

Present Status and Prospects for CIM/FA Technology

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1. Introduction

Under the circumstance of lower economic growth in Japan, many companies are asked to reconsider the condition of the manufacturing company and have a understanding to modify their business organization as required. Since the middle of 1980, the individual companies are more active to realize the job shop type production system and the short delivery time production system to meet to diversification of market needs. Furthermore faced with the subject of shortening of the total working hours, the almost chronic labor shortage in recent years and the keeping up with the fast moving technological innovation, many companies are pushing forward to improve the production streamlining at their factories and equipped steadily CIM (Computer Integrated Manufacturing)/FA (Factory Automation) systems to innovate all their corporate activities — sales, research/development, designing, production and shipping.

A scope of CIM/FA has been expanded from “production integration” to “integration of sales and productions” and “integration with the management functions” correspondent to the technical developments, and companies are working out for constructing and equipping a CIM system in an effort to adapt themselves to the current change in the business activity. The application area of CIM/FA is expanding primarily from machinery and assembly industries to PA (Process Automation) in the iron and steel, cement, petrochemical, food and other industries. The type of CIM/FA can be classified into the product design type, production type and sales type in accordance to the formations of the production- and sales-methods in each companies. The sophisticated CIM/FA is therefore integrated in one configuration with the material flow and information and a total integrated system with research/development, sales, production, purchasing, storage/shipping, and in the future, also with decentralize systems with autonomous functions will be spread throughout CIM/FA.

Fuji Electric has been actively pursuing the consolidation policy carried out the technical development and system integration (SI) based on the concept of “PA, FA and TA (Total Automation)”. The company participates in

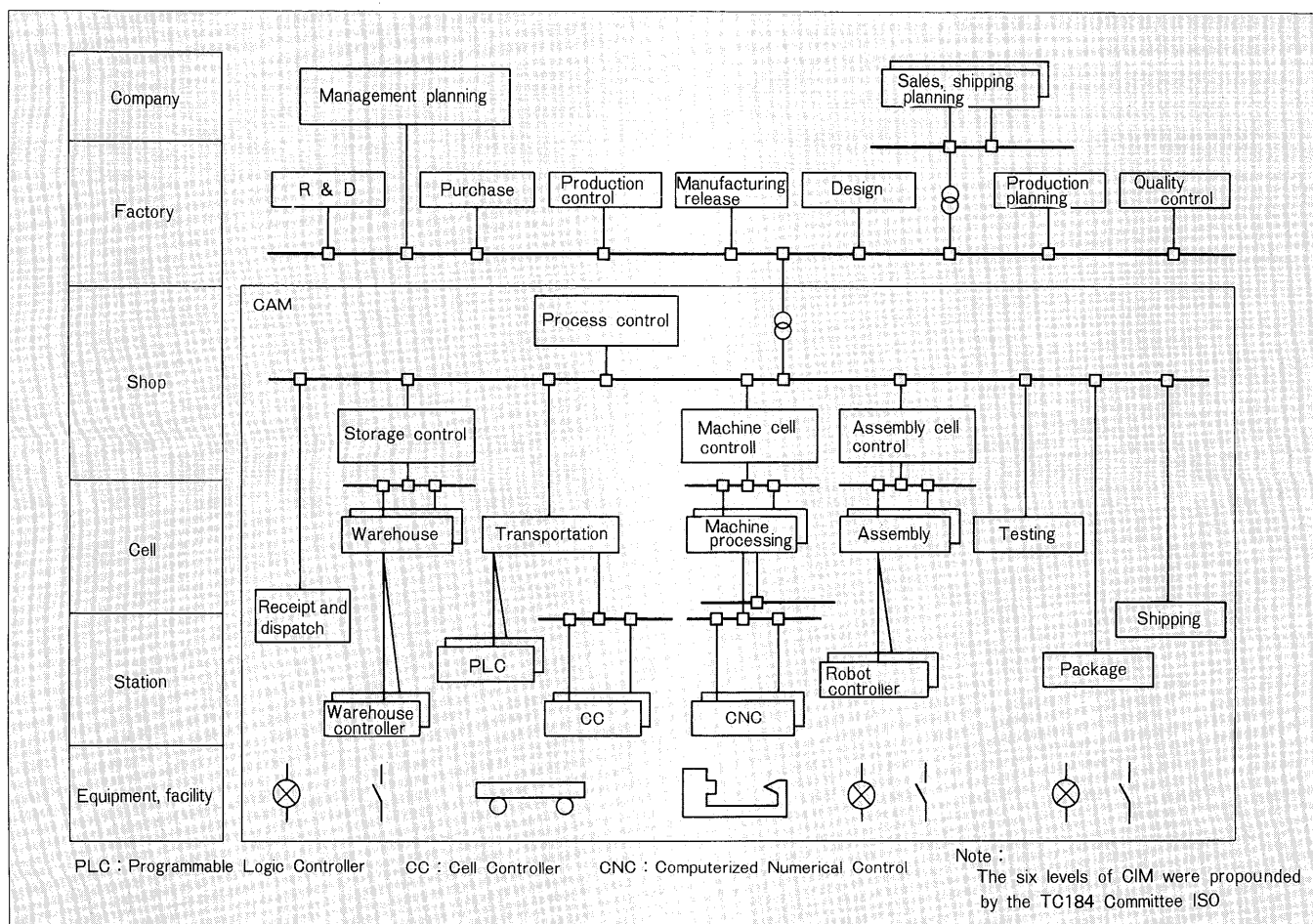
the national research project for IMS (Intelligent Manufacturing System) which rounds off the standardization and systematization of CIM/FA and studies an archetypical next generation system to realize a future production system. The company also cooperates in international standardization activities for LAN (Local Area Network), aiming at the development of MAP (Manufacturing Automation Protocol), Mini-MAP and others.

