

# Contribution to Innovation of Port Logistics by Simulation Technique for Automated Container Terminal

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## 1. Introduction

Container terminals with automated container handling and transferring equipment are spreading mainly in Europe, with the automation of container terminals being studied also in Japan as one of the policies to intensify the international competitiveness.

The operation control of the handling and transferring equipment in the yard, the container storage area, is an important and key technology to achieve effective handling in an automated container terminal.

Mitsubishi Heavy Industries, Ltd. (MHI) has designed an effective container operating method, and in order to put the method into effect, MHI has developed an equipment operation control simulator capable of expressing the actual operations in a container terminal, determining the operation rules and advanced verification (pre-verification) of required handling time, etc. The newly developed simulator is a useful tool for the design of automated container terminal, and is considered to contribute to the innovation of port logistics through advancement of automation.

This paper describes the effective operation of handling and transferring equipment and the simulation technology.

## 2. Operation of Handling and Transferring Equipment in Automated Terminal

The equipment and machines in a conventional terminal are generally allocated according to the pre-planning of container storage. However, the uncertain arrival date and time because of the external land trailers used for container operation (taking containers in and out) and the simultaneous container operation with on-ship operation are likely to cause load concentration on the scanty number of RTG (Rubber Tyred Gantry Crane) and local congestion of AGV (Automated Guided Vehicle), which may lead to deterioration of con-

tainer handling efficiency. Since the RTG intersects with AGV active line at the time of lane change in an automated terminal, it may cause interference between machines and is expected to give rise to major problems both in efficiency and security fields.

MHI has therefore designed an effective method given below for operation of handling and transferring equipment.

### (1) Real-time storage planning

MHI has come up with a new operating method to determine the real-time container storage position according to the load condition of RTG so as to minimize the traveling distance and lane change frequency, leading to the improvement in operating factor and security of RTG and AGV.

### (2) Zone control

A zone control system has been adopted to prevent the occurrence of deadlock as well as collision and interference of RTG/AGV at the crossing (intersection).

### (3) Search of optimum route for AGV

A system is used to select the AGV route needing shortest possible time, paying consideration to speed adjustment at curves and the state of congestion in addition to the traveling distance.

## 3. Equipment Operation Control Simulator

### 3.1 Features

The equipment operation control system is the key part of an automated terminal. The newly developed simulator has the features given below and can easily actualize the aforesaid container operating method.

(1) The simulator allows coping with the handling schedules for real operation through control of independent ID of container, carries out linkage operation simulation with consideration paid to the three-dimensional operation equivalent to the real handling and transferring equipment, and enables visual confirmation of the equipment operation.

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- (2) The simulator can be easily used to provide independent control function of equipment, to add, change or delete the function, allowing immediate correspondence to the changes in condition at the time of terminal planning.
- (3) Unlike the conventional simulation generally with exclusive language and program structure, the newly developed simulator adopts the language and program structure under the assumption of the operation of real equipment, so that the software developed for simulation can be used intact as the software of the real equipment.
- (4) Equipped with graphic function, the newly developed simulator is useful for verification of operation and investigation of problematic points.

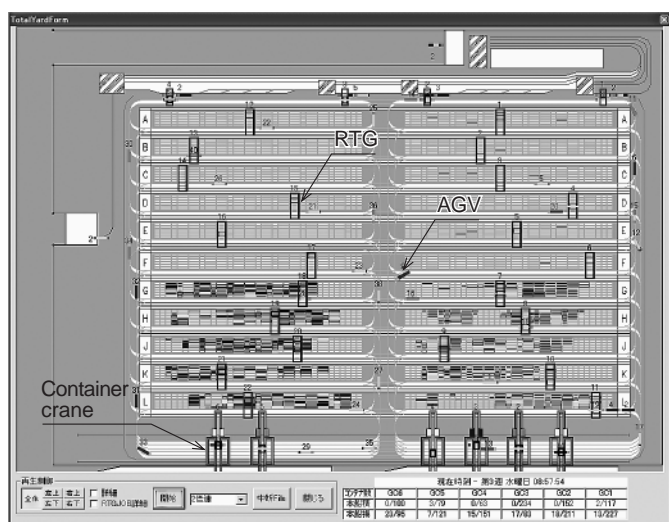
Fig. 1 shows the layout of an automated terminal us-

ing RTG developed by MHI for the first time in the world, indicating the 2D graphic viewer screen, while Fig. 2 shows the 3D graphic viewer screen.

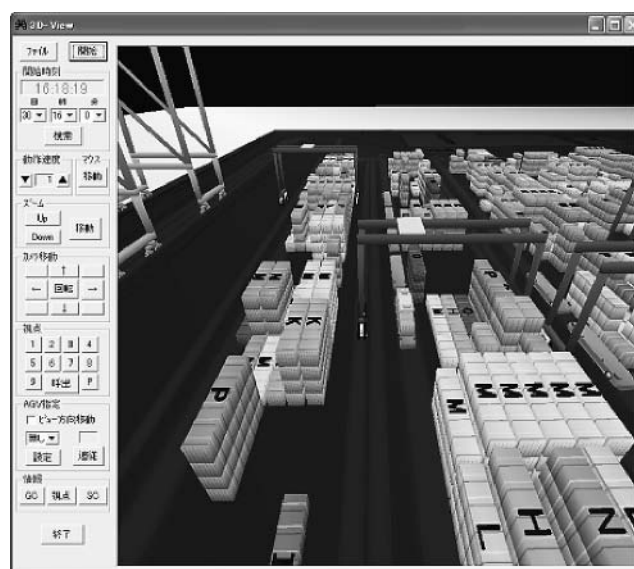
These graphic screens can be effectively used such as the 2D graphic for checking the AGV traveling route, the interference state at the crossing, deadlock, etc. whereas the 3D graphic for confirmation of the three-dimensional operation of the equipment and the condition of freight operation of containers.

