposition method in solving the Beijing subway network

To assess the performance of the two-phase decomposition method in solving the large-scale problems and evaluate the impact of the operational parameters involved in the last train service, we use the Beijing subway network.

Model MILP-1 was solved using CPLEX 12.6.1 in a workstation equipped with 2 processors of 402.5 GHz CPU and 32 GB of RAM. The optimal solution for the Beijing subway network improves the number of last train connections from 173 to 182, an increase of 5.2% from the original timetable. Based on these 182 connections, model MILP-2 was solved in the same computational environment. In this experiment, we set the maximum running time of the program to four hours (after many preliminary tests). The optimization processes are reported in Table 1. The minimum objective value for the linear programming solution is 7935 min. The gaps were reduced gradually with the program running, from 100%, to 76.39%, to 0.42%, to 0.22%, and to 0.03% finally. Correspondingly, the program occupied 0.03 GB of RAM for the first feasible solution found, and occupied 9.84 GB for the final optimal solution returned. Therefore, we can conclude that the computational time used by the two-phase decomposition method to solve large-scale problems in the CPLEX solver is acceptable, and the solution quality is satisfactory.

**Table 1 CPLEX solver records for model MILP-2**

| Stage | Nodes | Iterations | Gap | Objective | CPU time | Using RAM |
|---|---|---|---|---|---|---|
| 1 | 37 | 226 | 100% | 15868 min | 15 sec | 0.03 GB |
| 2 | 13,245 | 18,528 | 76.39% | 13993 min | 5 min 17 sec | 1.25 GB |
| 3 | 67,646 | 104,794 | 0.42% | 7966 min | 32 min 23 sec | 3.56 GB |
| 4 | 695,245 | 303,246 | 0.22% | 7950 min | 1 h 26 min | 4.88 GB |
| 5 | 1,969,952 | 1,005,966 | 0.03% | 7935 min | 3 h 59 min | 9.84 GB |

## Research Highlight 1: Two-phase Decomposition Method for the Last Train Departure Time Choice in Subway Networks, by Dr. Kang Liujiang (Track Leader: Professor MENG Qiang)

### Performance of the two-phase decomposition method in solving the Beijing subway network

Figure 3 shows the distribution of connection times for all transfer directions. As illustrated, the optimal timetable increases the number of directions with shorter connection times, e.g., connection times in $[0,1]$ min, $(1,5]$ min and $(5,10]$ min. With respect to missed connections, the optimal timetable reduces the number of such directions from 211 to 199.

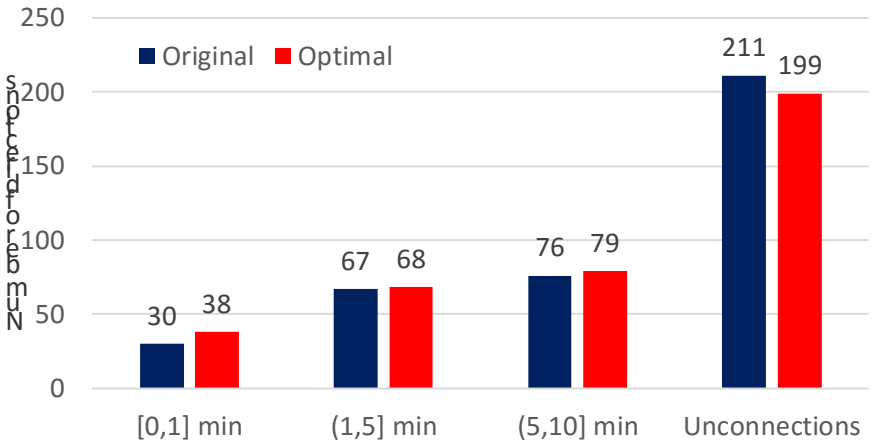



**Figure 3 Connection time bar chart of two last train timetables for the Beijing subway**

### Conclusion

The importance of the last train transfer issues has been raised by the urban subway operators. The problem of last train departure time choice considering passenger transfers in a large subway system is an inevitable and challenging optimization problem in practice. In this paper, we study the global optimization method for the last train departure time choice problem in a large subway network. The contributions of this study are threefold: (i) developing a novel MILP model for the last train departure time choice problem, (ii) proposing an effective global optimal method based on the model decomposing technique and (iii) carrying out a real case study from the full-scale Beijing subway network to show the effectiveness of the proposed global optimization method.

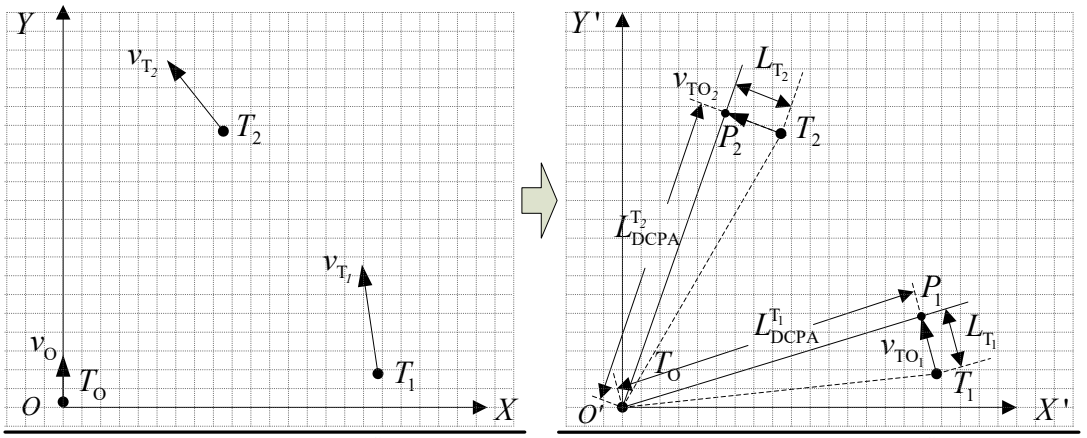
 

## Research Highlight 2: A Novel Model for Assessing Ship Collision Risk Based on Dynamic Ship Domain, by Ms. Wei Xiaoyang (Track Leader: Professor MENG Qiang)

### Background

The Distance to Closest Point of Approach (DCPA) and the Time to Closest Point of Approach (TCPA) are two parameters that are generally used in collision risk assessment, adopted as an industry standard in on board collision avoidance and decision support systems. However, such approaches have shortcomings in risk assessment.

For example, in Figure 1, risk assessment methods based on DCPA-TCPA consider the collision risk between ships $T_1$ and $T_O$ equals the collision risk between ships $T_2$ and $T_O$. Actually, according International Regulations for Preventing Collisions at Sea (COLREGS ) and ship's maneuverability practice, collision risk between ships $T_2$ and $T_O$ is more than that between ships $T_1$ and $T_O$.




| Ship | Speed (Knot) | Course (°) | Bearing of TS | Coordinates X | Coordinates Y | RD |
|---|---|---|---|---|---|---|
| $T_O$ | 7 | 0 | — | 0 | 0 | — |
| $T_1$ | 15.42 | 351.61 | 88.295 | 4.2 | 0.125 | 4.202 |
| $T_2$ | 12.81 | 321.34 | 31.127 | 2.18 | 3.61 | 4.217 |

| Ship | Speed (Knot) | Course (°) | Bearing of TS | Coordinates X | Coordinates Y | RD |
|---|---|---|---|---|---|---|
| $T_O$ | 0 | 0 | — | 0 | 0 | — |
| $T_1$ | 8.55 | 344.74 | 88.295 | 4.2 | 0.125 | 4.202 |
| $T_2$ | 8.55 | 290.68 | 31.127 | 2.18 | 3.61 | 4.217 |

Figure 1. Different collision risk levels with the same $DCPA$ and $TCPA$

### Objectives and Contributions

The paper aims to change the current state of things by presenting a solution to the domain violation problem. Two domain-based approach parameters - Spatial Approach Factor (SAF) and Temporal Approach Factor (TAF) - are introduced and formulas for both of them are derived.

Possible systems where SAF and TAF parameters could be applied include collision avoidance systems (CAS) as well as systems dedicated to navigation in special environmental conditions.

## Research Highlight 2: A Novel Model for Assessing Ship Collision Risk Based on Dynamic Ship Domain, by Ms. Wei Xiaoyang (Track Leader: Professor MENG Qiang)

### The Approximation of Ship Domain

The major advantages of an ellipse ship domain are its analyzability and computational simplicity.

It must be noted that many factors affecting ship domains' parameters (i.e. *a, b, h* and *k*).

Since the shape and size are presented here only for illustrative purposes, an ellipse ship domain which is calibrated using the data of vessel movements in Singapore Strait is presented in Figure 3.

