AmiEs-2017

A System Design and Simulation for the Optimal Operation of Transporter in Shipyard

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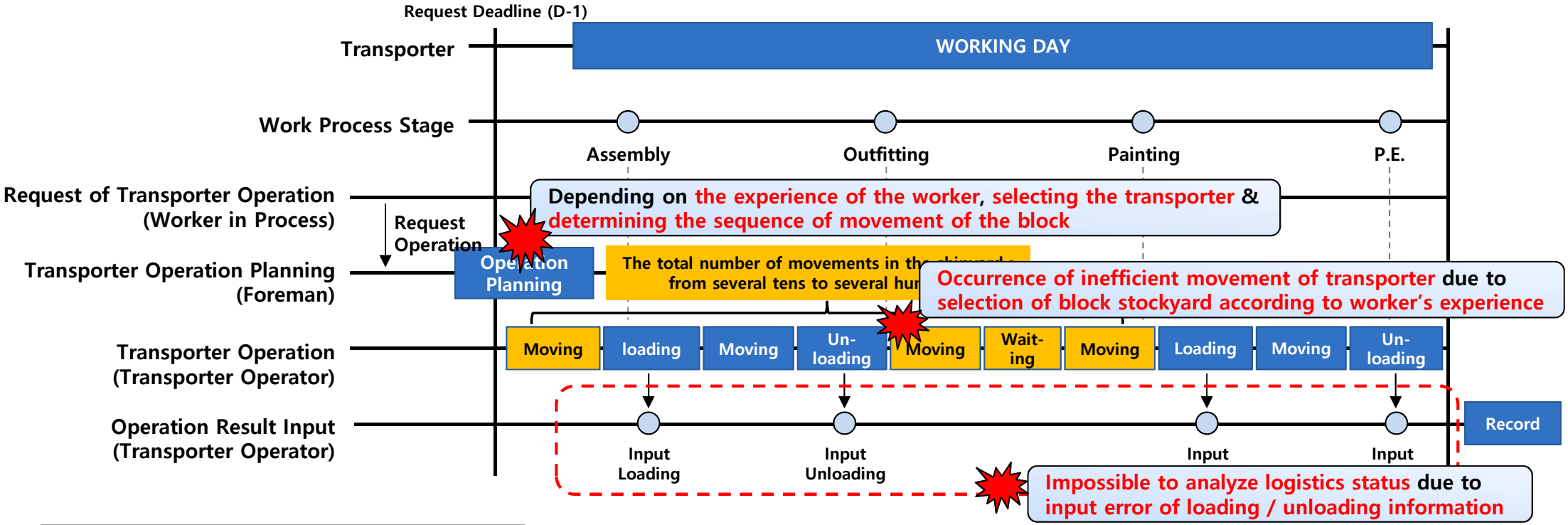
- Functional Component

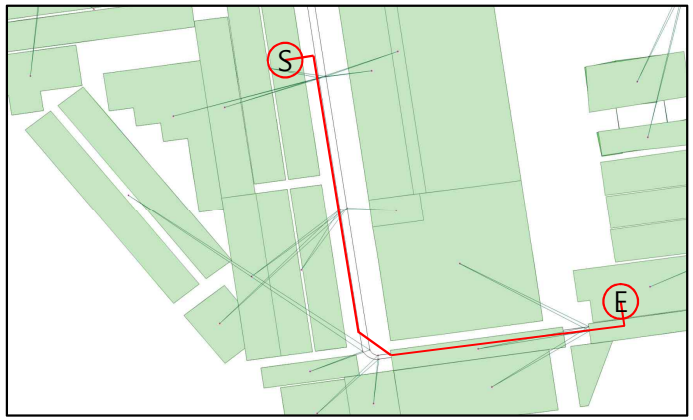
Implementation of Prototype & Test Results

Summary & Future Study

Introduction

▶ Current status of transporter operation in shipyard





Example of moving a transporter

Transporter operation result input

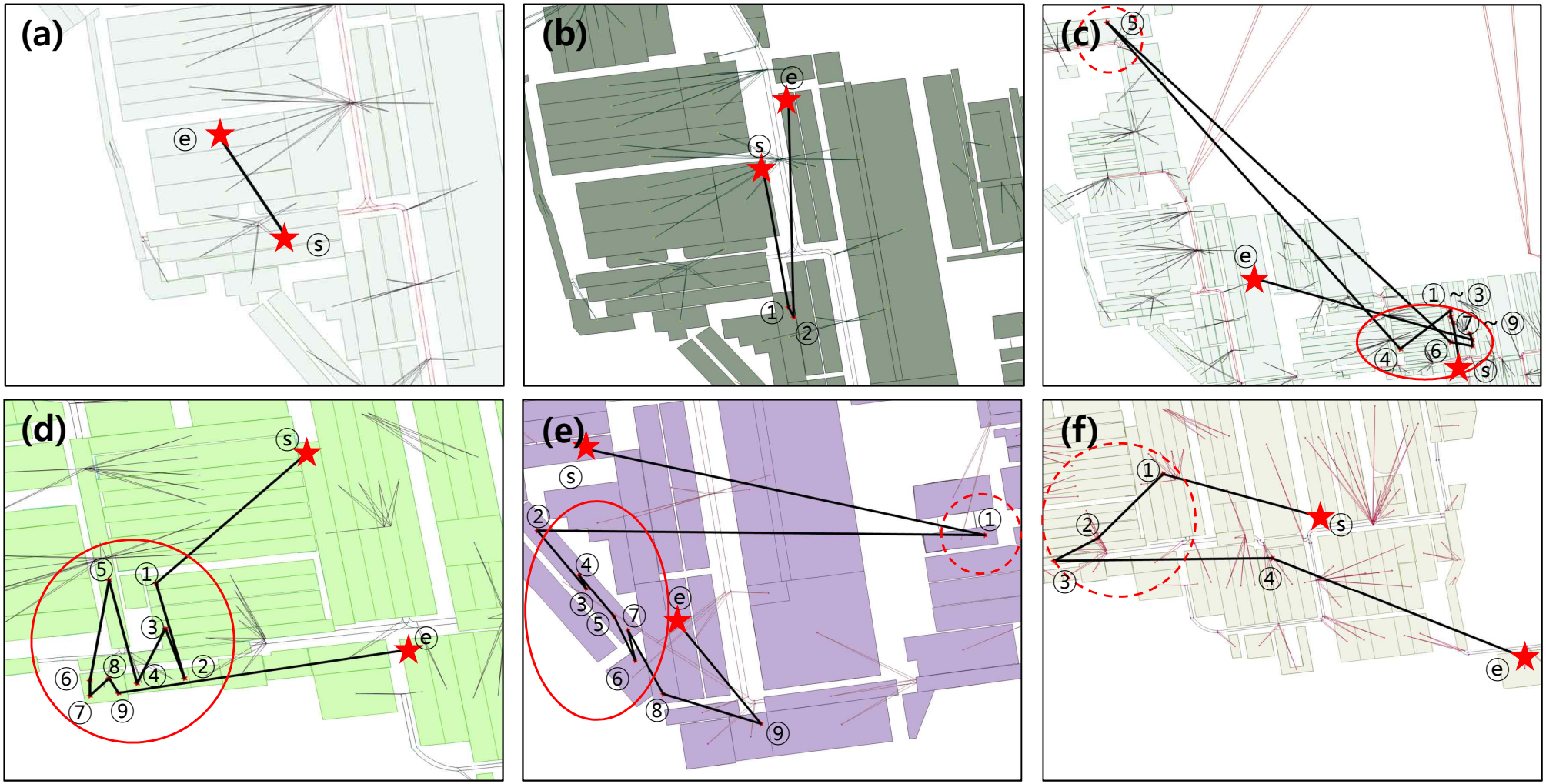
Work Scope	Moving Info.		Working Time		
	Loading Area	Unloading Area	Workday	Start Time	End Time
subsidiary Movement	unknown	3R52	2016-11-17	22:01	22:07
subsidiary Movement	unknown	3R43	2016-11-18	22:41	22:41
subsidiary Movement	3R43	3R5204	2016-11-19	8:25	8:26
subsidiary Movement	3R5204	3R51	2016-11-19	8:47	9:09
subsidiary Movement	3R5104	3R5204	2016-11-19	20:19	20:19
subsidiary Movement	3R5204	3R51	2016-11-21	9:20	9:22
subsidiary Movement	3R5105	3R5205	2016-11-21	22:28	22:31
subsidiary Movement	3R5204	3L17	2016-11-22	9:04	9:08
subsidiary Movement	3R15	3L08	2016-11-28	21:14	21:14

