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DISCRETE EVENT SIMULATION OF TRUCK APPOINTMENT SYSTEMS IN CONTAINER TERMINALS: A DUAL TRANSACTIONS APPROACH

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Agenda


Introduction


Literature Review


Problem Description

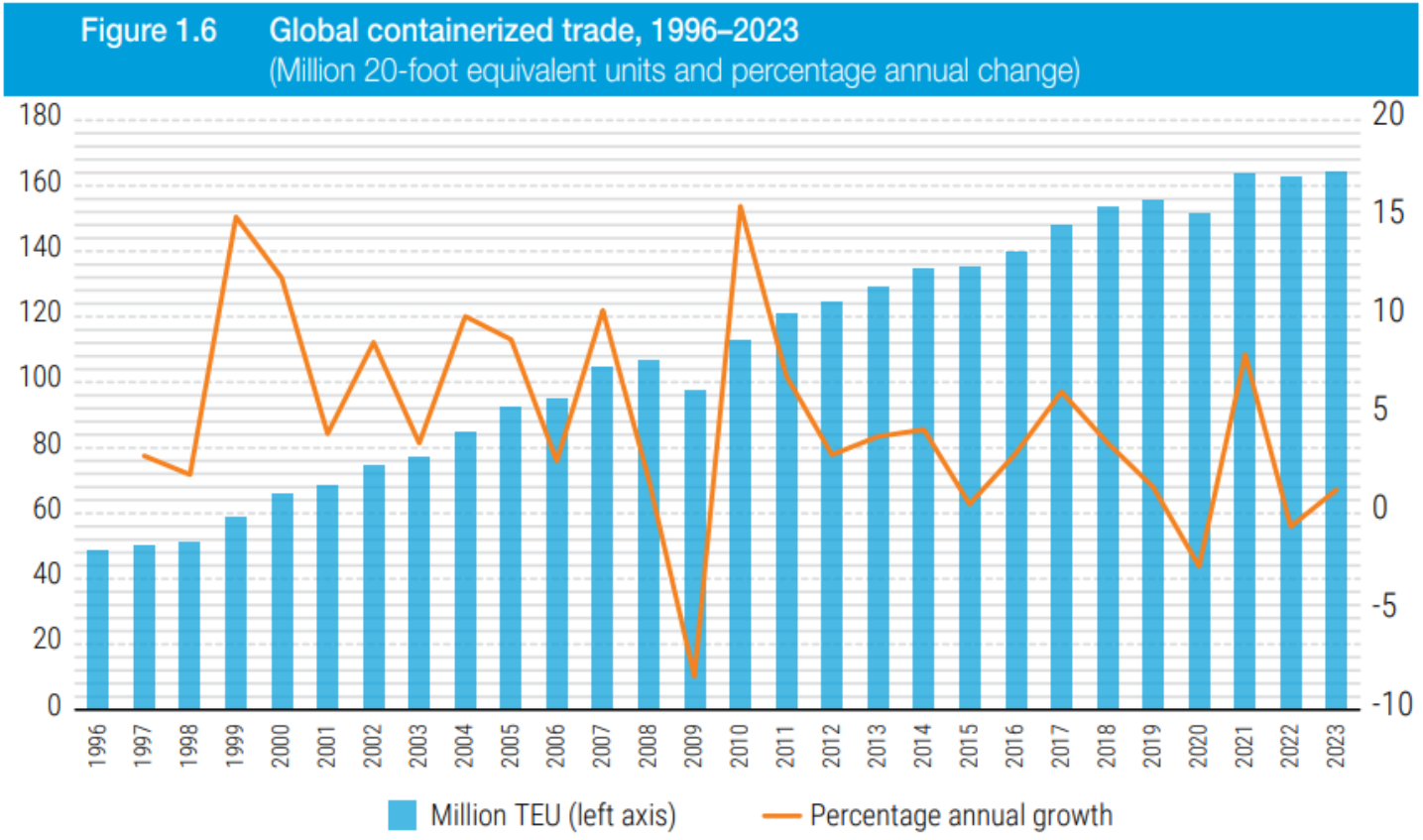

Methodology


Results and Discussion


Conclusion

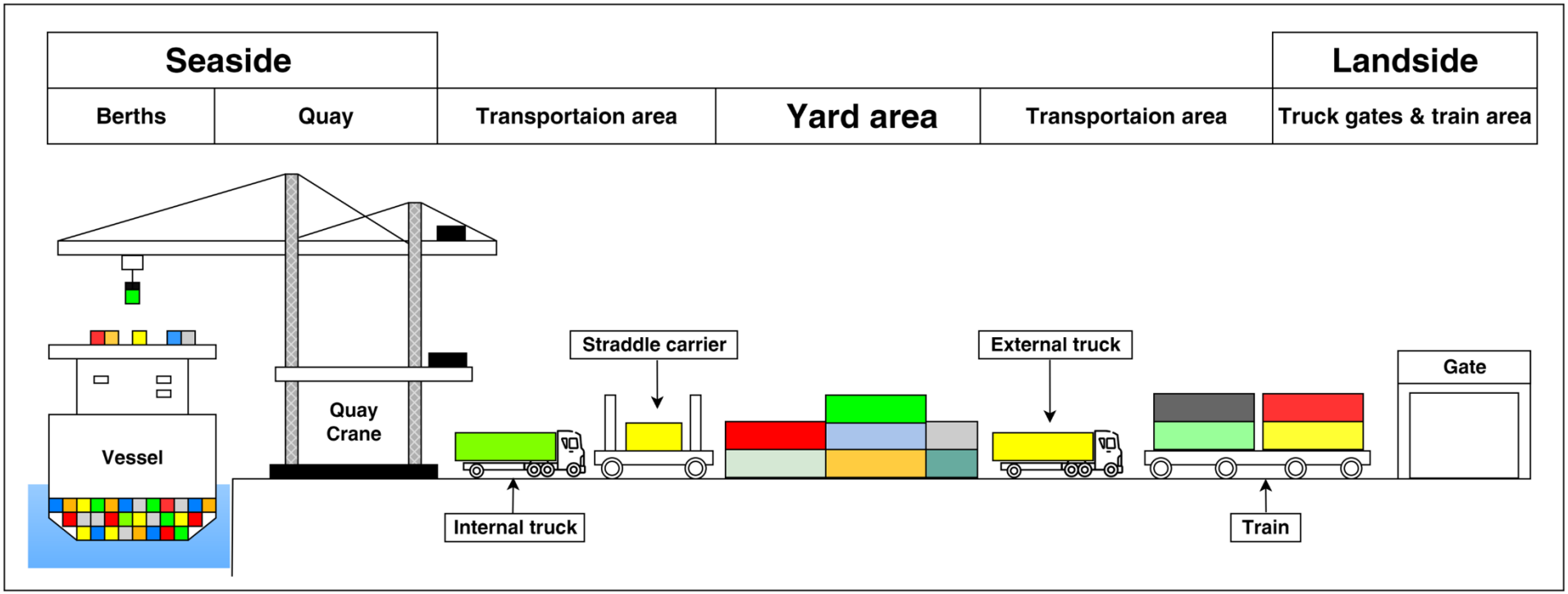

Future Work

Introduction



UNCTAD Trade and Development Report, 2023

Introduction (cont.)