The trends of CIM/FA are surveyed and Fuji Electric developments of CIM/FA are described below.

2. Trends of CIM/FA Technology and Technical Tasks

2.1 Trends of CIM/FA

Looking at the most important topics from the standpoint of management of Japanese companies that encompass existing company in the results of survey conducted by the Japan Management Association from 1988 to 1991, “shortening of production lead time”, “closer collaboration among the production, sales and development/design sections (simultaneous engineering)” and “job shop type production order made system” have always been in the top three places, indicating the recent intention of companies. CIM covers all the activities of a company. The current tendency is toward introduction of a system exactly matched with the managerial strategy of a company. At Fuji Electric’s electrical distribution and control products business, the shortening of the delivery time was accomplished in the order-made system to deliver about 8,000 types magnetic switches and contactors by refining production designing such as the standardization, modulation, easy assembling structure of products and parts, and by a thorough automated assembly method and automated setting. A system for shipping within 24 hours from the time of the order acceptance has been established on the basis of a day-to-day assembling sequence schedule at the Fukiage Factory, and a system for shipping ordered mold-case and earth leakage-circuit breakers by the end of the day of order placement has been realized at the Ohtawara Factory. The simultaneous engineering techniques were used to establish these production systems, where the development of integrated system with the sales, storage/shipping, development, design, production and also the



development of automated machines were simultaneously proceeded. The system "user plans the production schedule" was accomplished by the combination of the sales and production systems and through the on-line network of the sales, stock, production planning and dispatching system. In the vending machine field, a large-scale CAD/CAM system was introduced to shorten the product development period in an attempt to adapt itself to shortened life cycles of products. And the period of the production preparation was also shortened by the making of the production data simultaneously. A growing number of customers of the company is showing a product design type CIM system linked to CAD/CAM and a production type CIM system aimed to market needs. The concrete cases are introduced in this issue.

Process facilities industries such as the petrochemical, chemical, food and steel industries are seeking PA which is something more than mere process control automation but needs expansion to automation linked to CIM/FA.

