VIRTUAL GATE:

OVERCOMING SEVERE PORT CONGESTION AT BUSAN PORT

BPA | BUSAN PORT AUTHORITY

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BPA 부산항만공사 BUSAN PORT AUTHORITY

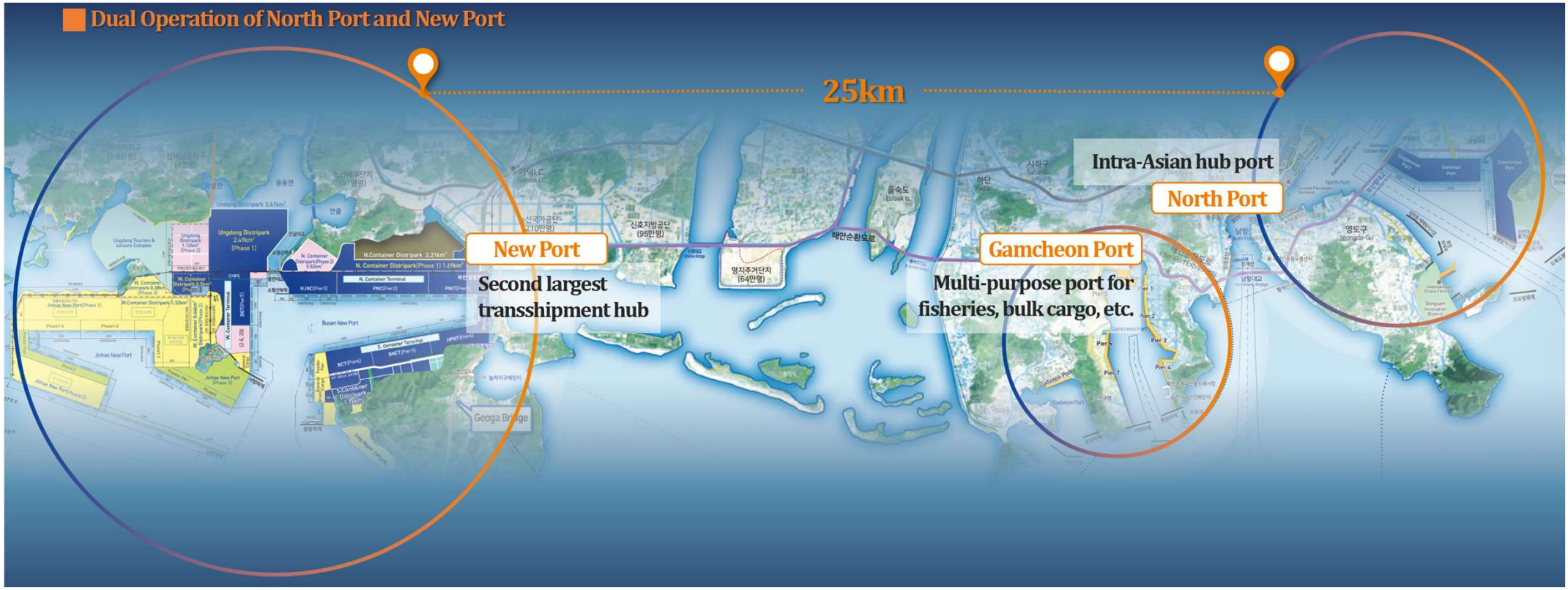
01 Overview of Busan Port

Since the early 1900s Busan Port(North Port) had functioned as Korea's principal trade gateway.

As cargo volumes at North Port increased steadily, the development of a new port area, Busan New Port, was initiated to accommodate the rising demand.

Currently, about 70% of Busan Port's container throughput is handled at New Port, while the remaining 30% is handled at North Port.

