전동차 시뮬레이터와 항공기 FTD 비교에 의한 구현기술에 대한 이식성 연구

A Portability Study on Implementation Technology by Comparing a Railway Simulator and an Aircraft FTD

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1. Introduction

Flight Simulator Industry has lead overall simulation technologies since the appearance of Link's first Trainer. Most people in simulation communities today understand or at least have some knowledge of, general requirements and technical specifications of airplane simulators. On the other hand, railway simulators have begun to attract customers' interests and formed a niche market since the beginning of 1980's. Information regarding railway simulators such as requirements, technical specifications, modeling, system components, etc is relatively unknown to simulation communities, and belongs to manufacturers of railway simulators or special research institutes. This paper reveals technical specifications of railway simulators in relative detail, which are being tested for practical use in Korea, and studies portability of simulation technologies by comparing the technical specifications with those of flight simulators. For practical comparison, technical specifications of CG-91 Flight Training Device[1,2,3] and PUTA (Pusan Urban Train Association) Line II Metro Simulators[4] are used as examples. Both of the simulators were developed by Korean Air between 1991 and 1998.

2. Railway Simulators

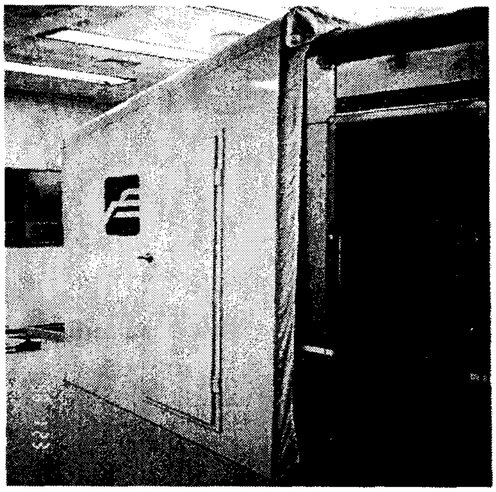
PUTA Line II Metro Simulators provide trainees with realistic driving environment of the Pusan City metro system and enable effective and safe training. The railway simulators are composed of a pair of cabs, which means two metro drivers, one at each cab, can be trained independently at the same time by an instructor at a common control station.

Training through railway simulators is categorized into basic and application courses, which is a little more elaborated in Table 1. The basic training courses encompass manipulation of on-board equipment and familiarization of track environment including signals on route. Their goals are familiarization with operation environment. The application courses include abnormal situations in addition to the basic training so that trainees can be trained and tested for their responses. Relevant training results and their evaluations are provided to trainees and an instructor either in printed report forms or on screen. A CCTV camera is installed in each cab and records whole training processes for later use during performance evaluation of a trainee.

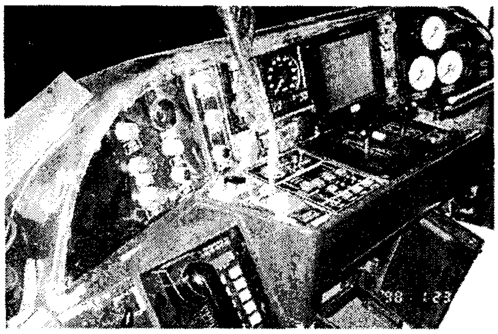
Interior and exterior of PUTA Line II Metro Simulators are shown in Figs. 1 and 2. H/W and S/W configurations of a set of railway simulators are illustrated in Figs. 3 and 4. As shown in the figures, the system hardware is composed of a pair of cabs and relevant electric signal and power lines, which are almost symmetric and connected to an Instructor Operation Station.

[Table 1] Training courses of a railway simulator

Basic Training	Application Training
Initial starting procedures	Basic Training
Start, operation, stop	Emergency procedures
Manipulation of on-board equipment	Malfunctions
Response to signals on route	Operation and stop on emergency conditions
Route familiarization by visual display of forward track views	



<Fig. 1> Exterior of PUTA Line II metro simulators



<Fig. 2> Interior of PUTA Line II metro simulators

The followings summarize configurations of simulator components and their functions shown in Fig. 3.