Example of data sheets for transport operation results input

Introduction

▶ **Analysis of movement of blocks based on past data & related data**

: Analysis of block motion path from one process to the next process



ⓢ : Advanced process work area

ⓔ : Outdoor planning process work area

: many movement & stockyard

: Abnormal stockyard

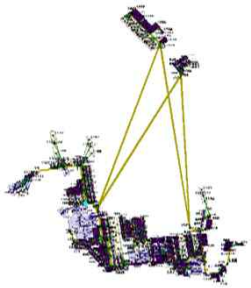
Introduction

▶ Operator experience based transporter operation & the need for operational optimization system

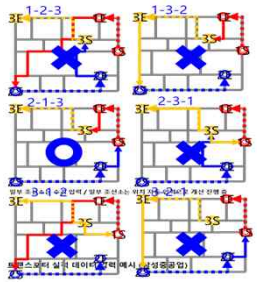
Work based on worker experience	Occurrence of operational inefficiency	The need for an operational optimization system
• Operational planning • Changing work plan • Selection of transporter for working • Block movement order & movement position selection	• Increase movement distance of block • Increase waiting time of transporter • Increase movement distance of empty transporter	• Improved input method of transporter operation result • Optimum block stockyard selection • Establishing an optimal operation planning In real-time • Reduced waiting time & empty transporter Moving time
Experience based operations & Handwriting input of operation result	**Increased importance of minimizing transporter operation cost**	**Logistics estimation / cost reduction / technology competitiveness**

▶ Major technologies and environments for optimal operation of transporters

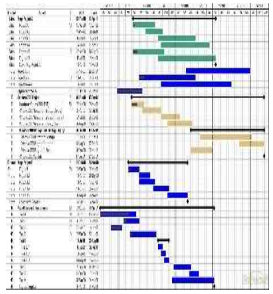
Real-time optimal operation planning technology



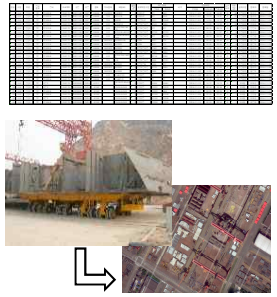
Yard GIS Map



Minimum Cost Route Search

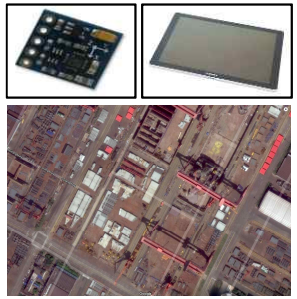


Optimal Operation Planning



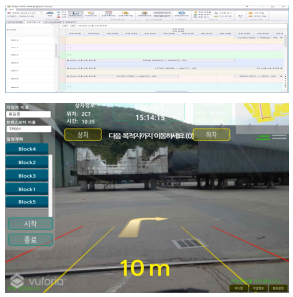
Selection of Block Stockyard

Automation technology to improve work environment



Real-Time Location Tracking

Environment Analysis



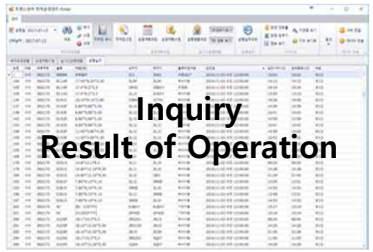
Work Information Visualization

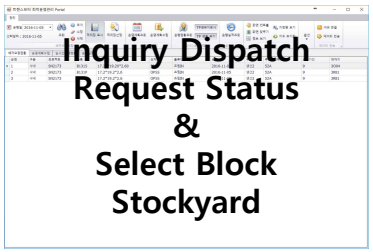
Overview : Transporter Optimal Operation System

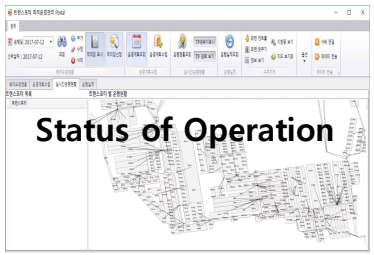
▶ Features and Configuration of Transporter Optimal Operation System

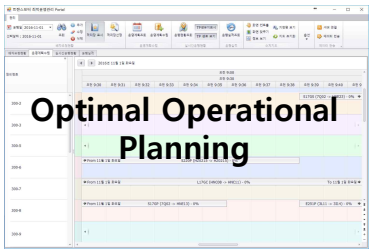
Transporter Optimal Operation Platform

Platform UI





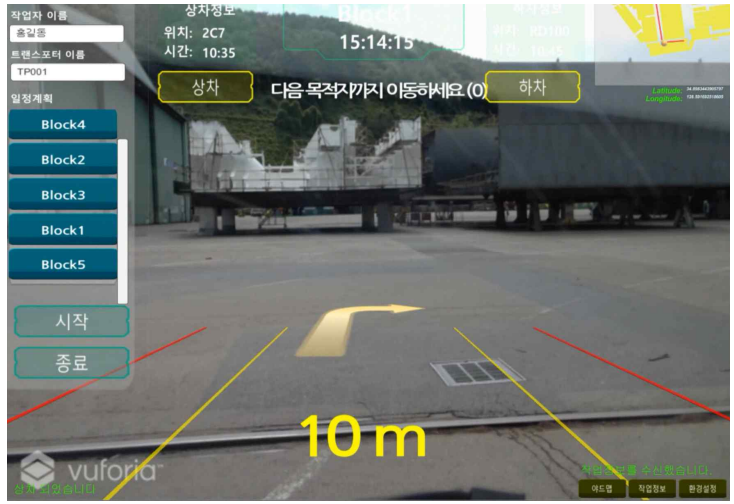




Transporter Operation Plan
(Block Movement Information)
Transporter Movement Path

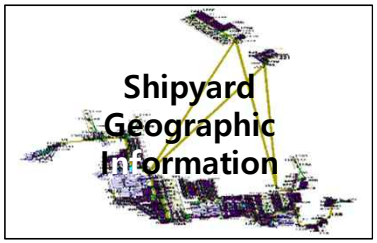
Transporter Operation Status
Transporter Operation Result