### 3.2 System configuration and IN/OUT data

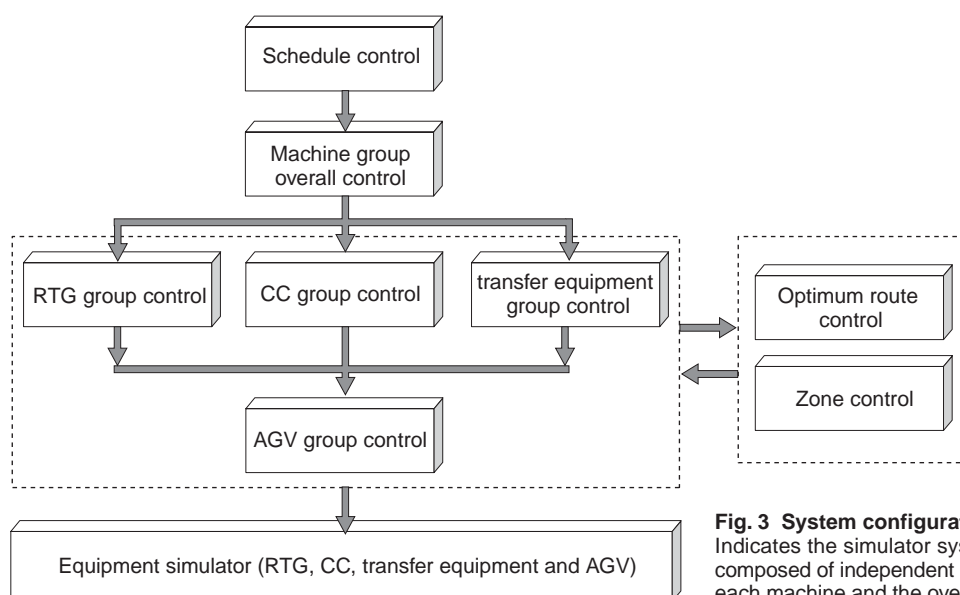
The system configuration shown in Fig. 3 indicates the overall schedule created by schedule control function on the basis of the arrival schedules of ships at the port, etc. The equipment control function is divided into overall control function and independent control function for each group of machines.



**Fig. 1 Automated terminal**  
Shows two-dimensional display of the operating status of handling equipment and container storage status in addition to the terminal layout.



**Fig. 2 Example of 3D graphic screen**  
Shows three-dimensional display of operating status of handling equipment and container storage status.



**Fig. 3 System configuration**  
Indicates the simulator system configuration composed of independent control functions of each machine and the overall control function.

The equipment simulator carries out simulation of operation of each machine, while the control function for each group of machines carries out optimum route control in addition to making communication with the zone control function to realize safe and effective traveling. The real-time storage plan is installed and included in control function for machine groups.

Further, in order to express the operation and management equivalent to an actual yard, the data from (a) to (f) given below are input at the time of simulation, with the data from (a) to (c) corresponding to the comparison with actually operating terminal for evaluation by making use of the records of the terminal actually in operation. The data from (d) to (f) precisely reflect the real performance (cycle time, operating conditions, etc.) of automated machines, leading to evaluation closer to the actual machines.

The results of simulation are recorded in output file, which can be used for a valuation of container handling efficiency such as operating factor of RTG, etc., for reproduction using graphic function and enables off-line study in detail.

- (a) Yard layout
- (b) Ship schedule and on-ship container allotment
- (c) Land carry IN/OUT schedule
- (d) Number, size and performance (speed, adjustable speed) of machines
- (e) Operation (operating time, allotment) of CC (Container Crane: Quay Side Container Crane) and transfer equipment
- (f) Allotment of AGV and RTG

#### 4. Conclusion

Conventionally, it was common to carry out simple simulation under the assumption of ideal, mutual linkage operation of handling machines and on the premise of statistic distribution (of containers) at the time of container storage, etc.

The newly developed simulator has come to be used successfully as a tool to simulate the management and operation equivalent to that of actual machines, and further to carry out pre-verification of the design and handling capacity of the automated terminal in correspondence with the actual operation at the time of changing the operation logic.

Further, the newly developed simulation technique presented in this paper can be applied not only to the automated terminal but also to the conventional terminal.

The newly developed simulator helps determine the actual terminal layout, number of machines and operation (management) draft, contributing to preparing high-accuracy layout draft by customers at the pre-study stage.

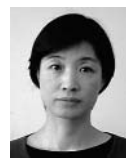
Study is under way to find an operating method, for example, at the time of trouble in a machine by using the newly developed simulator, and we are determined to pursue further improvements in the comprehensive container yard engineering capacity.



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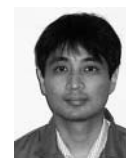
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