2.1 IOS computer

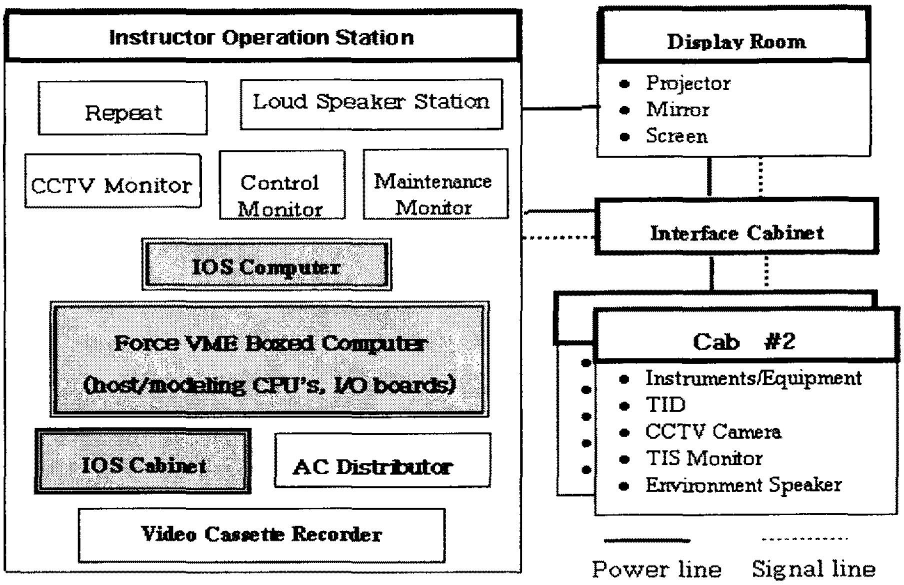
An IOS computer is used for a common terminal to the host computer and the operation environment of Graphical User Interface (GUI) group S/W. The monitor of the IOS computer is used as a control monitor to show IOS menus, and as a terminal of the host computer for maintenance purpose. Its technical specifications are as follows:

- Model: COMPAQ DESK PRO 2000
- Operating System: Window 95 or Windows NT
- Comm. Protocol : TCP/IP

2.2 Host CPU

A host CPU or a host computer is for system maintenance and operation environment of S/W modules belonging to the host group in Fig. 4. Each of execution files and data files is controlled and monitored by the host CPU, which is a part of a Force VMEbus computer system. The system comprises 1 host CPU board, 2 modelling CPU boards, and several I/O boards. The boards in the VME rack communicate with each other on VMEbus. Relevant system specifications are as follows:

- Model: Force VME Boxed System
- CPU: Sun SPARC 5V
- Operating System: Solaris 2.1(SunOS v4.1)
- Comm. Protocol : VMEbus, TCP/IP



<Fig. 3> **H/W configuration of PUTA Line II metro simulators**

2.3 Modeling CPU's

2 Modeling CPU's are for running S/W modules which belong to the modeling group in Fig. 4. Each of the CPU's independently drives relevant one of 2 cabs. Their connections to the cabs are almost symmetric, and malfunctions of a CPU affect the other CPU's or cab's operation to a minimum. That is, training of two cabs is coupled minimally. Major specifications are

- Model: SYS 68K/CPU-40B
- CPU: MC68040, 25 MHz
- DMA Controller: 32 Bit High Speed
- Serial Interface: RS232/RS422/RS485
- VMEbus Interrupter: IR 1-7