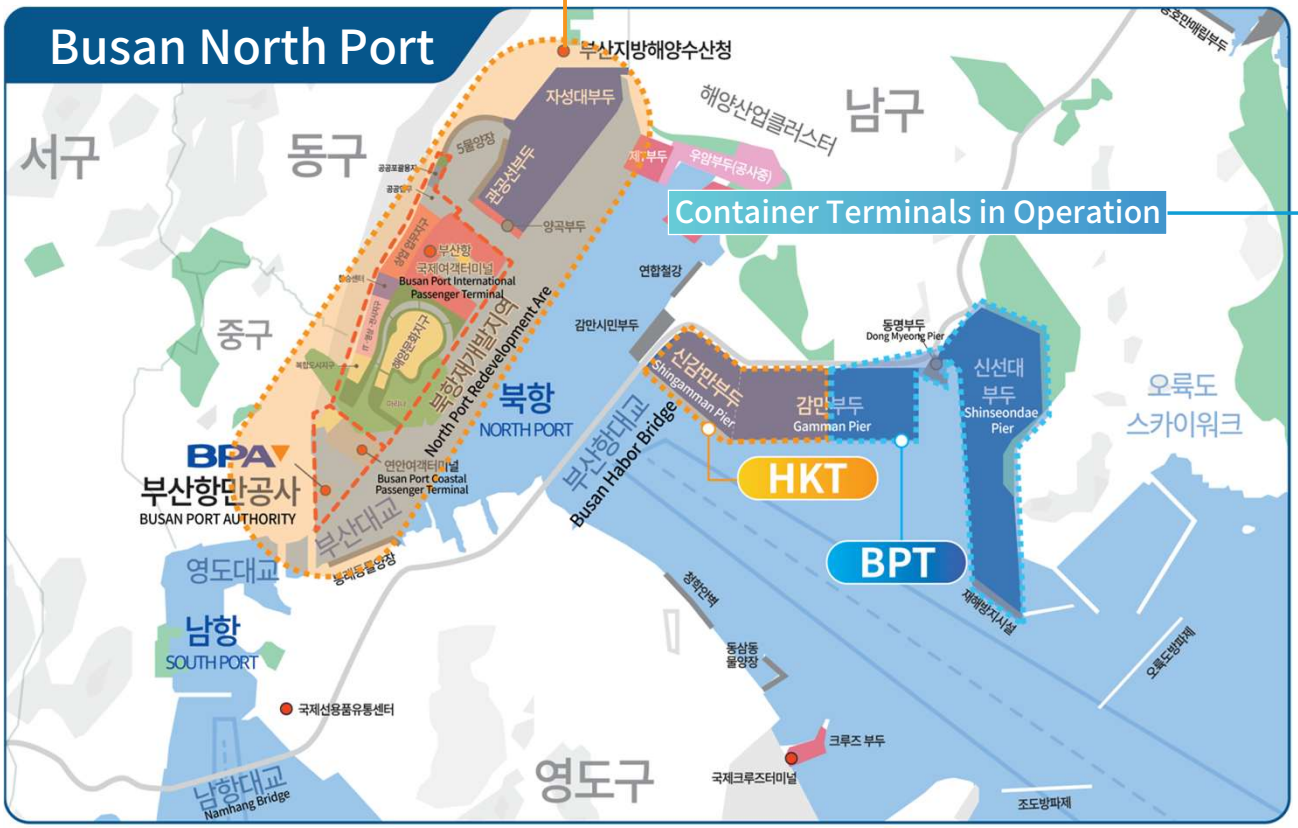
Dual Operation of North Port and New Port



02 Overview of Busan North Port

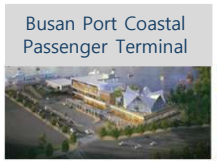
As the old port area, Busan North Port is divided by the Busan Harbor Bridge.

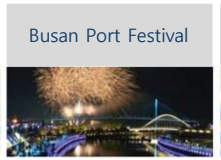
1 The inner area is being redeveloped into a maritime leisure and tourism complex.



Container Terminals in Operation

Busan North Port





2 The outer area continues to maintain its container terminal functions.

Hutchison Korea Terminals(HKT) relocated from the current North Port redevelopment area **to Singamman Terminal** and **part of Gamman Terminal**.

As a result, container terminal functions continue to be maintained in the outer port area through **Hutchison Korea Terminals(HKT)** and **Busan Port Terminal(BPT).**

03 Operational Structure of Gamman Terminal in North Port

Gamman Terminal consists of 4 Berths

Berths 1 — Operated by HKT since 2024

Berths 2 3 4 — Operated by BPT

Traffic Flow

As part of the old port area, Gamman TML is connected by narrow two-lane, two-way port access roads.

HKT OUTBOUND vehicles and BPT INBOUND vehicles use the same access road.