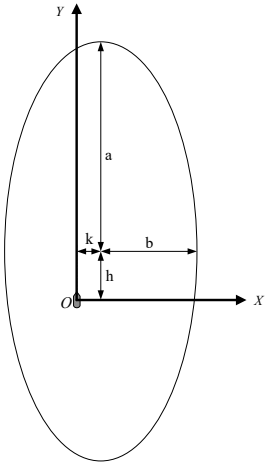
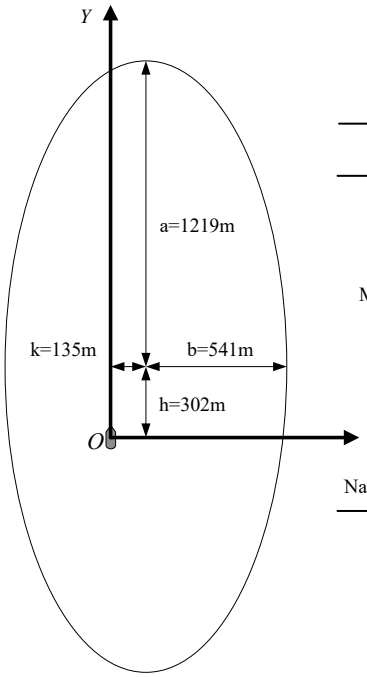



Figure 2. An ellipse ship domain

Table 1. Factors affecting ship domain

| Type | Factors |
|---|---|
| Physics | Ship size, type, manoeuvrability, etc. |
| Traffic dynamic | Position, speed, course, bearing, traffic density, encounter types (head-on, crossing, over-taking) |
| Environment | Visibility, tide, current, wind and other weather conditions |
| Human | Navigators' knowledge, skill, experience, mental and physical conditions |




| Factors | Values | Factors | Values |
|---|---|---|---|
| Ship type | Tanker | Time | 03:15（night） |
| Ship size | 319m | Visibility | 10nm |
| Manoeuvrability | — | Tide | 1.8m |
| Speed | 10.5 Knot | Current | 1.2knot |
| Position | 1.24N 103.92E | Wind | 3.7 knot |
| Course | 72° | Others | — |
| Navigators ( knowledge, skill, experience, mental, physical conditions) | — | | |

Figure 3. An ellipse ship domain for certain factors in Singapore Strait

## Research Highlight 2: A Novel Model for Assessing Ship Collision Risk Based on Dynamic Ship Domain, by Ms. Wei Xiaoyang (Track Leader: Professor MENG Qiang)

### Risk Measurement Model

#### I. Definitions

**Definition 1.** Given vectors of an own ship and a target ship's coordinates, the Spatial Approach Factor $f_S^t$ is equal to the shrink factor of the own ship's domain, namely, $f_S^t = \frac{D_i^t}{R_{\overrightarrow{ji}}^t}$. $f_S^t$ represents own ship's $f_S$ at time $t$, $R_{\overrightarrow{ji}}^t$ represents the radius of own ship's domain in the direction of $\overrightarrow{ji}$ at time $t$, $D_i^t$ represents the target ship's invaded depth in own ship's domain, see Figure 4.

**Definition 2.** Given vectors of an own ship and a target ship's coordinates, the Temporal Approach Factor $f_T$ is equal to the invaded depth divided by the relative speed of the target ship in the direction to the own ship, then divided by the Least Time to Avoid (LTA), namely,

$$f_T^t = \frac{D_i^t}{\overrightarrow{v_i^t}\left(x_i^t - x_j^t, \hat{y}_i^t - y_j^t\right)T_0}$$

. $f_T^t$ represents own ship's $f_T$ at time $t$, $D_i^t$ represents the invaded depth in own ship's domain, $\vec{v}_i^t\left(x_i^t - x_j^t, \hat{y}_i^t - y_j^t\right)$ represents the relative speed of the target ship in the direction to the own ship, $T_0$ is the least time to avoid (LTA), which means if give-way vessel do not start to avoid, the ships will collision, see Figure 4.

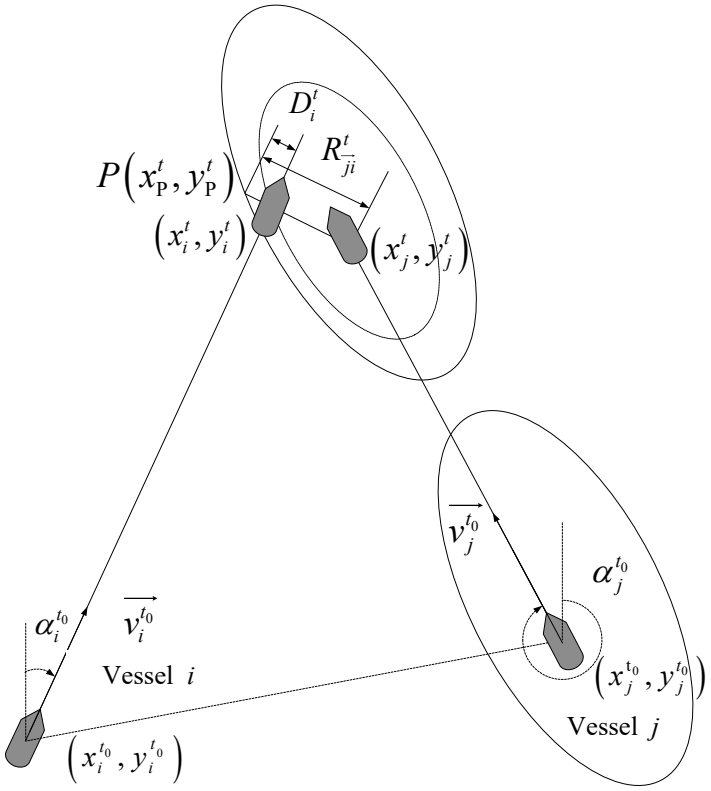



Figure 4. Illustration of the symbols used in the equations.

The symbols used and the formulas are illustrated as follows.

According the geometrical relationship in Figure 4,

$$D_i^t = \sqrt{\left(x_P^t - x_i^t\right)^2 + \left(y_P^t - y_i^t\right)^2} \quad (1)$$

$$R_{\overrightarrow{ji}}^t = \sqrt{\left(x_P^t - x_j^t\right)^2 + \left(y_P^t - y_j^t\right)^2} \quad (2)$$

## Research Highlight 2: A Novel Model for Assessing Ship Collision Risk Based on Dynamic Ship Domain, by Ms. Wei Xiaoyang (Track Leader: Professor MENG Qiang)

### Risk Measurement Model

$$\left(x_i^t - x_j^t, \hat{y_i^t - y_j^t}\right) = \frac{\overrightarrow{\left(x_i^t - x_j^t, y_i^t - y_j^t\right)}}{\sqrt{\left(x_i^t - x_j^t\right)^2 + \left(y_i^t - y_j^t\right)^2}} \tag{3}$$

Therefore, $f_S^t$ , $f_T^t$ can be achieved by the formula.

**II. Spatiotemporal comprehensive function for conflict measure**

It is necessary to develop a relationship between the risk and the two proximity indicators.

$$C(t) = f\left(\mathrm{X}_{PI}(t)\right) \tag{4}$$

Where $C(t)$ is the risk of collision in an interaction at time $t$ and $\mathrm{X}_{PI}(t)$ is a vector of the proximity indicators.

The comprehensive collision risk is:

$$C(t) = f_S^t f_T^t \tag{5}$$

The maximum of $C(t)$ in an interaction process, $C_{max}$ is taken to represent the conflict severity of that interaction.

**II. Method of measuring collision risk in a waterway**

To measure the proximity indicators of encounters and associated risks of collisions, a block diagram is presented in Figure 5 showing the steps of a developed program.