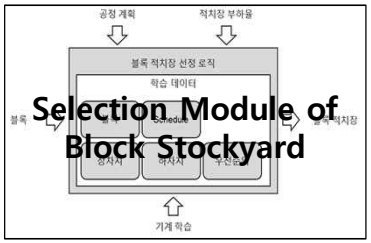
AR based Operation Support Module

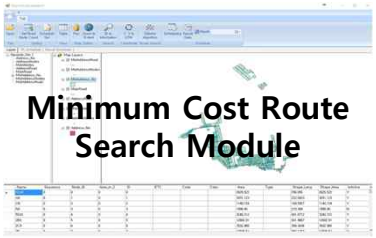


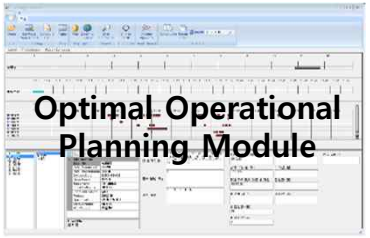
AR based OSM Screen

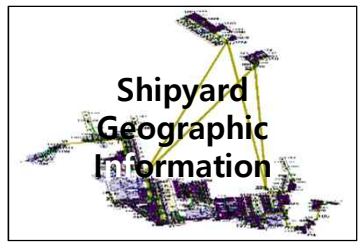
Data & Module for Platform







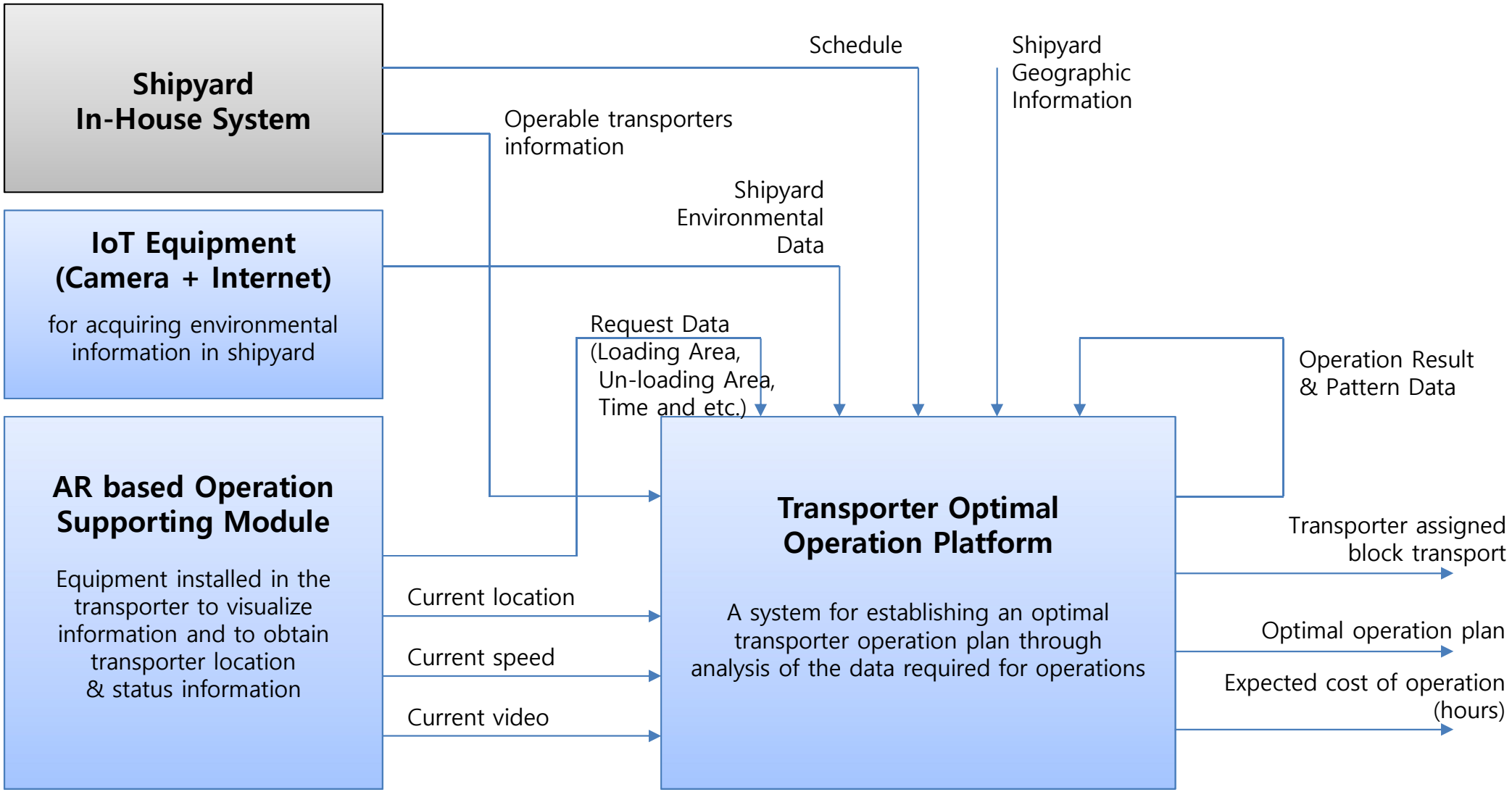




Data for OSM

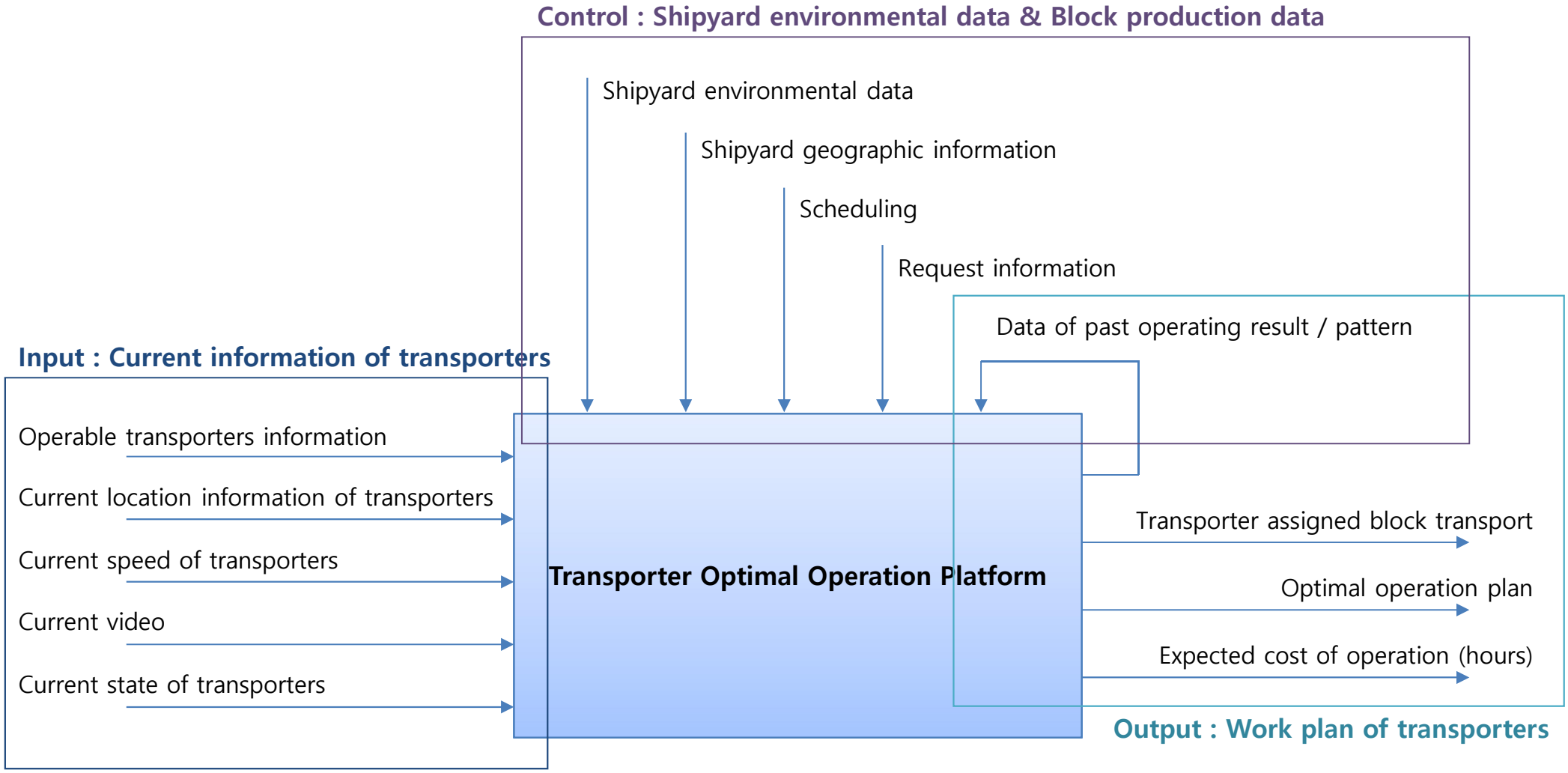
Platform Design for Optimal Operating of Transporter (1/3)