04-1 Severe Traffic Congestion – Cause of Bottleneck No. 1

Case 1

BPT Inbound Traffic

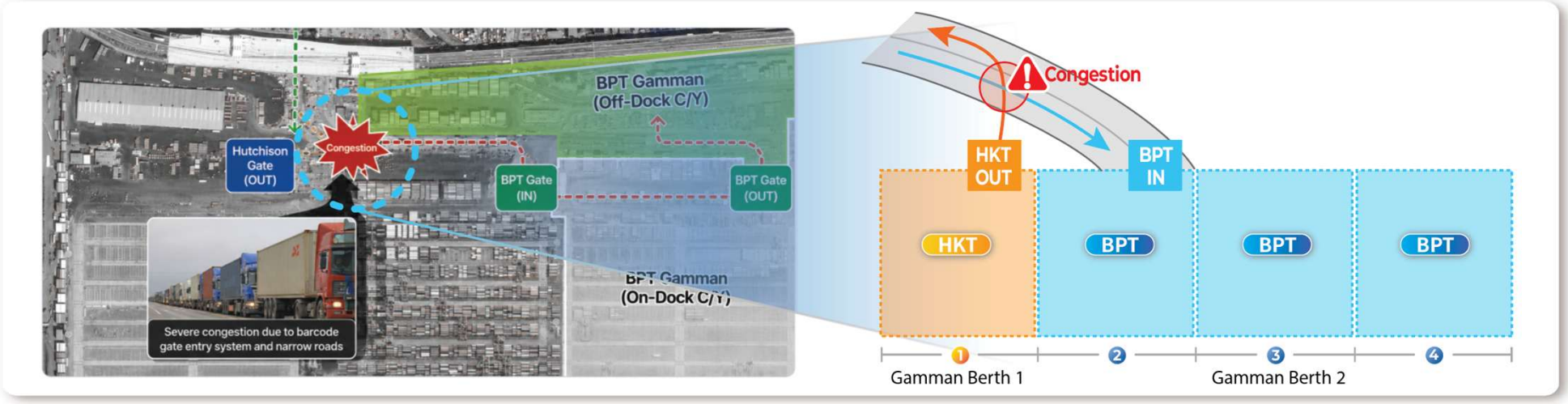
Trucks entering BPT Gamman Terminal

Case 2

HKT Outbound Traffic

Trucks exiting the HKT Gate at Berth 1

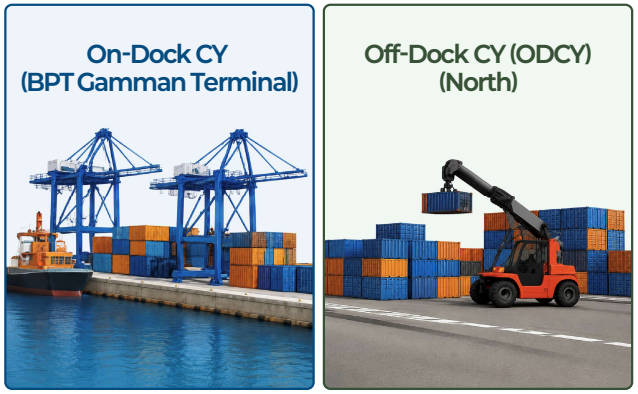
- Traffic congestion occurs as **"Case 1"** and **"Case 2"** intersect.
- Congestion worsens due to the large turning radius and slow acceleration/deceleration of heavy-duty vehicles.
- Traffic congestion spreads beyond the port and affects nearby city roads!



04-2 Severe Traffic Congestion – Cause of Bottleneck No. 2

1 BPT OPERATING STRUCTURE

BPT operates both an on-dock CY and an off-dock CY (ODCY)



2 TERMINAL OPERATING RULE

To receive container location information, trucks must pass through the terminal gate

Truck enters terminal gate

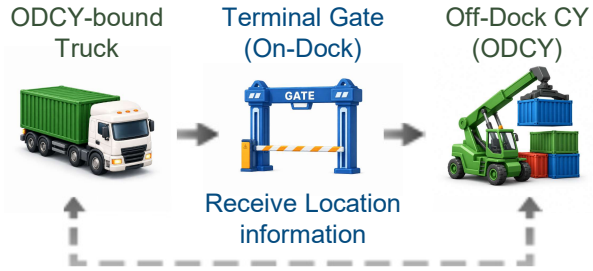
Information is provided after gate entry