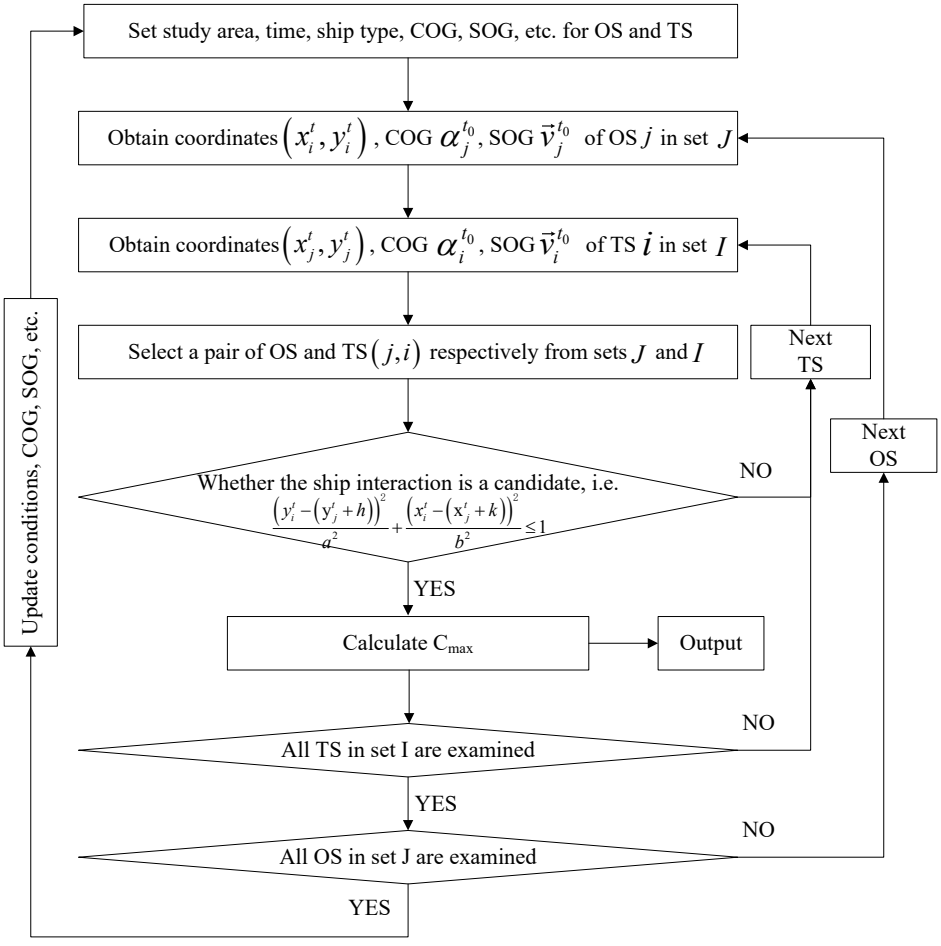



Figure 5. Block diagram of conflict analysis.

## Research Highlight 2: A Novel Model for Assessing Ship Collision Risk Based on Dynamic Ship Domain, by Ms. Wei Xiaoyang (Track Leader: Professor MENG Qiang)

### Risk Measurement Model

**IV. Probability distribution function (PDF) of collision risk**

The test statistics ( $AD^2$ ) measures how well the data follows a particular distribution.

$$AD^2 = \sum_{n=1}^{N} \frac{1-2n}{N}\left[\ln\left(F\left[D_n\right]\right)\right] + \ln\left(1-F\left[D_{N+1-n}\right]\right) - N \tag{6}$$

A PDF for a typical set of $C_{max}$ is shown in Figure 6. Where $\sigma$ , $\mu$ and $\gamma$ are expectation, variance and displacement respectively.

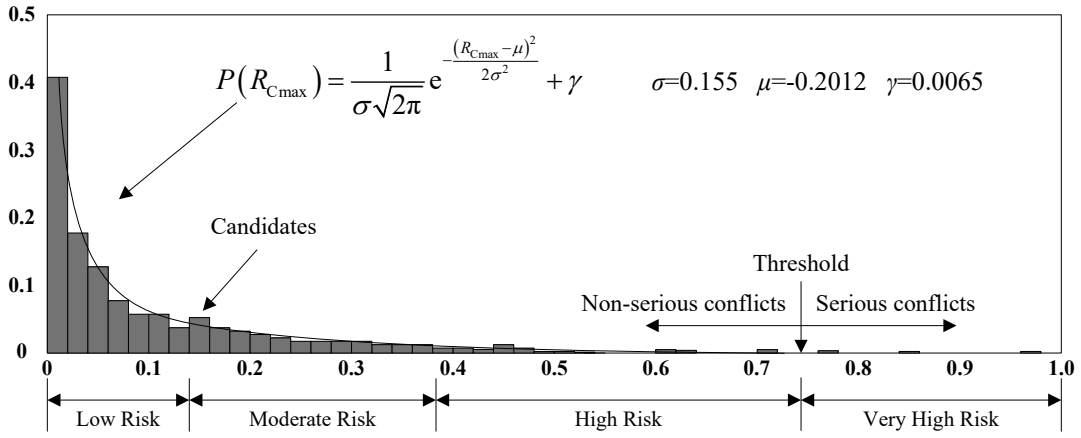



Figure 6. A typical probability distribution function (PDF) of $R_{Cmax}$ .

By utilizing the thresholds, the risk of collision in a waterway can be expressed as:

$$P_C = p\left(R_{C_{max}} > \tau\right) = 1 - F_\tau\left(\tau\right) \tag{7}$$

### Case Study

**I.Data collection and preparation**

In general, each AIS record consists of the following information for each ship at each reporting time (every 3-10 s): (i) MMSI (Maritime Mobile Service Identity) number; (ii) Latitude position; (iii) Longitude position; (iv) Speed over ground (SOG); (v) Course over ground (COG).

**II.Results and discussions**

The total occurrence frequency of ship collisions in the Singapore Strait is 2.15/year, which implies that there will be one ship collision occurred in the Strait every six months. Actually, the estimated collision frequency is quite close to the average actual frequency of 2.05/year which is calculated from historical accident records between the years of 1997 and 2004 in the Singapore Strait. In addition, among these ship collisions, there is a biggest proportion of crossing collisions (1.36/year), followed by the overtaking collisions (0.55/year) and the head-on collisions (0.24/year).

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### Case Study

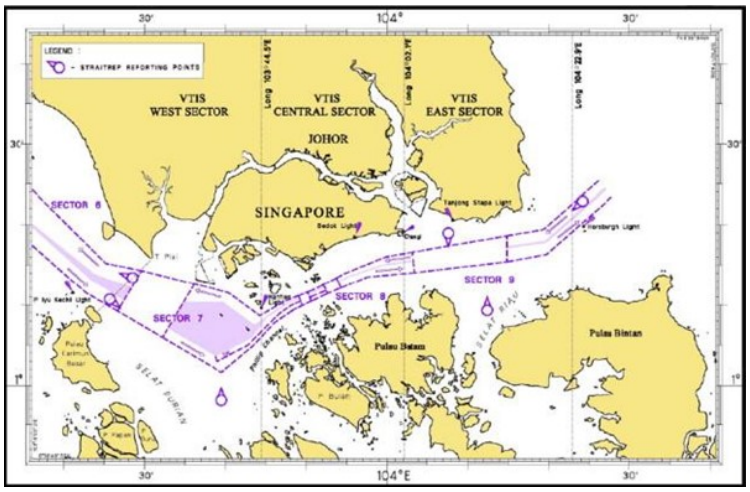
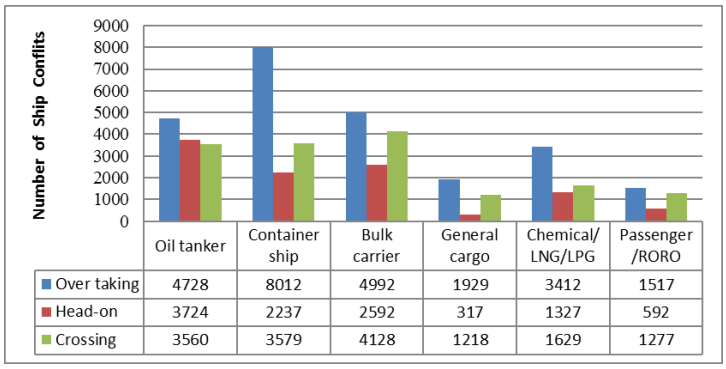



Figure 7. Map of Singapore Strait (MPA, 2015)




| | Oil tanker | Container ship | Bulk carrier | General cargo | Chemical/ LNG/LPG | Passenger /RORO |
|---|---|---|---|---|---|---|
| Over taking | 4728 | 8012 | 4992 | 1929 | 3412 | 1517 |
| Head-on | 3724 | 2237 | 2592 | 317 | 1327 | 592 |
| Crossing | 3560 | 3579 | 4128 | 1218 | 1629 | 1277 |

Figure 10. Number of ship conflict in the Singapore Strait per year

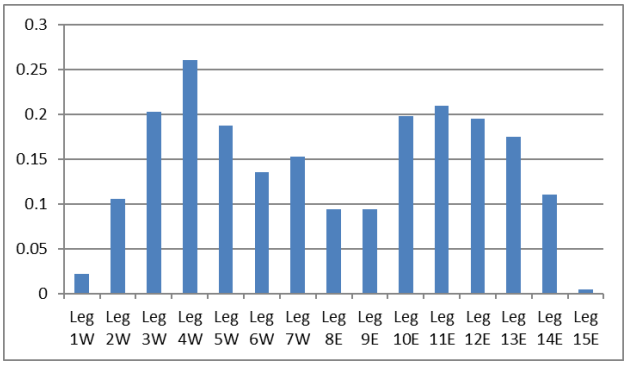



Figure 11. Spatial distribution of ship collisions

### Conclusion

Measured risks could be employed to compare safety in different waterways and time periods. To further extract meaningful inferences from the risks, measured values for different navigational scenarios can be compared to evaluate safety at those scenarios.

TAF would then be a natural replacement of TCPA, as for given motion parameters it would give time to violating those safe distances.