2.4 Visual Computers

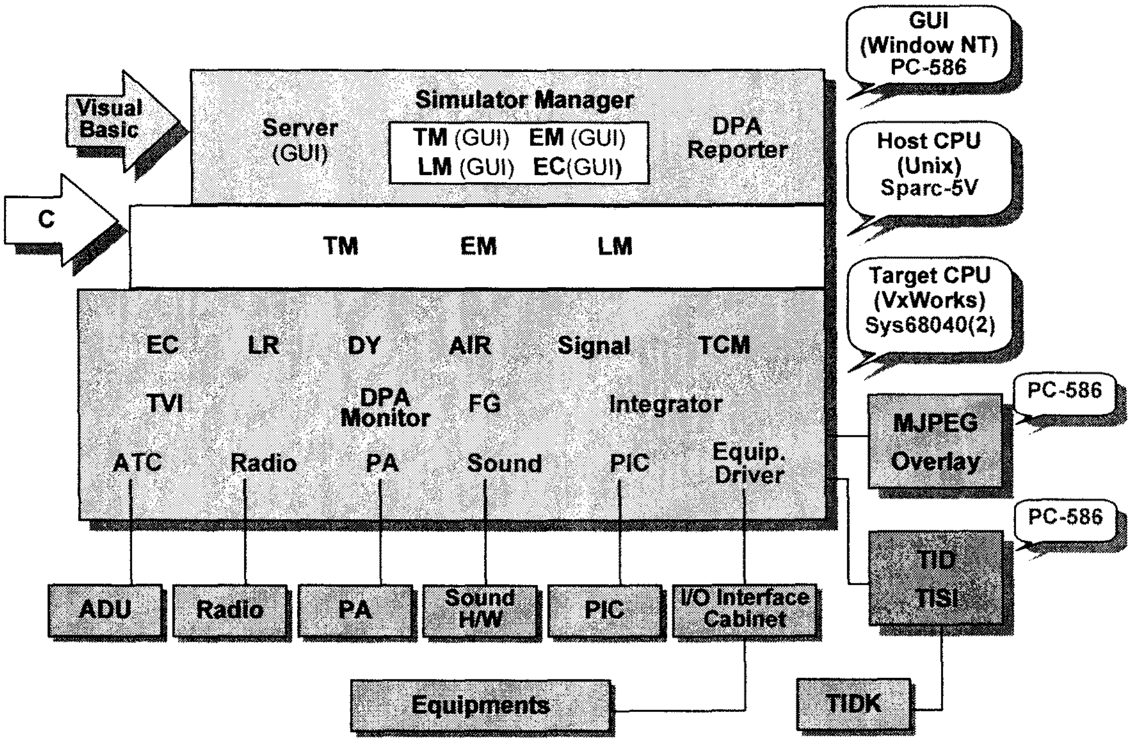
A pair of visual computers are located in the IOS cabinet. A visual computer for a cab receives position data of a train via Ethernet from the TVI(Track View Information) module on the relevant modeling CPU, and retrieves a visual image, front track-view, which is the most appropriate for the position among the filmed visual database compressed on computer hard disks. Motion JPEG is used for the purpose. A track-view image in the form of Motion JPEG is transmitted to an overlay card, and superimposed by light signals generated with computer graphics. The resultant visual image is finally transmitted to the repeat monitor in the IOS and the visual projector for a trainee in a cab. Major specifications are as follows:

- Model: COMPAQ DESK PRO 2000
- Overlay Card: Digi-Mix
- M-JPEG board: Digi-Motion

  (9 GB hard disks included)
- Operating System: Windows 95 or Windows NT

2.5 TIDK-TID driving computer

A pair of TIDK-TID driving computers is also located in the IOS cabinet as the visual computers. One computer per cab is for generating signals to TID (Track Information



<Fig. 4> **Overall S/W configuration**

Display) and TIDK (Train Information Display and Keyboard). The specifications are

- Model: COMPAQ DESK PRO 2000
- FIP control box

All the S/W modules running on the above computers are programmed in either C or Visual Basic depending on their functions and hardware plat-forms. Table 2 summarizes major S/W modules along with their relevant operating environments.

Major data files used by execution programs of PUTA Line II simulators are categorized into

- track data
- performance data of the trains
- electric circuit data of relevant on-board equipments
- pneumatic data of relevant on-board equipments

2.6 Database

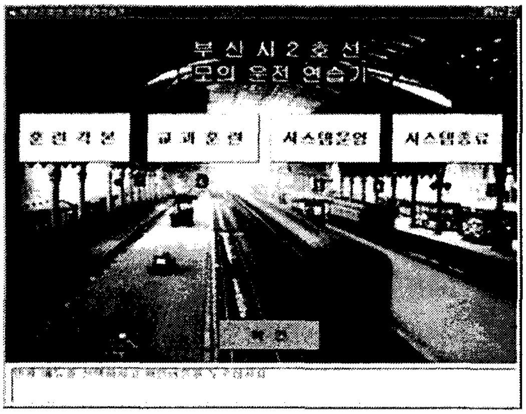
[Table 2] Programming languages and operating environments