Container location information received via mobile

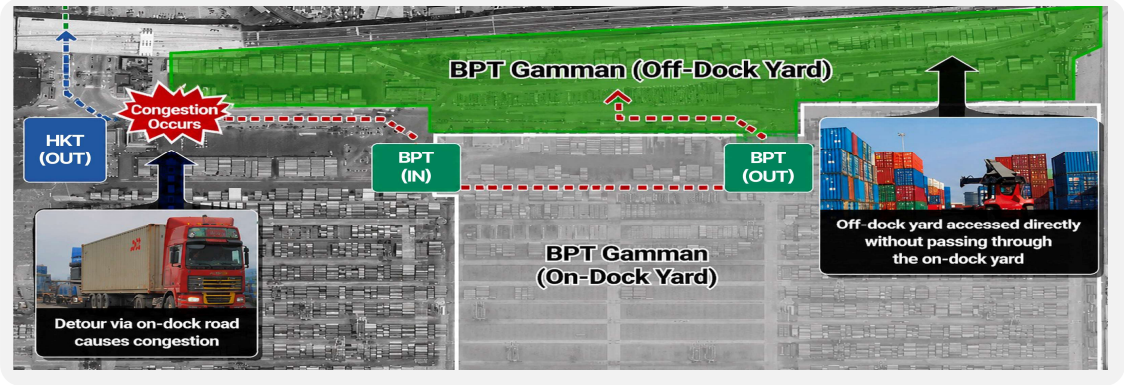
Location information is only available after gate entry.

3 IMPACT ON ODCY-BOUND TRUCKS

Therefore, trucks heading to the ODCY must first visit the on-dock terminal gate to receive container location information



Unnecessary detour(before going to ODCY)



Both on-dock and off-dock truck flows converge at the same gate.

- Traffic congestion
- Operational inefficiency occur

04-3 Sharp Increase in Complaints from Truck Drivers and Citizens

Truck drivers

Waiting times are too long.
We have to make unnecessary loops around the off-dock yard.
Every minute counts!

Terminal operators

On-site complaints are increasing due to gate congestion.
Yard operations and cargo handling flows are also being disrupted.

Citizens

Traffic always gets congested around this section of the port.
Long lines of waiting trucks are also intimidating!

1. HKT outbound trucks
2. BPT on-dock yard trucks
3. BPT off-dock yard trucks

How Can Triple Traffic Congestion Be Resolved?

The most intuitive solution

Construction of a new gate providing direct access to the off-dock empty container yard

However, substantial time and costs are required

- land acquisition
- civil works
- equipment installation
- security system adjustments
- terminal system integration

05-1 Rethinking the Solution

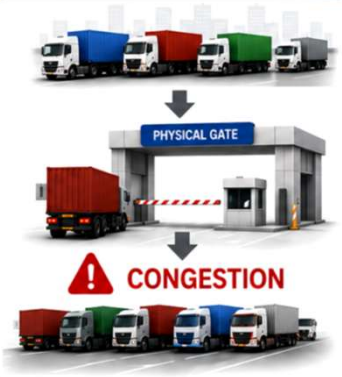
Redefining the core issue

1 Was congestion simply caused by too many trucks?

NO.

ODCY-bound trucks did not need to enter the terminal.

However, they were still required to pass through the terminal gate to receive container location information.



2 Do trucks really need to physically enter the gate to receive cargo information?

NO.

The gate function itself can be digitalized through a Virtual Gate System.

New solution

BEFORE : Physical Gate

AFTER : Virtual Gate

“Build a virtual gate!”

Shifting the function of a physical gate into a digital environment!