- (1) FA system combining the receipts of raw material in upstream of production line, quantity measurement and the transport and shipping phase in downstream of PA system.
- (2) System for more individualized adaptation to market

needs by the linkage to the production control activities and the higher process control level, such as the dispatching and the data-collection system.

The high function and high performance of transportation facilities and robot controller as the components of the CIM/FA as well as the designing of an open system and hardware downsizing are rapidly advanced currently. The electronic controllers used in this system, have the high data processing in addition to control processing. The data not only for the identification of products and parts, but also for machine- and assembly-processing and data of customers can be stored in the Data-carrier, bar code and "P-code" (pixel-code) as data carrier device. The classification of system levels and its decentralization for each function are making progress in depend of easy system structure, the extensity and cost. Expected additional features of CIM in the future will be AI (Artificial Intelligence) technique for incorporating human knowledge into a system, a sensor similar to a human organ, intelligent measurement, high-speed data transmission and autonomous decentralization.

2.2 Concept of CIM/FA

CIM covers all aspects of a company's activities. It is

therefore very important to establish a CAM system that integrates the three basic functions of a manufacturing company—engineering/production, sales and management planning—through a network to enhance its operational efficiency and make a strategic management possible. The hierarchic structure of a CIM system and its network are showed in the conceptual diagram in Fig. 1. In the model showed in this diagram, a company's activities are divided into six levels, and a definite set of functions is assigned to each of these levels. At the highest level—"company", company's management and sales/shipping plans are controlled. At the "factory" level, research and development, designing, production control, purchasing, quality control and all other functions of the factory are under control. All the administrative functions for the production control on the shop floor are backed up by a common data base provided at this level.

A plurality of machines and facilities as automated warehouse, transportation system, machines and facilities, assembling-, inspection- and testing-equipments are managed and controlled at the "cell" level. The actions and the sequence of such machines, facilities and devices are directed at the "station" level. At lower level, "equipment, facility" are driven by it's direction. The network for the smooth information flow among those levels is most important, and the installation of a high-speed, open system network is expected.

The following themes will be essential to realize CIM in the future:

- (1) Basic concepts by PA, FA and TA
- (2) Computer technology suited for each system-level
- (3) Open network
- (4) Intelligent FA/PA sensor, component, man-machine device
- (5) High-level use of human knowledge by AI
- (6) SI (System Integration) technology

3. Fuji Electric's CIM/FA

3.1 Computer technology

Fuji Electric offers its A series, K series, UFAS series and FA personal computers as general-purpose computers covering a wide range from the "company" and "factory" levels to cell management/control level in conformity to ISO standard, to facilitate the designing of a system matched to a user's need.

3.1.1 Actual needs

The actual needs (tasks) encountered at the time of installation of CIM will be explained here.

- (1) Gradual installation of system

If the job standardization is inadequate, the improvement needs of the facilities or interface, or some other technical problem exists, a partial installation may be initially carried out, and rest may be installed later, because there is much risk of the establishing the system at a time.

- (2) Shortening of development time

A production system advanced in comparison with the similar systems of other companies must be worked out in a

short time in order to keep up with a change on the market, to adapt the company to the shortened life cycles of products or to make a model change promptly.

- (3) Correspond to multi-vendor

Linkage to a different computer or a equipment of some other company is required for the purpose of horizontal coordination with a control-level computer via LAN and for the purpose of vertical coordination with remarkably innovated FA equipment and a programmable controller for equipment/device control.

- (4) End user computing

The improvements and charges for the better found in the operation of system after the completed system is put to use should be made by user himself. To support such a user, efforts are being made to strength the network, to meet the need related to multi-vender, to give assistance in end-user computing and to push forward a downsizing program and standard systems suited to different jobs and fields are prepared.

3.1.2 Basic configurations

Figure 2 shows the basic configurations suited to different user needs, which are designed to serve user's prime purposes, with Fuji Electric's computers placed at the crucial points.

- (1) Information system

The primary function of the information system is to check up "objects" against "information" on the receipt of raw material, production plan and shipping plans. The buffer control actions for the before process and the behind process include stock control and transport control.

