GUIDE TO COURSES

FRENCH-SINGAPORE INSTITUTE

GERMAN-SINGAPORE INSTITUTE

JAPAN-SINGAPORE INSTITUTE OF SOFTWARE TECHNOLOGY

Economic Development Board

CONTENTS

INTRODUCTION

The restructuring of Singapore's economy with its emphasis on new technology industries and higher productivity through automation has created increased demands for new skills. Manpower development is therefore a critical aspect of our overall economic development strategy.

A direct consequence is hence the need to upgrade the skills of existing industrial manpower as well as to train newcomers in the required skills of higher technology. In 1981, the Economic Development Board extended its manpower training activities accordingly onto broader scopes and higher levels and into specialised areas of technology complementing the efforts of other technical institutions.

To support this objective, three institutes have been established with the joint co-operation of the governments of West Germany, France and Japan, ie, the German-Singapore Institute (GSI), the French-Singapore Institute (FSI), and the Japan-Singapore Institute of Software Technology (JSIST) respectively. Consistent with the EDB approach in manpower training, the curricula of the three institutes are aimed at developing practice-oriented technicians and EDP professionals competent in their own field of responsibilities. To achieve the best results in effecting the needs of industries close interaction with the industrial community which the institutes serve will be maintained.

It is hoped that this guide will provide the information to students and teachers alike who may be interested in the training undertaken by the EDB institutes.

GENERAL INFORMATION

COURSES OFFERED

The three EDB Institutes, each conducting a 2-year full-time training programme in its specialised field of technology, offer the following courses:

1. French-Singapore Institute
   – the diploma course in electrotechnology
2. German-Singapore Institute
   – the diploma course in production technology
3. Japan-Singapore Institute of Software Technology
   – the diploma course in programming and systems analysis

INTAKE OF STUDENTS

A 2-intake system is adopted for the EDB Institutes. At six-monthly intervals – normally in January and July each year – students will be accepted into the Institutes for various 2-year full-time diploma courses.

SEMESTERS

There are two semesters in a session. Each semester consists of twenty-four weeks.

INSTITUTE RULES & REGULATIONS

A student will comply with all the rules and regulations that apply to his Institute.

EDB INSTITUTE TRAINING CALENDAR

July 1985 Intake

Session 1985 – 1986	
First Semester	Mon 8 July 85 – Sat 21 Dec 85
Holidays	Mon 23 Dec 85 – Sat 4 Jan 86
Second Semester	Mon 6 Jan 86 – Sat 21 June 86
Holidays	Mon 23 June 86 – Sat 5 July 86

Session 1986 – 1987	
First Semester	Mon 7 July 86 – Sat 20 Dec 86
Holidays	Mon 22 Dec 86 – Sat 3 Jan 87
Second Semester	Mon 5 Jan 87 – Sat 20 June 87
Holidays	Mon 22 June 87 – Sat 4 July 87

January 1986 Intake

Session 1986 – 1987	
First Semester	Mon 6 Jan 86 – Sat 21 June 86
Holidays	Mon 23 June 86 – Sat 7 July 86
Second Semester	Mon 7 July 86 – Sat 20 Dec 86
Holidays	Mon 22 Dec 86 – Sat 3 Jan 87

Session 1987 – 1988	
First Semester	Mon 5 Jan 87 – Sat 20 June 87
Holidays	Mon 22 June 87 – Sat 4 July 87
Second Semester	Mon 6 July 87 – Sat 19 Dec 87
Holidays	Mon 21 Dec 87 – Sat 2 Jan 88

LOCATION OF THE INSTITUTES

The Institutes –

French-Singapore Institute (FSI)

German-Singapore Institute (GSI)

Japan-Singapore Institute of Software Technology (JSIST)

are three of EDB new generation institutes.

Each institute is separately housed with up-to-date facilities of its own eg. workshops, laboratories, etc.

The locations:

French-Singapore Institute
12 Science Centre Road, Jurong
Singapore 2260
Tel: 5611400

German-Singapore Institute
10 Science Centre Road, Jurong
Singapore 2260
Tel: 5613866

Japan-Singapore Institute of Software Technology
1 Maritime Square # 12-11 World Trade Centre (Lobby B)
Singapore 0409
Tel: 2730777

ADMISSION

Admission to the Institutes for the above courses is open to:

1. persons awarded the EDB bursary or
2. persons sponsored by their employers or
3. persons previously trained under the Joint Industrial Training Scheme (or those considered as having equivalent standing).

ENTRY QUALIFICATION

The minimum requirements of admission to all EDB Institutes for the diploma courses are:

(I) GCE Advanced Level

a. Possession of a GCE at Advanced Level including a Mathematics subject

b. A pass in English Language at GCE 'O' Level, or a pass in General Paper (English) in the GCE 'A' Level examination or equivalent

Note: The Higher School Certificate will be accepted as equivalent to the GCE 'A' Level.

(II) **Applicable for admission to the German-Singapore Institute only:**

Besides GCE 'A' Level holders, the German-Singapore Institute accepts applicants offering:

a. The EDB Craftsman Certificate or

b. The full National Trade Certificate Grade 2 in relevant trades eg. metal machining/tool & die making or

c. The Industrial Technician Certificate (Mechanical Engineering/Mechanical Engineering Drawing & Design).

As a basis for admission, holders of the National Trade Certificate Grade 2 or the Industrial Technician Certificate should have at least 2 years' relevant post-certificate industrial experience.

Such applicants should also possess GCE 'O' Level passes in the following subjects:

a. English Language
b. Elementary Mathematics and
c. An appropriate Mathematics/Science/Technical subject.

COURSE FEES

The fees for the 2-year full-time Diploma courses are as follows:

Institute	Full-time Diploma Courses	Duration	Yearly Course Fees
	Diploma Courses	Years	
French-Singapore Institute	a) Electrotechnology	2	1,000
German-Singapore Institute	b) Production Technology	2	1,000
Japan-Singapore Institute of Software Technology	c) Programming and Systems Analysis	2	2,000

REGISTRATION FEE

All students shall pay on admission a sum of $50 as registration fee (non-refundable).

STUDENTS' INSURANCE FEES

All full-time students must participate in the EDB Students' Group Personal Accidents Insurance Scheme.

STUDENT SPONSORSHIP

SPONSORSHIP BY COMPANIES

To assist in meeting the technological advances in the area of their operations, companies are encouraged to sponsor employees for training at the Institutes:

SDF IN-PRINCIPLE APPROVAL

The courses leading to the award of the:

- Diploma in Electrotechnology
- Diploma in Production Technology
- Diploma in Programming and Systems Analysis

conducted at the EDB Institutes are courses recognised as having in-principle approval for grants by the Skills Development Fund. SDF grants will cover 70% of the Absentee Payroll and the Course Fees for any employee sponsored.

APPLICATIONS

For further information, companies intending to sponsor their employees are requested to contact:

Training Unit
Manpower Division
Economic Development Board
1 Maritime Square # 10-40
World Trade Centre
Telok Blangah Road
Singapore 0409

Tel No: 2710844

EDB BURSARY

The award of the EDB Bursary qualifies a student for admission to the diploma course at one of the Institutes.

The value of the EDB Bursary is given in the following table:

Full-Time Courses	Institute	Duration	Bursary Annual Value
1. Diploma in Electrotechnology	French-Singapore Institute	2 years	$3,600 p.a.
2. Diploma in Production Technology	German-Singapore Institute	2 years	$3,600 p.a.
3. Diploma in Programming and System Analysis	Japan-Singapore Institute of Software Technology	2 years	$3,600 p.a.

Additionally, a Bursary holder will also receive the relevant annual course fees in accordance with the terms of the bursary.

BOND

On successful completion of the course, such EDB Bursary holders are required to serve a three-year bond in the industrial or business sector as may be assigned by the Economic Development Board.

ELIGIBILITY

An applicant submitting the GCE 'A' Level as a basis of admission will be considered for the bursary award. Graduates from tertiary institutions, however, will not be eligible.

EDB STUDY LOAN

A study loan scheme is made available by the Economic Development Board for the full-time Diploma course studies at the German-Singapore Institute.

The loans shall be for the purpose of assisting qualified skilled workers from the precision engineering industries who may encounter financial difficulties whilst pursuing the GSI course.

Loans shall have an annual value of either $3,000 or $6,000 and shall be granted to cover only the minimum period of two years required for the course.

A minimal interest rate, presently at 7% per annum on the loan, is charged.

Loan repayment may be made by instalments within a period of thirty (30) or sixty (60) months, depending on the loan granted, beginning not later than six months after graduation or from the date the student withdraws from or leaves the Institute.

HOW TO APPLY FOR ADMISSION

Applications must be submitted in the prescribed forms. Applicants are required to complete and return the form accompanied by a passport photograph within the stated time.

Applicants must be prepared to appear for interviews and to undergo such tests as may be required of them by the Admissions Committee.

For further information, please contact:-

Manpower Division
Economic Development Board
1 Maritime Square # 10-40
World Trade Centre (Lobby D)
Singapore 0409

Tel No: 2787200/2710844

FRENCH-SINGAPORE INSTITUTE

INTRODUCTION

The latest of the new generation institutes established by EDB, the French-Singapore Institute (FSI) is a joint project between the governments of France and Singapore. FSI, besides being well-equipped with the latest in its workshops and laboratories, draws its expertise from the Ecole Superieure d'Ingenieurs en Electro-technique et Electronique (ESIEE) of Paris, a higher institute of electro-technology and electronics known for its industry-oriented program.

In keeping with Singapore's policy of restructuring its industries by moving towards greater automation and computerisation, the FSI is geared specially to train a pool of technicians/technologists in the field of electronic technology with special emphasis on electronics, instrumentation, automation, industrial control, computer and microprocessor applications.

TRAINING AIMS

The main aim of FSI is to prepare students to be competent both in theory and the practical aspects of electronic technology. The training is designed to ensure a dynamic link with industries and be of benefit to the industrialists.

Accordingly, a major part of the students' work concerns the practical use of industrial equipment which they are likely to meet during their professional career. In addition, all students undertake case studies and a full-time project lasting one semester (24 weeks).

On successful completion of the course, students will have a strong foundation in the broad field of electronics and computers with emphasis in practical applications. Their training will be relevant to any organisation engaged in the design, manufacture or use of sophisticated electronic, computer and telecommunications equipment.

DIPLOMA IN ELECTROTECHNOLOGY

The course entails two years of full-time training and leads to the award of the Diploma in Electrotechnology.

COURSE CURRICULUM

The course curriculum includes both theory and practice in the following subjects:

General
- Engineering Mathematics
- Engineering Physics

Electrical Technology
- Basic Circuits
- Basic Electricity
- Electrical Machines
- Electrical Technology
- Static Convertors

Instrumentation & Electronics
- Transducers, A/D, D/A Convertors
- Basic Instrumentation
- Basic Measurement Methods
- Quality Control
- Basic Electronics
- Applied Electronics
- P C Board and Hybrid Circuits
- Communication and Signal Processing

Automation
- Basic Automation
- Robotics
- Numerical Control
- Applied Microprocessors

Microprocessor & Systems
- Basic Microprocessor
- Assembler
- Computer Languages
- Operating Systems
- Input/Output
- Computer-Aided-Design/Computer-Aided-Manufacturing (CAD/CAM)

Industrial Development
- Industrial Development including Case Studies and Project Work
- Workshop Management
- Mechanics (Machine Practice)

PROJECT WORK

A significant characteristic of this diploma course is the strong emphasis placed on practical training. Besides two projects in the first and second semesters, each student is required to do a 6-month full-time project in the final semester. These projects are prepared by industry and are jointly supervised by the industry and by the FSI. In doing these projects, the students will be involved in all phases of project development, from specification input to design, material sourcing, prototype construction and evaluation. Students while taking turns to be project leaders, will be trained to cope with real-life situations like co-ordinating and working with people, making decisions regarding trade-offs and priorities on factors such as costs, time, performance, reliability, etc.

In this way, students at the FSI will be better prepared to cope with both technical as well as non-technical problems which they may encounter in industry.

GERMAN-SINGAPORE INSTITUTE

INTRODUCTION

The German-Singapore Institute (GSI), established as a training institute at tertiary level in 1982, is a technical co-operation project between the governments of Singapore and the Federal Republic of Germany.

The aim of GSI is two fold –

- To train a breed of practice-oriented technicians knowledgeable in production technology combined with the essential operational skills.
- To provide further training and upgrading of skilled craftsmen in precision engineering industries and instructors from the vocational institutes and training centres.