## Published Technical Papers (with Abstracts)

1. **Jia Sheng Yang (2017), Hybrid active and passive control of a very large floating beam structure.** ***Nonlinear Dynamics, Volume 87, Issue 3, Pages 1835-1845.***

**Abstract:**

In this paper, we present a novel hybrid active and passive control method for very large floating structure (VLFS) to reduce the hydroelastic response, such that the resulting controlled VLFS can enhance its serviceability on the whole area. The floating beam structure is described as a distributed parameter system with partial differential equation (PDE). According to Lyapunov stability principle, a hybrid active and passive controller is designed to suppress the vibration of VLFS for the improvement in serviceability. In the active control design, two boundary controllers are developed to act on the upstream and downstream ends of VLFS, respectively. In passive control design, passive control components with high elastic rigidities are used to absorb the dynamic energy of VLFS from waves. Numerical simulations with comparison to the existing active control method are used to verify the effectiveness of the proposed control method. The parametric studies are given to examine the effects of various parameters to the vibration response of VLFS.

2. **H Wang, BW Ang, Bin Su (2017), Multiplicative structural decomposition analysis of energy and emission intensities: Some methodological issues.** ***Energy, Volume 123, Pages 47-63.***

**Abstract:**

Structural decomposition analysis (SDA) has been a popular tool for studying a country's energy or emission performance. At the same time, there has been an increasing use of intensity indicators, such as energy consumption and carbon emissions per unit of economic output, in energy and emission performance reporting. The ratio change of an energy or emission intensity indicator can be more conveniently handled in the multiplicative form. In the context of multiplicative SDA of intensity indicators, this study investigates three specific methodological issues. The first is about sub-aggregate decomposition which provides detailed results at the sectoral/regional level to explain the observed aggregate intensity change. The second is the possible linkages between multiplicative SDA and additive SDA when studying changes in an intensity indicator over time. Arising from the convergence between SDA and index decomposition analysis (IDA) in application, the third issue is about the conceptual and empirical linkages between these two decomposition analysis techniques in the multiplicative form. A better understanding of these three issues will help to promote the use of multiplicative SDA of intensity indicators. A case study that looks into China's energy intensity change from 2007 to 2012 is presented.

3. **BW Ang, H Wang, Xiaojing Ma (2017), Climatic influence on electricity consumption: The case of Singapore and Hong Kong.** ***Energy, Volume 127, Pages 534-543.***

**Abstract:**

Global warming and the associated risks for natural and human systems have been major global concerns. The International Panel on Climate Change (IPCC) has projected average global surface temperature to increase by between 0.3 °C and 4.8 °C by the end of this century, depending on the greenhouse gas emission scenarios assessed. In the tropical and sub-tropical regions increases in temperature will lead to greater use of electricity for space cooling, a development that is undesirable from energy and sustainability viewpoints. We investigate how temperature increases affect electricity consumption in Singapore and Hong Kong. This is done by consuming sector, i.e. residential, commercial and industrial. Singapore and Hong Kong are respectively two tropical and subtropical cities with comparable physical, population and economy sizes. Two different approaches are used to relate their sectoral electricity consumption to temperature using regression analysis. It is estimated that total annual electricity consumption would increase by between 3% and 4% in Singapore in 2015 if there were to be a 1 °C rise in temperature. The corresponding estimates for Hong Kong are between 4% and 5%. In both cities, increases would be the greatest in the residential sector, followed by the commercial sector and the industrial sector.

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4. **Bin Su, BW Ang, Yingzhu Li (2017), Input-output and structural decomposition analysis of Singapore's carbon emissions.** ***Energy Policy, Volume 2015, Pages 484-492.***

**Abstract:**

Singapore is an island city-state. It lacks conventional energy resources and is alternative energy disadvantaged. In the past decade (2000–2010), its energy-related carbon emissions increased from 37.8 to 44.4 million tonnes of CO2. This paper analyses the city state's carbon emissions from the demand perspective using the input-output (I-O) method and investigate the drivers of emission changes using structural decomposition analysis (SDA). It is the first comprehensive analysis of Singapore's emissions using the I-O framework. The results obtained show that exports accounted for nearly two-thirds of its total emissions and growth in its emissions in the last decade was largely export-driven. Emissions increased as export-oriented industries and export volume expanded. Fuel switching and energy efficiency, however, helped to lower growth in emissions. Besides exports, household-related emissions accounted for about a quarter of Singapore's total emissions. The emissions related to different household groups remained fairly stable as increases in embodied (indirect) emissions were offset by decreases in direct emissions. The high-income household group registered the largest increase in direct emissions, while the middle-income household group registered the largest increase in embodied emissions. The policy implications of our findings are discussed.

5. **Bin Su, BW Ang (2017), Multiplicative structural decomposition analysis of aggregate embodied energy and emission intensities.** ***Energy Economies, Volume 65, Pages 137-147.***

**Abstract:**

Aggregate intensity indicators, such as the ratio of a country's energy and emissions to its GDP, are often used by researchers and policymakers to study energy and environmental performance. This paper analyzes the relationship between energy (or emissions) and value added (or GDP) from a different viewpoint, namely from the demand rather than the production perspective, using the input–output (I–O) framework. The aggregate embodied intensity (AEI), defined as the ratio of embodied energy (or emissions) to embodied value added, can be defined at the aggregate, final demand category and sectoral levels. The total aggregate intensity can be presented as a weighted sum of the AEIs at the final demand category or sectoral level. Changes of the AEI at different levels can be decomposed to identify the driving forces using multiplicative SDA. A study using the latest 2007 and 2012 datasets of China indicates that (a) its aggregate intensity of CO2 emissions was mainly determined by the AEI in investment and (b) the emission intensity effect generally contributed the most to the AEI ratio changes at different levels. The proposed framework can be applied to other aggregate intensity indicators and extended to multi-country/region analysis.

6. **H Wang, BW Ang, Bin Su (2017), Assessing drivers of economy-wide energy use and emissions: IDA versus SDA.** ***Energy Policy, Volume 107, Pages 585-599.***

**Abstract:**

Index decomposition analysis (IDA) and structural decomposition analysis (SDA) are analytical techniques that have been extensively used by researchers to study drivers of changes in energy consumption and energy-related emissions for energy and climate policy assessment and development. We compare the two techniques from the methodological and application viewpoints and with specific reference to economy-wide analysis where the overlap between the two is the greatest. Our study brings up to date several previous studies and provides a detailed assessment of the post-2010 developments. In addition, a framework for additive and multiplicative decomposition methods is presented, specific application in policy analysis is discussed with representative examples given, and the selection between the two techniques is described. Despite the differences between the two techniques in terms of origin, there has been some convergence in their application in some specific areas. However, even if the same

 

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dataset is used, application of the two techniques will lead to different numerical results due to underlying differences in some core concepts and the meanings of the drivers of change defined. A good understanding of these similarities and differences will help researchers in making sound judgment in their adoption and implementation in policy studies.

7. **H Wang, BW Ang, Bin Su (2017), A multi-region structural decomposition analysis of global CO 2 emission intensity.** ***Ecological Economics, Volume 142, Pages 163-176.***

**Abstract:**

This paper studies changes in global and national CO2 emission intensities using the multi-region structural decomposition analysis (SDA) technique. Emission intensities such as the ratio of CO2 emissions to GDP have lately been widely used to characterize national emission performance. Meanwhile the impact of international trade has been found to be important in global emission accounting. It is therefore important to analyze changes in emission intensities by taking trade into consideration. In this study, we first propose two SDA models, one at the global level and the other at the country level, to quantify both the domestic and trade related effects on an intensity indicator. The models are then used to study changes in global and countries' CO2 emission intensities from 2000 to 2009. The results show that sectoral emission efficiency improvement was the main contributor to the slight decrease in global emission intensity during the period, while international trade marginally hampered improvement of global emission intensity. Comparisons of the performance between emerging economies and advanced economies reveal the importance of production structure and final demand structure in emission intensity reduction. The policy implications of the findings are presented.

8. **H Wang, BW Ang, P Zhou (2017), Decomposing aggregate CO2 emission changes with heterogeneity: An extended production-theoretical approach.** ***The Energy Journal, Volume 39, Issue 1.***

**Abstract:**

Quantifying the driving forces behind changes in aggregate CO2 emissions provides valuable information for supporting policy making in addressing climate change. We study this issue using the production-theoretical decomposition analysis (PDA) technique. Within a production theory framework, PDA examines CO2 emission changes from the perspective of productive efficiency. Although regional and sectoral heterogeneities in energy consumption and emission patterns prevail, they have not been taken into account in the PDA literature. By incorporating relevant decomposition methods, this study proposes an extended PDA approach to resolving the heterogeneity issue. The approach is applied to examine China's aggregate CO2 emission changes in its 11th five-year plan period (2005- 2010). By accounting for the heterogeneities, detailed results at the regional and sectoral levels are generated and further discussions presented.