- (2) Processing/assembling

The primary function is the control and the issue instruction for the automatic equipments and facilities on the production line under a production plan. The other functions include the conversion of a production plan into a manufacturing plan and the stock control and transportation control for parts and products.

- (3) Continuous/batch process

This configuration is intended for a case where process devices are main production equipment. Process control is performed by a dispersive control system (DCS) while production and manufacturing planning are under the control of the A Series. AI-AWS equipped with advanced control functions matched with sophisticated control, is provided.

- (4) Decentralization

The organization of business activity is divided into sections by "rational decentralization of control and operation functions and information". An FA personal computer or other controllers is allocated to each of these sections to form a decentralization system. UFAS or the A series may be used for a section depend on duty.

3.2 Process CIM

The core technology of Fuji Electric's CIM for the process equipment industry is the integration control system MICREX which controls the integration of PA and CIM/FA and has contributed toward the automation in

Fig. 2 Basic configurations suited to different purposes of users

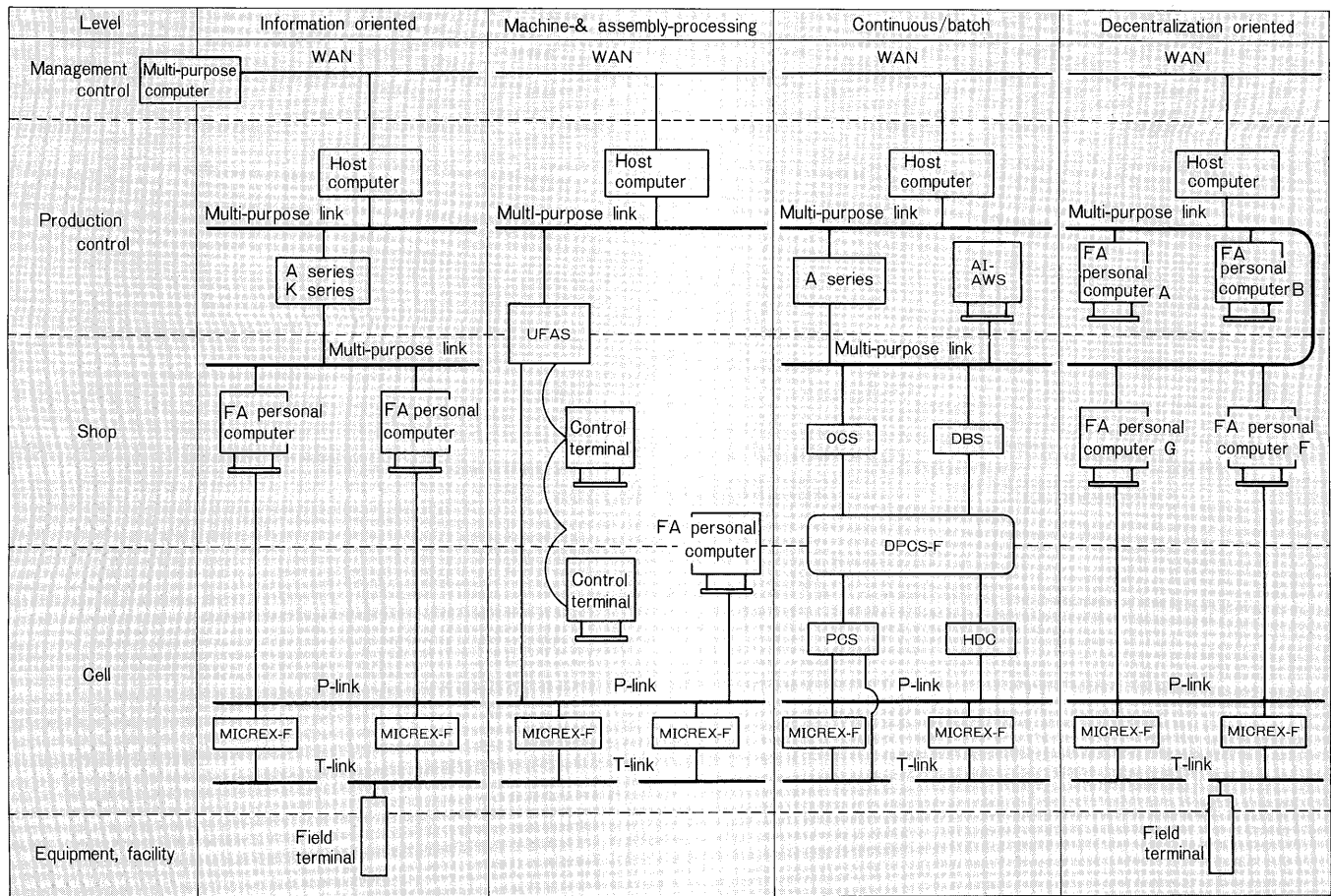
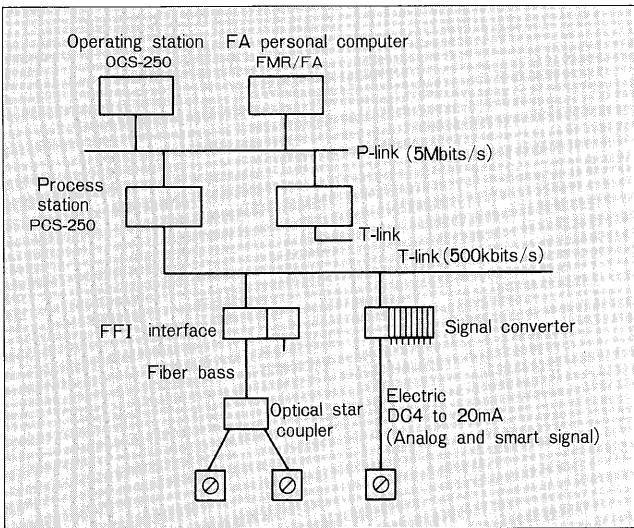