Layout of a typical Container Terminal

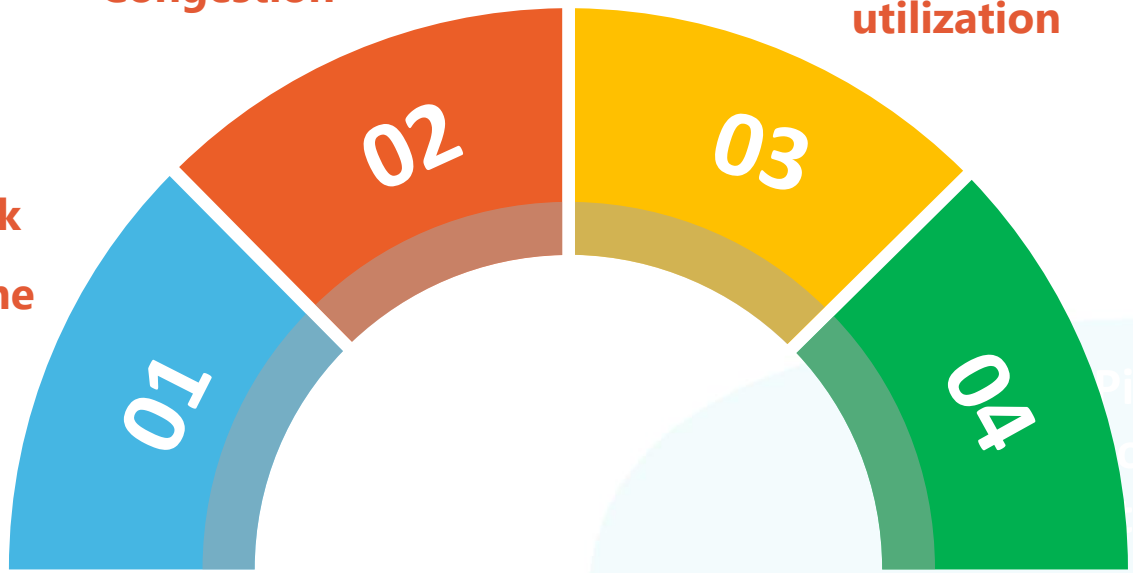
Introduction(cont.)

Modes of transporting containerized goods

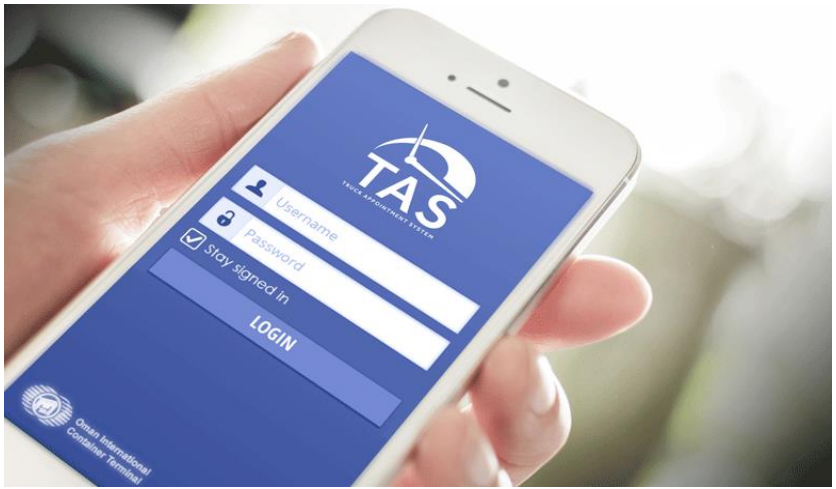
Introduction(cont.)

Introduction (cont.)

- Challenges posed by unmanaged arrivals of ETs



Introduction (cont.)



Truck Appointment Systems

Smart ports

according to topics

Uncertainty

Flexible schedules

Port Visibility, Vulnerability

Introduction(cont.)

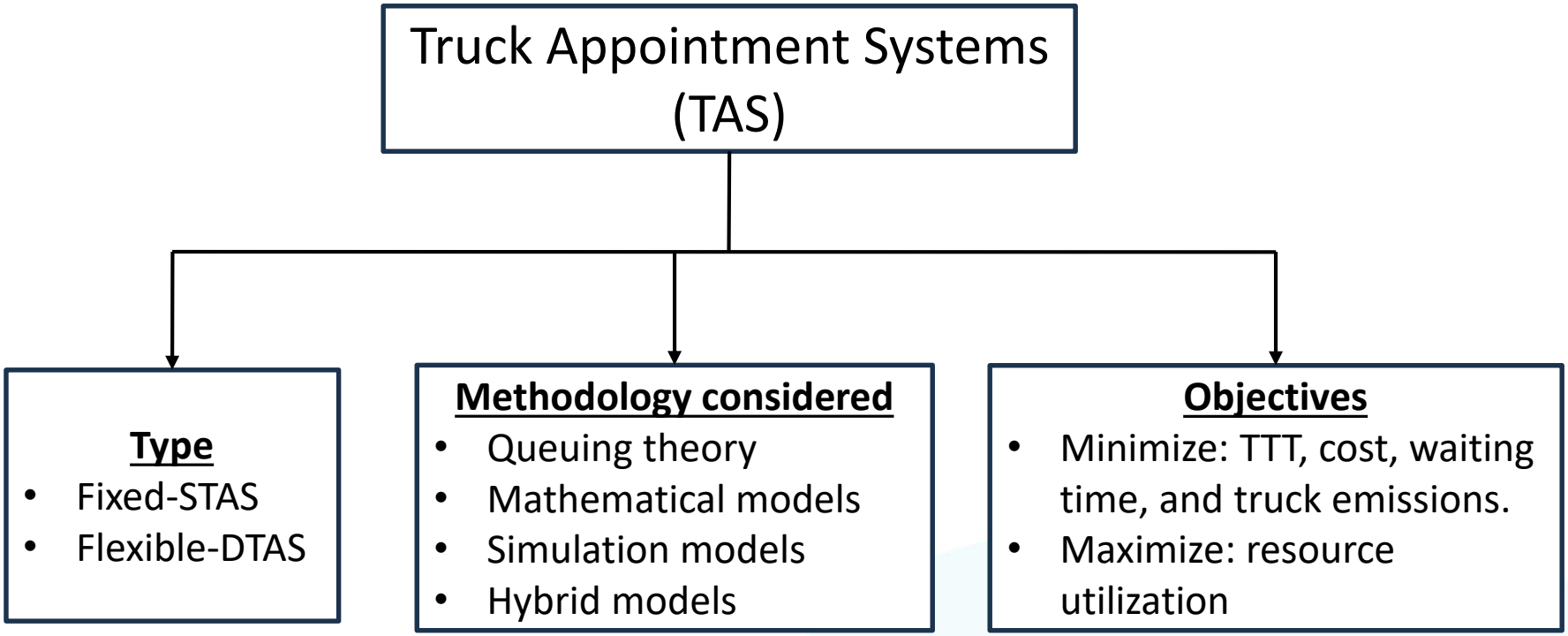
- Proposed work:
  - Develop a Discrete Event Simulation model
  - Dual transactions approach

- Aim: Investigate the effect of considering uncertainty in the average TTT of the ETs

- Managerial implication: Findings to provide insight into the ***assignment*** and ***appointment*** decisions.