UNIQUE CHARACTERISTICS OF GSI

The GSI training concept is adapted from the established German system of technician training where the training programme is specially designed so as to produce mid-level technical personnel equipped with both good skills and a sound knowledge of up-to-date production techniques.

The course programme at GSI therefore provides more than just institutional training. A practical work environment of the industry is built into the training system which combines to offer a fundamental framework for the expansion and application of advanced technology and methods in the manufacturing industry.

GSI DIPLOMA COURSE

The GSI offers a 2-year full-time course leading to the award of the Diploma in Production Technology. The course structure is as follows:

Phase			Nature	Duration
First Year	–	Phase I	Basic Training	1 Semester
First Year	–	Phase II	Common Core	1 Semester
Second Year	–	Phase III	Advanced Training	2 Semesters

PHASE I – BASIC TRAINING (One Semester)

Basic Course 'A'	Basic Course 'B'
1. Workshop Practice – Machining Processes, Welding Techniques, Assembly/Fitting (25%)	1. Workshop Practice – Machining Processes, Welding Techniques, Assembly/Fitting (70%)
2. Theoretical Training – including Engineering Mathematics, Engineering Science, Materials Technology, Production Techniques I, Engineering Drawing, Mechanics I (75%)	2. Theoretical Training – including Engineering Drawing, Materials Technology, Production Techniques I, Mechanics I (30%)

Note: NTC 2 holders and EDB Craftsmen or equivalent will undergo Basic Course 'A'. In the case of GCE 'A' Level holders and ITC holders, the Basic Course 'B' applies.

PHASE II – COMMON CORE (One Semester)

During this phase, all students will receive training in the following subjects where equal emphasis will be given to both the theoretical and the practical aspects:

a. Production Techniques II (incl. Computer Numerical Control Techniques)
b. Workshop Practice II (incl. Tool & Die)
c. Design I
d. Materials Technology II (incl. Heat Treatment & Materials Testing)
e. Plastics Technology I
f. Industrial Automation I
g. Quality Control I (Metrology)
h. EDP I
i. Industrial Management I
j. Mechanics II

PHASE III — ADVANCED TRAINING (Two Semesters)

Additional exposure will be given to the students in the various manufacturing processes during this phase of training. Modern technology such as Robotics, Computer-Aided-Design/Computer-Aided-Manufacturing (CAD/CAM) will be included. Students will be required to take one of the following Electives:

1. Cutting Technology & CNC Techniques
2. Design (Tool & Die/Jigs & Fixtures)
3. Industrial Automation

Subjects for Phase III include:

a. Production Techniques III
b. Production Techniques IV (Computer Numerical Control Techniques only)
c. Workshop Practice III (Advanced Cutting Technology)
d. Workshop Practice IV (Tool & Die)
e. Design II (Jigs & Fixtures)
f. Design III (Plastic Mould/Press Tool Design)
g. Materials Technology III
h. Plastics Technology II
i. Industrial Automation II
j. Industrial Automation III
k. Quality Control II (incl. Statistical Quality Control)
l. Quality Control III
m. EDP II
n. EDP III (Computer-Aided Planning)
o. Industrial Management II
p. Surface Treatment

Equal emphasis is given to both theory and practice.

All students are required to undertake project work at the end of the semester. The project work may include industrial projects from local companies.

German Language: Throughout the course, the German Language will be taught as a subject.

JAPAN-SINGAPORE INSTITUTE OF SOFTWARE TECHNOLOGY

INTRODUCTION

The Japan-Singapore Institute of Software Technology (JSIST) is one of the EDB's new generation institutes of technology. Established in December 1980 as a joint co-operation project with the Japanese Government, the aim of JSIST is to train a pool of EDP professionals both for the national computerisation efforts as well as for the software industry in Singapore.

To achieve this, JSIST training is designed to prepare young Singaporeans for careers in computer-based data processing, either as application programmers or as systems analysts, within the industry, commercial or the public sector.

COURSE STRUCTURE

Accordingly, a specially-structured programme has been prepared, and is being offered as a 2-year full-time course leading to the award of the Diploma in Programming and Systems Analysis.

The central theme of this course is computer-based data processing with its main areas of study concentrated in

a) programming,
b) computer systems, and
c) systems analysis and design.

DIPLOMA IN PROGRAMMING AND SYSTEMS ANALYSIS

COURSE CURRICULUM

1st Year

Subjects

Introduction to Computers & Data Processing
Introduction to Hardware
Introduction to Software
Introduction to File Processing
Operating Systems
Systems Development
Assembly Language (Micro)
PASCAL
COBOL I
COBOL II
BASIC
FORTRAN
Mathematics I
Communication Skills I
Management Accounting
Debugging and Testing
Industrial Visits I
Programming Project

2nd Year

Subjects

Mathematics II
Fundamentals of On-Line Systems
Data Communication
Database Systems I
Database Systems II
RPG
Real-Time Systems Packages
Compiler Concepts
Operations Research
Human Resource Management
Communication Skills II
Industrial Visits II
Applications Packages
Security and Privacy
Systems Evaluation and Maintenance
Systems Analysis/Systems Design
a. Feasibility Study
b. General Design
c. Detailed Design
Industrial Project

EMPHASIS ON HANDS-ON EXPERIENCE

As the emphasis of the Institute is on practice-oriented training, 50% of the core subject time is spent on practical work to ensure that students develop sufficient practical skills which are relevant to their future careers.

Two major projects are compulsory. Students will be engaged in group projects at the end of the First Year and in individual projects in the last three months of the Second Year.

COMPUTER HARDWARE IN JSIST

- 1 NEC ACOS 450 MULTIPROCESSOR SYSTEM (14MB)
- 64 CRT TERMINALS
- 4 'INTELLIGENT' TERMINALS
- 2 PORTABLE TELETYPEWRITER TERMINALS
- 12 MAGNETIC DISK DRIVES (2.4 GIGABYTES)
- 4 MAGNETIC TAPE DRIVES
- 2 LINE PRINTERS
- 2 COLOUR GRAPHIC DISPLAYS
- 1 X-Y PLOTTER
- 6 KEY-TO-FLOPPY DATA ENTRY EQUIPMENT
- 2 OPERATOR CONSOLES
- 1 CARD-PUNCH
- 1 CARD-READER
- 1 NEC SYSTEM 100/80 MINI-COMPUTER
- 1 NEC SYSTEM 100/85 MINI-COMPUTER
- 10 NEC PC8001 PERSONAL COMPUTERS
- 12 NEC PC8801 PERSONAL COMPUTERS
- 10 FUJITSU FM-16 PERSONAL COMPUTERS
- 4 NEC APC III PERSONAL COMPUTERS
- 1 NEC PC9801 PERSONAL COMPUTER
- 2 SUPER PC/XT

INDUSTRIAL AUTOMATION TRAINING

Four specialist units have been established by the EDB to provide training in industrial automation. The units are:

1. Computervision-EDB CAD/CAM Training Unit (CECTU)
2. ASEA-EDB Robotics Training Unit (AERTU)
3. Mentor Graphics-EDB CAE (IC Design) Training Unit (MECTU)
4. Hewlett Packard-EDB CAD/CAM/CAE Training Unit (HECTU)

Training complements that in the institutes of technology and is designed to give students the specialised exposure, both in terms of hardware and software, as prescribed in the curricula of the institutes.

CECTU TRAINING	AERTU TRAINING
• mechanical design and drafting • numerical control • structural engineering/design • printed circuit board design • integrated circuit design	• application/project engineering • programming and operation • maintenance and servicing
MECTU TRAINING	**HECTU TRAINING**
• integrated circuit (IC) design • computer-aided engineering techniques in (IC) design	• mechanical drawing and tooling design • numerical control • electronics circuit design • printed circuit board design

付属資料(17)—①

会 社 概 要

1.	会 社 名	SINGAPORE TIME PTE. LTD. (略称SPT)
2.	所 在 地	No. 2 MARSILING LANE. TEL 2696906 WOODLANDS NEW TOWN. TLX SINTIME RS—23465 SINGAPORE 2573 FAX 2690776
3.	設 立	1973年9月12日 (OFFICIAL PRODUCTION DAYは1976年4月1日)
4.	資 本 金	授権資本 S$25.0 MILLION 払込資本 S$21.4 MILLION
5.	出 資 者	セイコー電子工業㈱ 50% セイコーエプソン㈱ 50%
6.	土地・建物	土地 12エーカー (約 14,800坪) 建物 第1期 5,763㎡ (1,746坪) 1975年 7月設置 第2期 2,566㎡ (777坪) 1978年 7月 第3期 12,100㎡ (3,667坪) 1982年11月 厚生棟 600㎡ (181坪) 1983年 3月 合 計 21,029㎡ (6,371坪)
7.	製造品目	婦人用クォーツウォッチ 3機種 月産350千個 紳士用自働巻ウォッチ 1機種 月産180千個 合 計 4機種 530千個
8.	製造体制	ウォッチ部品の製造から完成品までの一貫製造体制 一部MOV'Tでの出荷
9.	仕 向 先	HONG KONG, 日本の販売会社を経由して世界各国へ輸出 SEIKO, ALBA PULSARの各ブランド, 一部OEM製品として全数輸出

労 働 条 件

1. 従業員構成　男子 261名 (33%)　女子 524名 (67%)　合計 785名 (10/85)

平均年齢	男子 28才　女子 21才
平均勤続	4.3年
人種構成	中国人66%, マレー人23%, インド人11%
出 勤 率	95%以上
転 職 率	3.0% / 月以下

組合参加率	53% OPEN SHOP制
平均給与	S$598
日本人出向者数	8名
2. 就業時間	7.30AM～4.30PM
	昼食45分，TEA BREAK 10分×2回，実働7時間55分／日
3. 年間労働時間	労働日数 267日，2114時／年
	休日数 99日，（国民祝日11，日曜52，会社休日35）
4. 年次休暇	7日／初年度＋1日／次年度 MAX 16日
病気休暇	入院不要時14日，入院必要時60日（但し医師の診断を要す）
出産休暇	6ケ月以上勤続の女子従業員に産前産後各1カ月，男子に1日
慶弔休暇	結婚4日，死亡3日，危篤1日
5. 残業手当	通常労働日1.5倍，休日・祝祭日2倍の割増賃金
	3.5時間以上の長時間残業の場合3$の食事手当支給
6. 医療費負担	会社は治療・投薬等の医療費を補助負担する
7. 通勤手当	会社はバスで送迎する
8. 年間補充賃金（ボーナス）	勤続12カ月以上の従業員 1カ月賃金相当
	勤続12カ月未満の従業員 1カ月賃金 $\times \frac{勤続カ月}{12}$
9. 定年制	55才を定年とする。会社と本人との1年契約で60才まで延長可

Introduction

As part of the Government's efforts towards promoting and encouraging the greater use of robotics and automation in Singapore, positive steps were taken to incorporate a company to spearhead this drive, and create an environment in which the necessary resources for such upgrading can be made easily available.

With this objective in mind, Robot Leasing & Consultancy Pte Ltd (RLC) was established in March 1984 as a joint venture between the Economic Development Board, SAL Leasing (Pte) Ltd and Japan Robot Leasing Company Ltd.

There are two main services provided by RLC:

- Factory automation consultancy
- Low-cost financing

Consultancy

Factory automation consultancy services are provided by RLC's specialised division -- the Automation Applications Centre (AAC). AAC is conveniently located at the Singapore Science Park.

Under the Skills Development Fund's INTECH Scheme, RLC receives financial support so that factory automation consultancy services can be made available to the industries at the lowest possible cost. Singapore companies receiving technical assistance from the AAC need to pay only 10% of the costs involved.

Scope of consultancy services

Each consultancy is carried out in four different phases. They are:

- Investigation study
- Feasibility and application study
- Implementation
- Monitoring and integration

Investigation study

This involves data collection and analysis leading to identification of problems and scope for improvement.

Feasibility and application study

This consists of in-depth study of existing manufacturing plant and work methods as well as generation of solutions and preparation of system application.

Implementation

Involved here is project management for the co-ordination and supervision of supply and installation of equipment by the contracted suppliers. Technical support is also provided during commissioning of the new system.

Monitoring and integration

This final phase monitors the performance after the start-up of the new system to ensure that the objectives of the project are met.