	S/W module	Compiler	Operating System
Modeling CPU	Master Driver #1	GNU .68KC compiler	VxWorks 5.3
Host CPU	Master Driver #2	GNU C compiler	Solaris
PC-586	IOS S/W	Visual Basic 5.0	Windows NT/Windows 95
PC-586	Visual S/W	Visual Basic 5.0	Windows 95

2.7 GUI group (IOS) S/W

Modules in this GUI (Graphical User Interface) S/W group are programmed in Visual Basic 5.0 of Microsoft in order to decrease development process as well as its time and increase maintainability of the modules. With on-screen menus representing the GUI group S/W an instructor controls and monitors the whole system including 2 cabs. The GUI group S/W is a window to relevant S/W modules in host and target CPU's. An example of on-screen menus is shown in Fig. 5 and a part of the IOS menu hierarchy in Fig. 6. The GUI group S/W is composed of following sub-components:

- TM(GUI): Track Manager GUI invokes TM in the host CPU.
- EM(GUI): Exercise Manager GUI invokes EM in the host CPU.
- LM(GUI): Lesson Manager GUI invokes LM in the host CPU.
- EC(GUI): Exercise Controller GUI invokes EC in the target CPU.
- DPA RPT (Driver's Performance Assessment Reporter): The DPA Reporter generates either a trip-log of events or an assessment of the events in a lesson.
- Server(GUI): Server GUI invokes Server.

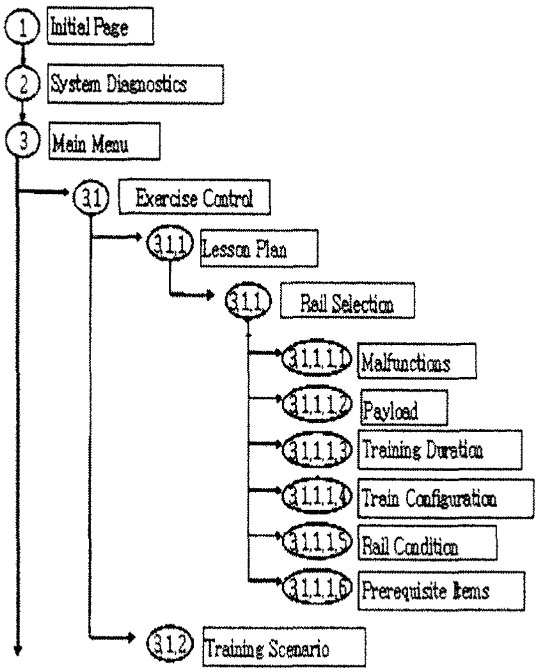


<Fig. 5> An example of IOS menu on screen

2.8 Host group S/W

The host group S/W in Fig. 4 is composed of TM (Track Manager), EM (Exercise Manager), and LM (Lesson Manager). These components are common to a pair of simulator cabs and do not communicate frequently with modeling group S/W once training lessons begin. They take important roles as lessons begin or are completed. The S/W components and their functions are listed below

- TM (Track Manager): TM is comprised of 3 interlocking tasks, manage track sections, manage media and manage routing, which combine to handle the building and amendment of track sections, media information, and route validation and selection.
- EM (Exercise Manager): EM manages lessons and comprises Exercise Builder and Exercise Management Facilities. Exercise Builder generates a table with the route information TM provides, in order for the other modules to refer. Exercise Management Facilities changes exercises depending on selected conditions such as faults and signals.
- LM (Lesson Manager): LM supplies exercise signal information during initialization of lesson. Exercise signals consist of id, distance, type, state, fog repeater indicator, auto signal indicator and distance/speed/state that the auto signal is checked against.