- Stakeholders: Terminal operators, Trucking companies (TC), Port Authorities

Literature review



Literature review(cont.)

Gap:

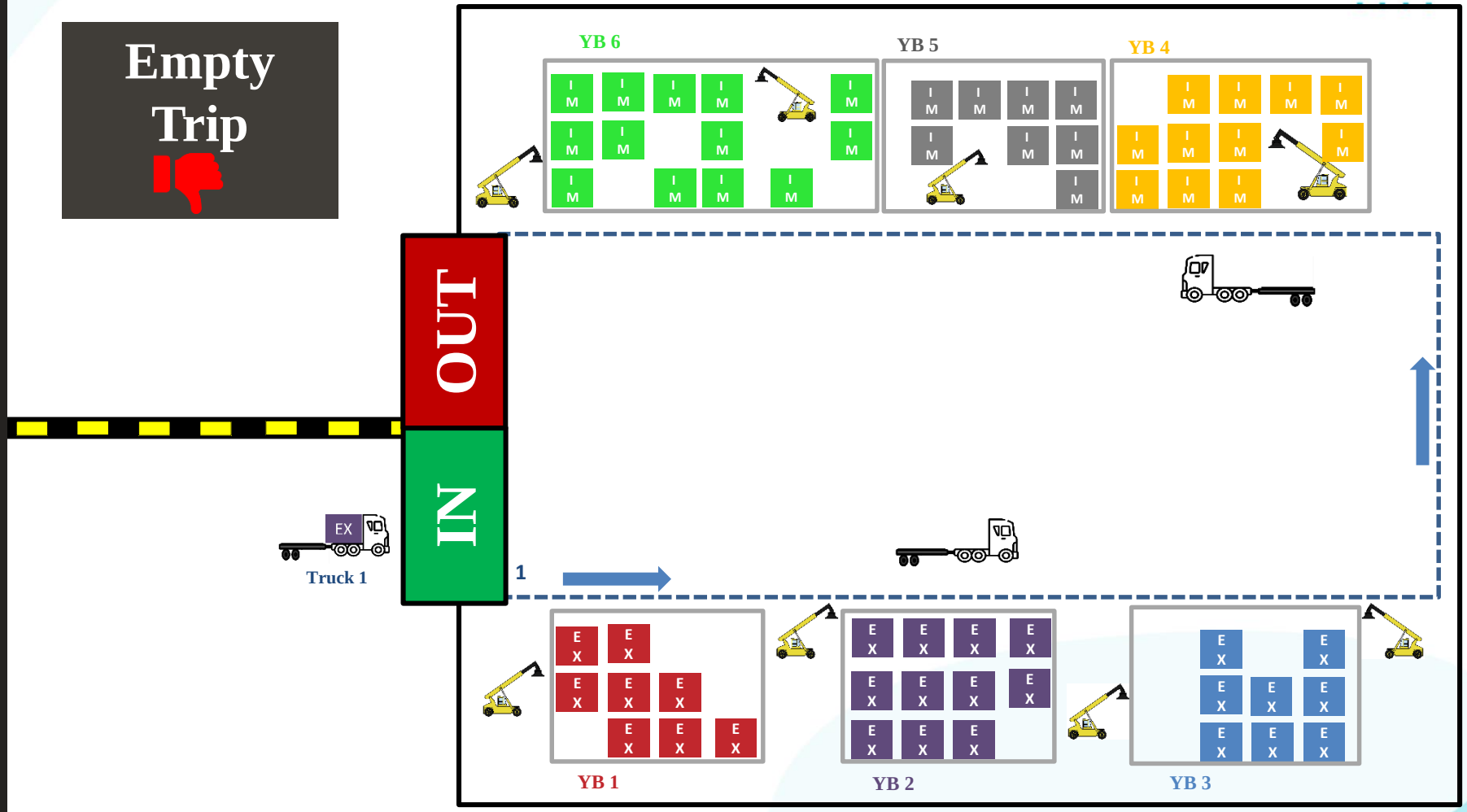
- –Dynamic factors: Traffic congestion
- –Static factors: Inter-terminal road network layout
- –Dual transactions approach

Contribution:

- – Related work; A. Azab(2020), A. Karam(2019), AM Abdelmagid(2022)
- –Developed a DES model based on previous works done by *Taalat et al.(2023)*
- –Evaluate the effect of considering uncertainty in the arrival schedules on the average TTT
- –Considers before and after gate, yard area