9. **Yi Tao, Ek Peng Chew, Loo Hay Lee, Yuran Shi (2017), A column generation approach for the route planning problem in fourth party logistics.** ***Journal of the Operational Research Society, Volume 68, Issue 2, Pages 165-181.***

**Abstract**:

Abstract In this paper, we address the route planning problem in fourth party logistics (4PL). The problem calls for the selection of the logistics companies by a 4PL provider to optimize the routes of delivering goods through a transportation network. The concept of 4PL emerged in response to the shortfall in services capabilities of traditional third party logistics and has been proven to be capable of integrating logistics resources in order to fulfill complex transportation demands. A mixed-integer programming model is established for the planning problem with setup cost and edge cost discount policies which are commonly seen in practice. We propose a column generation approach combined with graph search heuristic to efficiently solve the problem. The good performance in

 

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terms of the solution quality and computational efficiency of our approach is shown through extensive numerical experiments on various scales of test instances. Impacts of cost policies on routing decision are also investigated and managerial insights are drawn.

10. **Haobin Li, Loo Hay Lee, Ek Peng Chew, Chun-Hung Chen (2017), GO-POLARS: A Steerable Stochastic Search on the Strength of Hyper-Spherical Coordinates.** ***IEEE Transactions on Automatic Control, Issue 99.***

**Abstract**:

Search algorithms for optimizing a complex problem are mainly categorized as gradient-driven and stochastic search, each with its advantages and shortcomings. A newly developed algorithm, GO-POLARS, is proposed with a hyper-spherical coordinate framework, which could perturb a given direction with well-controlled variation. It designs a steerable stochastic search algorithm that explores towards a promising direction, such as the gradient, at any desired levels. In this note, we provide an analytical study on the hyper-spherical coordinates and the corresponding random distributions, and thus proves the local convergence property of GO-POLARS. Extensive numerical experiments are illustrated to show its advantages compared to conventional search algorithms.

11. **Chenhao Zhou, Ek Peng Chew, Loo Hay Lee (2017), Information-Based Allocation Strategy for GRID-Based Transshipment Automated Container Terminal.** ***Transportation Science.*** **Retrieved June 25, 2017, from http://pubsonline.informs.org/doi/pdf/10.1287/trsc.2017.0736.**

**Abstract:**

In this paper, we introduce a storage allocation strategy for a transshipment container hub using a new automated container terminal called the hybrid GRID system. This study provides a novel approach of developing an efficient storage allocation strategy for new terminal concepts so that the complex formulations can be approximated by simple functions that can be quickly computed. Specifically, the storage allocation strategy is derived from an optimal allocation decision learned from a Mixed Integer Programming (MIP) model. Some input parameters of the MIP model are collected from a simulation model. An index measuring the storage location convenience is proposed and we regress this index with important variables to build an empirical model that provides recommendations on where to allocate containers to storage locations. The advantage of using the empirical approach is that it allows for fast computation which is expected in the dynamic and uncertain port environment. Numerical results show that four variables can significantly affect the performance of the allocation decision. This strategy is shown to be robust for different scenarios in terms of terminal configuration and container workload. In addition, the new strategy performs better than the commonly used strategies found in warehousing literatures, and the solution is close to the optimal allocation decision.

12. **Si Zhang, Jie Xu, Loo Hay Lee, Ek Peng Chew, Wai Peng Wong, Chun-Hung Chen (2017), Optimal computing budget allocation for particle swarm optimization in stochastic optimization.** ***IEEE Transactions on Evolutionary Computation, Volume 21, Issue 2, Pages 206-219.***

**Abstract:**

Particle swarm optimization (PSO) is a popular metaheuristic for deterministic optimization. Originated in the interpretations of the movement of individuals in a bird flock or fish school, PSO introduces the concept of personal best and global best to simulate the pattern of searching for food by flocking and successfully translate the natural phenomena to the optimization of complex functions. Many real-life applications of PSO cope with stochastic problems. To solve a stochastic problem using PSO, a straightforward approach is to equally allocate computational effort among all particles and obtain the same number of samples of fitness values. This is not an efficient use of computational budget and leaves considerable room for improvement. This paper proposes a seamless integration

 

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of the concept of optimal computing budget allocation into PSO to improve the computational efficiency of PSO for stochastic optimization problems. We derive an asymptotically optimal allocation rule to intelligently determine the number of samples for all particles such that the PSO algorithm can efficiently select the personal best and global best when there is stochastic estimation noise in fitness values. We also propose an easy-to-implement sequential procedure. Numerical tests show that our new approach can obtain much better results using the same amount of computational effort.

13. **Yi Tao, Ek Peng Chew, Loo Hay Lee, Lu Wang (In Press), A capacity pricing and reservation problem under option contract in the air cargo freight industry.** ***Computers & Industrial Engineering.***

**Abstract:**

Option contracts have been increasingly applied in the air cargo freight industry over the last several decades due to its ability to mitigate asset provider's capacity utilization risk. By entering into option contract with an air cargo carrier, freight forwarders reserve a certain amount of capacity upon signing the contract and execute the option partially or completely after the market demand is realized. In this work, we address the capacity pricing and reservation problem under option contract in the air cargo freight industry. A Stackelberg game model is established to simulate the behaviors of air cargo carrier and freight forwarders. We then respectively derive optimal pricing and reservation policy for both parties with the aim to maximize their expected profits. Numerical experiments and sensitivity analysis are subsequently conducted and managerial insights are drawn for both asset provider and freight forwarders to serve as guidelines for industry participators.

14. **Yi Tao, Loo Hay Lee, Ek Peng Chew, Gang Sun, Vincent Charles (2017), Inventory control policy for a periodic review system with expediting.** ***Applied Mathematical Modelling, Volume 49, Pages 375-393.***

**Abstract:**

In this work, we examine a single stage, periodic review inventory system where two modes, namely regular mode and expediting mode are available for a firm to obtain its replenishment. The firm can choose expediting mode with shorter lead time at a higher cost when necessary. A two-replenishment-mode model, with random expediting points is established and an innovative ordering policy (S, e) which replenishes the inventory level to S in every cycle and expedites a part of the order using fast mode when the inventory level drops to or below a certain level e, is proposed. A simulation-based optimization approach is employed to solve the problem. To be specific, an infinitesimal perturbation analysis (IPA) method is applied to estimate the gradients of the objective function and a gradient search algorithm is then used to find the best (S, e). Numerical experiments have validated the IPA estimate of (S, e) and shown that our new (S, e) policy outperforms the pure order-up-to policy and two single review moment policies. Sensitivity analysis has been conducted to evaluate the impact of system parameters of interest and managerial insights have been drawn.

15. **Chunjiang Zhang, Kay Chen Tan, Loo Hay Lee, Liang Gao (2017), Adjust weight vectors in MOEA/D for bi-objective optimization problems with discontinuous Pareto fronts.** ***Soft Computing, Pages 1-16.***

**Abstract:**

Multi-objective evolutionary algorithm based on decomposition (MOEA/D) is a recently proposed algorithm which is a research focus in the field of multi-objective evolutionary optimization. It decomposes a multi-objective problem into subproblems by mathematic programming methods and applies evolutionary algorithms to optimize the subproblems simultaneously. MOEA/D is good at finding Pareto solutions which are evenly distributed.

 

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However, it can be improved for problems with discontinuous Pareto fronts (PF). Many solutions will assemble in breakpoints in this situation. A method for adjusting weight vectors for bi-objective optimization problems with discontinuous PF is proposed. Firstly, this method detects the weight vectors which need to be adjusted using a property of MOEA/D. Secondly, the reserved vectors are divided into several subsets. Thirdly, after calculating the ideal number of vectors in each subset, vectors are adjusted evenly. Lastly, the corresponding solutions are updated by a linear interpolation. Numerical experiment shows the proposed method obtains good diversity and convergence on approached PF.

**16. Yuan Wang, Dongxiang Zhang, Lu Hu, Yang Yang, Loo Hay Lee (2017), A data-driven and optimal bus scheduling model with time-dependent traffic and demand.** ***IEEE Transactions on Intelligent Transportation Systems, Issue 99.***

**Abstract:**

Urban bus companies have collected a tremendous amount of travel data from passengers in the past years. In spite of great value for bus schedule optimization, these data have not been fully exploited. In this paper, we leverage hundreds of millions of bus transaction records, generated when passengers board and alight, to infer time-dependent traffic and customer demand. When the traffic and demand information are available, we build an optimal model to schedule the departure time of each bus service with the objective of minimizing the average waiting time. Experimental results show that compared with the existing bus scheduling system, our model can help reduce the waiting time by a wide margin.

**17. Qiang Meng, Yiru Zhang, Min Xu (2017), Viability of transarctic shipping routes: a literature review from the navigational and commercial perspectives.** ***Maritime Policy & Management, Volume 44, Issue 1, Pages 16-41.***

**Abstract:**

The continuous ice retreat in the Arctic has fueled speculations of new transarctic shipping routes to be operational soon. While the media vigorously propagates the great potentials of these routes, researchers have accessed the feasibility of opening of transarctic shipping routes from various perspectives; diverse and some polarized conclusions have emerged. This paper aims to critically review the studies that examine the necessary conditions and requirements that make transarctic shipping routes sufficiently viable. We mainly focus on two aspects: navigation conditions and commercial features. Selected studies are analyzed and compared in depth. Finally, possible future research directions are put forward.This article is a revised and expanded version of a paper entitled Viability of Transarctic Shipping Routes: An Overview, presented at the International Conference on 'Global Integration of Economies and Connectivity Development' in Taiwan on 31 August 2015.