<Fig. 6> An example of IOS menu hierarchy

2.9 Modeling group S/W

Pairs of S/W modules in the Modeling group operate independently on two symmetrical modeling CPU boards. S/W modules belonging to this group are as follows:

- EC(Exercise Controller): EC synchronizes tasks in a lesson and logs events generated during the lesson and controls a snapshot.
- LR(Lesson Reviewer) : LR reviews lessons performed.
- DY (Dynamics): DY supplies train position and speed. The DY model calculations can be split into four main areas such as longitudinal, carriage weight, cab distance, and train motion.
- AIR (Air System): The air system model provides six basic functions such as initialization, control, air pressure model, response to opening and closing valves, generation of outputs on pressure thresholds, and calculation of air braking force in response to requests of dynamics.
- SIG (Signal): All signals are initialized to a default state of having the topmost bulb set. If this is not the required state then it is changed from the graphical user interface.
- DPA Mnt (Driver's Performance Assessment Monitor): DPA Mnt provides events that are used when assessing the drivers performance. The DPA monitor is provided with the speed limits, stop zones, their positions, and obstacles on the track.
- TVI (Track View Interface): TVI provides an interface on Ethernet between IOS and visual computers. It converts data/control signals of Master Driver into the format required by the visual computers.
- TCM (Train Circuit Modeler): TCM models the circuit diagrams in such areas as door control, round train & safety, traction & braking, driving & auxiliary control, train lines & car wires, and a compressor system.
- FG(Fault Generator): FG generates faults or malfunctions of on-board systems or signals, which can be selected or deselected either interactively or at a specific distance selected during definition of an exercise.
- Integ (Integrity test): Integ diagnoses system problems.
- ATC: ATC(Automatic Train Controller) emulator
- Radio: radio driver
- PA: PA(Passenger Address) driver
- Sound: This simulates sounds normally generated by equipment in the cab or the environment. The audio system is controlled by the Exercise Controller.
- PIC (Passenger Information Controller): PIC driver

- Equip Drv.: On-board equipment drivers

2.10 Cab #1, #2

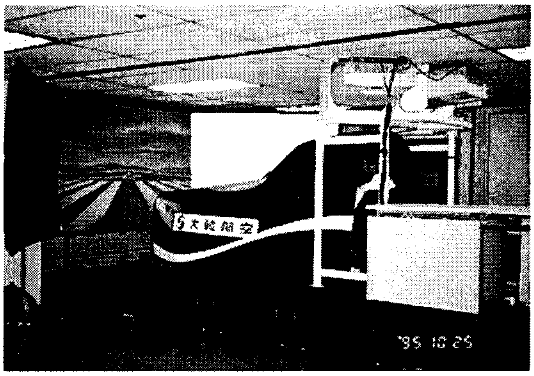
In simulation of switches, indicators, and equipment in the cabs an applied principle is to minimize their modification. If major modification is necessary, the actual system is replaced by a digitally controllable simulated system. For some equipment such as Passenger Information Controller and TIDK (Train Information Display and Keyboard) stimulation is rather adopted. That is, signal inputs to the equipment are simulated. Table 3 is a list of switches, indicators, and equipment simulated or stimulated, where AI (analog input), AO (analog output), DI (digital input), and DO (digital output) mean interfacing ports of VME I/O boards which drive the switches, indicators and instrument.

[Table 3] A list of on-board equipment

No	Switches/Indicator/Equipment	Interface
1	Master Controller	AI
2	TRCP(Train Radio Control Panel)	RS485
3	window wiper switch	DI
4	MDH(Mode Direction Handle)	DI
5	ADU (Automatic Display Unit)	AO
6	dimmer switch	AI
7	push button switch (3EA)	DI
8	push button switch (11EA)	DI
9	indicating lamp (4EA)	DO
10	duplex pressure gauge	AO
11	DC volt meter (3KV)	AO
12	DC volt meter (150KV)	AO
13	PIC (Passenger Information Controller)	RS485
14	TIS (Train Information System)	RS485
15	NFB	DI & DO
16	head lamp control switch	DI
17	whistle valve with foot pedal	DI
18	lamp push button switch	DI
19	destination indicator	DI
20	train number indicator	DI
21	emergency brake cut out switch	DI
22	rescue operating switch	DI
23	emergency brake switch	DI

3. Airplane Simulators

In order to study portability of S/W and H/W in simulators technical specifications of PUTA Line II metro simulators are introduced above. For comparison technical specifications of airplane simulators are briefly described here. The airplane simulator selected as an example is a flight training device developed by Korean Air between 1991 and 1995 to train pilots of a light aircraft, ChangGong-91. The aircraft was also developed by Korean Air in 1991. The flight training device is shown in Fig. 7. Its S/W and H/W configurations are illustrated in Figs. 8 and 9.