Projects handled

Since its inception, AAC has received tremendous support from the industries. Projects committed cover many sectors of the industry and the services offered ranged from basic industrial engineering to complicated system design and integration. Projects undertaken include:

- Design of an automated assembly line for battery elements.
- Design of an automated assembly machine for protector and short connector for a medical equipment manufacturer
- Improvement in the production method, inspection, loose thread cutting, ironing, transportation and storage of a garment manufacturer
- Investigation study for the installation of a robotic spray-painting system for a printing and coating services company
- Productivity improvement study of the production line of an electronic parts manufacturing company
- Improvement of material handling, environment and selection of equipment for a food packaging company
- Design and installation of a robotic spray painting system for an electric iron manufacturer
- Design and installation of an automated glass mould assembly line for an organic lens manufacturer

Business analysis

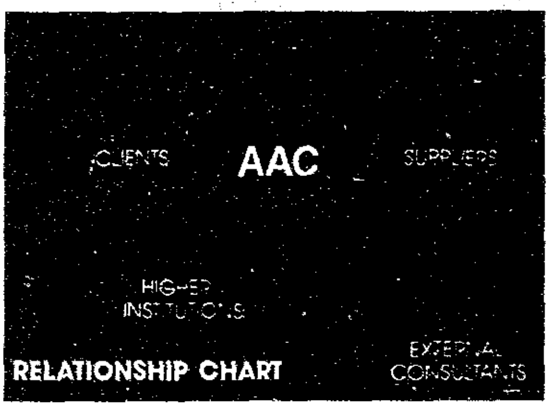
RLC aims to assist the industries to implement automation projects that are not only technically feasible but also economically viable. In this respect, the services of business analysts are also made available. Recommendations put up by the engineering project team can be further studied by the business analysts to assess the volume-profit relationship. Other qualitative factors, such as product, market, competition and management are also studied in order to test the overall viability of an automation project.

Manpower strength and network

The consultancy work is carried out by a competent team of professionals who have had considerable experience and expertise in the area of factory automation and robotics.

They are led by a technical director and include a number of senior consultants, each of whom has had more than 15 years' experience.

To strengthen its technical expertise, AAC has established a network of contacts for close collaboration with other renowned overseas consultancy firms and vendor specialists.



RELATIONSHIP CHART

AAC facilities

Permanent Demonstration Hall

The only one of its kind in South East Asia, the hall displays the latest robotic/automation systems from leading manufacturers for public demonstration and viewing.

Leading manufacturers participating in this permanent demonstration are:

- Bosch (Germany)
- Festo (Germany)
- Mitsubishi Electric (Japan)
- NEC (Japan)
- Orii (Japan)
- Yaskawa Electric (Japan)
- Kawasaki (Japan)
- Matsushita (Japan)
- Fuji Electric (Japan)
- Daifuku (Japan)
- Kobe (Japan)
- Seiko (Japan)
- ASEA (Sweden)
- Intelledex (US)
- Rimrock (US)

Technical Information Resource Centre

This is an extremely unique library well-stocked with a comprehensive range of books, magazines, newsletters, catalogues and brochures from leading robotic and automation equipment manufacturers and suppliers. The library also contains a good collection of video-tapes showing the various robotic systems in their respective fields of applications.

This Information Centre ensures that the scope and depth of AAC's technical expertise can be enhanced on a continuous basis. The information in this Centre is also made accessible to the industry and the public.

Low-cost financing

The objective of offering low-cost financing is to encourage more manufacturers to use robotic and automation equipment without straining their financial resources.

The effective interest rate charged is only 4.5% per annum, or 3.5% per annum for local companies. This is made possible through a credit line extended to RLC by the Skills Development Fund.

To make it even easier for manufacturers to enjoy the facility, there is no minimum or maximum on the quantum of financing.

Types of financing

- Leasing • Hire Purchase • Mortgage Loan

Eligible equipment

The following types of equipment of any make or model and from any supplier or source are eligible under our low-cost financing scheme:

- Industrial robots
- CAD/CAM equipment
- Auto insertion machines
- Flexible manufacturing system/cell, which may consist of a combination of CNC machine tools and/or machining centres and/or robots
- Custom-built automation system

- All other automation equipment or systems not mentioned above will be assessed on its own merits

Principal factors

The actual rentals per month will be fixed depending on the following factors:

- Amount of lease (Singapore dollars only)
- Period of lease (3 to 7 years)
- Amount of residual value (for lease financing)
- Amount of security deposit (for lease financing)
- Amount of downpayment (for HP financing)

Examples

Example 1 (HP financing)
Company A wishes to acquire a piece of automation equipment costing $100,000. The monthly rental will be $1,765 based on the following factors:

[illegible]

Example 2 (Lease financing)
Company B wishes to acquire an automated assembly system costing $1 million. The monthly rental will be $13,475 based on the following factors:

[illegible]

Critical supporting industries

Companies designated by the Economic Development Board as critical supporting industries can effectively enjoy zero interest funding due to further rebates of 4.5%.

Pioneer status and other incentive schemes

For companies that are enjoying pioneer status or export incentive scheme, the cost of their leased assets will be considered as part of the required investments by the Economic Development Board.

For companies enjoying an investment allowance, HP and mortgage loan financing will be arranged so that the assets financed will be considered as part of the required investments.

Special assistance to local industries

As part of our deliberate effort to assist the small and medium sized companies to automate and upgrade, the low-cost consultancy and financing schemes are specially amended to further benefit them.

Consultancy Scheme — experienced engineers have been assigned to provide 2-3 days' preliminary advisory services to interested companies. Should the need arise, such cases will be referred to our normal consultancy section for more in-depth assistance.

Financing Scheme — the low-cost financing is further reduced from the effective interest rate of 4.5% p.a. to 3.5% p.a. The equipment eligibility is also further expanded to include the following equipment:

• CNC machines • Stamping press with auto-transfer mechanism • Laser cutting and welding equipment • Die-casting machines with robotic attachments • Palletizing machines • Electroplating machines • Auto die and wire bonders • Automatic testing equipment • Machining centres • Coordinate measuring machines with auto-probes • EDM and wire-cut machines

SUMMARY

1 TOTAL NO. OF INDUSTRIAL ROBOTS IN USED AS AT 31 OCT 84: 150

2 TOTAL NUMBER OF COMPANIES USING INDUSTRIAL ROBOTS : 52

3 APPROXIMATE RATIO OF INDUSTRIAL ROBOTS TYPE

SERVO ELECTRIC	HYDRAULIC	OTHERS
103	27	4

4 % OF INDUSTRIAL ROBOTS' USERS (REF. ANNEX I):

JAPANESE:	26.92 %	14 companies	52
AMERICAN:	9.62 %	5 companies	
EUROPEAN:	3.85 %	2 companies	
LOCAL :	59.61 %	31 companies	

5 % OF INDUSTRIAL ROBOTS' MAKERS:

JAPAN :	64.67 %	97 units
AMERICA :	2.00 %	3 units
EUROPE :	33.33 %	27 units

6 % OF INDUSTRIAL ROBOTS BY APPLICATIONS (REF. ANNEX II):

SPRAY PAINTING :	16.00 %	24 units
WELDING :	10.67 %	16 units
MATERIAL HANDLING:	13.33 %	20 units
ASSEMBLY :	31.33 %	47 units
EDUCATIONAL :	20.00 %	30 units
OTHERS (VENDORS) :	8.67 %	13 units

7 NUMBER OF INDUSTRIAL ROBOTS INSTALLED (REF. ANNEX III):

BEFORE AND IN 1981:	5
IN 1982:	20
IN 1983:	46
IN 1984:	50
IN 1985:	29
GRAND TOTAL :	150

AUTOMATION NEWS

MC(P) 104/8/85 NOVEMBER 1985

AUTOMATION GUIDE -

A GOOD APPROACH TO AUTOMATION

by Mr Jorgen Centerman, Managing Director, ASEA Singapore

In recent weeks, we have had forceful reminders that Singapore's phenomenal growth has been arrested. For the first time in many years, the country tastes retrenchment and a spate of bankruptcies. Government, industry, commerce and trade union are in general agreement that we are in for at least two years of restraint, hard work and uncomfortable change if Singapore is to regain its competitive edge in exports and its appeal as an option for investors.

With a small domestic market, Singapore's success in the past has relied on its stability; excellent infrastructure, the efficiency of its services

Mr Jorgen Centerman — Managing Director ASEA Singapore explaining the ASEA Master System at Instrument Asia '85.

and solid manufacturing base yielding keenly priced, high quality products for world markets.

Singapore's government has already set up clear markers for renewal and recovery in manufacturing. Industries have been asked to reappraise, restructure and consider automation. To those manufacturers who may have been deterred by the somewhat longer pay-off time and apparently high start-up cost of automation, this short write-up may offer some reassurance and a few useful guidelines on the subject.

Flexible Manufacturing System

Flexible Manufacturing Systems -- or FMS -- are no novelty. Throughout the world, they have been installed and proven.

In my own Swedish homeland, production with limited manning has been applied for many years to:

- Automatic production with limited or no operator supervision for periods of up to 16 hours
- Automation of frequent or repetitive working tasks
- Limitation of manual labour by preparation and storage of workpieces, tools, programmes, etc
- Manufacture of relatively small series.

FMS should not be dismissed after only a cursory glance as an expensive means of total automation. Approach instead as a versatile and flexible means of adapting your plant – large or small – to greater cost efficiency at a pace you dictate.

- At its most modest level, FMS can be a mobile machine with simple processing equipment ...
- Or it can be a group of machines served by a common industrial robot ...
- Or it can be a system involving several machines connected by a common transport system and computerised network for control and supervision. Irrespective of plant size, the functions can be divided into several groups – tool system, machine system, handling system, control and supervision system and transport system. These must be integrated to form a unit working with other functions within the total production flow.

Why Automate?

. Some or all of the following factors may be on your mind as you consider automation:

- Higher production capacity
- More reliable or shorter delivery times
- Lower costs per production unit
- Improved working environment with reduced turnover of staff and less absenteeism. Job enrichment for high calibre staff
- Need for a wider range of products – enabling you to adapt swiftly to changes in market demand
- Improved technological status

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EDITORIAL COMMITTEE

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EDITOR'S NOTE

The voice of robotics and automation has arrived!

After months of hard work and incessant debates, the Editorial Committe, comprising representatives from the Economic Development Board, the National University of Singapore, the Nanyang Technological Institute and Robot Leasing and Consultancy Pte Ltd, is pleased to launch our maiden issue of Automation News – a quarterly review of issues pertaining to robotics and automation both locally and abroad. The underlying objective of this newsletter is to create greater awareness and consciousness among the industries of robotics and automation.

As a useful information source, the newsletter will focus on crucial areas such as the Government's policies and schemes on automation, industrial trends and development, new products/processes, case studies, research and development, manpower training as well as a calendar of international events.

In striving to achieve a good balance, we have painstakingly selected articles which will reflect adequately both managerial and technical issues.

As robotics and automation will feature even more prominently and effectively in future production technologies, we hope, through the newsletter, to capture the essence of such technological development and breakthroughs and keep our industries abreast with technology.

The mode of communication is intended to be two-way. So please drop us a line if you have any interesting information, feedback or significant development to publicize. Your kind cooperation and support will help us reach greater heights.

INSIDE

AUTOMATION CONSULTANCY

An interview with Mr Au Eng Fong General Manager, Robot Leasing & Consultancy And SAL Leasing

Mid 1984, the industries witnessed the birth of Robot Leasing & Consultancy Pte Ltd (RLC) — a joint venture between the Economic Development Board, SAL Leasing and Japan Robot Leasing Company (JAROL). Much publicity surrounded its inception, much expectation on its future.

Today, just over a year of existence, we speak to the man at the helm – Mr Au Eng Fong, General Manager, RLC, on his perception, vision and the role of the company.

Question:

We understand that the Government is increasingly concerned with the need for the industries to upgrade to remain competitive – both locally and abroad. This being particularly crucial to the local industries, is the existence of (RLC) a direct reflection of this concern?

Mr Au:

Well, to be precise, the history of our company dates back to 1983 when serious efforts were made to understand better the problems confronting the local industries. Whichever way the problems were discussed, it was obvious that they gravitated to two significant issues, namely, financial and technical. Chances are, most local companies are lacking on both accounts. Let me elaborate on this. Firstly, in any upgrading process involving robotics and automation, a high initial capital outlay is required. The larger companies have less difficulty in coping with this but unfortunately the same cannot be said of the small and medium-sized companies. Some form of low cost financing with longer repayment period is therefore necessary to assist them to tide over their cashflow problems. Secondly, the evaluation and selection of appropriate automation equipment and systems requires the services of a team of good experienced technical people. Again, many local firms are not able to maintain a core of such people. There is therefore a strong need to make available a pool of highly trained professionals at an affordable price. Through our set-up, industries will now be able to utilise our low-cost financing services and our low-cost factory automation consultancy services to assist them in upgrading their operations.