**18. Min Xu, Qiang Meng, Kai Liu, Toshiyuki Yamamoto (In Press), Joint charging mode and location choice model for battery electric vehicle users.** ***Transportation Research Part B: Methodological.***

**Abstract:**

This paper aims to investigate the choice for charging mode and location with the revealed preference data of battery electric vehicle (BEV) users in Japan. Three alternatives including the normal charging at home (for private BEVs)/company premise (for commercial BEVs), normal charging at public charging stations and fast charging at public charging stations are defined. A mixed logit model is developed to investigate what and how factors influence BEV users' choice of charging mode (normal or fast) and location (home/company or public stations), by identifying an appropriate instrumental variable to correct the serious endogeneity problem caused by the midnight indicator. The parameters estimation and results interpretation are conducted for private and commercial BEVs respectively. They suggest that the battery capacity, midnight indicator, initial state of charge (SOC) and number

 

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of past fast charging events are the main predictors for users' choice of charging mode and location, that the day interval between current charging and next trip positively affects the normal charging at home/company. In addition, with the increasing of vehicle-kilometers of travel (VKT)/travel duration on former/next travel day, the probability of normal charging at home/company is increased for commercial BEVs, while is decreased for private BEVs. The findings obtained herein have provided new insights into the realization of power peak-load shifting and operation strategy for public charging stations, as well as inspired the development and application of new models and methodologies to determine the density and deployment of public charging stations.

**19. Shuaian Wang, Qiang Meng (2017), Container liner fleet deployment: A systematic overview.** ***Transportation Research Part C: Emerging Technologies, Volume 787, Pages 389-404.***

**Abstract:**

Container liner fleet deployment (CLFD) is the assignment of containerships to port rotations (ship routes) for efficient transport of containers. As liner shipping services have fixed schedules, the ship-related operating cost is determined at the CLFD stage. This paper provides a critical review of existing mathematical models developed for the CLFD problems. It first gives a systematic overview of the fundamental assumptions used by the existing CLFD models. The operating characteristics dealt with in existing studies are then examined, including container transshipment and routing, uncertain demand, empty container repositioning, ship sailing speed optimization and ship repositioning. Finally, this paper points out four important future research opportunities: fleet deployment considering ship surveys and inspections, service dependent demand, pollutant emissions, and CLFD for shipping alliances.

**20. Zhaoyang Lu, Qiang Meng (2017), Analysis of optimal BOT highway capacity and economic toll adjustment provisions under traffic demand uncertainty.** ***Transportation Research Part E: Logistics and Transportation Review, Volume 100, Pages 17-37.***

**Abstract:**

For planning a build-operate-transfer (BOT) highway, a rigid contract between a government and private firms with fixed capacity and economic toll adjustment (ETA) provisions to traffic demand variations is practically adopted to cope with the risk caused by uncertain traffic demand. This study develops a two-stage stochastic programming model to determine its optimal highway capacity and ETA strategy, and deeply analyze some insightful properties of this type of contract. Finally, it is compared with two other "very rigid" single-stage BOT contracts with the fixed toll and capacity provisions.

**21. Liujiang Kang, Qiang Meng (In Press), Two-phase decomposition method for the last train departure time choice in subway networks.** ***Transportation Research Part B: Methodological.***

**Abstract:**

An urban subway network with a number of service lines forms the backbone of the public transport system for a large city of high population, such as Singapore, Hong Kong and Beijing. Passengers in these large cities heavily rely on urban subway networks for their daily life. The departure times of the last trains running on different lines of an urban subway network should be well coordinated in order to serve more passengers who can successfully transfer from one line to another, which is referred to as the last train departure time choice problem. This study aims to develop a global optimization method that can solve the last train departure time choice problem for large-scale urban subway networks. To do so, it first formulates a mixed-integer linear programming (MILP) model by introducing auxiliary binary and integer decision variables. For the real-life and large-scale instances, however, the formulated MILP model cannot be solved directly by the global optimization methods such as branch-and-bound algorithm invoked by CPLEX – one of the powerful optimization solvers because of the instance sizes. An

 

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effective two-phase decomposition method is thus proposed to globally solve the large-scale problems by decomposing the original MILP into two MILP models with small sizes. Finally, a real case study from the Beijing subway network is conducted to assess the efficiency and applicability of the two-phase decomposition method and perform the necessary sensitivity analysis of the operational parameters involved in the last train departure time choice problem.

**22. Min Xu, Qiang Meng, Kai Liu (2017), Network user equilibrium problems for the mixed battery electric vehicles and gasoline vehicles subject to battery swapping stations and road grade constraints.** ***Transportation Research Part B: Methodological, Volume 99, Pages 138-166.***

**Abstract:**

There has been growing attention on battery electric vehicles (BEVs) due to their energy efficiency and environmental friendliness. This paper deals with the user equilibrium (UE) problems for the mixed BEVs and traditional gasoline vehicles (GVs) in transportation networks with battery swapping stations and road grade constraints. Under the assumption that electricity consumption rate is not affected by traveling speed or traffic flow, a nonlinear minimization model in terms of path flows is first formulated by incorporating effects of road grade on the electricity consumption rate. The battery swapping action based paths are defined for BEVs in the represented network to facilitate the model building with flow-dependent dwell time at the battery swapping stations. The Frank-Wolfe (F-W) algorithm, where descent direction is found by the multi-label method in a pseudo-polynomial time, is adopted to solve the model. Moreover, the aforementioned assumption about the flow-independent electricity consumption rate is then relaxed and a system of inequalities has been proposed to formulate the UE conditions. For the nonlinear minimization model, two numerical examples are presented to assess the propose model and algorithm, as well as to analyze the impact of usable battery capacity, BEVs' market share and some attributes of battery swapping stations on the equilibrium link flows and/or swapping flows. The system of inequalities is exactly solved for a small network by path enumeration to demonstrate the non-uniqueness of UE link flow solutions.

**23. Qiang Meng, Zhaoyang Lu (2017), Quantitative analyses of highway franchising under build-operate-transfer scheme: Critical review and future research directions.** ***Transportation Research Part B: Methodological, Volume 102, Pages 105-123.***

**Abstract:**

Private provision of the public highways through the build-operate-transfer (BOT) scheme has become popular worldwide. Studies published in dozens of academic journals have investigated various kinds of cases of BOT highway projects. However, there appears to be a lack of systematic and critical overview on what specific problems and research methodologies these studies proposed and used for quantitatively analyzing the BOT highway projects. Therefore, this study critically reviews the relevant traffic oriented quantitative studies, which mainly focus on the determination of fundamental design factors for a BOT highway project in the planning stage. The existing studies are thoroughly examined according to the characters of BOT highway projects. To conclude, this study points out the limitations of the current studies and provides some tangible future research directions with practical relevance.

**24. Qiang Meng, Jinxian Weng, L Suyi (2017), Impact analysis of mega vessels on container terminal operations.** ***Transportation Research Procedia, Volume 25, Pages 187-204.***

**Abstract:**

Mega vessels currently play a vital role in maritime transportation and their deployment may have significant impacts on container terminal operations. This study is concerned with the impact analysis of mega vessels on container terminal operations. First, the container operation process at a container terminal is formulated as a queuing

 

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network. Based on the queuing network, a simulation model is then developed. Because of the computational complexity of the simulation, the ARENA© software tool is used to solve the developed model, based on a realistic case involving the Hong Kong port. The case analysis comprises ten scenarios that represent current and possible future situations regarding the utilization of more mega container vessels. The results suggest that the current port facilities may not be sufficient to accommodate more mega container vessels.

**25. Hooi Ling Khoo, Chun You Tang, Qiang Meng (2017), A novel control strategy for roundabout system with origin-destination flow pattern.** ***Transportation Research Procedia, Volume 25, Pages 1556-1567.***

**Abstract:**

This study proposes and evaluates a novel control strategy that aims to regulate the roundabout approach inflow by taking into consideration its origin-destination demand pattern. The average density of the circular segment is controlled at a pre-defined range of optimal density which is derived using the Macroscopic Fundamental Diagram (MFD). A case study of a two-lane roundabout in Selangor, Malaysia, is developed in a microscopic simulation environment to study and test the effectiveness of the proposed control strategy. It is shown that the proposed control strategy could reduce the system travel time and increase throughput especially during medium to high level of demand. In addition, the sensitivity analysis reveals that its effectiveness is sensitive to the parameters' setting such as: the roundabout lane geometry, origin-destination demand level, and traffic congestion level.