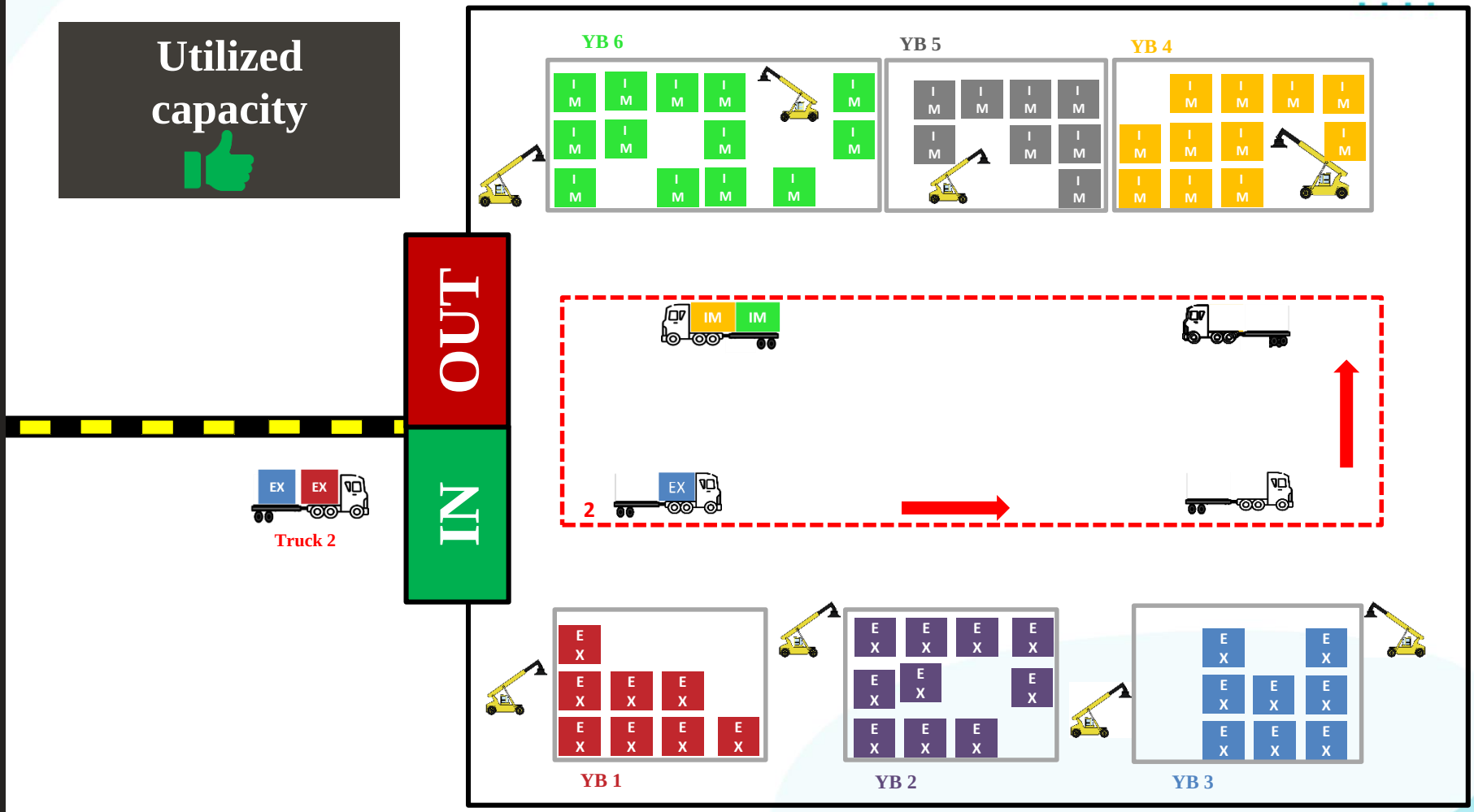
Single transaction trip

Empty Trip



Dual transaction trip

Utilized capacity



Problem Description

- Each truck can carry at most two containers per trip depending on the size (20ft or 40ft).

Possible combinations for truck trips:-

Scenario	No.of Export Containers	No.of Import Containers
1	1	0
2	2	0
3	0	1
4	0	2
5	1	1
6	1	2
7	2	1
8	2	2

Problem Description(cont.)

Input Tuple List

Truck Trip No.	Export	Import	A1	A2	A3	A4	Preferred TW	Priority Index
1	(2, 33)	(373, 391)	7	7	3	3	3	2
2	(280, 312)	(408, 661)	6	7	3	3	2	2
3	(335, 406)	(551, 565)	7	8	4	4	3	2
4	(509, 533)	(18, 124)	6	7	3	3	3	2
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
287	(None, None)	(544, None)	0	0	5	0	8	1

KEY:

A1, A2 – Destination Export Blocks

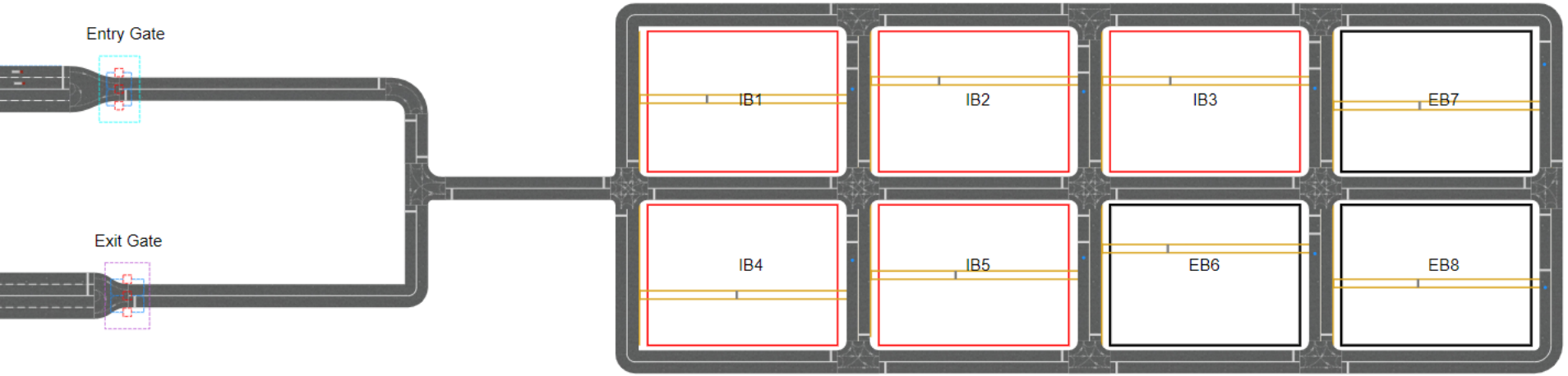
A3, A4 – Destination Import Blocks

TW – Time Window (8- hour shift plan)

Priority Index – (1 - single transaction**, 2 -** double transaction**)**

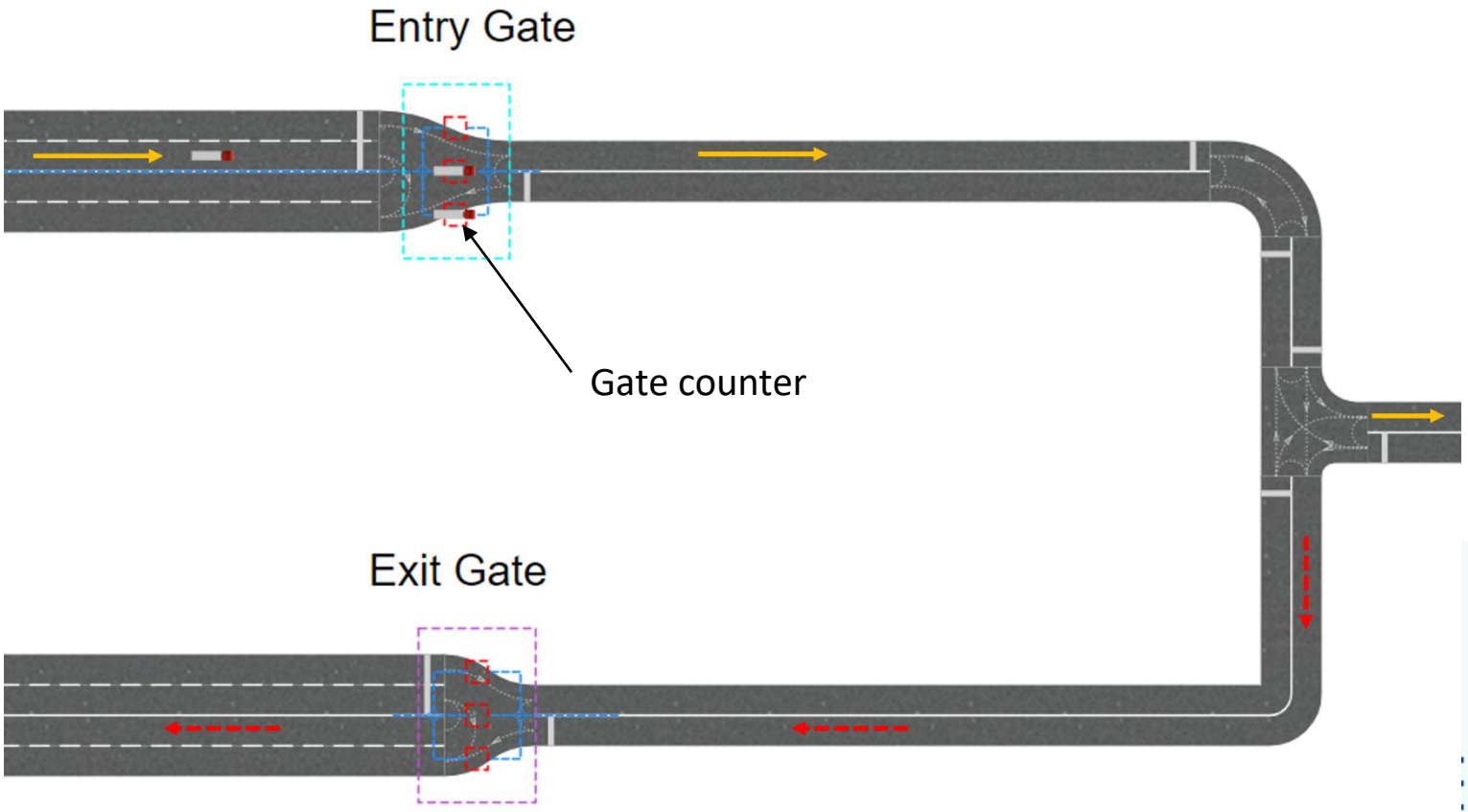
Problem Description(cont.)