Structurally, you will notice that through RLC, we hope to bring together the best available resources. The Economic Development Board provides the policies and direction, SAL Leasing, its expertise in financing and management and JAROL, its exceptionally strong technical resource base. With this effective combination, we hope to make things happen, to make upgrading possible.

Question:

While it is good to bring together all such resources under one roof, the question is, how can these services be made readily available to the industries and, more importantly, within their reach?

Mr Au:

In response to this, I must say that we are extremely fortunate to receive strong and positive support from the Skills Development Fund. (SDF)

Under its INTECH Scheme, we receive financial grants which enable us to offer our factory automation consultancy services to the industries at only 10% of the total cost.

In addition, the SDF also extends to us a credit line which allows us to provide low cost financing to the industries at an extremely attractive effective rate of 4.5% pa. This covers equipment such as industrial robots, CAD/CAM systems, flexible manufacturing systems and custom-built automation systems. As an additional effort to assist the small and medium-sized companies, this rate has recently been further reduced to 3.5% for this group.

All these imply that all our services are easily and readily available to the industries.

Question:

As the field of robotics and automation is wide and varied, how can your company ensure that every project is well attended to?

Mr Au:

First of all, internally, we have recruited experienced staff with expertise in the area of factory automation. This is further strengthened by the addition of three expatriate experts – each of whom has had more than 20 years' experience in robotics and automation. Staff are continually sent abroad for specialised training to keep them abreast with the latest technologies.

Externally, we have struck up a strong relationship with some leading international consultancy firms whereby we are able to engage them on a joint-project basis.

In fact, on the local scene we have had several discussions with local specialists to work out some collaborative arrangement.

Question:

It has been said that many technically sound projects often end up as commercial failures – this is particulary true in today's highly dynamic environment. What steps have you taken to ensure that your proposals are both technically and commercially sound?

Mr Au:

We are extremely conscious of this and have added the services of Business Analysts. Volume-profit relationship is analysed. Other qualitative factors such as product, market, competition, management and skills of labour are also studied. But the important point is that we are determined to be professional and well organised in our approach in providing factory automation consultancy services. Our practice is to enlist client's commitment through senior management's participation – this will facilitate our evaluation of project's commercial viability.

Question:

As one of your company's important objectives is to promote and encourage the greater use of robotics and automation among the industries, what other steps have you taken to make this happen?

Mr Au:

Well, the greater use of robotics and automation can only come through first knowing of their existence and then understanding their usefulness. Creating awareness among the industries is therefore an equally important task of our company.

One useful approach is through our Demonstration Hall where a total of 13 latest robotic systems are put on display for public viewing. This is possibly the only one of its kind in Asia apart from Japan where actual robotic systems are put in operation each depicting a different work environment.

In addition, we have also established a unique Technical Information Resource Centre well stocked with a comprehensive range of books, catalogues, magazines, brochures as well as video tapes on robotics and automation. So far, we have had discussions with the various trade and industry groups and associations to make them aware of our facilities. Our next step is to gear up our promotional campaign through seminars, workshops and exhibitions.

Question:

We are aware that there are presently other firms which are also offering consultancy services to the industries. Will there be any unfair competition since you will obviously be able to offer a more attractive package?

Mr Au:

Let me take this opportunity to clear up some basic misconceptions over our role vis-a-vis other consultancy firms. I will be the first to admit that we are not experts in all areas of automation. I like to believe that we are the generalist consultant overseeing client's overall automation programme. In areas of specialised application such as vision inspection, coating services, etc, we will have to work with existing consultancy firms to seek their specialist knowledge and experience. There is therefore room for co-operation . . . our role is really complementary. In fact, on the positive side, our low-cost consultancy services will be likely to generate more interest among the local industries and this will lead to more opportunities for the specialist consultancy firms to work alongside us.

In short, the potential is there for closer collaboration with other consultancy and specialist firms.

Question:

In carrying out your factory automation consultancy services, are you influenced by certain equipment or system suppliers who may have established a better relationship with your organisation?

Mr Au:

We pride ourselves as an independent professional consultancy firm ...

trying to offer the most appropriate solutions to our clients. This would imply that we will select and evaluate equipment or systems in strict accordance with client's requirements. To do this, we have to look into such factors as cost effectiveness, profit-volume relationship, safety and maintenance, system support and back-up and many others. Despite this, the final decision is still with the client.

As a rule, our project team will try initially to seek out standard equipment or systems to interface with client's existing production system. Failing which, we will proceed to work out some custom-designed automation system which will best suit client's requirement.

It is therefore a totally independent approach with client's interests at heart.

Question:

Finally, with most of the initial problems ironed out, what is your vision on the future of your company?

Mr Au:

I think all of us will agree that robotics and automation are here to stay. The future trend of production technology will likely be centred around them.

The demand for consultancy services in robotics and automation will always be there and is likely to surge ahead in the future. It is therefore essentially a question of building up our own professional and technical expertise to cope with the more demanding challenges ahead. We must not allow ourselves to fall behind the technological wave.

With the strong support of our partners and our sponsors and with the total commitment of our staff, I am highly confident that we will achieve greater heights.

YOSHITAKE'S COLUMN

by Mr Masahiko Yoshitake
(Authorised Small Scale Industries Consultant)
Senior Consultant Robot Leasing and Consultancy Pte Ltd

SMALL SCALE INDUSTRIES AND PRODUCTIVITY IMPROVEMENT — A JAPANESE EXPERIENCE

In response to the Prime Minister's speech at the National Day Rally on the 11th August, there were serious discussions on the productivity improvement of existing industries in Singapore, especially the local small scale industries.

Some of the solutions for this issue might be found in the experiences of Japanese Medium and Small Scale Industries (hereunder MSSI) from 1980 to 1985. The problems and affliction of entrepreneurs of MSSI in Japan during the 5 years, can be summarised into the two following areas:

(1) Coping with the hardship of rapid changes of market situation and products due to the advanced high technology. Issues include what and how to introduce an appropriate advanced technology to their management.

(2) Well timed retirement of owners and succession problems — some of them founded their enterprises just after the war and are now well over 60.

With regard to item (2), such problems do not exist in Singapore and the other NICs, as the entrepreneurs are still young.

In Japan, MSSI is defined by the law (Minor Enterprise Act) as follows:

Paid up Capital — Less than S$900K
No of employee — Less than 300

The effects of the advanced technology, which could be termed as the new industrial revolution prevailing all over the world, have taken shape in the following manner:-

(1) **Changes Of Products**
Decrease of traditional products - some being replaced by substitute products and composite technology products.

(2) **Change Of Market**
Diversity and individuality of market needs giving rise to small lot production and sales, more and more market-in concept than product-out concept.

CHART 1 — MSSI STATISTICS IN JAPAN

	TOTAL INDUSTRIES IN JAPAN	LARGE SCALE INDUSTRIES	SMALL & MEDIUM SCALE INDUSTRIES
1 No of Industries (xk) (%)	872 (100.0)	4 (0.5)	868 (99.5)
2 No of Employees (xk) (%)	12863 (100.0)	3311 (25.7)	9552 (74.3)
3 Output S$ (x Trillion) (%)	2.05 (100.0)	1.0 (48.8)	1.05 (51.2)
4 Added Value S$ (x Trillion) (%)	0.66 (100.0)	0.29 (43.8)	0.37 (56.2)
5 Added Value per head S$ (xk) (ratio)	67.6	98.0 (100.0)	52.8 (53.9)
6 Labour's relative share (to added value) (%)	37.3	33.1	40.6
7 Labour's relative share (to output) (%) (ratio)	12.0	9.5 (100.0)	14.3 (150.0)
I Wage percentage cost in Singapore Industries (%) (ratio)		7.0 (Large), 8.0 (Small) (100.0)	21.0 (Large), 15.0 (Others) (200.0) (300.0)

1983 (MITI White Paper)

The government (MSSI Agency) has been making efforts to promote and strengthen MSSI since 1955. In Japan, 99.5% of the industries are classified as MSSI and 75.0% of the total workers belong to MSSI.

Chart 1 shows the comparison of the productivity between large scale industries and MSSI.

As shown in item 5 of the chart, the added value productivity of MSSI is much lower than the large scale industries — that is about 54%. The labour's relative share is 40.6% in MSSI and 33.1% in the large scale industries. Consequently, the labour's relative share to output becomes 9.5% in the large scale industries and 14.5% in MSSI — that is, about 1.5 times.

During the last decade, MSSI in Japan suffered severe blows twice. One was during the oil crisis of 1973 and the other was the effect of advanced technology which was activated around 1980 and is still going on. These two critical situations were of quite different nature. The latter was more of an industrial structure problem and hence, the counter measures taken were different. One of the reasons of the recent slowdown in the economies of NIC is also due to industrial structure problem.

(3) **Change Of Design**
More system design than elemental equipment design. More co-ordination between design and production.

(4) **Change Of Production**
Use of the computer-rapid progress in accurancy, new material, small lot production and automation.

(5) **Change Of Investment**
Increase of investment capital due to high cost facilities for advanced technology. More engineering staff are also required.

Chart 2 shows the statistics collected by MMSI agency, regarding how the MSSI enterprises have felt at each critical situation.

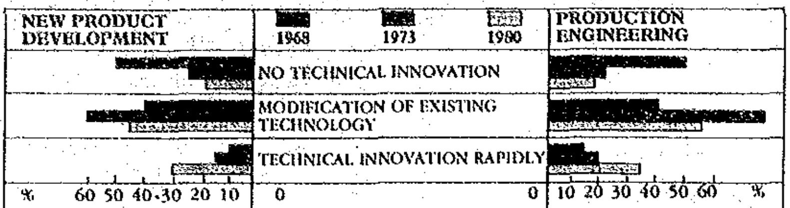
The strategy and counter- measures by MMSI co-operative associations and individual enterprises in Japan, can be summarized into the following three items.

STRATEGY 1

The policy decision for introduction of advanced technology.

In order to survive in the new industrial revolution, MSSI had to make the decision to select which way was the most suitable to their enterprises in the following categories:-

CHART 2 — MSSI ENTERPRISES FEELING



1983 (MITI White Paper)

1 Development of the advanced technology products.
2 Application (utilization) of the advanced technology products, namely:
   (2-1) The application to their existing products itself.
   (2-2) The application to their existing production process and management.

Most of the enterprises selected item 2. The reason was because they wanted to avoid the risk of development as it was too early to predict the result, and even if it could succeed it would be difficult to maintain against the large scale industries. The other important reason was that the size of the market for item 2 was much larger — about 3.5 times according to a famous research centre — than that of item 1. This decision has a certain resemblance to the decision policy of industrialisation of NIC against the advanced industrial power.

The following three ways to introduce the advanced technology have been proposed:
1 Introduction by their own engineering resources
2 Introduction by assistance from other parties. (The advanced technology equipment manufacturer, the parent company, the official engineering research institute)
3 Introduction by joint activity. (The co-operative association, the same field association, the different field association)

In the case of Japanese MSSI, many enterprises selected item (2), but recently item (3) is increasing gradually through the guidance of MSSI agency MITI. Some of them are doing very unique activities – co-operative design, co-operative manufacturing by making the best use of each professional engineering and also joint sales through the company of co-operative finance. This means that the engineering boundary of new products is becoming more complex and indefinite.

STRATEGY 2

Approach to the market where activities are concentrated. MSSI had made effort approaching these markets.

STRATEGY 3

Establishment of the enterprises' individuality and identity. In the new market of changing needs brought about by diversity and individuality, it is difficult to sell traditional products even at a competitive price. The answer to this problem was establishment of some individualities at the professional level. Some companies found it in the distinctive design, the superior quality, the perfect afterservice, and prompt delivery, etc.. This was also causing the large scale companies to recognise their professional individuality and identity. This concept will become more important in the world market in future whether it is the matter of an individual, an enterprise, a district or a nation.

How MSSI in Japan developed these strategies concretely will be discussed in the next issue.