Fig. 3 Network for MICREX-MS, FCX and FFI



this field. The company offers a variety of field units with characteristic equipments and devices for industrial processes:

- (1) FCX series, a family of new-generation electronic signal transmitters (available in two types—precision analog-output type and smart type).

- (2) FFI, an optical field measurement system (optical field bus).

A network interlinking MICREX-MS and FFI, and other interlinking MICREX-MS and FCX are shown in Fig. 3.

3.3 Production control, CIM configuration technique and network

As the core technology, an integrated production control system carried out the just-in processing of the market-in information flow combined with production control and CAD/CAM at the factory. Information data flows between “SFC” (Shop Flow Control) and “machines/devices” and between “physical distribution” and “Information”, and it is feed back to “production control”. A prediction function is provided at each level, and various optimum systems can be constructed regardless of the kind of production—order made production or stock production—and regardless of type of industry, business condition and the size of company.

An “integrated production control system” permits conversion of the core-function section into a highly reliable standard package and incorporation of a necessary additional function. Use of the procedure based on the

CIM/FA system construction method is highly effective for exact grasp of a company's task, recognition of the current conditions and distinct presentation of a target and a system concept. The above procedure is highly helpful toward the construction of a system with an information processing function for company management and for company decision making. Fuji Electric provides LAN series suited to proper scales for general connections and data processing. MAP has already accomplished commercialization.

3.4 AI

Bottom-up approach from the field seemed effective for incorporation of AI into a system, and a domain shell which can present the field know-how in a plain form was developed. Fuji Electric developed expert systems for the steel, cement, automobile, waterworks, chemical, petroleum, food and other industries by use of such AI shells and acquired much AI application know-how thereby. Hence the AIMAX Series was developed toward high-speed deduction, the ease of knowledge collection and the ease of system construction. A knowledge review function was later added to the series. To enhance the degree of intelligence of a production system, Fuji Electric will aim at developing a system linked to object-oriented technology, which will be a "common language", so to speak, for communication with an AI system designed to acquire and rearrange expert knowledge on the field, in order to increase the efficiency of man-to-machine communication. The company has developed PROMI-Z as an object-oriented system for use for simulation of a production system process.