**26. Zhonghua Zhang, Yuhuan Zhao, Bin Su, Yongfeng Zhang, Song Wang, Ya Liu, Hao Li (2017), Embodied carbon in China's foreign trade: An online SCI-E and SSCI based literature review.** ***Renewable and Sustainable Energy Reviews, Volume 68, Pages 492-510.***

**Abstract:**

This paper systematically presents a survey of the empirical literature studying the embodied CO2 emissions in China's foreign trade (ECCT). Based on the bibliometric method and the online version of Science Citation Index-Expanded (SCI-E) and Social Sciences Citation Index (SSCI), this study summarizes the latest publications regarding ECCT in peer-reviewed journals in terms of quantities, most productive countries, institutions, authors, citations, and disciplines. By using synthetic analysis of keyword frequency, this study reveals the most popular methodologies applied in measuring ECCT, discusses the variation of numerical results in the literature, and reasons and countermeasures for the results uncertainties. Continuous investigation of the literature releases the methodology employed for measuring ECCT becoming more reasonable and the results more critical. However, the numerical results of ECCT are of great discrepancies within given year by different considerations on methodology specification, accounting principles, and data sources and processing. For instance, the estimates of CO2 embodied in China's exports changed from 478 Mt to over 3000 Mt and those of in China's imports ranged from 140 Mt to over 1700 Mt in 2007. Therefore, overcoming data inherent limitations and reducing discrepancies among available databases should be urgently considered. The results imply that the prospective research tendencies on ECCT are to (1) improve China's regional input-output data and energy intensity data to more precise estimates under global perspective; (2) estimate China's carbon emission at firm level by different firm ownerships in production and consumption worldwide; (3) assess China's carbon emission from processing or non-processing trade by compiling more detailed multi-regional input-output table; (4) evaluate city level carbon mitigation capacity in China under global MRIO model; (5) explore new carbon management experience in China's carbon trading market and new trade expansion policy of 'one belt and one road' in her new growth era.

 

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**27. Keyi Ju, Bin Su, Dequn Zhou, Junmin Wu (2017), Does energy-price regulation benefit China's economy and environment? Evidence from energy-price distortions.** ***Energy Policy, Volume 105, Pages 108-119.***

**Abstract:**

China's energy prices have long been regulated due to the critical role energy plays in economic growth and social development, which leads to energy-price distortion to some extent. To figure out whether energy-price regulations will benefit China's economy (measured by GDP growth) and environment (measured by carbon emissions), we conducted an in-depth simulation using path analysis, where five energy products (natural gas, gasoline, fuel oil, steam coal, and coking coal) are selected and three measurements (absolute, relative, and moving) of energy-price distortions are calculated. The results indicate that, with a series of energy pricing policies, the price distortion for a single type of energy has gradually transformed, while the energy pricing system in China is not fully market-oriented yet. Furthermore, China's economy benefits from relative and moving distortions, while the absolute distortions of energy prices have negative impacts on economic growth. Finally, with regard to the environment, carbon emissions call for fewer distortions.

 

## Conference Papers (with Abstracts)

1. **Xinhao Lin, Giulia Pedrielli, Loo Hay Lee, Ek Peng Chew (2017), Decision Making in Decentralized Shipping Network with Stochastic Revenue Based Empty Container Repositioning.** ***In proceedings of the 5th International Maritime-Port Technology and Development Conference (MTEC 2017). 26-28, April, 2017, Singapore.***

   **Abstract:**

   Shipping companies costs related to handling and moving empty containers (due to trade imbalance between different parts of the world) have become a significant part of the total operational costs bared by the companies, with consequent pressure on the profit level. This is the empty container repositioning problem (ECR): at each port of call, we need to choose how many empty containers to reposition, thus losing the ability to accept demand, and the resulting potential profit.

   This work solves the ECR considering: 1) inelastic demand faced by shipping companies; 2) frieght rate uncertainty; and 3) differing objectives between the equipment office who oversees repositioning containers and the local offices selling the vessel space.

   We propose a Target Price Policy where the equipment office could charge local sales offices the target prices derived from a stochastic model to push them to make better demand fulfillment decisions. The proposed Target Price policy does not require accurate forecast of future price and demand, hence showing its practical value.

   The optimal target prices are also influenced by the price distribution: the volatility of price has a larger impact on the desired level of imbalance between eastbound laden container flow and westbound laden container flow.

2. **Qitong Zhao, Ek Peng Chew, Loo Hay Lee, Vinsensius Albert (2017), Modular Control of the AGV System in Horizontal Container Terminal.** ***In proceedings of the 5th International Maritime-Port Technology and Development Conference (MTEC 2017). 26-28, April, 2017, Singapore.***

   **Abstract:**

   Automated Guided Vehicles (AGVs) have been put into operations to efficiently transport containers between the quay and the yard side in vertical container terminal. The main concern in developing such a system in parallel transshipment port is preventing deadlock and collisions while maximizing throughput. The objective for this paper is to evaluate proposed designs and algorithms for the low-level scheduling layer. A simulation model is used to test and evaluate the effectiveness and efficiency of these designs and algorithms. The performance metrics obtained from this paper can be used as parameters for the high-level routing layer. Moreover, a valid conceptual and simulation model for this low-level scheduling layer is crucial to allow testing and evaluation of other proposed routing rules in the future as well as providing design parameters for other research. This paper lays the groundwork for the analysis and development of vehicle routing rules for an Automated Guided Vehicle system for a real large automated container port.

3. **Chenhao Zhou, Ek Peng Chew, Loo Hay Lee (2017), Grid-Act, an Emerging Concept for Future Transhipment Terminals.** ***In proceedings of the 5th International Maritime-Port Technology and Development Conference (MTEC 2017). 26-28, April, 2017, Singapore.***

   **Abstract:**

   Along with the increasing of the global transshipment trade, the issues of land scarcity and increasing labor cost become the primary concerns for the future container terminals. Thus, sustainable solutions are highly expected by the terminal operators to keep competitive.

   Targeting the above challenges, a new conceptual design of the automated container terminal was introduced as a potential solution which is named GRID-ACT. The GRID-ACT is based on the GRID module which is invented

 

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by BEC Industries LLC. As a fully automated, multi-directional overhead handling structure, transfer units are moving above the ground so the sky space is highly utilized for travelling and ground space for storing. By linking each individual GRID modules with the ground transport, the GRID-ACT comes into the picture.

As an emerging technology, we first introduced the key features of the system with real time vehicle control policy. The simulation experiment showed that GRID-ACT has great potential in terms of the overall throughput. Next, we looked into the container allocation problem in the GRID-ACT as the structure and mechanism is very different from conventional ACTs. An innovating methodology was introduced to allocate containers into the system. Thirdly, we solved the vehicle routing problem in the GRID module with an innovating concept. Last but not the least, future topics and applications were discussed on both GRID module and GRID-ACT.

4. **Debabrota Basu, Giulia Pedrielli, Weidong Chen, Szu Hui Ng, Loo Hay Lee, Stephane Bressan (2017), Sequential Vessel Speed Optimization under Dynamic Weather Conditions.** ***In proceedings of the 5th International Maritime-Port Technology and Development Conference (MTEC 2017). 26-28, April, 2017, Singapore.***

**Abstract:**

The International Maritime Organization (IMO) identifies speed optimization as a key operational measure for achieving energy efficiency through reduced emissions. Ocean Liner services have fixed port rotations and schedules. While the speed can be optimized for emissions, the service level in terms of schedules arrival and departure need to be carefully considered not to loose market share. This already challenging problem is futher complicated when dynamic weather conditions along the service route are considered. In fact, few contributions can be found that address this issue.

We study the operational problem of dynamically determining a vessel's speed, departure time and arrival time at each port of call under dynamic weather conditions. We model the minimization of cost, namely bunkering costs and early and delayed departure and arrival penalties, using calculus of variations. The proposed algorithm leverages upon a disretization technique based on the Weierstrass-Erdmann condition. The numerical tests show the efficiency and effectiveness of this algorithm over standard techniques like IVP.

5. **Yajuan Xie, Qiang Meng(2017), Analysis of spatial traffic distribution and ship characteristics in the Singapore Strait.** ***In proceedings of 2017 World Transport Convention. 4-6, June, 2017, Beijing, China.***

**Abstract:**

Spatial ship traffic distribution and ship characteristics are vital for the ship traffic management of Singapore Strait especially for those legs with high ship traffic flow. The aim of this study is to investigate spatial ship traffic distribution and large-ship characteristics in the Strait by using one-month AIS (Automatic Identification System) data with 18 billion records and ship characteristics database with 70,160 vessels. Our analyses exhibit those vessels with length more than 300m account for 5.8%, vessels between 200m and 300m 6.8%, between 100m and 200m 27.2%, and less than 100m 50.2%. The analyses of ship traffic spatial distribution show that ships passing through the legs 3W, 4W, 12E, and 13E of the Strait constitute the 42.2% of the total traffic flow. More efforts for the ship traffic management and monitoring on these four legs can be invested although the current ship traffic on these four legs are managed and monitored well.