05-2 Building a Virtual Gate System

Step 1 Trucks enter the designated virtual zone

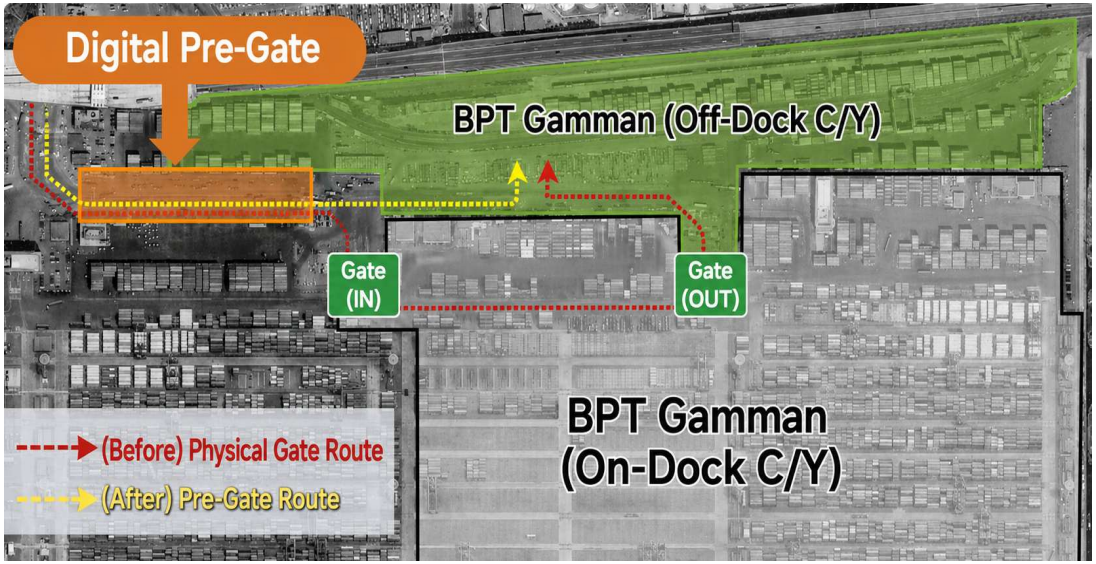
When a truck enters the zone,

Its GPS location is automatically recognized.

Step 2 Issue an e-EIR to truck drivers

Once the truck enters The Virtual Gate Zone,

Container location information (e-EIR) is automatically sent to the driver's mobile device.



- In Busan Port, the mobile-based e-EIR system has already been implemented across all 9 container terminals.
  - e-EIR((Electronic Equipment Interchange Receipt))
    = Container location information required for cargo pickup/delivery

Trucks entering the BPT Gamman off-dock yard no longer need to detour through the on-dock yard.

They can now directly access the off-dock yard through the virtual gate system.

Significant reduction in traffic congestion

06-1 Challenges and Solutions

Key Technical Challenge: How can the system distinguish inbound trucks from outbound trucks within the same virtual gate zone?

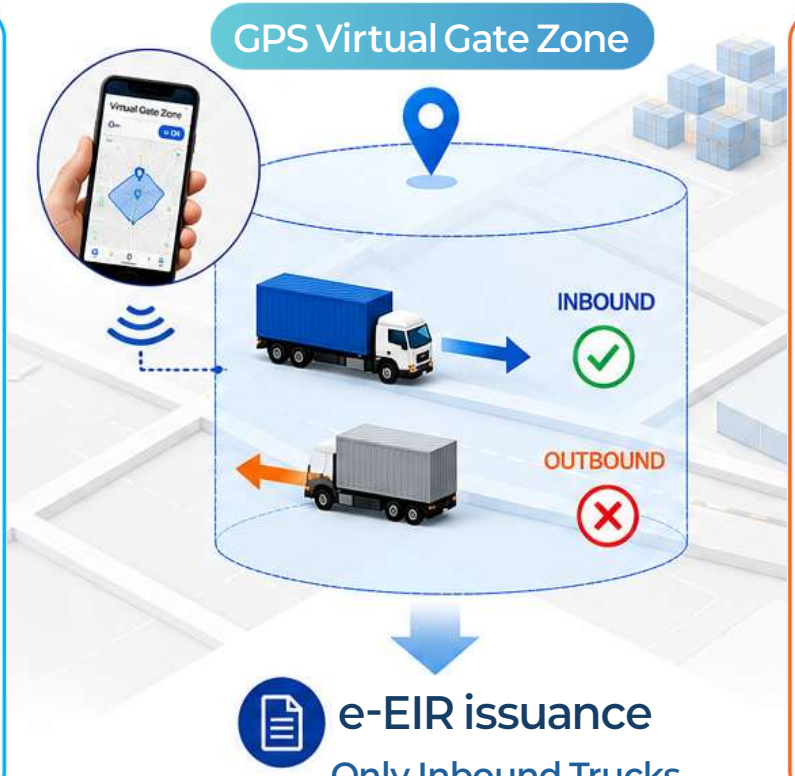
The virtual gate must issue e-EIR only to trucks entering the terminal,
even though both inbound and outbound trucks travel through the same area.