▶ Configuration of Transporter Optimal Operation Platform



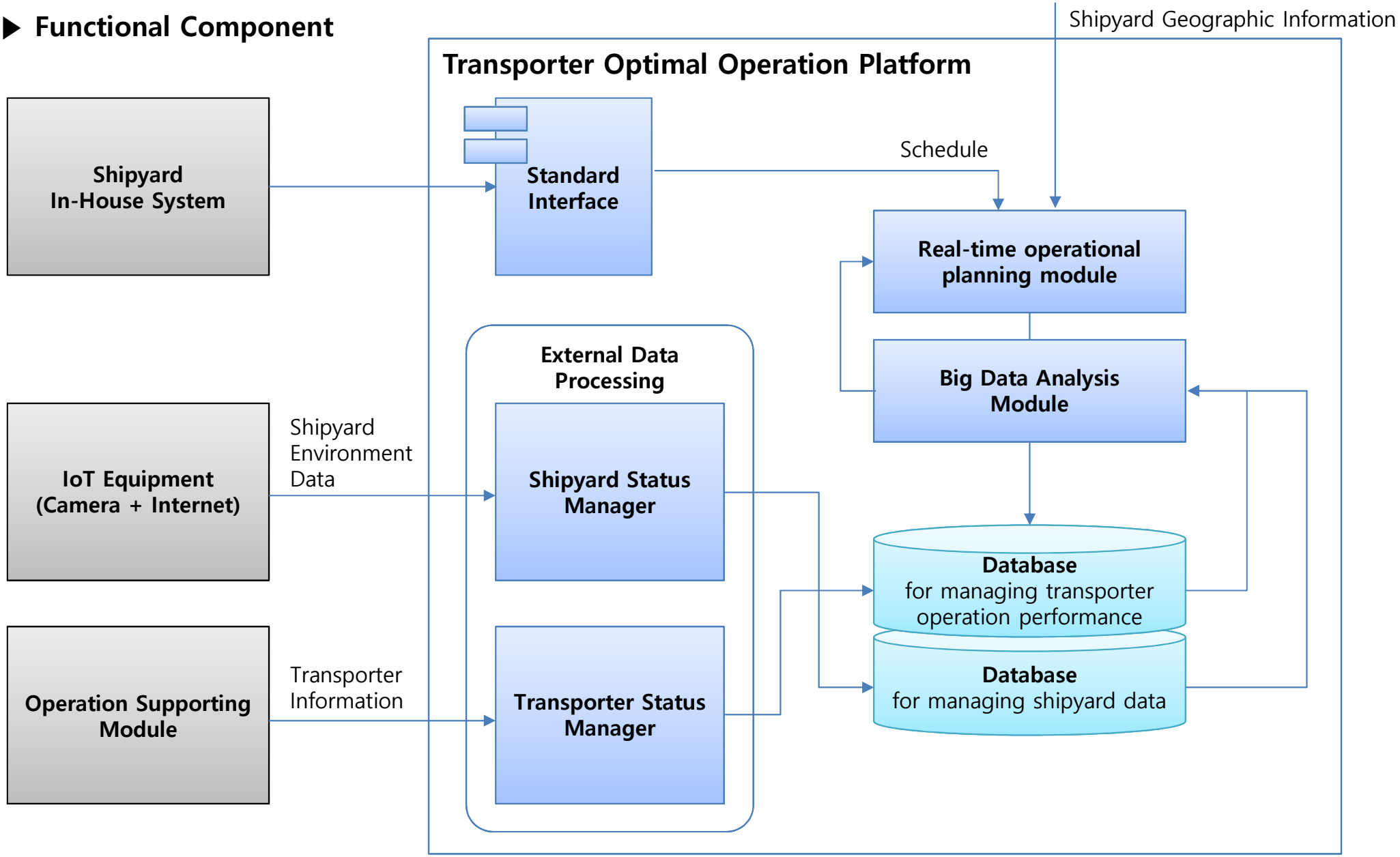
Platform Design for Optimal Operating of Transporter (2/3)

▶ Definitions of I / O and Control Data (Level : IDEF0)



Platform Design for Optimal Operating of Transporter (3/3)

▶ Functional Component

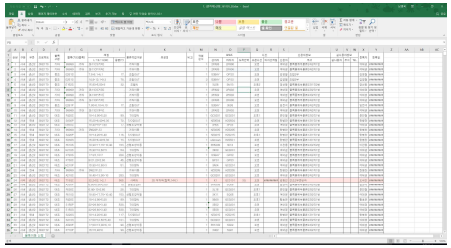


Development of Core Modules (1/5)

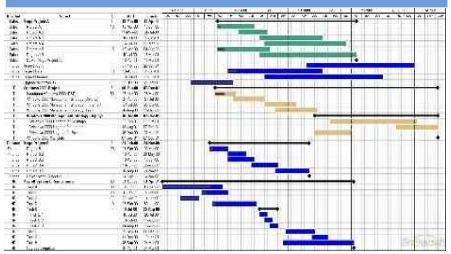
▶ Selection of Block Stockyard

Data involved in block movement

Past & Dispatch Data



Block production planning



Stockyards around the Workshops

Data analysis and classification

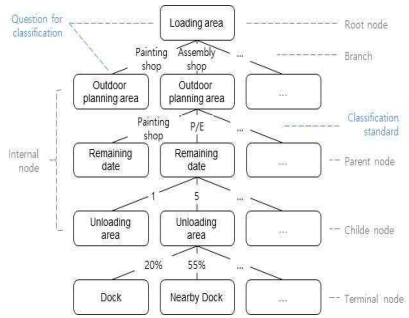
Core Data

프로젝트	블록	상차지	하차지	운행 요청일	공정 작업 수행일	공정 작업장 위치	남은 일자	우선 순위
SN2172	A121P	2C1	3A01	2016-11-03	2016-11-08	S5A	5	MIDDLE
SN2172	A12AP	2C1	7Q01	2016-11-04	2016-11-04	S3D	0	FAST
SN2172	A12AP	7Q01	PS302	2016-11-04	2016-11-16	S3C	12	SLOW
SN2172	A12AS	2C501	PB05	2016-11-11	2016-11-14	S3D	3	FAST
SN2172	A12AS	2C7	2C7	2016-11-17	2016-11-25	S3A	8	MIDDLE
SN2172	A12AS	2C732	2C722	2016-11-21	2016-11-21	S5A	0	FAST
SN2172	A12AS	2C7	2B736	2016-11-22	2016-11-27	S5A	5	MIDDLE
SN2172	A12AS	4Q01	PT4	2016-11-25	2016-12-02	S5A	7	MIDDLE
SN2172	A12AS	4Q01	PT4	2016-11-25	2016-12-07	S5A	12	SLOW
SN2172	A12BP	PT401	PB05	2016-11-29	2016-12-02	S3A	3	FAST
SN2172	A12BP	PT401	PB05	2016-11-29	2016-12-07	S1B	8	MIDDLE
SN2172	A12BP	2B746	RD90	2016-11-29	2016-12-06	S1A	7	MIDDLE
SN2172	A12BS	PB05	2C721	2016-11-30	2016-12-05	S5A	5	MIDDLE
SN2172	A12BS	PB05	2C7	2016-11-30	2016-11-30	S5A	0	FAST
SN2172	A12BS	2C731	PB05	2016-11-30	2016-12-13	3P1	13	SLOW
SN2172	A12CP	PB05	2C7	2016-11-30	2016-12-03	3P1	3	FAST
SN2173	A12CP	S7	S7	2016-11-30	2016-12-08	3P1	8	MIDDLE
SN2173	A12CP	S7	S7	2016-11-30	2016-11-30	3P1	0	FAST
SN2170	A12CP	S3BAY	S3BAY	2016-11-19	2016-11-23	S3D	4	MIDDLE
SN2170	A12CS	PS222	PS222	2016-11-14	2016-11-14	S3C	0	FAST
SN2170	A12CS	PS222	3J06	2016-11-21	2016-12-01	S3D	10	SLOW
SN2170	A12CS	RD100	RD100	2016-11-08	2016-11-11	SK1	3	FAST
SN2170	A12CS	RD100	PS208	2016-11-14	2016-11-22	SK1	8	MIDDLE
SN2170	A12DP	PS208	PS205	2016-11-15	2016-11-16	SK1	1	FAST
SN2170	A12DP	PS205	PS211	2016-11-15	2016-11-20	S3D	5	MIDDLE
SN2170	A12DP	PS210	3N02	2016-11-24	2016-11-26	S1A	2	FAST
SN2170	A12DS	3N02	3R81	2016-11-24	2016-12-05	S1B	11	SLOW
SN2170	A12DS	3R81	RD100	2016-11-15	2016-11-18	S1A	3	FAST
SN2170	A12DS	RD100	RPS101	2016-11-17	2016-11-25	3P1	8	MIDDLE
SN2170	A12DS	RPS101	3J07	2016-11-22	2016-11-23	SK1	1	FAST
SN2170	A312P	RPS103	RPS103	2016-11-16	2016-11-21	S3D	5	MIDDLE
SN2170	A312S	RPS103	RPS104	2016-11-23	2016-11-23	S1A	0	FAST