RESEARCH

RESEARCH NEEDED IN THE KINEMATICS AND DYNAMICS OF ROBOTS

by Dr Lim Kah Bin, Senior Lecturer
Mechanical and Production Engineering Department
National University of Singapore

1. INTRODUCTION

The research and development in robotics require different kinds of knowledge which are multi-disciplinary in nature. Contribution must come from computer science, artificial intelligence, control theory kinematics, dynamics, geometry, operation research, electronics and other disciplines within the context of the special needs of robotics. Different combinations of these different disciplines provide the various essential functions that an intelligent robot must possess. These functions are namely (1):

- Intelligence and decision making.
- Control.
- Manipulation
- Locomotion.
- Sensors.
- Communication.

A perfect integration of these functions is necessary to produce an intelligent robot, especially when we are heading towards the development of the "Third Generation Robot" (2).

2. IMPORTANCE OF KINEMATICS AND DYNAMICS OF ROBOTS

A robot is basically a mechanical manipulator that consists of several links, connected by revolute or prismatic joints. The kinematic configuration of the robot i.e, geometry of the links, type of joints, is very important because once the configuration is established, it will define limits to the set of tasks to which the robot may be effectively applied. In addition, the dynamics, i.e. the equations of motion of the robot are also largely governed by its kinematic configuration.

From the control point of view, the system response is also largely affected by the said mechanical characteristics of the robot. For example, while the sensory devices, visual or tactile, are gathering information from the external environment, the full control algorithms will have to take into account the kinematics and dynamics of the system and compute the forces and torques necessary to drive the end-effector along desired trajectories in the working spaces.

In view of the importance of the mechanical characteristics of robots, it is essential to be aware of the state of technology in this area and henceforth to identify the research required.

3. KINEMATICS OF ROBOTS

3.1 Kinematic Transformation

While the kinematic configuration design of a robot involves the selection of the structure properties which relate adjacent joints, the robot kinematics deals with the spatial configuration of the robot as a function of time, in particular, the relations between the joint-variable space and the position and orientation of a robot arm. The robot kinematics is one of the better understood areas of Robotics (3.4).

Robots are powered by motors at the joints between links. Associated with a motor are quantities which define its position, velocity, acceleration, and torque. It is therefore most efficient to control robots in joint-space. However, programmers of robots prefer to think of position using orthogonal, cylindrical or spherical Cartesian co-ordinate frames. Therefore, there is a need for kinematic transformations to transform one co-ordinate frame to the other.

The kinematics of robot are defined mathematically based on its configuration and the driving mechanisms (revolute or prismatic). The requirement that the kinematics can be efficiently computed adds constraint, that ultimately affects mechanical design. The transformation from joint co-ordinates to Cartesian co-ordinates, known as direct kinematics, is quite straightforward. However, many object specifications are given in Cartesian co-ordinates, which necessitate the transformation to joint co-ordinates. This inverse kinematics computation, from Cartesian to joint co-ordinates, is often more complex, in some cases, geometric intuition may be required (3).

Several efficient algorithms have been developed to solve the inverse kinematics computation problems. Hollerbach (5) discussed a recursive scheme for computing the kinematics for both the Lagrangian and Newton-Euler formulations of the dynamics. Luh et al. (6) presented a new method based on the Newton-Euler transformation which is independent of the type of robot configuration. Their method, using the relationships of moving co-ordinate systems, involves the successive transformation of velocities and accelerations from the base of the robot to the gripper

Lee and Ziegler (7) used a geometric approach to solve the inverse kinematics of PUMA robots, while Mancini et al. (8) discussed yet another new approach based on parallel computation of each joint co-ordinate.

There are still many other methods presented by various researchers in this area. However, further research are still required to improve the computational speed and accuracy. Improvement in hardware might help to overcome these short-comings; for example, the parallel computation approach of Mancini et al. (8) may be efficient but it can only be used to its full advantage with a computer having a common memory multi-processor system.

3.2 Performance Evaluation

Another important issue in the kinematics of robots is the kinematics performance evaluation. The position accuracy and response time could be evaluated by time–base measures, such as velocities and accelerations. Unfortunately, such work is not known. In fact, what we need is a full understanding of the functional dependence between performance measures and the structural kinematic parameters.

Wu (9) has presented an Error model describing the six possible Cartesian errors and the four independent kinematic errors from which the Cartesian error envelopes due to any four kinds of kinematic errors can be found. Although this error model is helpful in evaluating the kinematic configuration of a robot, time–base performance evaluation is still not possible.

Another useful set of performance measures could be based on force and torque, and might also entail aspects of reliability, repeatability and work space usage.

3.3 Collision Avoidance

Manipulator kinematics should also be studied from the point of view of the interdependence between the kinematics of the robot and the kinematics of the work environment which includes everything which moves or resists motion. In short, we should look into methods to minimize the collision avoidance problem. Associated with this will be the research issue in the object representation for collision detection programs, and the path planning for collision avoidance. The well known Artificial Intelligence Laboratory, Massachusetts Institute of Technology is very active in this area of research.

The algorithm of Brooks (10,11) involves first, the finding of collision–free motion segments, and later, the linking of them to form a complete collision–free path for the robot. Chien et al.(12) has presented another similar algorithm for collision–free path planning, but it is highly mathematical and requires a good understanding in Topology and Graph Theory. Freund and Hoyer (13) have implemented a time–efficient control strategy for the control of guided collision avoidance in an automatic assembly line involving two robots, and was found to be effective.

We might also make use of sensory devices, such as visual or ultrasonic sensors to solve the collision avoidance problem. However, for the present moment, at least, we must first solve the problem of cost and the large amount of information to be processed by the controllers.

4. DYNAMICS OF ROBOTS

The dynamic equations of a robot arm of n–links consist of n coupled, second order, differential equations in the positions, velocities, and accelerations of the joint variables. The equations are complex because they involve terms from two adjacent joints corresponding to torques due to coupling inertias, centripetal forces and Coriolis forces.

In case of slow motion and mechanical configuration with weakly coupled sub–systems, the dynamics of the robot may not be important. But, in cases of high speed motion and strongly coupled sub–systems, a complete analysis of the dynamics of the system is necessary (14). In view of the fact that high speed manipulation is always required in most industrial applications, a thorough understanding of robot dynamics, and the development of a fast and accurate computational scheme are necessary. Conventional techniques have simplified dynamics by dropping or linearizing terms, or have proposed table look–up techniques.

Paul (3), using the Standford Arm as illustration, has shown the steps involved in deriving the robot motion equations by Lagrangian Formulation. This classical method, although the most accurate one, involves very tedious and complex computation, and may not be appropriate for real–time control of robot. Luh et al. (6) have presented a new method based on the method of Newton–Euler formulation and is independent of the type of robot configuration. A recently "recursive" recurrence formulations of the dynamics equations have also been developed by Hollerbach (5), that the computational requirement is proportional to the number of links (n).

Kane's formulation of dynamics for robot structures has also been adopted by Huston et al. (15) and Kane and Levifson (16). Featherstone (17) presented another algorithm based on recursive formulae involving quantities called articulated–body inertias. The computation requirement also varies linearly with the number of joints.

While the aforesaid developed algorithms provide for time–efficient and effective computational methods to solve the robot dynamic equation. Research in robot dynamics has to be extended in several directions. A major area is the problem of friction at the joints, because friction is the major source of the discrepancy between the model and the real world. The development of direct–drive technology by Prof. Asada at MIT helps to keep the friction and backlash low at the joints (18,19).

Other possible research studies that should be carried out may be:

– the effect of vibrations due to impact forces,

– the sizable deflections of links in comparison to the general dimensions of the robot,

– the selection of manipulator trajectories which minimize task time (Path analysis, is a large research topic by itself),

– the learning of how to exploit kinetic energy to improve the dynamics of manipulation.

– the development of improved power transmission devices.

As far as the dynamics of robots is concerned, work on the formulation of equations of motion which can be coded for rapid solutions should continue. The existing dynamic control schemes should be evaluated to select the best one from a computational point of view. In brief, simple dynamic models of robots are needed!!

5. CONCLUSION

The above discussions summarize briefly the existing knowledge and the further research needed in Kinematics and Dynamics of Robots. While solving problems in these areas, we should be aware that they are just part of Robotics, which is the field concerned with the connection of perception to action. Therefore, other important areas, such as artificial intelligence, control engineering, vision and tactile sensors technology, whose developments are also very crucial in the advancement of research in Robotics, must be examined in great depth. As for the Robotics in the near future, we should study the communications between man and robot which, at the present moment, are of a one–way nature. The desired communications between man and robot should be closed to that between humans. To this end, artificial intelligence and knowledge data base system technology should be established.

6. REFERENCE

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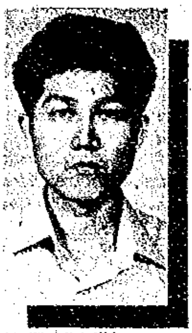
CASE STUDY

CASE STUDY — ZENITH LABEL PRINTING COMPANY



Mr Wan Pak Khiong — Proprieter Zenith Label Printing Company

Small businesses should take their cue from Zenith Label Printing Company. Undaunted by the tough times ahead, the proprietor, Mr Wan Pak Khiong, believes automation to be the key to improving his firms's competitive edge and ensuring its long term business viability.

In mapping out his firm's strategy, Mr Wan commented: "Our present manual system of spray painting does not ensure consistent product quality. Besides, with increasingly high expenses, the operation would no longer be cost effective due to low productivity and high wastage. We need to automate to become more competitive and take on bigger orders".

Started in 1979, the company has grown steadily over the years and is presently providing essential supporting services to some of the leading MNCs. In its relentless search for higher technology, the company, like many small businesses, is seriously hampered by its lack of competent technical staff skilled in analysing company's needs and assessing appropriate systems.

With the establishment of the Automation Applications Centre, (AAC) this will now be a thing of the past. A beaming Mr Wan remarked: "It was fortunate for us that AAC was just around — this allows us access to a *pool of expertise at relatively low cost*. They helped us greatly in realising our needs through better utilisation of our existing financial and technical resources".

In its first phase consultancy operation, the AAC Project Team systematically collected and analysed the company's data on its existing production systems before launching into the second phase of an application engineering study. In selecting and evaluating the appropriate robotic spray painting system, the Project Team conducted a thorough study considering such factors as' cost effectiveness of system, profit-volume analysis, product range distribution, maintenance, health and safety, delivery and installation, cycle time as well as interruption to existing production. The Project Team considered the advantages and disadvantages of the following four systems:

- automatic reciprocating spray painting system
- V feedback conveyor robot system with circular oven conveyor
- 180°C turntable robot system with linear conveyorised oven
- robot coupled with closed loop horizontal conveyor and oven

With the above factors in mind, the Project Team recommended the spray robot coupled with 180° turntable as the best alternative.

The Project Team was subsequently commissioned to design an improved management information system which will assist company's manufacturing control for the spray painting department. Factors such as current production level, quality control, communication patterns and the needs of the business were thoroughly analysed before drawing up the final system.

In discussing the success of this project, AAC's Technical Director, Mr James Ling, stressed on the importance of client's complete management support and commitment. Mr Ling elaborated: "As consultants, we are there to help analyse the problems and formulate the solutions. Our experience and knowledge is essential but management's understanding and cooperation is crucial".

Zenith's determination and foresight is exemplary. The message is simple — you are never too small to automate.

TRAINING & EDUCATION

EDB'S TRAINING FACILITIES FOR INDUSTRIAL ROBOTICS

Since 1983, the Economic Development Board has established several training facilities in industrial robotics & automation in collaboration with leading robot and automation manufacturers. These facilities have the following objectives:

- to integrate robotics & automation topics into the curricula of the EDB training institutions.
- to offer modular courses to engineers & technicians from industry.

The technology promotion efforts

in the above are further augmented by the design and building of automation systems around the robots with these systems serving as demonstration of feasible robotic applications.

The ultimate objective is hence the promotion of the implementation of robotics and automation systems in industries in Singapore via training, project work and demonstrations.

Organised within the Manpower Division of the EDB are the training facilities formed to date in co-operation with ASEA AB of Sweden, SEIKO of Japan and Sankyo Seiki also of Japan.

The ASEA-EDB Robotics Training Unit (AERTU) was operational since June 1983 and is located within the German Singapore Institute. Its original facilities of 11 vertically articulated robots have since been updated to now include SCARA assembly robots, one 'pendulum-type' high speed assembly robot and vision systems.

The SEIKO-EDB Robotics Lab (SERL) is also located at the German Singapore Institute and has been operational since July 1985. The 10 precision assembly robots provided by SEIKO are of the cylindrical, X-Y and SCARA types. Currently, systems design and building are proceeding on these robots.