3.5 FA equipment, transportation system and loader

Fuji Electric's major CIM/FA components are listed in Table 1.

3.5.1 FA equipment group

(1) Laser-applied equipment and vision system

Fuji Electric has put on the market a laser marker (FALL 50/100) with a scanning mechanism equipped with a high-performance, high-reliability man-to-machine interface function. A vision system is extensively used as the "eye" for an CIM/FA system. The company offers an attractive system with excellent peripheral units to meet customer needs.

(2) Data input equipment

The company has developed a bar code, a data carrier and a "P-code" recognition code system using approx. 4mm-by-4mm square code area where a 20-digit code can be accommodated, as provision for "matching pieces of information with objects". Much is expected of this automatic recognition system with many objects including printed circuit board with SMT and provision for reading a marking on such a light, thin or small product on which printing can not be apparently used.

3.5.2 Automated transportation system

Fuji electric has delivered an AGV (Automatic Guided

Vehicle) with a maximum load carrying capacity of 3t for machine tool manufacturing factory. It also put on the market an omnidirectional advanced-function AGV with a load carrying capacity of 1.3 t, traversing and spin turn function and a lifting apparatus. The Uni-carrier-APC (Automatic Programmable Control System) can automatically generate a run control program simply by "input of a run layout through a dialogue" to meet these needs, and can adapt itself to a change very easily.

A new idea of sensor, a installation of servo motor, etc. realized a smoother and reduced-noise operation at a rate of maximum 160 m/min. The company has developed and delivered an automatic storage and distribution system with which one piece of a various size corrugated cardboard box can be placed on a rack and automatically picked at the time of shipment. Sales of storage and picking systems and parts distribution systems to production line and for shipment formed by a combination with a warehouse, an AGV, conveyors, robots, etc. have expanded.

The auto loader is rated high for its high-speed operation and high mobility. The time for attaching the device to and detaching from machine tools reached in the order of 2 sec. The remarkable improvements were in pursuit of light weight of the running body and the method of a electric supply device. The setting of the different position of attachment/detachment is possible freely and also different size of the work pieces can be worked continuously without the rest-time. An auto loader with a "Z" axis compensation function was newly developed which enables to handle pieces processed to various shapes at different attachment/detachment levels without setting time. The auto loader can therefore work with a pin cutting machine and a journal cutting machine transporting variously shaped work pieces on the crankshaft cutting line. A digital AC servo and a position controller with an absolute encoder were installed as a means for high speed and high-precision action. The functions of the control unit for auto loader were upgraded to facilitate both easily to link to the production control system and improvement of the operator's operation.

Various "pallet changers" were developed to assist the robot in feeding parts to the assembly line. Pieces of complicated shape which are easily deformed and must be strictly protected from damage can be automatically aligned, received and forwarded. The company also developed a robot-system for non-destructive examination of the tail assembly of an airplane and a high-speed transport robot with an anti-corrosive hold-up mechanism which permits the wet cleaning of wafers without applying forces to them.

4. Conclusion

There is a strong demand for an integrated system for a company that covers production line automation, production control, development/designing and management and is gentle to and coexist harmoniously with human. Fuji electric is an acknowledged CIM/FA integrator having