The developed Container Terminal Simulation Model



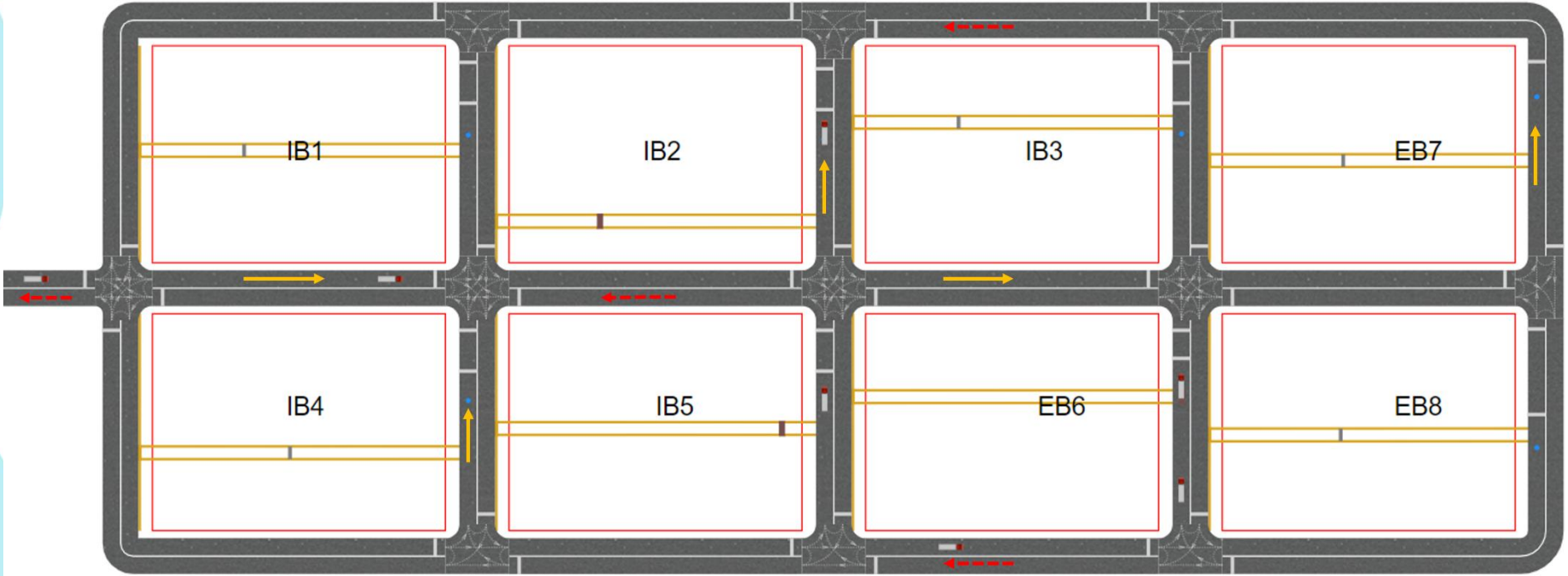
Problem Description(cont.)

Gate Area of the developed Simulation Model



Problem Description(cont.)

Yard Area of the developed Simulation Model



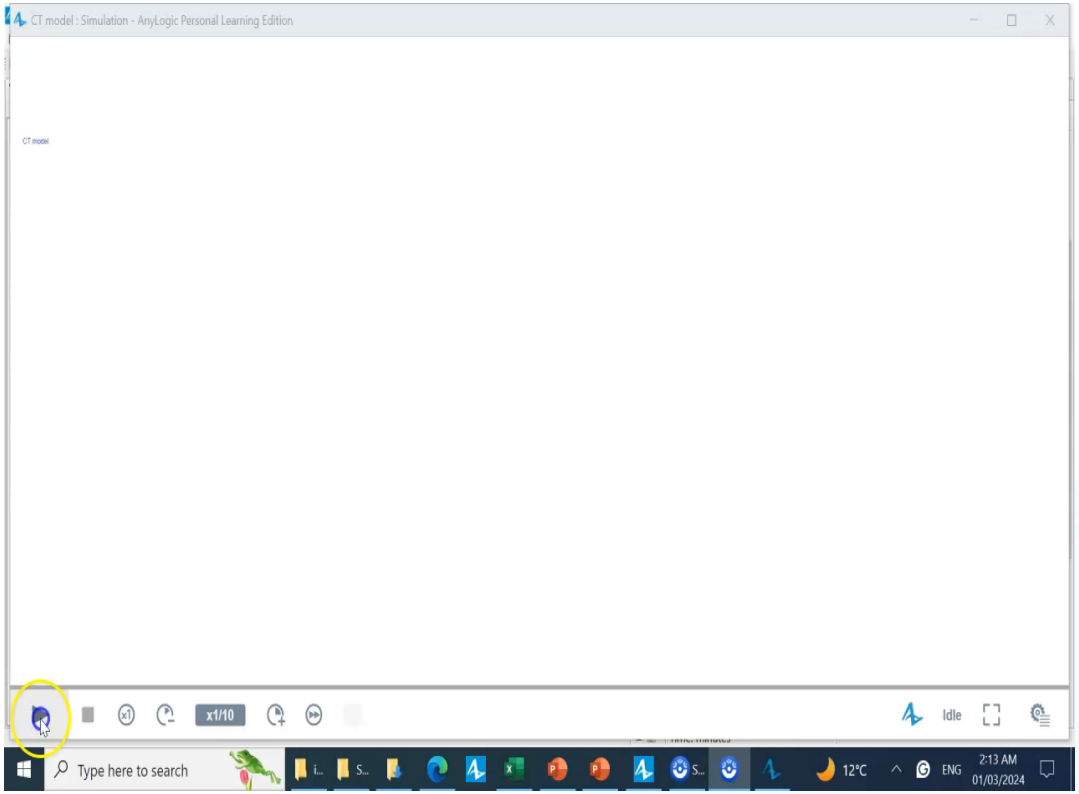
KEY:

IB – Import Block

EB – Export Block

Problem Description (cont.)