The SANKYO SEIKI-EDB Robotics Lab (SSERL) is located at the Brown Boveri Government Training Centre and has been operational since June 1985. The 5 precision assembly SCARA type robots and 11 co-ordinate type robots are currently being interfaced into prototype systems.

The Robotics Group is further augmented by two donations of robots from NEC of Japan and Volkswagen of the FRG. The 2 NEC SCARA assembly robots are at the Japan-Singapore Technical Institute while the Volkswagen vertically articulated robot is at German Singapore Institute. Courses for the industry conducted by the Robotics Group range from programming and application courses (involving both assembly and vertically articulated robots) to interfacing courses and specialised courses in welding applications. Two to three courses are conducted each month and todate more than 700 industry participants have attended courses there. The courses conducted at the facilities include:

Introduction to Robotics & Programming
(including assembly robot operations)
Applications & Interfaces in Robotics
Robotics — Projects Engineering
Automation with Vision Systems
Assembly Robot Operations

NTI STEPS UP ITS TRAINING ON AUTO — MATION & ROBOTICS

With the widespread use of robots in highly automated industries, interest on their design & fabrication is increasing alongside with knowledge gained on their applications and limitations. At the Nanyang Technological Institute, it has been envisaged that the science of robotics within the broader field of automation will benefit local engineers in post-application design. Furthermore, high technology industries with plans to fabricate robots and interface them with other automated equipment will stand to gain by having a fundamental course on robot design and control.

The 50 hour course on Automation and Robotics will be taught for the first time to final year students. Amongst the topics covered in the first 26 hours will be spatial analysis of objects in 3D, principles of prime movers and their construction and programming through electronic interfaces with special emphasis on microprocessor control. The concepts of robot standards and safety as well as its economic justification and implementation in sunrise industries are also included. The next 22 hours are devoted to low-cost automation — a field that finds ready application, particularly in Singapore's numerous small sized, batch production industries. The use of sequencing using programmable logic controllers in designing pick and place devices/orientations may be more readily financed by small firms as opposed to sophisticated robots. Linear and non-linear (real world) analysis of controlling multi-variable systems in state-space domains. An introduction to digital systems and sampling, lays the foundation to designing suitable sensor signal lines, vital in complex automated controls.

This new course also looks into future emergent technologies — such as vision and voice systems for automatic inspections/assembly. The role of robots in islands of automation such as FMS work cells are reviewed with the trend towards computer integrated manufacturing.

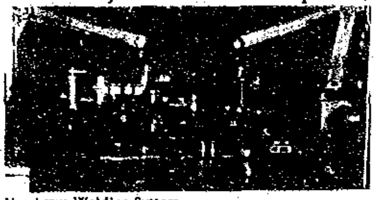
PRODUCT NEWS

WELDING SYSTEMS FOR AGRICULTURAL MACHINES

In Oct, 1984 YASAKAWA Electric Mfg. Co., Ltd. produced the arc welding system, which was available for the multi part production line for the Japanese agricultural machine manufacturing company. This total system includes: 7 pairs of 5 axis prosthetic type robots: Motoman-L10W, digital interface control, CO_2 welding power source, wire feeder, filler metals, welding torch holders with shock sensor, torch, large and small size jigs, jig stockers, chain conveyors and control console.

All the robots are being used to weld agricultural machine parts including frames and chassis. Workpiece jigs are positioned in the stocker having a rack construction and is operated by means of an external signal. Workpieces are transported by the chain conveyor in welding station and the workpieces are manually set. After welding, the operator takes out the workpiece and the workpiece jigs are transported by the chain conveyor to the stocker again.

The full electric industrial robot, Motoman-L10W, consists of a welding robot proper, numerical control unit YASNAC-RX and teaching pendant. It has the largest working area in its class. Smooth, high speed torch movement is accurate within ±0.2 m/m. YASNAC-RX has a modular construction. All faults should in principle be repaired by replacing defective units or modules. In a conventional welding system, based on teaching-play back type robots, welding torches may unavoidably collide with work-pieces,



Yasakawa Welding System

welding fixtures, etc, occasionally, causing damage to the robot, torches, or torch holders, and as a result, torches and torch holders are deformed. The teaching program must be corrected each time this happens. This is not only dangerous to the working personnel, but also detrimental to the operational efficiency of the welding process. The welding torch holders with shock sensor is designed not only to enhance operation safety of Motoman systems, but also to protect the Motoman proper and the teaching program from troubles due to collision, as well as shortens the repair time in eventual collision cases. So far this device has been very successful.

INTELLEDEX — A More Intellegent Approach to Automation

Technological progress is swift in the fields of robotics and computer vision systems. Intelledex sets the pace with a major commitment to research and development, supporting on-going work in robot, vision and end-effector design.

Intelledex robots are designed as peripherals for computers. They can be programmed off-line, away from the factory floor, to reach points with exceptional precision. This capability is called Accuracy. It results in significantly less time required for on-line teaching of each point. It enables progress to be downloaded from a host computer directly to the robot controller, facilitating the Computer Integrated Manufacturing (CIM) technology of the the future.

There's a special system in Intelledex's robots for end-effector control, with electronics integral to the mechanical arm enabling easy implementation of force-feedback or other

Intelledex Robot —
with Intelligence and Communications capabilities to manage an entire work cell

sensors in end-of-arm tooling.

Intelledex's current range of Models 405, 605 & 705 robots are all driven by the same powerful controller with the intelligence and communications capability to manage an entire work cell. Further, its IntellecVue 200 Computer Vision system is a plug-in option for robot guidance. It is equally well suited for stand-alone inspection tasks, with gray scale vision processing, windowing, erosion and dilation and other advanced features.

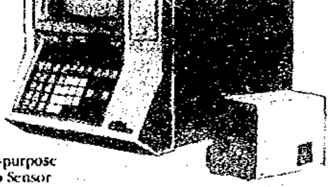
The communications capabilities are broad and powerful, intended for implementation in a CIM environment: RS-232C, 8-bit parallel ports, SECS-II, IEEE-488 and expandability to a maximum of 256 opto-isolated I/O lines for controlling ancillary equipment in the workcell.

These products represent the next generation of intelligent automation equipment — machines uniquely designed for the specialised tasks found in high-technology industries.

EFFICIENT INSPECTION WITH MULTI-WINDOW VIDEO SENSOR

Fuji electric has introduced the "multi-window" video sensor to assist the industries with automated visual inspection. Fuji has also developed standard and exclusive type application devices that match diversified needs.

In connection with this, users are planning to set up automated systems of production lines utilising the image processing technologies of devices such as the video sensor. Under the circumstances, a programming device which can be used freely according to the purpose of application has been strongly demanded instead of a device used for programming according to the specification of users' lines. (visual inspection, classification, etc) Fuji's "multi-window" video sensor requires no special programming technologies and can be used for a wide application like a personal computer. This video sensor is now operating in many lines. A variety of optional functions are also available for increased application range.



Fuji
Multi-purpose
Video Sensor

Visual inspection is indispensable for every line. It is required not only for production lines which need to be inspected by a number of inspectors but also for lines which have to be inspected by a workman while operating machines.

Visual inspection can be functionally classified as follows:

Appearance inspection —
inspection of the appearance of product for dimensions and entry of foreign objects.

Inspection of defects —
inspection of appearance for presence of flaws and deposits of dirt and dust.

Sorting & classification —
sorting into several groups by shapes, symbols and other features.

Verification of characters, etc —
checking of manufacturing date, type symbol, other specifed patterns.

Record of characters, etc —
check of weight, and characters and symbols which may be changed at random in complex lines.

Monitoring of status —
monitoring of status of materials and half-finished goods which changes momentarily during process control.

The multi-window case checker is an application that will be useful to many industries as it allows for automatic surface checking without contacting the object. The checking takes place when the case is moving on the conveyor and a bad case is automatically rejected. A high checking speed of 0.1 second can be achieved.

PROCESS NEWS

FORD ADOPTS FLEXIBLE APPROACH WITH BLOCK TOOL SYSTEM

During the last few years the Ford Motor Co transmission factory at Blanquefort, Bordeaux has been transformed from a conventional machine shop to a show-case of how rational, mass production is performed with flexible machining.

With 1.3 billion Francs invested in CNC techniques, new machining methods and modern, rational tool handling technology, the Ford Bordeaux plant is geared towards high-capacity and high-flexible machining for new and future demands in production.

The company is now completing its second phase of modernising production, investing an additional 1.2 billion Francs for the manufacture of a new 5-speed continuous automatic transmission, the CTX.

Block Tools System makes it possible to automise the production cycle in this line of IT front lathes.

From manufacturing two transmissions types, the production has had to be adapted to a bigger number of variations and models. Today 27 types are manufactured and assembled in the Blanquefort transaxle factory. The production and methods engineers at Ford Bordeaux have had to take a new approach to production techniques, tool management and machine-tool technology.

"With our earlier production mixture, big series and few batch changes, it was no problem for us changing batches once a month or so. But to do it maybe twenty-five times would create problems and expensive down-times", explains Mr Daniel Birebont, process and design supervisor in manufacturing engineering department.

Under the new circumstances more attention has to be paid to increase flexibility and capacity utilisation. Modern machining methods and rational tool handling technology were two main factors that Ford focussed on.

A significant part of this flexible machining is today performed in some 60 CNC lathes in the two machine shops. In these, the company can turn out components for the assembly of up to 4,800 transmissions a day or over one million per year.

"But leaving the re-tooling of our plants with merely introducing CNC would mean incomplete use of capacity. We would still have been faced with long tool changing times if using conventional, rigid tooling", says Mr Claude Flamant, process and design supervisor in manufacturing engineering department.

With the use of Sandvik Coromant's Block Tool System, the tool-changing time has been reduced by 3-5 times. According to the estimations of the Ford Bordeaux people, the improvement in machine utilisation is due one third to CNC techniques, one third to automation of material handling and control, and one third to the Block Tool System.

The tool handling at Ford Bordeaux is adapted to a special system, where each set of tools comes in a box. At the end of the shift all the cutting units on a turret are changed. The used units are in their box for insert change, cleaning, measuring and marking.

Thanks to rationalised tool handling much has already been gained in production rationalisation and flexibility. In the machine shop for automatic gear-boxes there is, for instance, a line of four Salome lathes, and that line is served by only one operator — for feeding the automated system with work-pieces and to survey the production flow. Workpiece control, loading and unloading of the machine is done by gantry robots, transportation of components is also done by automatic equipment. Tools are changed at the end of the shift.

The next step towards complete automation in the flexible production development — and automatic tool changing — is already in the mind of the management.

"Block tools have become an established tooling system to us and it offers us the advantages of flexibility, increased capacity utilisation and options for automation in the future", says Mr G Levy, Bordeaux operations General Manager.

The latest 1.2 billion Francs investment for the next CTV Transmission production is clearly geared towards this direction.

MELCO DEVELOPED SEMI CONDUCTOR COPPER WIRE BONDING TECHNOLOGY

Mitsubishi Electric Corporation (MELCO) has succeeded in developing the world's first copper wire bonding technology applicable to mass production of semiconductors. This technology is suitable for use in mass production lines and, when compared to conventional gold wire bonding, the new technology will facilitate production of more reliable semiconductors.

In semiconductor chips in molded packages, currently the most commonly manufactured type, gold wire bonding is used for connecting the chip electrodes with outer leads. But when the chips are used at temperatures surpassing the highest allowable ceiling for gold wire, the aluminium electrode tends to enlarge, resulting in disconnection.

Therefore, to achieve long-term reliability and increase chip life in high temperature environments, it is important to curb enlargement of the joining section. In view of the considerably slower speed of enlargement of the section joining a copper wire and an aluminium electrode, MELCO has developed a new copper wire bonding technology, featuring mass production capability similar to that of conventional gold wire bonding, for manufacture of more reliable semiconductors.

In addition, copper wire bonding has the following advantages:

a. higher bonding speeds can be achieved because copper has a strength when compared to its specific gravity.
b. high-temperature strength is produced by the mold package by the mold package process.
c. the electrical resistance ratio of copper is low so thinner wires can be used.
d. the material cost is less and the quality more stable.

(Source: Mitsubishi Companies Communique)

VOLVO KOMPONENTER AB — First Foundry In The World to Install A Robot

When Volvo Komponenter AB in Arvika, Sweden became the first foundry in the world to install a robot in an integrated production cell for cleaning of castings, the robot's production

Cleaning of castings by ASEA IRB 60

proved to be 30% faster, and gives a more consistent quality.