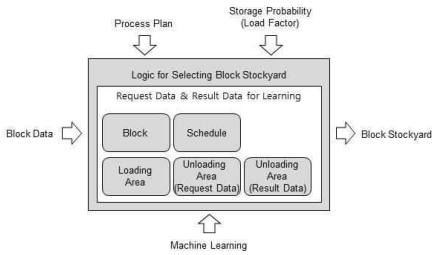
- Project No.
- Block No.
- Loading Area
- Unloading Area
- Date of Transport Request
- Production work schedule
- Production work location
- Remaining work to date
- Work priority

Data Learning

The result of learning with decision tree (C5.0)

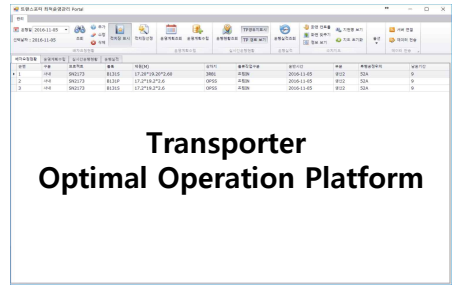


Stockyard selection logic



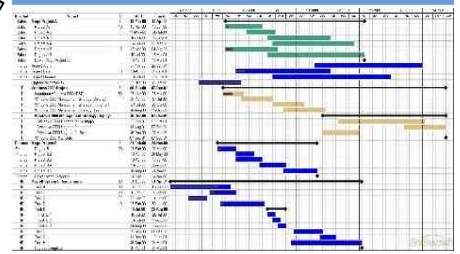
Block Stockyard Selection

Dispatch inquiry and Stockyard selection



Transporter Optimal Operation Platform

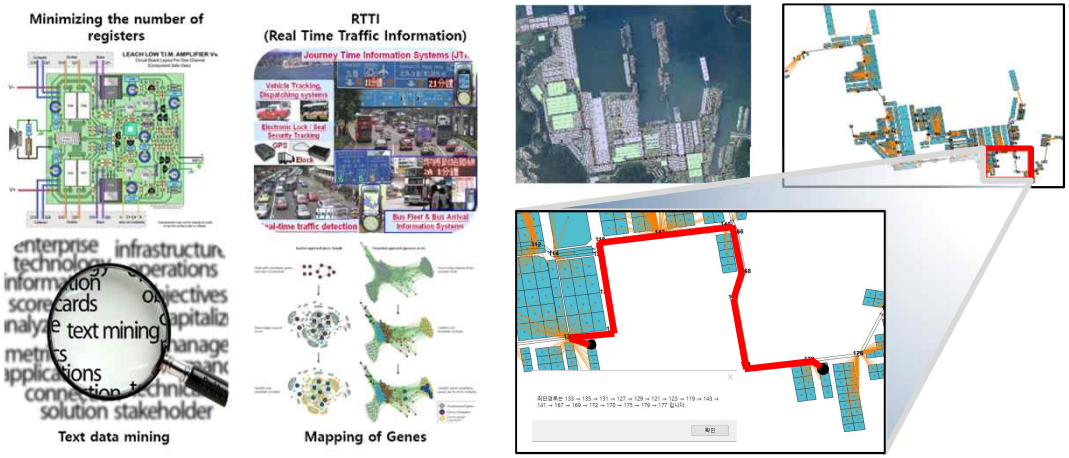
Block production planning



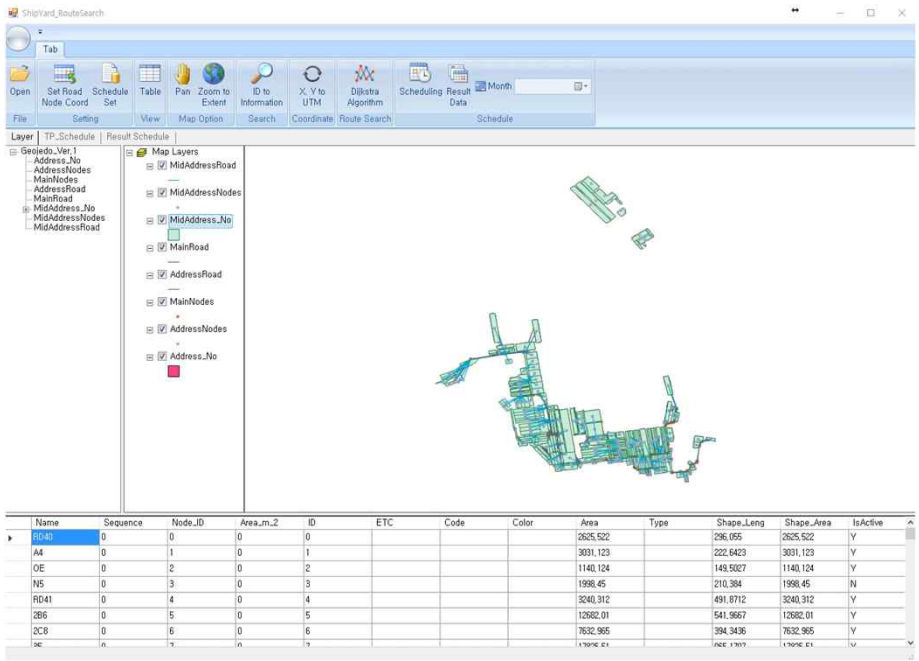
Development of Core Modules (2/5)

▶ Minimum Cost Route Search

Dijkstra Algorithm

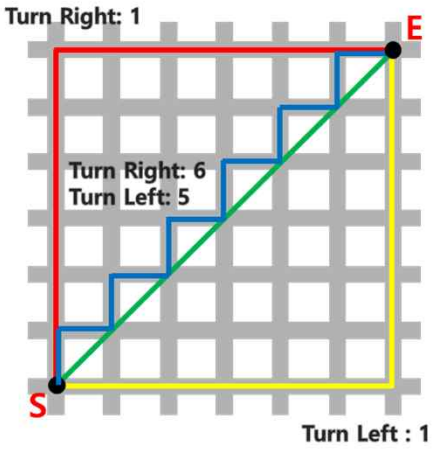


Minimum Cost Route Search

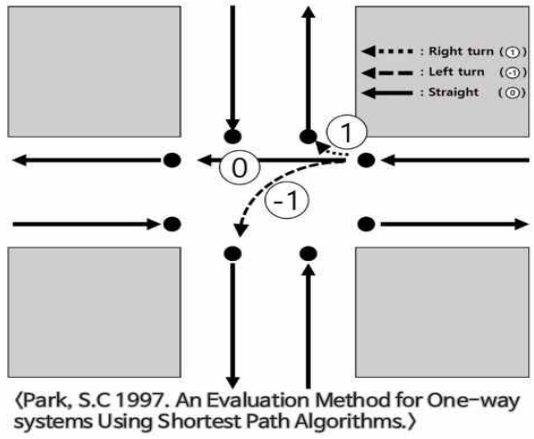


* Dijkstra algorithm

Rotation vs. straight line



Intersection Penalty



(Park, S.C 1997. An Evaluation Method for One-way systems Using Shortest Path Algorithms.)