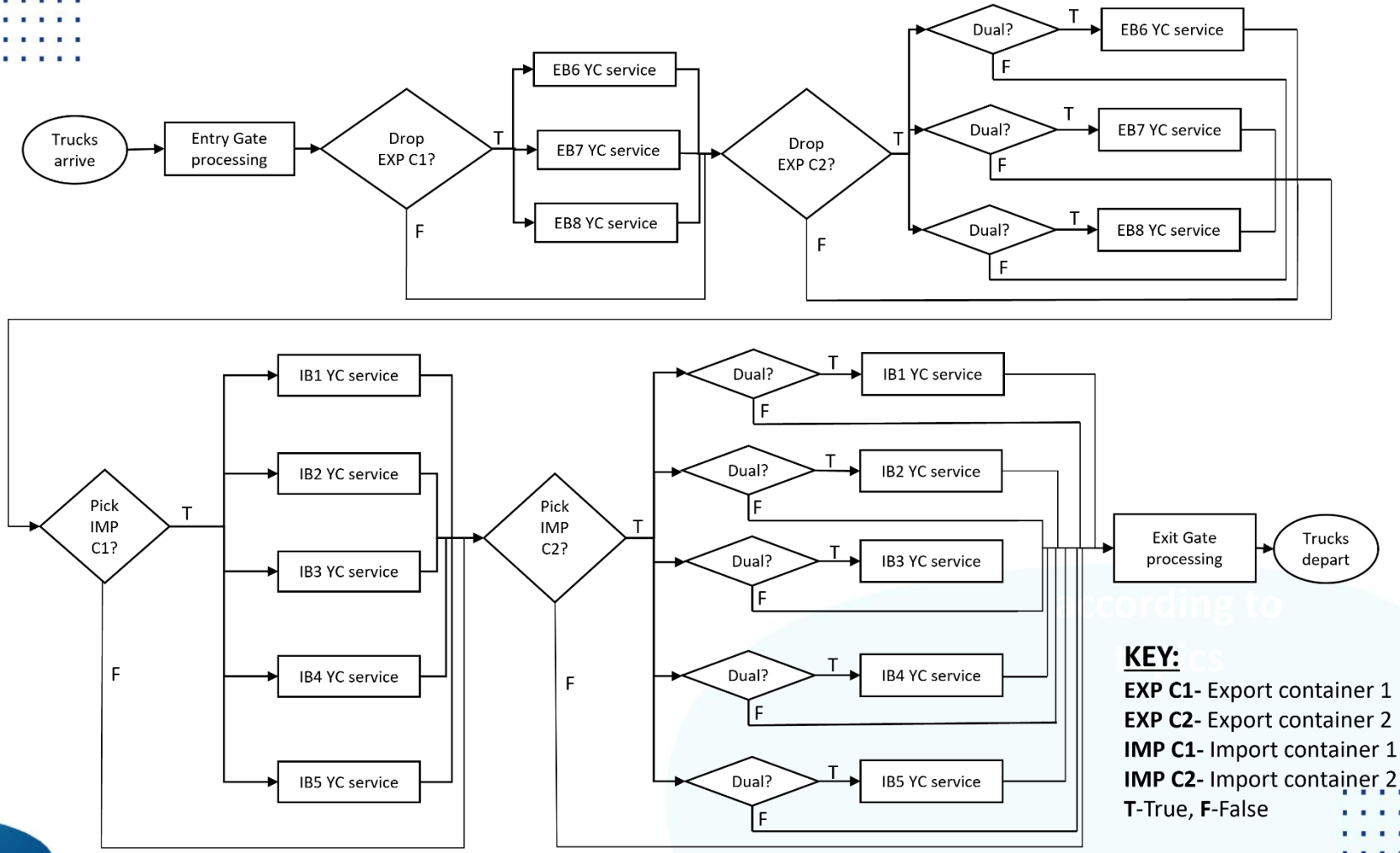
3D Animation of the Discrete Event Simulation Model



Methodology

- *Discrete Event Simulation* modelling technique
- *Entities*: Trucks, Containers
- *Resources*: Entry and Exit gates, Overhead Yard Cranes
- *Processes*: ETs arrival, gate processing, container drop off and (or) pick up, YC loading and (or unloading), ETs departure
- Road network complete with intersections
- Hypothetical CT layout configuration

Methodology (cont.)



KEY:

EXP C1- Export container 1
EXP C2- Export container 2
IMP C1- Import container 1
IMP C2- Import container 2
T-True, **F**-False

Methodology (cont.)

Model input parameters

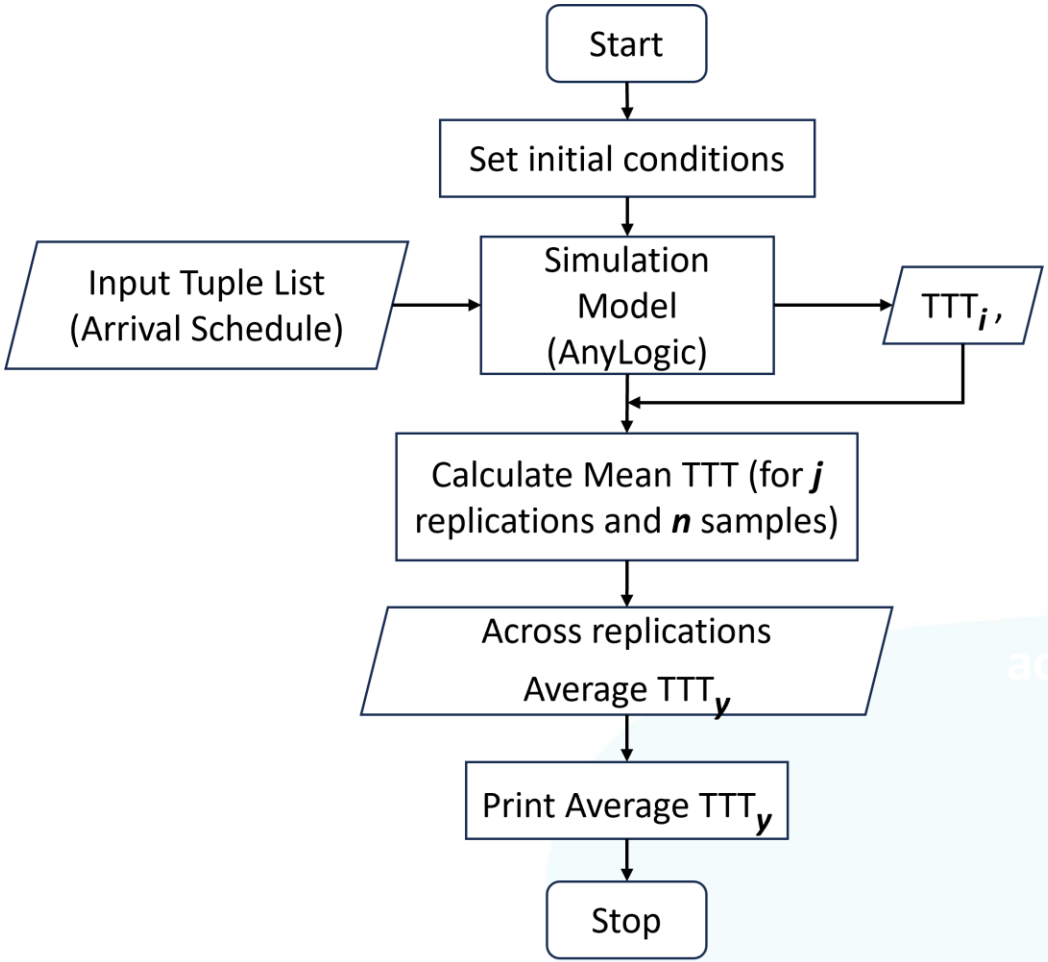
Gate parameters	
Shift 1 working hours	12:00 a.m. – 8:00 a.m.
Truck speed (max)	18km/hour (A. Azab, Karam, and Eltawil 2017)
Entry processing time	TRIA(0.5, 1, 4) minutes (Huynh 2009)
Exit processing time with no survey of container	TRIA(0.02, 0.099, 0.3) minutes (Huynn, Walton, and Davis 2004)
Number of gate counters at Entry	3
Number of gate counters at Exit	3
Yard parameters	
Number of import blocks (IB)	5 (Talaat et al. 2023)
Number of export blocks (EB)	3 (Talaat et al. 2023)
Number of Yard Cranes (YC)	8 (Talaat et al. 2023)
Unloading/Loading time	0.26+LOGN(0.941,0.519) minutes (Huynh 2009)
Yard bridge speed(Gantry travel) max	135m/min (KoneCranes 2021)
Trolley speed(max); with/without load	82m/min (KoneCranes 2021)
Hoist speed(max)with load	31m/min (KoneCranes 2021)
Road parameters	
Lane width	3.5m
Number of Gate Entry/Exit lanes	2