Challenge 1.

Simultaneous Recognition of Inbound and Outbound Trucks

ISSUE Only inbound trucks should receive e-EIR.

But, GPS location alone cannot distinguish entry from exit



Solution 1.

Geofencing + Direction Vector

Geofencing
Creates a virtual gate zone using GPS coordinates

Direction Vector
Determines whether a truck is entering or exiting

Key Achievement

- Direction Vector + Geofencing
- Accurate Recognition of Inbound Trucks
- Automatic e-EIR Issuance

06-2 Challenges and Solutions

Challenge 2.

GPS Signals Are Often Distorted in Port Areas

- The virtual gate system operates using GPS location data from the truck drivers' mobile app.
- However, GPS errors occur far more frequently in port environments than in urban areas.

WHY dose this happen?

High-stacked containers

Large port structures

Cargo handling equipment

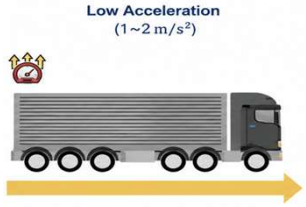
GPS signals may be distorted, causing inaccurate location data.

Solution 2.

Multi-Layer GPS Validation Logic

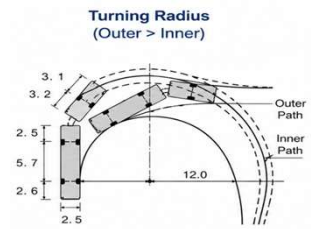
1 Route Validation

Remove GPS coordinates that indicate impossible movements.



2 Speed & Acceleration Validation

Filter abnormal acceleration data.



3 Turning Radius Validation

Filter movements exceeding the truck's physical turning capability.

06-3 Challenges and Solutions

Challenge 3.

Existing Logic Could Not Handle ALL GPS Errors

- Existing correction logic is able to improve basic GPS errors.
- However, complex GPS errors still occur in actual port environments

WHY?

Rule-based logic **works well for predictable errors,**

but struggles with complex and irregular GPS patterns.

Solution 3.

AI-Based GPS Error Detection and Correction

1. **GPS data preprocessing and movement feature extraction**
   - Analyzing sequential travel routes, speed, and turning patterns
2. **AI-based movement pattern analysis**
   - Automatically identifying normal routes and abnormal GPS patterns
3. **Automatic GPS error correction**
   - Removing inaccurate GPS points and improve location accuracy

07 Driving User Adoption of the Virtual Gate System

Technology works only when users actually use it.

Challenge

Truck drivers must **keep the GPS function on in their mobile devices** for the virtual gate system to operate properly.

Reality

Average driver age: **56**
Many drivers are **unfamiliar with smartphone** GPS settings and functions.

Field adoption was the key to successful implementation.