Rotation section application penalty

※ Shortest Path → Minimum Cost Path

$$\sum\left(\underbrace{\text{Shortest Disance between Nodes}}_{\text{(All sections)}}\right) \rightarrow \sum\{\underbrace{\left(\text{Shortest Disance between Nodes}\right)}_{\text{(Straight section excluding the rotation section)}} + \overbrace{(\text{Turn Right} \times \alpha) + (\text{Turn Left} \times \beta) + (\text{Straight} \times \gamma)}^{\text{(Intersection)}}\}$$

※ α, β, γ: Rotation section application penalty

Development of Core Modules (3/5)

▶ Optimal Operation Planning

Minimize)

$$F = \alpha \sum_{h=0}^{n_B} \sum_{i=1}^{n_B} \sum_{k=1}^{n_T} x_{hi}^k \left(\frac{e_{hi}^k}{V^k} \right)$$

: Empty Transporter Mileage

Subject to)

$w_i \le c_k$ ⟶ Block weight ≤ Transportable weight

$r_i \le p_i^k$ ⟶ Planned block transport time ≤ Actual T / P transportation start time

$d_i^k \le s_i$ ⟶ Actual T / P transportation end time ≤ end time of planned block

$p_j \le p_i$ ⟶ The start time of the block with low priority ≤ High-priority block transport start time

$i, j = 1, \cdots, n_B$

$k = 1, \cdots, n_T$

$h = 0$ (A virtual block for carrying the first block of each transporter)

$, 1, 2, \cdots,$ B (단, $h \neq i$)

e_{hi}^k: Distance considering the actual travel time when the transporter k moves to the block i position after carrying the block h.

V^k: speed of transporter k

$x_{hi}^k = 1$: When the transporter k carries block i after carrying block h

$x_{hi}^k = 0$: Transporter k does not carry block i after carrying block h

w_i: Weight of block i

c_k: Load weight that transporter k can carry

r_i: Planned transportable time of block i

p_i^k: Start time at which transporter k carries block i

d_i^k: Time when transporter k completed transporting block i

s_i: Planned completion time of block i

p_i: Transport start time of block i with higher priority

p_j: Transport start time of block i with lower priority

B: Total number of blocks to carry

T: Total number of available transporters

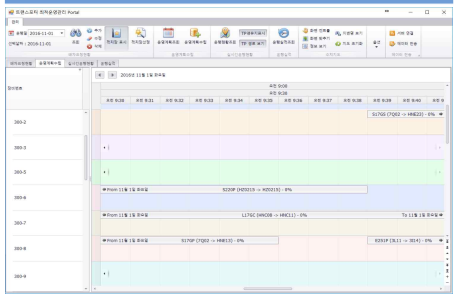
α: weight factor

Development of Core Modules (4/5)

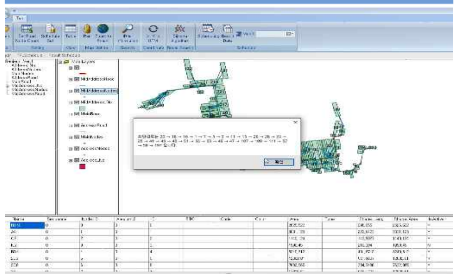
▶ AR based Operation Support

Transporter Optimal Operation Platform

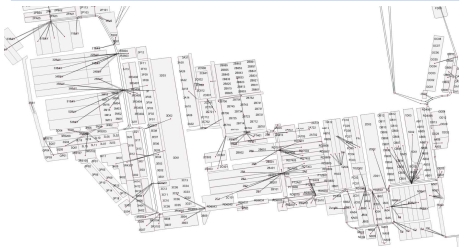
Optimal Operation Planning



Optimal Route



Shipyard Numerical Map



AR based Operation Support Module

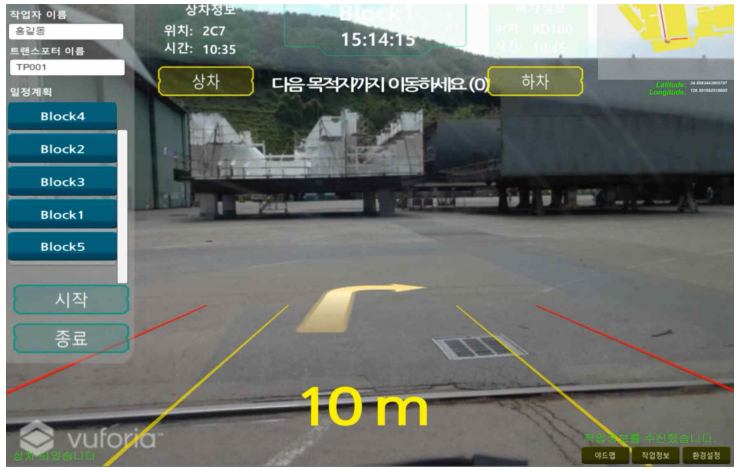
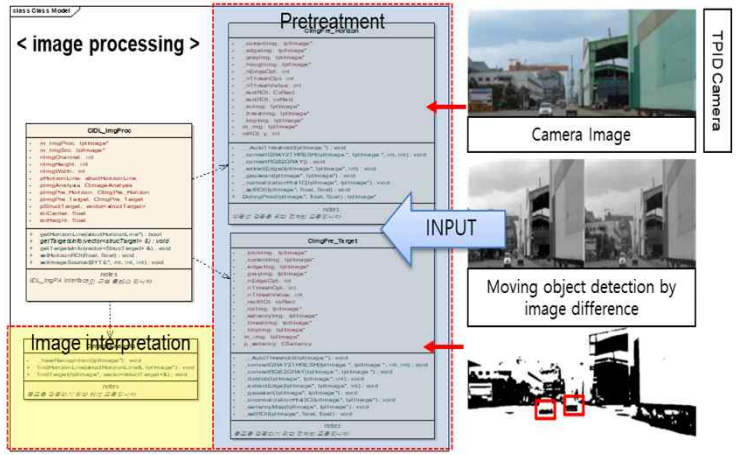
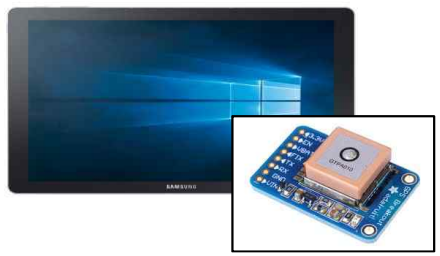