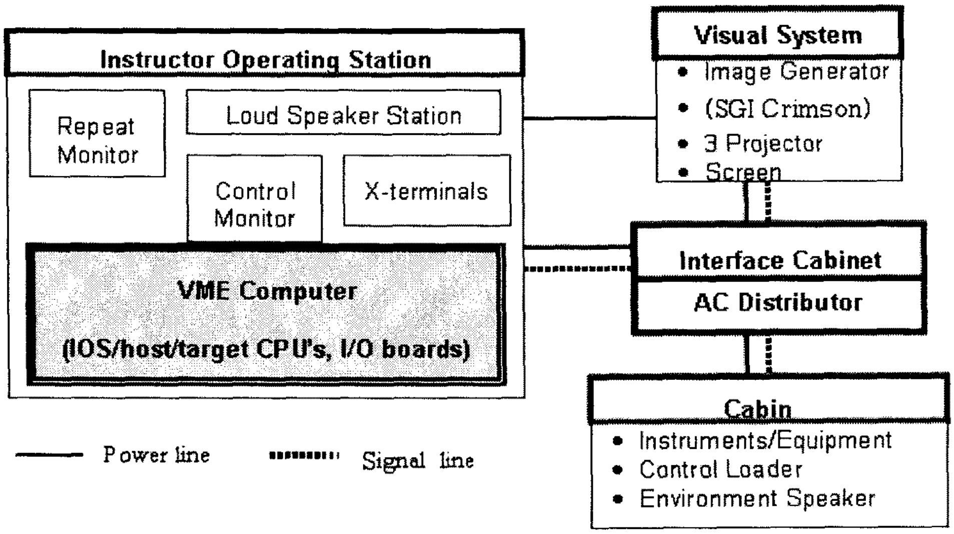


<Fig. 7> ChangGong-91 Flight Training Device

4. Portability study of S/W and H/W

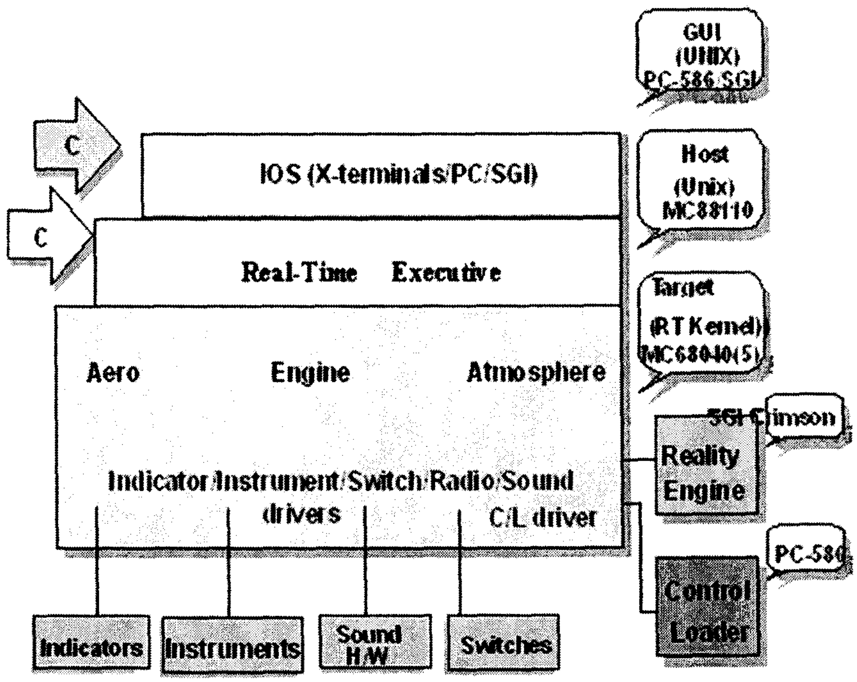
In this paper parts of technical specifications of a railway simulator and a flight training device are briefly introduced. The portability of H/W and S/W concentrated in the paper is about computer H/W, S/W, and IOS, which are actually major components of simulators. They really determine performance and value of a simulator.