1 User-Friendly Guides

A4 브로셔

X-배너

2 On-site Guidance and Operational Support

3 One-on-One Assistance For Elderly Drivers

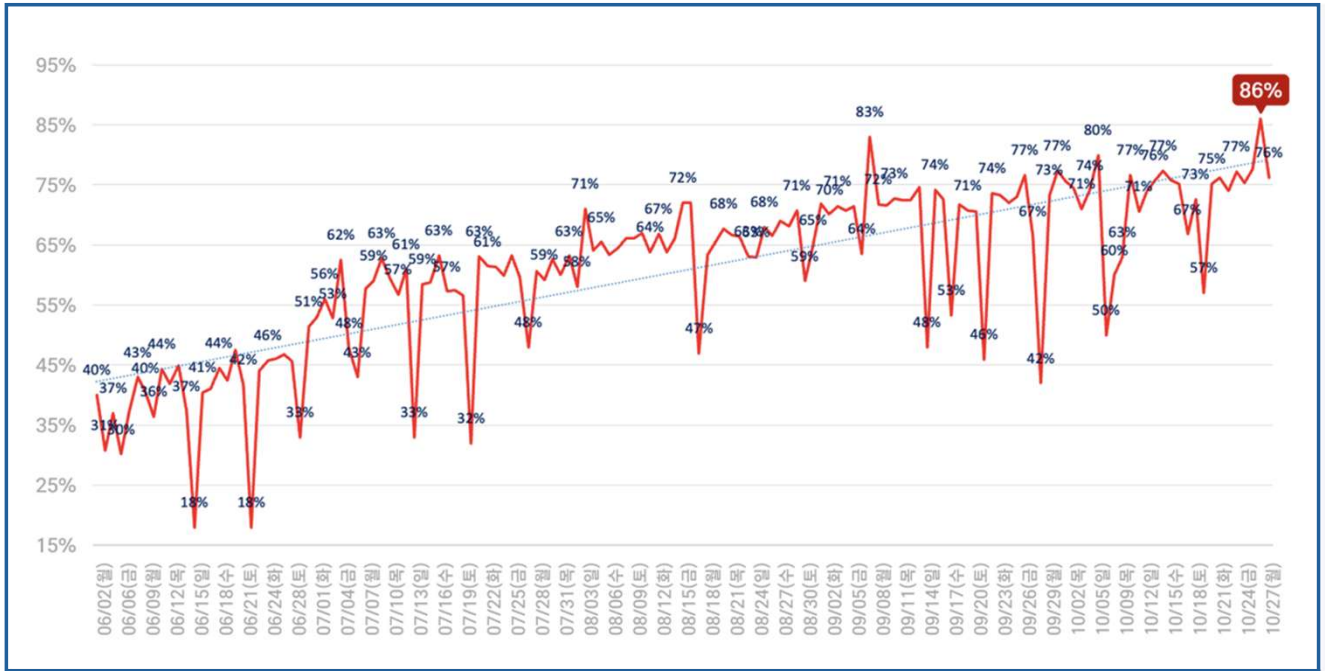
08 Virtual Gate System Adoption and Impact

Adoption Reached 86% Within Four Months

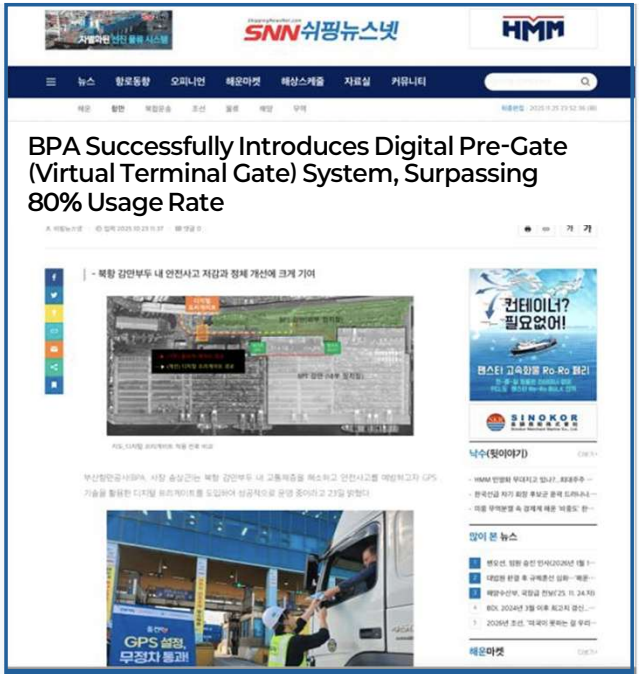
Since its launch in June 2025, more than 60,000 truck movements have been processed through the virtual gate system.