A subsidiary of the Volvo auto group, Volvo Komponenter employs 450 and produces more than 24,000 tons of castings per year — 18,000 tons of nodular iron and the rest sand castings. These become parts in Volvo autos, loaders and heavy vehicles.

About 20 employees currently clean castings by hand, the heaviest and most demanding job in a foundry. "It is getting more and more difficult to find employees willing to do manual cleaning," says Mr Pekka Nikula, project leader for the installation.

The primary obstacle to mechanization of cleaning has been the lack of a robot with sufficient precision and strength to handle the heavy components. ASEA's IRb 60 selected for the Arivka foundry can lift up to 60kg (including the gripper) and has a positioning accuracy of ±0.2mm. This lift capacity is quite adequate for the largest component handled the automated cleaning cell, a 55kg rear gearbox heavy vehicle.

Castings are fed to the robot in a new handling and hopper system developed by MHT Systems of Saffle, Sweden. The hopper holds up to 96 components at a time; components are moved to the robot automatically, and returned to the hopper after cleaning.

Explained Mr Nikula: "The hopper system lets us operate the installation unmanned at night. We load the hopper in the evening after the final shift, and the robot works all night. By morning we have a supply of cleaned castings equal to production during an eight-hour shift."

The robot works with four tools; cutting wheel, grinding wheel, chisel and rotary file. In the first step of the cleaning operation, feeders are cut from the gearbox, as the robot presses the hydraulic cutting wheel against the component.

During the next three steps, the robot lifts the 55kg gearbox and holds it up to the stationary tools. Outer edges of the gearbox are ground, and burrs inside removed, partly with the chisel, partly with the rotary file.

A major benefit of robot cleaning lies in the elimination of a heavy and demanding job for employees, and both mangement and union officials agree that robots should take over cleaning of castings.

Programming of the robot is simple. An experienced operator controls the robot in a portable programming unit. Once it has determined the simplest and fastest movement in every step, it is stored in the program memory via a single pushbutton command. Changing the programme is equally simple.

Mr Nikula declared that four or five robot lines for cleaning will be needed before the end of this decade to keep six employees per line — and they aren't able to provide the same consistent, high quality standards as the robot.

PRODUCTION TIME CUT TO A THIRD

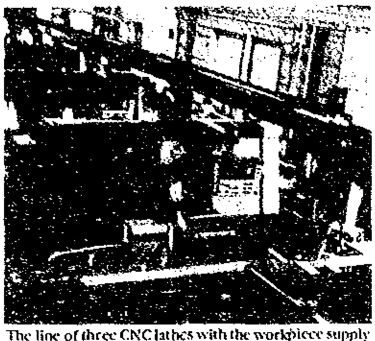
Hitachi Seiki, one of Japan's leading machine tool builders, has recently invested in a new Flexible Machining System composed of nine machining centres and three CNC lathes. Today, the FMS plant consists of three lines but four lines are planned for the future, for various types and sizes of components. The application features newly developed software techniques in work scheduling and process designing. It has also adopted automatic tool changing and tool storage for operations. The plant represents an interesting new combination of machining centres and lathes for FMS applications.

Two of the FMS machining lines at Hitachi Seiki are made up of horizontal and vertical machining centres to manufacture boxtype components for machine tools. The third line, however, has been designed for machining batches of 460 different gears. The line consists of three CNC lathes and a horizontal machining centre.

Parallel to the line of four machines there is a conveyor belt supplying workpieces. A robot in front of each machine lifts off the workpiece, placing it in the machining chuck or fixture. A gantry has been placed over the three lathes for the tool-changer to move along. With two grippers, it supplies the turrets with Block Tool cutting units from a rotary drum magazine at one end of the line. The drum holds twenty-four magazines, each with five cutting units in. The rotary drums permit a continuous supply of tools to be made available for long periods of machining without stopping any of the machines.

This line is designed for operating an optimum amount of hours per month, a much higher level compared to an alternative involving a conventional machining line. The aims behind the design of the FMS plant with these three lines were to actually develop automated technology for turning machines as well as machining centres, to rationalize production and to show potential customers what Hitachi Seiki is capable of.

The lines are run by a computer which chooses the part programmes, work-pieces and tools to manufacture specific batches. The transition from one gear type to another is automatic with the least possible production disruption. Hitachi Seiki is optimistic about their FMS plant and expects it to have beneficial effects on production rationalisation. They predict that manufacturing time will be shortened to a third of previous times.



The line of three CNC lathes with the workpiece supply conveyor to the left. A robot supplies each machine with workpieces while the tool changer gantry runs above the three machines.

INTERNATIONAL NEWS

FRANCE

Aerospatiale Plasma Torch and Metallurgy

Aerospatiale company has recently installed a 3 plasma torch system in one of the blast furnances of SOCIETE DU FERROMANGANESE of Paris. This system that works successfully is the first one of its kind in Europe, if not the world over.

The torch of Aerospatiale is the result of twenty years of research. It is possible to obtain a power of 1 to 10 megawatts per touch and thus to supply a very hot gas with 1 to 20 bars pressure.

The system is very flexible and can be adopted to any kind of industry other than metallurgy, iron and steel industry and iron alloy industry. It can also be used as a thermal drilling or welding or even cutting tools. Its electodes resists for 400 welding hours in very tough conditions. Another advantage is the saving of energy when using direct current.

(Source: Scientific and Technological News, French Embassy)

A Robot To Clean The Hulls Of Ships

A remote control robot for automatic careening of ships has just been built. It cleans the hulls to clear off shellfish and marine deposits. This Marine Robot from Normed Shipyards in Dunkerque weighs about 100 kg and because of its three legs being provided with electromagnetic suction plugs and a cleaning arm equipped with a rotating brush, it can be moved at a speed of 150 metres per hour in all directions.

Result: 5000m² of hull is cleaned per day without the ship having to be in dry dock.

Apart from cleaning, the robot will eventually be adapted for other types of work, viz. inspection and control of welding; coating and painting.

(Source: Scientific and Technical News — French Embassy)

AUSTRALIA

CAD/CAM gives manufacturers competitive edge

Australia, with other developed countries, has adopted computer-aided design (CAD) and computer aided manufacture (CAM) to compete more effectively with increased domestic and international competition.

Australia's progress in this technology is partly the result of a far-sighted decision taken in the early 1970s to set up a professional advisory body, the Association for Computer-Aided Design. This organisation acts as a clearing house for new developments in CAD/CAM technology, provides a link between the various companies working in the field, gives independent technical advice and maintains an extensive software and book library for members.

In a recent development, a CAD/CAM centre has been established by the State Government of Victoria, to service first time and existing CAD/CAM users and computer hardware and software houses.

The scale of Australia's industry is smaller than most, and thus engineers are required to have broadly-based experience and an ability to span technologies. Since both of these characteristics are particularly desirable in the software industry, this is probably a major reason why Australian firms are at the leading edge of international CAD/CAM technology.

(Source: Australian Trading News, Australian Trade Commission)

FINLAND

FMS applied to Tractor Production

The Tractor Works FMS was devised round a Valmet multiple spindle machining centre built at the Linnavuori Works and two US manufactured Kearney & Trecker machining centres. In classic Valmet style, the system was in-house designed following engineer-tuned breadboard design, rather than buying a turn-key system.

Besides the machining equipment itself, the system consists of an automated pallet conveyor system for parts pallets and pallet storage. The transposers were built by the Valmet Transportation Elevator Division in Tampere.

The FMS was designed to machine casing components such as oil pans, back plates and medium power class transmission casings.

It strives to combine the advantages of short run and long run productions. Since there are several production lots on the line at any given moment, capital tied up in inventory is minimal. The machining equipment stores present parameters for a number of parts, so adjustment times do not reduce machining time.

Throughput is rapid — at Suolahti, replacement of the multiple spindle chuck head of a machining centre takes only 30 seconds, whereas machining itself takes between three and twenty minutes, depending on the part. Parts can be detached and attached during machining.

Alterations to the construction can be made with greater freedom than in serial production. Minor revisions in the constructions do not cause extra equipment costs — only the programme needs to be changed.

In this system, assembly may be the pace setters for the FMS. All the parts needed for the assembly can be produced in an even flow with the FMS' aid.

(Source: Finnish Trade Review — Finnish Embassy)

JAPAN

Intermediate Range Robot

Robots with capabilities of around 30 kg have been identified by Japanese robot makers as an important missing link in their ranges. After concentrating on machines able to handle workpieces up to around 10 kg, some turned to the 60kg machines, but now 30kg is the target.

One reason for this is that such robots can be used to install windscreens and a number of other heavy units such as seats and batteries in cars. They are also suitable for handling television tubes and a number of the large electronic assemblies that lend themselves to automatic assembly.

(Source: Robot News International)

UK

Prototype SCARA Robot

A prototype four-axis SCARA-type robot with 1 kg payload has been designed and built at Imperial College, London, to meet the requirements of specialised pick-and-place and assembly applications.

The basis of the design of this horizontally articulated robot are the "joint modules" supplied by Harmonic Drive of Horsham. These consist of a complete joint with flanged input and output, powered through a Harmonic gearset by an integral permanent magnet DC motor. An incremental encoder is incorporated in the joint to provide angular positional feedback and the units come complete with a solid-state amplifier and power supply.

The SCARA robot has a bent-arm configuration such that the work envelope is large enough to cover a double Eurocard size PCB for possible PCB assembly applications. The end unit, providing rotational and vertical motion to the gripper, connects directly to the output flange from the elbow joint. On the grounds of cost, stepper motors have been used in the prototype robot to drive the gripper rotation and vertical motion axes, though it is envisaged that further end units will incorporate DC motors for improved performance.

Thus the mechanical manufacture of the robot is based on assembling a small number of bought-out parts and the user has a considerable degree of freedom in tailoring the robot's configuration, dimensions and performance to suit a particular application. (Source: Robot News International)

Thorn-EMI to Market Mini-Mate

A low-cost British designed and built light industrial robot with a repeatable accuracy of 1.05mm is being marketed in the UK under an exclusive agreement announced by Thorn-EMI Robotics.

The Mini-Mate is the development of Twickenham — based Reckie Research. It will be sold and supported by Thorn EMI Robotics in the UK into applications which require a high precision machine.

Typical users will be electronics companies producing complex but short-run, circuit boards. Installed in cells of up to four machines controlled by one personal computer, the robots can perform quickly and accurately — at a fraction of the cost of dedicated equipment.

"The robot lends itself particularly well to this application," said Thorn-EMI Robotics Managing Director, John Deare. "Areas of use will include light engineering applications where companies are dealing with irregular or non-compatible shapes".

The Mini-Mate is a sophisticated Cartesian design with five axes — four plus end effector — of movement. Its remarkable repeatability is a direct result of its use of two harmonic gears. Electric motors move the robot through its horizontal axes while pneumatics give the motive force for vertical and gripper movement. For electronic assembly operations, the gripper can be replaced by a sucker.

WANTED

NEW PRODUCTS?
NEW PROCESS?

We welcome any queries or comments from readers on news about automation. If you have any contributions or suggestions that you would like to see published in our next quarterly issue, write to

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CALENDAR

DATE	EVENT	VENUE
	1985 CONFERENCE & EXHIBITION	
CONFERENCE		
Oct 09-11	Robots East	Boston, USA
Oct 15-17	3rd International Conference on Automated Guided Vehicle Systems (AGVS3)	Stockholm, Sweden
Oct 15-17	4th International Conference on Flexible Manufacturing Systems (FMS 4)	Stockholm, Sweden
Oct 15-17	6th International Conference on Automation on Warehousing (ICAW6)	Stockholm, Sweden
Oct 29-31	5th International Conference on Robot Vision and Sensory Controls (RoViSec 5)	Amsterdam, Netherlands
EXHIBITION		
Nov 06-09	AUTOMATEX 85 (Exhibition on Industrial Robots, Automation & Machine-Tools) 3rd show	Singapore

DATE	EVENT	VENUE
	1986 CONFERENCE & EXHIBITION	
CONFERENCE		
Feb	7th International Conference on Assembly Automation (7ICCA)	Switzerland
Mar 19-21	3rd International Conference on Automated Materials Handling (AMH-3)	UK
Jun 03-05	3rd International Conference on Lasers in Manufacturing	Paris, France
Jun 03-05	6th International Conference on Robot Vision & Sensory Controls (RoViSec6)	Paris, France
Jun 24-26	4th International Conference on Automated Manufacturing (AUTOMAN '86)	USA
Jun 24-26	4th International Conference on Simulation in Manufacturing (SIM-2)	USA
Aug	LFA 86 (Language for Automation)	Singapore (Institute of Science)
Sep 09-11	8th International Conference on Automated Inspection & Product Control (AIPC-8)	USA
Sep 29 — Oct 2	16th International Symposium on Industrial Robots (16th ISIR)	Belgium
Oct 20-22	7th International Conference on Automation in Warehousing (7th ICAW)	USA
Nov 04-06	5th International Conference in Flexible Manufacturing Systems (FMS-5)	UK
EXHIBITION		
Nov 18-22	AUTOMASIA 86 (Automated Manufacturing Technology & Robotics Exhibition)	Singapore

CON'T FROM PG 1

What Is Automation ?