Let us investigate computer H/W of PUTA metro simulators. The host and modeling computers in the simulator are of VMEbus type. VMEbus computers are also used for the ChangGong-91



<Fig. 8> H/W configuration of ChangGong-91 FTD

FTD, and frequently chosen for computer systems of airplane, ship, and automotive simulators. Complexity of VMEbus cards'combination depends on application. As higher fidelity simulation is required, or as the simulated system is more complicated, higher performance CPU boards and more I/O channels may be included in the VMEbus computer. That is, complexity and fidelity of simulation determine configuration of a VMEbus computer. That is why different configurations ofVMEbus computers are applied to PUTA metro simulators and ChangGong-91 FTD. However, computer-related technologies during implementation such as HILS



<Fig. 9> S/W configuration of ChangGong-91 FTD

(Hardware-In- the-Loop-Simulation) technology and relevant equipment, are basically the same either in railway or airplane simulators.

S/W such as real-time OS, I/O drivers, and communication S/W is closely related with computer H/W, and its portability depends on the computer H/W. Such S/W may be amended partially in order to meet interface requirements of modeling S/W and simulated/stimulated equipment. However, accumulated technologies through experience of system developments allow easy alternation of the S/W. Let us compare Figs. 3, 4, 8, and 9. Similarity of H/W and S/W configurations of the railway simulator and the FTD is revealed. S/W of an airplane simulator is stricter to real-time requirements and rapider response time is expected. In case of a railway simulator these constraints are less stringent. That is a rational of applying an executive-type time controller to an airplane simulator and an event-driven scheduler to a railway simulator. However, it is considered reasonable to adopt executive-type scheduler even in a railway

simulator if simulation model is stricter and more sophisticated, and if exact response characteristics is required.

In case of IOS menu designs similar observation is obtained. Menu contents can be very diverse depending on simulated systems and customer's requirements. However, S/W tools, programming languages, and menu hierarchies to realize IOS menus are about the same. Standardized procedures can be set and applied independent of simulated systems based on implementation experiences. Apparent features and operating procedures of IOS' may look quite different from one another. But striking similarities in training procedures and IOS-inherent features, which enable effective training,are observed between railway and airplane simulators. For example, configuration, concept and methodology behind training lessons, normal and emergency procedures are very close to each other.

[Table 3] Comparison of H/W and S/W configurations of railway and airplane simulators

		Flight Simulator		Railway Simulator	
		Typical	CG-91	Typical	PUTA II
H/W	Host Computer	W/S VMEbus (off-the-shelf set)	VMEbus (assembled)	VMEbus (off-the-shelf set)	VMEbus (off-the-shelf set)
	Visual system Image generator Display System Database	Exclusive CGI Collimated CG	Graphic W/S Non-collimated CG	LD⇒CGI Non-Collimated Video film⇒CG	CGI+MJPEG Non-Collimated Video film, CG
	Cab	Simulated	Simulated	Simulated	Actual
	Motion Platform	6 DOF	fixed	fixed, 4 DOF	fixed
	IOS	Graphic W/S	X-term, PC, W/S	PC	PC
S/W	Language	Fortran, C	C	C, C++	Visual C, Basic
	OS	Exclus.⇒Unix POSIX comp. Executive type	VMEexec Non-POSIX Executive type	Unix derivatives POSIX comp. Event-driven	VxWorks POSIX comp. Event-driven
	Comm. Protocol	Ethernet, bus	Ethernet, bus	Ethernet, FTP	Ethernet, FTP
	System Model	Accurate Test data	Accurate Test data	Simplified Actual+Generic	Simplified Actual+Generic
	IOS Menu	GUI	GUI	GUI	GUI
Relevant Regulations		FAA, CAA, etc.	FAA, CAA, etc.	none	none

5. Conclusions

The experiences show that models may be diverse depending on the objects but implementation technologies are about the same. Maximizing portability of implementation technologies is a matter of an organization's strategy of adopting standardized processes and modular technologies available and most economic to them. Table 4, which compares technical specifications of railway and airplane simulators, makes this conclusion more obvious.

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