86%
Peak Adoption Rate
(as of October 2025)

60,940
Virtual Gate Uses
(June-October 2025)



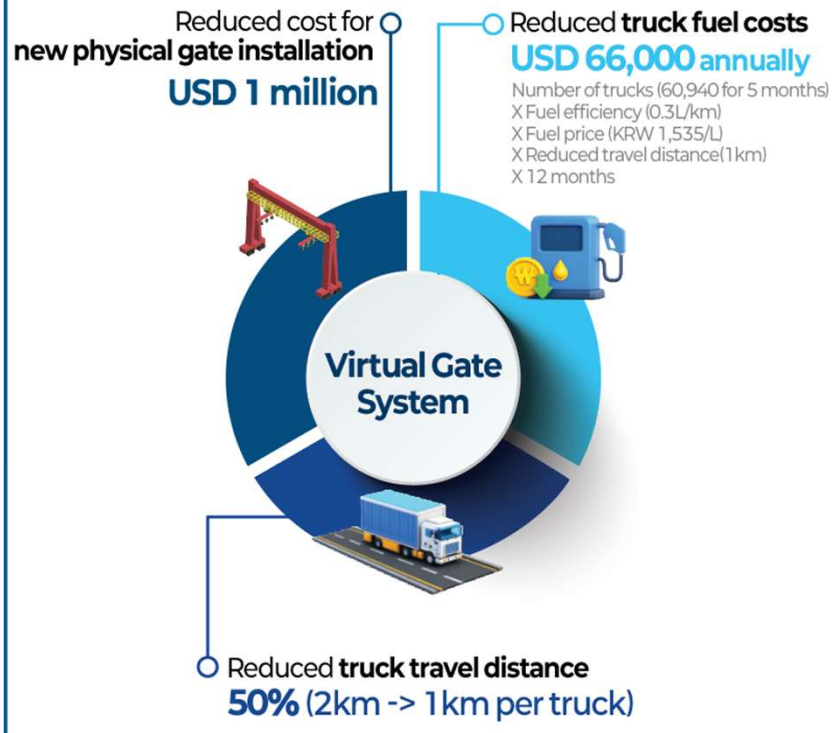
Virtual Gate Utilization



a report on a related article

08 Virtual Gate System Adoption and Impact

1. Quantitative Results



2. Qualitative Results

Improved congestion and traffic flow

At Gamman TML and nearby roads

Enhanced convenience for truck drivers

through reduced waiting times and driving distances

Korea's first GPS-based virtual gate system

A Pioneering smart-port innovation

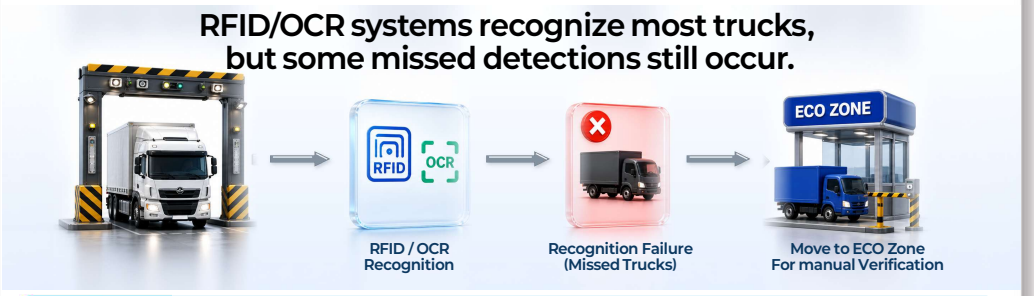
09 Expansion Beyond Gamman Terminal

From Traffic Management
To Smart Gate Enhancement

Overlaying BPA's Technology on Existing Gate Systems to Capture 100% of Trucks

1. Current Challenge at Terminal Gates

RFID/OCR systems recognize most trucks, but some missed detections still occur.



Sensor limitations lead to missed trucks, causing delays and manual work.

2. BPA Solution: OVERLAY Our Technology

Overlay BPA's proven technologies on existing gate systems without additional physical infrastructure.

Existing Gate System
(RFID / OCR)

OVERLAY

- Geofencing Technology
- Direction Vector Logic

Detects Missed Trucks & Delivers Information to Mobile

Missed trucks are captured and container location information is delivered 100% to driver's mobile devices.

3. Real-World Expansion Status

A terminal in Busan New Port
(H Terminal) has requested BPA's technology to improve truck recognition performance.

Implementation is currently in progress

Current Expansion Underway	Future Expansion Plan Remaining
1 Terminal	8 Terminal

Plan to expand to the remaining 8 terminals in Busan Port

4. Expected Economic Benefits

Per Terminal

Avoided sensor installation and maintenance costs

USD 1.43 Million

Across Busan Port

9 Container Terminals

Potential Savings Across Busan Port

USD 12.86 Million

Thank you

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