Table 1 Fuji Electric's CIM/FA components

Component	Model and others	Main specification
FA Computer	K series K690Si, K670Si, K650Si, K630Si, K150Si, K100	Main memory capacity: 512 k bytes to 1 M bytes/4 to 64 M bytes Disc capacity: 20 M bytes to Max. 10.2 G bytes Max. No. of line 2 to 48 lines
	A family super series A 32 bit super mini computer A700, A600, A500, A300II, A400II	Main memory capacity: max. 95 M bytes Built-in disc capacity: max. 580 bytes Basic software: OVIS/S
	A family compact series A A100HR, A100, A80HR, A80, A60, A50S, A50	Main micro-processor: MC68020/68030 (16.7/25 MHz) Main memory capacity: max. 64 M bytes, auxiliary memory capacity: max. 670 bytes Basic software: UNIX OS SX/A
	A station A station 330 Σ , A station 340 Σ A station 350 Σ , A station 230 Σ A station 240 Σ , A station 250 Σ	Main micro-processor: MC68020/68030 (25 MHz) Main memory capacity: max. 64 M bytes, basic disc capacity: 180/330 M bytes Basic software: UNIX OS SX/A
	FASMIC G series FASMIC G500FX	Main micro-processor: MC68030 (25 MHz) Processor memory capacity: max. 40 M bytes(Address space: 4 G bytes) A multi-processor can be established (up to 4 units)
	FA personal computer FMR series FMR-70FA, FMR-50FA	Main micro-processor: 80286/80386 (12/16 MHz) Main memory capacity: max. 16 M bytes, Built-in disc capacity: max. 40 M bytes
Programmable controller	Advanced-function dedicated controller PMS-500, HDC-500	Main program capacity: 128 k words, data capacity: 64 k words Man-machine memory: 3 M bytes, No. of I/O: max. 8,192 points
	Multi-purpose controller MICREX-F series	No. of program step: max. 200,000, data: max. 512 k words No. of I/O: max. 6,400 points
Automated warehouse system	Rack type 50 kg, 100 kg, 300 kg, 500 kg, 1 t, 2.5 t	Bucket type, pallet type Running speed: max. 160 m/min, Forklift & up-down speed: max. 40 m/min
	Horizontal circulation type: 30 kg, 50 kg	Bucket, pallet type
Automated transportation system	Uni-carrier (rail guided vehicle) RW500, RW1000, RW2000, RW3000, RW5000, RW15000	For machine and sheet metal machining FMS Load capacity: 500 to 15,000 kg
	Uni-carrier (automatic guided vehicle) GW50, GW150, GW300/500, GW1000, GW3000	Optical, electromagnetic, magnetic induction, automatic recognition, autonomous running, traverse running, wirelesscommunication, robots, loader, clean room specification load capacity: 50 to 3,000 kg
	Space uni-carrier (overhead running)	Warehouse, kitting, transportation: 60 m/min, Load capacity: 70 to 300 kg
	S-shuttle	For clean room: 0.1 μ m, class 10, LPM drive
	Uni-carrier-APC	Automatic dialog control programming
Video sensor	Robot handling use: VR-1000 Character reading use: VR-1000Z Multi-window: MW-2000, MW-2100, MW-2200, MW-2600, MW-3000	Robot dedicated, OCR dedicated, visual inspection use, class storing, fast response, multi-window judgement, unitization, advanced function, mounting chip, bio bottle use.
Laser mate Light-beam	LASERMATE-50	Laser capacity: 50 W, Printing speed: 200 mm/s
	LASERMATE-TEA	Mask type, TEA-CO ₂ Gas-laser printing
	LASERMATE-50SD	For lasersoldering
Autoloader	Standard, high-speed servo, small high-speed servo, 3-axis high-speed servo	Load capacity: max. 60 kg Running speed: max. 1,800 mm/s, Arm lifting speed: max. 1,500 mm/s
Data carrier	FAMDAS-100, FAMDAS-1000	Induction guide type: Data capacity 100 bytes, 1,000 bytes (100 bytes x 10 page)

system components, computers, control devices related to the technology of network, engineering technology for system integration and various software package and the strengthened ability to develop the application software. Fuji Electric hopes to develop and improve AI technique and intelligent components under the motto "PA, FA, and

TA" to realize a next-generation production system, upgrade the system construction technique in order to make systems optimum, continue accumulating technical know-how and experience and thereby supply CIM/FA systems that can fully satisfy customers.