Image analysis module



Built-in GPS device

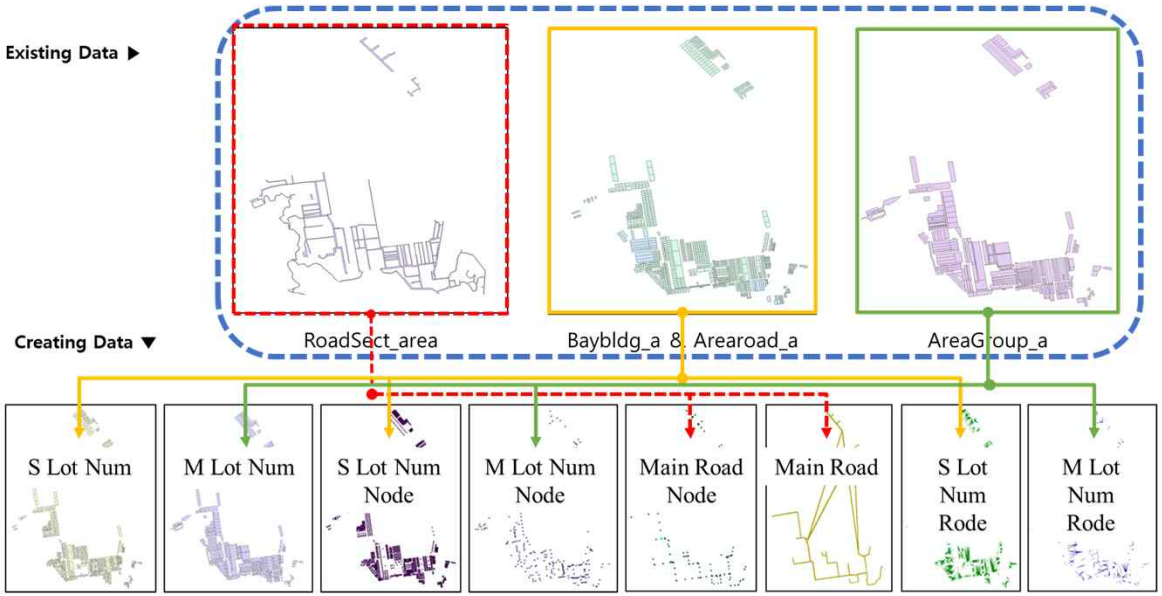


Obstacle detection

Development of Core Modules (5/5)

▶ Shipyard Numerical Map

Creating shipyard numerical map layer and defining layer columns



- Node Attribute -

ID	String	Number
X	Double	X
Y	Double	Y
Latitude	Double	Latitude
Longitude	Double	Longitude

- MainRoad Attribute -

ID	String	Number
First_Node	String	Start Node
Sec_Node	String	End Node
Distance	Double	Distance
Breadth	Double	Breadth
Directon	Long	Direction
IsActive	String	Is Active
Start_X	Double	X of Road Start
Start_Y	Double	Y of Road Start
End_X	Double	X of Road End
End_Y	Double	Y of Road End
CrossRoad	Long	Cross Road

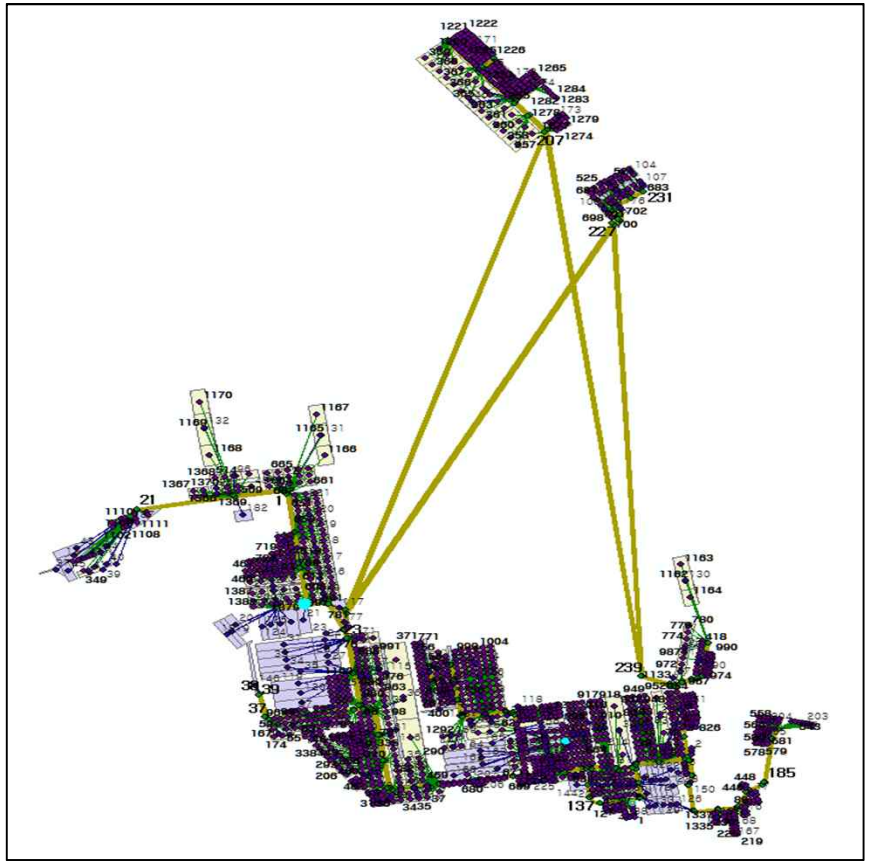
- AddressRoad Attribute -

ID	String	Number
First_Node	String	Start Node
Sec_Node	String	End Node
Distance	Double	Distance
Breadth	Double	Breadth
Directon	Long	Direction
IsActive	String	Is Active
Start_X	Double	X of Road Start
Start_Y	Double	Y of Road Start
End_X	Double	X of Road End
End_Y	Double	Y of Road End

- AddressNo Attribute -

Name	String	Name
Sequence	Long	
Node_ID	Long	Lot Number Node Number
Area_m_2	Double	
Shop_No	Long	Shop Number
Stock_No	Long	Stock Number
Quay_No	Long	Quay Number
ID	Long	Lot Number
ETC	String	ETC
Code	String	
Color	string	Color
Area	Double	Area
Type	String	
Shape_Leng	Double	Edge
Shape_Area	Double	Area
Group_Node	String	Group Node