Results

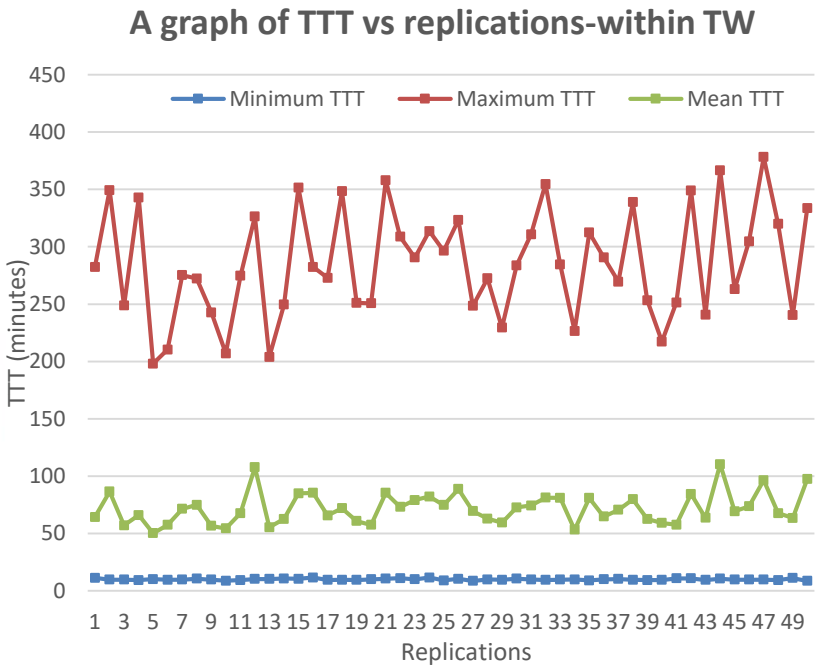
Simulation experiment set-up

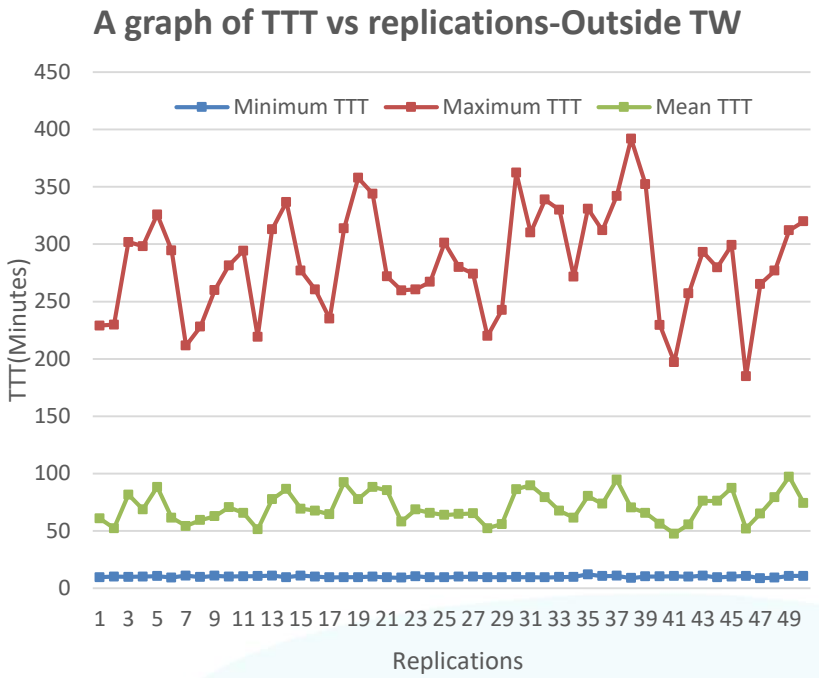
- AnyLogic University v8.8.4
- Lenovo, Core i7-10700, CPU @ 2.90GHz, 8GB RAM
- 2 scenarios:
  - Arrival within the preferred TW
  - Arrivals outside the preferred TW
- Terminating, random seed, 50-replication, 3 gates
- 8 hours run length: (1 shift, 8TW of @ 1 hour)
- Point estimator (Mean TTT), Confidence Interval

Results(cont.)



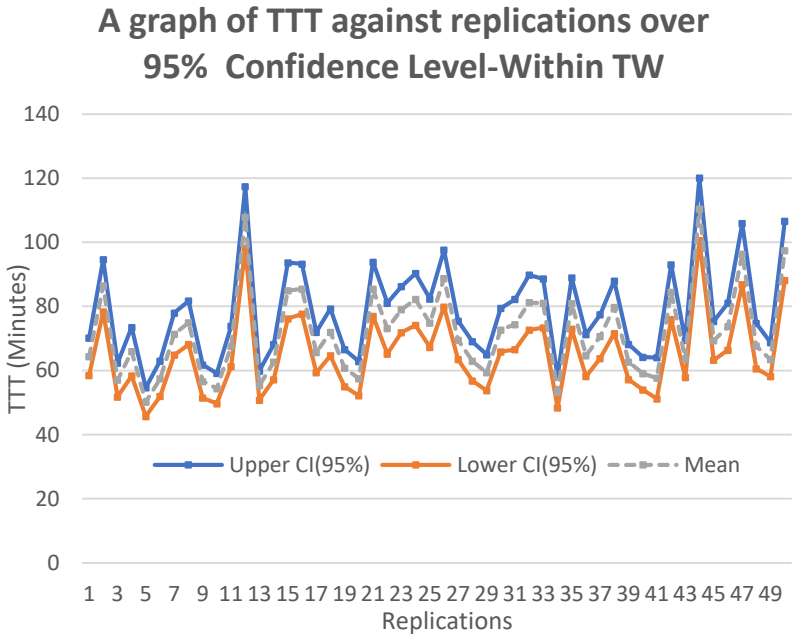
Results(cont.)