 

## CMS Research Seminars

1. **Intelligent Systems for Dynamic Control in Manufacturing, by Invited Guest Assistant Professor Wei Weng**

   **Seminar Abstract:**

   Intelligent systems such as multi-agent systems and distributed systems are being applied to industrial engineering for the purpose of control and manufacturing. One advantage of such systems is that they are able to deal with dynamic problems such as new job arrival and unexpected machine breakdown. Another is that their online working mechanism makes it possible to solve large-size problems in real-time. This presentation introduces some of our research on such systems, the objective including achieving lower inventories, tardiness, and energy consumption in manufacturing processes. We design the multi-agent systems by dividing a complex manufacturing system into multiple independent local parts and assigning an agent to each local part. We show how the agents work interactively for achieving a common goal and what differences there might be when applying the systems to different manufacturing processes.

2. **Analysis of Spatial Traffic Distribution and Ship Characteristics in the Singapore Strait, by Researcher Dr. Xie Yajuan (Track leader: Professor Meng Qiang)**

   **Seminar Abstract:**

   Spatial ship traffic distribution and ship characteristics are vital for the ship traffic management of Singapore Strait especially for those legs with high ship traffic flow. The aim of this study is to investigate spatial ship traffic distribution and large-ship characteristics in the Strait by using one-month AIS (Automatic Identification System) data with 18 billion records and ship characteristics database with 70,160 vessels. Our analyses exhibit those vessels with length more than 300m account for 5.8%, vessels between 200m and 300m 6.8%, between 100m and 200m 27.2%, and less than 100m 50.2%. The analyses of ship traffic spatial distribution show that ships passing through the legs 3W, 4W, 12E, and 13E of the Strait constitute the 42.2% of the total traffic flow. More efforts for the ship traffic management and monitoring on these four legs can be invested although the current ship traffic on these four legs are managed and monitored well.

3. **How to Avoid Head-on Ship-to-ship Collision: Maritime Simulator Based Experiments and Survey Results, by Researcher Dr. Kang Liujiang (Track leader: Professor Meng Qiang)**

   **Seminar Abstract:**

   DCPA and TCPA are two important indicators in navigation. When the DCPA is less than the preset threshold distance and the TCPA is less than the preset threshold time, collisions may occur if navigators do not take actions effectively. In this study, we aim to find how close of the DCPA and how much of the TCPA will drive navigators to take actions. On the other hand, we are also interested in what actions navigators will response to the risk of collision. Accordingly, we develop a discrete event simulation based ship interaction model for head-on ships. To calibrate the parameters in the model, a series of navigational experiments were conducted in navigation simulators. The results indicate that the TCPA value plays a more important role in identifying risk of collision and the DCPA value is the major indicator in returning-course decisions. In addition, changing course generally plays a more effective role than changing speed in collision avoidance. In terms of ship size, captains tend to keep a larger DCPA to a larger ship.

 

## CMS Research Seminars

### 4. Estimating Link Travel Time Functions for Heterogeneous Traffic Flows on Freeways, by Researcher Dr. Lu Zhaoyang (Track Leader: Professor Meng Qiang)

**Seminar Abstract:**

Oversized vehicles, such as trucks, significantly contribute to traffic delays on freeways. Heterogeneous traffic populations, i.e. those consisting of multiple vehicles types, can exhibit more complicated travel behaviors in the operating speed and performance, depending on the traffic volume as well as the proportions of vehicle types. In order to estimate the component travel time functions for heterogeneous traffic flows on a freeway, this study develops a microscopic traffic-simulation based four-step method. A piecewise continuous function is proposed for each vehicle type and its parameters are estimated using the traffic data generated by a microscopic traffic simulation model. The illustrated experiments based on VISSIM model indicate that (i) in addition to traffic volume, traffic composition has significant influence on the travel time of vehicles and (ii) the respective estimations for travel time of heterogeneous flows could greatly improve their estimation accuracy.

### 5. Estimating Water Depth Spatial Distribution in the Singapore Strait, by Researcher Mr. Wei Xiaoyang (Track Leader: Professor Meng Qiang)

**Seminar Abstract:**

The Singapore Strait plays a vital role in the global maritime transportation network and its navigational safety is utmost import to the shipping industry. The nautical chart of the Strait provides the water depth spatial distribution in a low resolution. To further enhance the navigational safety in the Singapore Strait, therefore, it is necessary to estimate the water depth spatial distribution with high resolution. The seabed and water levels determine the water depth. However, only limited sounding data in Singapore Strait are available to describe the seabed level. In addition, the water level in the Singapore Strait varies significantly from the regular tidal behavior due to the multiple ocean currents moving into and out of the Strait as well as the short-term meteorological effects. This study proposes a tangible approach including two models to estimate the water depth spatial distribution with high resolution in the Singapore Strait. The first model estimates the seabed level based on the available sounding data by integrating three data interpolation methods. The second model predicts the water level using the genetic programming (GP) method. The proposed approach is also validated. The implications and limitations of this approach are discussed and a number of suggestions are provided for further studies.

### 6. Game Analysis of Port Dangerous Goods Management—based on the Vision of CSV, by Visiting Scholar Associate Professor Han Zhen (Track Leader: Professor Meng Qiang)

**Seminar Abstract:**

With the development of ports in China, the sudden and serious accidents about port dangerous goods occurred frequently and safety requirement of society and environment become more and more important. Hence, how to balance the relationship, between Port Corporations and Government Regulators, becomes the key to solve these problems.

There are three steps to carry out the research works. Step one is to consider the safety management from a new vision of CSV. Step two is to analyze the port logistics system and clarify relations among the subjects. Step three is to establish the framework of 2 games analysis based on Responsibility-Cost-Benefit. Game 1, between Port Corporations and Government Regulators, is to make an evolutionary game analysis. Game 2 is to make two stages leader-follower game analysis. And Stage 1 is a Leader-follower game between Port Resources Operators and Logistics Service Providers. Stage 2 is also a Leader-follower game between Port Corporations and Government Regulators.

 

## CMS Research Seminars

The results show that the view of CSV is suit for management of Port dangerous goods. With introducing Dynamic Penalty and Reward variables, the ESS can be found, which is in a win-win situation for both two sides. Meanwhile, The system safety level (S*) and basic administration cost (K2), are the main means and tools in safety governance, which reflected in the government's expectations of Social Responsibility for Corporate.

### 7. Green Feedback Control for Dynamic System in Marine Fields, by Researcher Dr. Yang Jiasheng (Track Leader: Professor Fwa Tien Fang)

**Seminar Abstract:**

Due to the significant effect of uncertain ocean environments, large marine structures would consume massive energy to improve their dynamic performance. It would increase operational cost, and probably causes the overload of the actuator and even destroys the actuator. In this study, we investigate a green feedback control for the dynamic system to achieve their desired performance with input minimization. Based on $H_\infty$ control theory and matrix inequality techniques, we develop a novel $H_\infty$ controller with input limitation. It could be solved by a LMI convex optimization solver in Matlab. Finally, several numerical examples are given to validate the proposed models and methods.

### 8. Two Phase Decomposition Method for the Last-train Departure Time Choice Problem in Subway Networks, by Researcher Dr. Kang Liujiang (Track Leader: Professor Meng Qiang)

**Seminar Abstract:**

An urban subway network with a number of service lines forms the backbone of the public transport system for a large city of high population, such as Singapore, Hong Kong and Beijing. Passengers in these large cities heavily rely on urban subway networks for their daily life. The departure times of the last trains running on different lines of an urban subway network should be well coordinated in order to serve more passengers who can successfully transfer from one line to another, which is referred to as the last train departure time choice problem. This study aims to develop a global optimization method that can solve the last train departure time choice problem for large-scale urban subway networks. To do so, it first formulates a mixed-integer linear programming (MILP) model by introducing auxiliary binary and integer decision variables. For the real-life and large-scale instances, however, the formulated MILP model cannot be solved directly by the global optimization methods such as branch-and-bound algorithm invoked by CPLEX because of the instance sizes. An effective two-phase decomposition method is thus proposed to globally solve the large-scale problems by decomposing the original MILP into two MILP models with small sizes. Finally, a real case study from the Beijing subway network is conducted to assess the efficiency and applicability of the two-phase decomposition method and perform the necessary sensitivity analysis of the operational parameters involved in the last train departure time choice problem.

### 9. Introduction of Traffic Stream Flow Models, by Researcher Dr. Lu Zhaoyang (Track Leader: Professor Meng Qiang)

**Seminar Abstract:**

Speed, flow and density are the most important elements of the traffic flow. In this seminar, we choose the speed density as a function of speed, then introduce some classic the speed-density models. In the numerical example, the speed-density regression models are compared between congested city road and the tolled highway based on traffic flow data on Beijing Third Ring Road (BTRR) and Jing Jin Tang Highway (JJTH) in China. These data are collected by road detectors on each road. The speed-density regression curves are analyzed based on four the classical models: Greenshields, Greenberg, Underwood, and Bell-shape models.

 