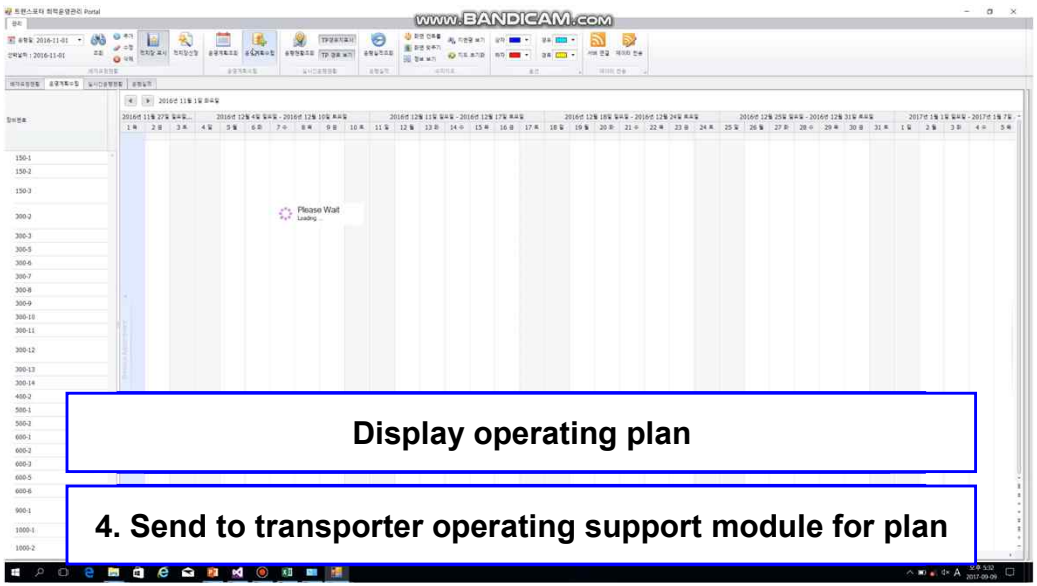
Shipyard numerical map



* DotSpatial 1.9

Implementation of Prototype

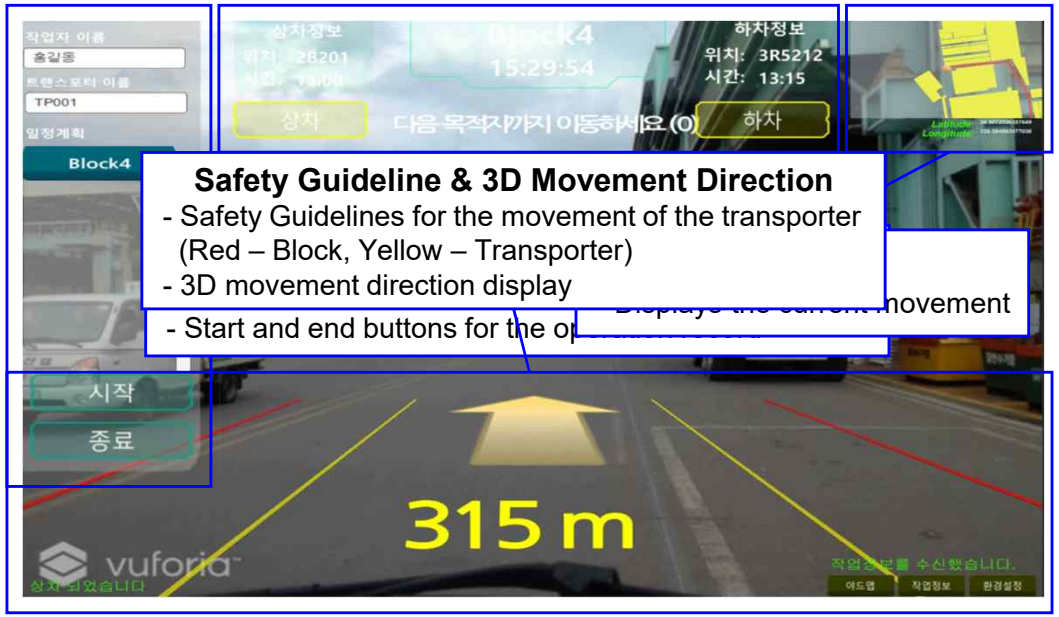
▶ Transporter Optimal Operation Platform



Display operating plan

4. Send to transporter operating support module for plan

▶ AR based Operation Support Module

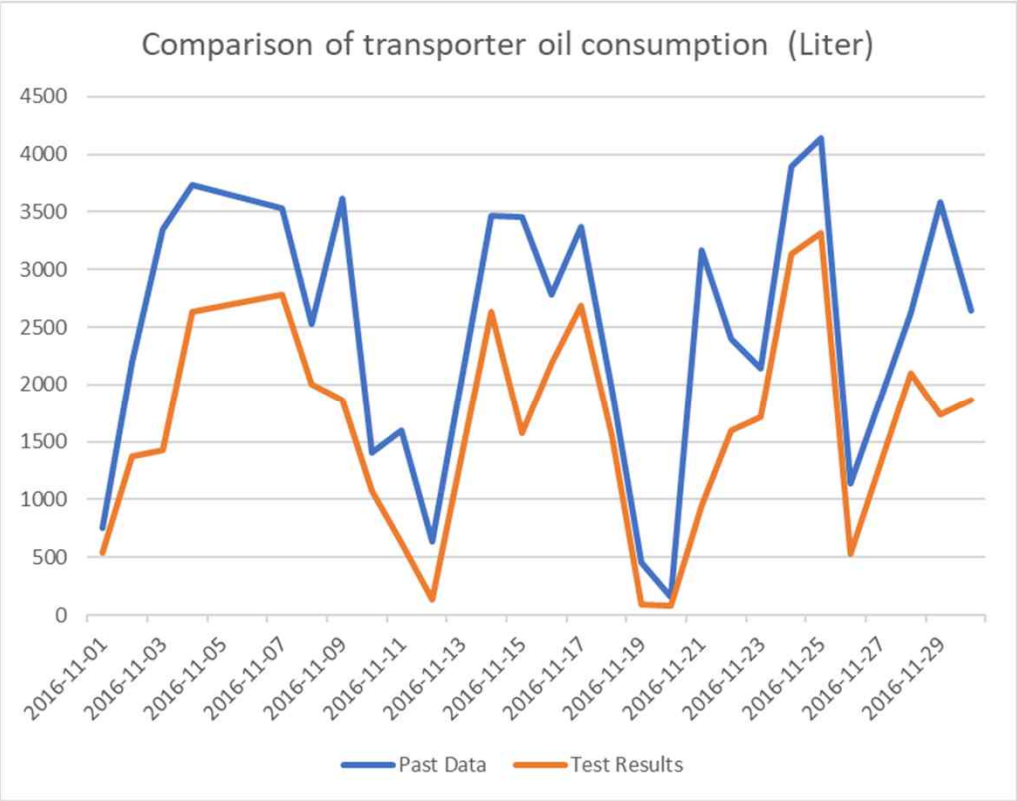


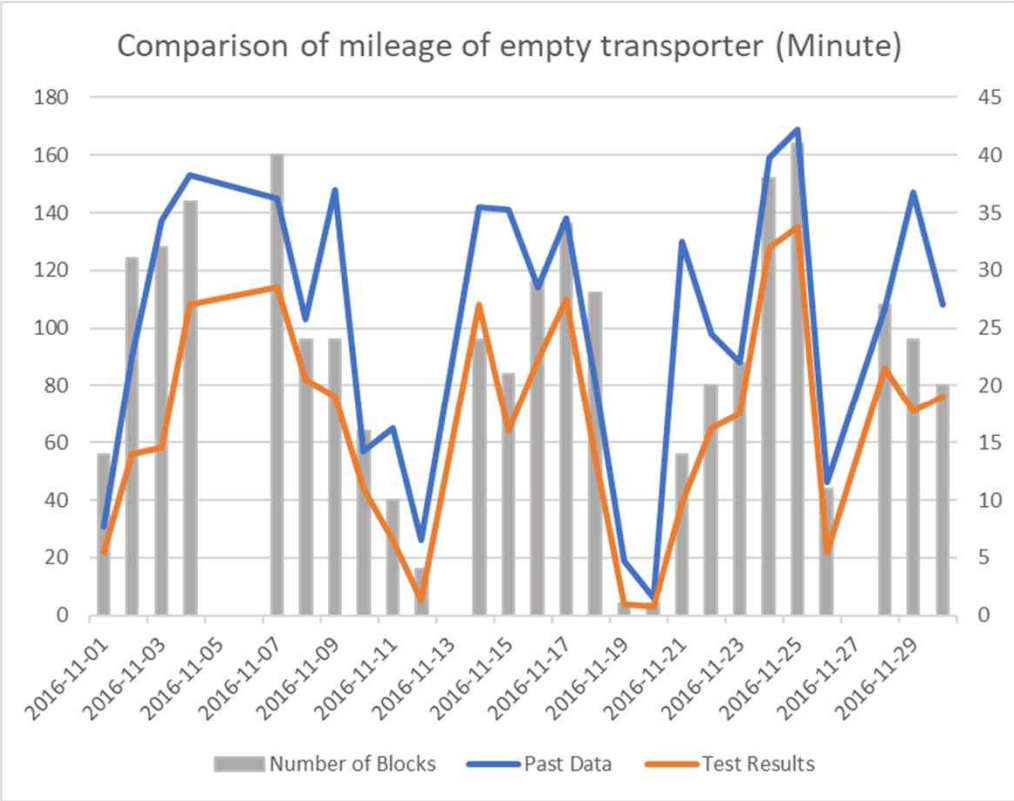
Safety Guideline & 3D Movement Direction
- Safety Guidelines for the movement of the transporter (Red – Block, Yellow – Transporter)
- 3D movement direction display

- Start and end buttons for the op

ovement

Test Results





Conclusions & Future Study

- We have studied and developed a system that supports optimal operation of transporter to reduce human errors and logistics costs.
- We designed and developed an optimal operation platform for operators to establish and manage operational plans.
- We designed and developed an augmented reality-based operational support module that allows the driver to reduce the dependency of the flagger and determine the surrounding situation of transporter.
- Through testing, we have demonstrated the necessity and importance of the developed system.
- Improvement of configuration technology and module performance
  - Intelligence of block stockyard selection module
  - Development of environmental recognition module around transporter
  - Development of environment recognition module in shipyard(identify operational status of stockyard)
- We will be commercialized for domestic and overseas shipyards.

THANK YOU
for your
ATTENTION!

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