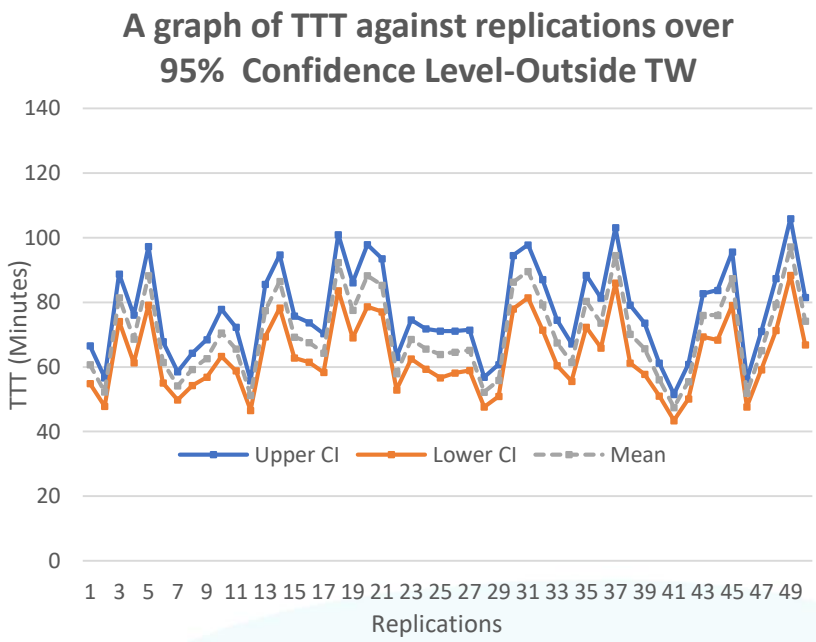
	Within TW			Outside TW		
	MaxTTT	MinTTT	Ave	MaxTTT	MinTTT	Ave
Upper (minutes)	378.2	11.6	110.4	391.9	12	97.2
Lower (minutes)	198	8.6	50.2	184.9	8.7	47.5

Results(cont.)



Mean TTT:

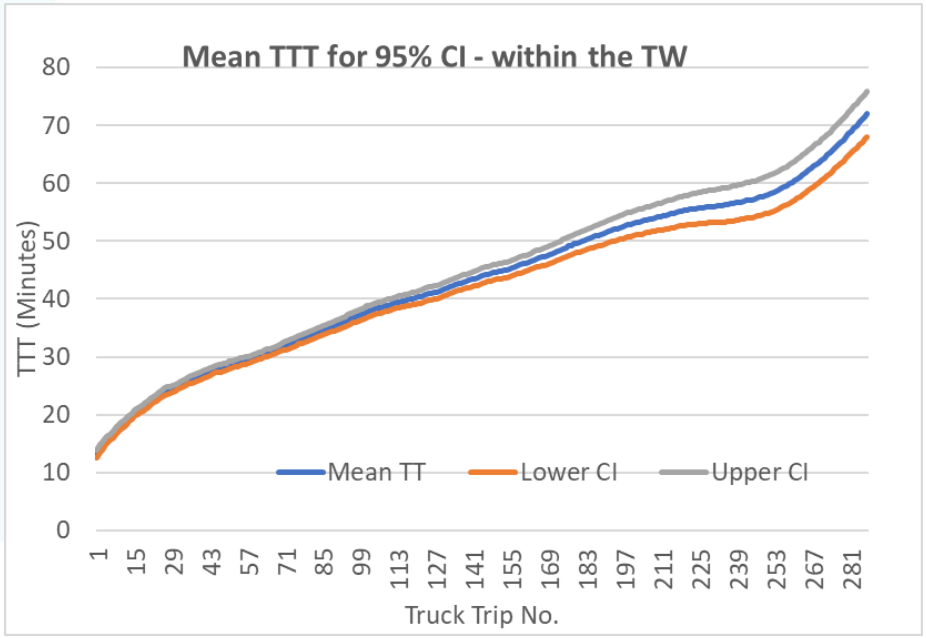
71.96 minutes



Mean TTT:

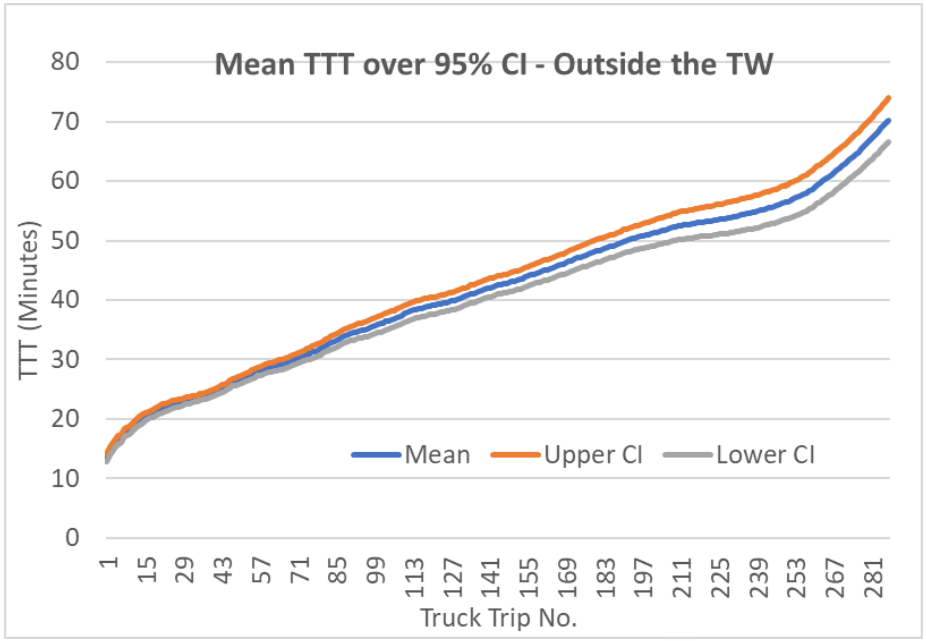
70.29 minutes

Results(cont.)



Cumulative mean TTT range

13.25 - 71.96 minutes



Cumulative mean TTT range

13.49 - 70.29 minutes

Discussion

- It is important to not only consider the mean TTT value in decision-making but also investigate other factors causing variability

- Consider resource availability when making the slots for appointment by the Trucking companies

- The randomness of the output values indicates the need to address uncertainty during the development of schedules (not always deterministic)

Conclusion

- A DES model for TAS scheduling was developed
- It considers the dual transactions approach
- Adopted input parameters from the literature to verify the model
- 2 scenarios are considered: Arrivals within and outside the preferred TW
- Average TTT obtained is 71.96 and 70.28 minutes for scenarios 1 and 2 respectively
- Model demonstrates *variability* in randomized outputs of TTT
- The benefit of using simulation to analyze need for *trade-offs* is illustrated

Future work

- Optimize the operations through dynamic resource allocation
- Optimize the traffic congestion within the CT
- Obtain real CT layout configurations to validate the model.
- Integrate it with ML and smart technologies to develop a Digital Twin for use in ETs and yard crane scheduling and in conventional CTs
- The contribution of this work agrees with the Marlog13 conference theme (“Green, Smart, Blue”)

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Thank You

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