Most people regard automation as CAD/CAM and robots. In fact, automation can have various formations comprising some or all of the following features:

- Drives (electrical or hydraulic)
- Fixed automation (customised machinery)
- Control systems
- Supervisory systems
- Man/machine interfaces
- Communications networks

Uncertainty

Even with this knowledge, the decision-maker may be assailed with doubts:

- Is automation too ambitious for my plant?
- Can my staff make use of the new techniques?
- Will the system function reliably?
- How much downtime should I expect?
- Can my sales increase to match the new production capacity?

Common Sense Approach

Anyone confronted with a new idea or unfamiliar concept owes it to himself to seek the best advice available. He should turn to a proven, reputable and well established organisation which can provide:

- Thorough feasibility study
- System analysis
- System design
- Installation
- Commissioning
- Staff training
- Documentataion
- 24-hour after-sales service
- The certainty that you will be able to work with your supplier for years to come.

If you find yourself discussing automation with a company that does not offer this comprehensive range of services, be sure to redirect your search to a more professional supplier.

Penalty Of Second-best Advice

There can be high penalties for taking your first step towards automation in the company of "second best" partners. Initially, you might be tempted by their lower start-up costs but, ultimately, you will find yourself paying for system inconsistencies and long term constraints which the supplier failed to anticipate. By that time, a high proportion of your production capacity may rely on badly planned systems.

One other common error made by the inexperienced is that no provision is made in the start-up investment for longer term flexibility.

Flexibility

Manufacturers have to be prepared to adapt products (or to introduce new products) to meet changing market demand in the years ahead. In the same way, his automated manufacturing system must be capable of change, adaptation and expansion. He should be able to start with a small control system or robot and add new units when the need arises.

Failure to build in this type of flexibility at the outset ignores the certainty of demand for product changes, system changes and technological developments in automation in the next few years.

So it pays to work with experts now so that even if your present needs are limited - changes can be made to the system purchased by your start-up investment. Thus, headaches and excessive costs can be avoided should you need to reorganise, reprogramme or expand.

"Talking" Units

One essential ingredient of flexibility is that the units you buy today must be able to exchange information and to co-operate with each other. In short, your first system needs an adequate communications network. One benefit, for example, might be a control system which monitors your production processes to provide information like

- shift reports
- units produced
- uptime per unit
- production stops
- event list
- alarm list

Imagine what would happen if (by taking short cuts to make false savings) you chose to buy a number of incompatible units from different vendors. In no time at all, you would be having interface problems. If automation units cannot "talk" to one another, they can hardly co-operate in your production processes.

Service Support

Let's assume that one of you evaluates and buys automation for your plant's three-shift operation.

You have estimated that the whole system will pay for itself over a 3-year period. So far, so good – but have you included the servicing factor?

Machines, like human beings, have their breakdowns but the medical leave of one employee has minimal impact compared to the shattering impact of a problem affecting an automation system upon which you rely 100%.

The answer, yet again, is to make sure that you are dealing with an established supplier who can guarantee you round-the-clock servicing capability, seven days a week. Better still, a supplier with whom you can sign up a service agreement – backed by sophisticated preventive maintenance checks and guaranteeing maximum show-up time after their team's visits to your plant.

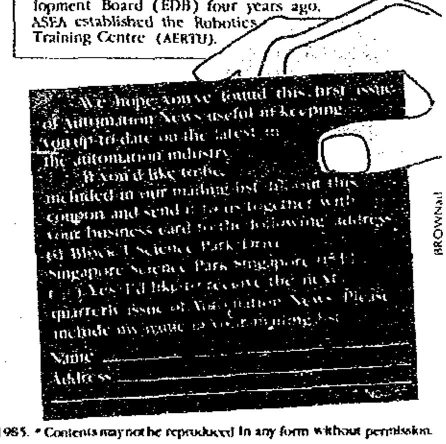
Automation Recap

- Take great care in selecting your supplier
- Choose an established organisation offering a broad range of compatible products and back-up services
- Stay with one supplier and develop a close working partnership with that supplier
- Start with a thorough feasibility study
- Start modestly, one step at a time. Automate one part of your operation and gain experience as it proves the cost/quality effectiveness. Never buy less than you need. Never buy an inferior product simply because it appears to offer a short term cost saving.
- By pre-planning, prepare your organisation for the phased changeover to FMS. Attrition over a period of time can minimise the need for retrenchment. For high calibre employees remaining, be prepared to explain the reasons for change and help staff to understand the benefits in job security and job enrichment offered by the new systems.
- Insist on a supplier that offers you full co-operation in system analysis, design and implementation; installation; commissioning; training; and a comprehensive 24-hour after sales service.
- When part-automation has earned your confidence, be prepared to develop your FMS capability. Avoid buying incompatible automation units, piecemeal, from different vendors. If units cannot interface – or "talk" each other – they cannot co-operate in the total production process.

The best suppliers can be your partners in a real sense. Choose well and that partner can help expand and accelerate your production capacity and product range – ensuring job enrichment for your workforce and regaining your competitive edge in the market. Step by step, that means a return to stable profit.

The writer of our automation feature story is Jorgen Centerman – Managing Director of ASEA Singapore. Mr Centerman has held marketing management posts for ASEA Electronics for which one of the spearhead products is the MASTER System for process control and factory automation. A Master of Science graduate in electronics from Sweden's University of Lund, he arrived in Singapore with his wife and two children earlier this year.

ASEA was founded over 100 years ago and currently ranks amongst the world's top ten electrical companies. It is Sweden's largest electrical and nuclear power equipment group and one of the world's leading robotics company. The ASEA Group employs over 59,000 people worldwide. ASEA-Singapore, a wholly owned subsidiary, was founded in 1970 with headquarters in Jurong for its manufacturing, engineering, marketing and service operations. The company has been restructured to match Singapore's increasing emphasis on high technology, automation and skills transfer. In a joint venture with Singapore Economic Development Board (EDB) four years ago, ASEA established the Robotics Training Centre (AERTU).



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付属資料(18)

1986年9月

シンガポールの概況

——主要指標を中心に——

☆☆

＜目　　次＞

☆☆

在シンガポール日本国大使館

EMBASSY OF JAPAN, SINGAPORE

・概　　要

面　　積	６２０．２平方ＫＭ（ほぼ淡路島と同じ大きさ）
位　　置	東径　　１０３度３８分－１０４度０６分
	北緯　　　１度０９分－　１度２９分
気　　温	日中の平均最高気温　　　３０．８度
	日中の平均最低気温　　　２４．０度
	年間雨量　　　２．６８７ＭＭ
人　　口	２５２万９千人（うち２５歳未満４６．１％）　＜８４年年央推計＞
	中国人系　　　１９３万５千人（７７％）
	マレー人系　　　３７万４千人（１５％）
	インド人系　　　１６万３千人（　６％）
	その他　　　５万７千人（　２％）
人口増加率	１．１％（参考：１９６０年＝３．５％）
国　　語	マレー語
公 用 語	マレー語・中国語・英語・タミール語
宗　　教	仏教・回教・ヒンズー教・キリスト教・道教
教　　育	義務教育なし（６－４－２－３制） （就学率：小学校約１００％、中学校約８５％、高等学校約２３％）　＜１９８３年
識 字 率	約８４％（このうち、２カ国語以上話せる者３８％）

国民の祝日（１９８５年）

新　　年	(NEW YEAR DAY)	１月　１日（火）
*春　　節	(CHINESE NEW YEAR)	２月２０、２１日（水、木）
キリスト受難日	(GOOD FRIDAY)	４月　５日（金）
メイ・デイ	(LABOUR DAY)	５月　１日（水）
ベサク・デイ	(VESAK DAY)	６月　３日（月）
*ハリ・ラヤ・プアサ	(HARI RAJA PUASA)	６月２０日（木）
建国記念日	(NATIONAL DAY)	８月　９日（金）
*ハリ・ラヤ・ハジ	(HARI RAJA HAJI)	８月２６日（月）
ディ・パバリ	(DEEPAVALI)	１１月１１日（月）
クリスマス	(CHRISTMAS)	１２月２５日（水）

II．政　　治

独立年月日	１９６５年８月９日
政　　体	共和制
政治理念	民主社会主義
元　　首	大統領（ウィー・キム・ウィー）
行政府	内閣（閣僚　１２名）
首　　相	リー・クァン・ユー
立法府	一院制議会
議席数	７９（普通小選挙区制）
議員任期	５年
政　　党	人民行動党（ＰＡＰ）・・・・・・オン・テン・チョン党首 リー・クァン・ユー書記長 社会主義戦線、労働者党、他（共産党は非合法）
国　　防	英・豪・ＮＺ・マレーシアと５カ国防衛取極に依拠する他、徴兵制による自国軍を保有する。
軍事力	陸軍（４５，０００人）　予備役（１５０，０００人）　海軍（４，５００人） 空軍（６，０００、作戦機１６７機）　＜８４－８５　ミリタリー・バランスによ
外　　交	非同盟中立。　ＡＳＥＡＮの結束を重視
地方制度	なし

内　閣　（１９８５年９月現在）

首　　相	リー・クァン・ユー
上級大臣（総理府担当）	Ｓ．ラジャラトナム
第一副首相兼国防相（首相不在の場合は首相代理）	ゴー・チョク・トン
第二副首相	オン・テン・チョン
法務相	Ｅ．Ｗ．バーカー
国家開発相	テー・チャン・ワン
外相兼社会開発相	Ｓ．　ダナバラン
教育相兼商工相	トニー・タン
環境相	アハマッド・マッター
通信情報相兼第二国防相	ヨー・ニン・ホン
内務相兼第二法務相	Ｓ．　ジャヤクマール
蔵相兼保健相	リチャード・フー
労働相（代行）	リー・ヨク・スアン

III．経　済（単位＝USドル）

（1）概　況

国内総生産（GDP）	16，323百万ドル
国民総生産（GNP）	17，728百万ドル（1人当り7，010ドル）
実質経済成長率推移	80年　81年　82年　83年　84年 10．2%　9．9%　6．3%　7．9%　8．2% 85年上半期　（第1四半期）　（第2四半期） 0．6%　（2．7%）　（△1．4%） （70年代の平均実質経済成長率：9．4%）
GDPの産業別構成	農漁業（1%）　製造業（20%）　建設業（ 9%） 商業・ホテル・レストラン（23%）　運輸・通信（21%） 金融・保険（21%）　その他（5%）
主要製造業	石油精製業（付加価値額で全製造業部門の14．1%） 輸送機械（　同　上　の 9．5%） 産業機械・電子電器機械（　同　上　の32．9%）
国際収支	1，487百万ドル　黒字（総合収支）
外貨準備残高	10，471百万ドル
対外債務残高	295百万ドル

（2）貿易・投資

輸出額	84年	23．632百万ドル	（対前年9．1%増）
	85年上半期	11．959百万ドル	（対前年同期2．7%増）
輸入額	84年	28．140百万ドル	（対前年0．8%増）
	85年上半期	13．767百万ドル	（対前年同期1．6%減）

輸出の主要国地域別シェア		84年
	（1）米国	20．0%
	（2）マレーシア	16．2%
	（3）日本	9．4%
	（4）香港	6．2%
	（5）タイ	4．8%
	（6）オーストラリア	3．4%
	EC	9．7%
	ASEAN（除くインドネシア）	23．1%

			84年
輸入の主要国地域別シェア	(1)	日　　本 ・・・・・	18.3%
	(2)	マレーシア ・・・・・	15.0%
	(3)	米　　国 ・・・・・	14.6%
	(4)	サウジアラビア ・・・	9.3%
	(5)	中　　国 ・・・・・	4.7%
	(6)	台　　湾 ・・・・・	3.3%
		E　　C ・・・・・	10.0%
		ASEAN ・・・・・ （除くインドネシア）	18.6%
輸出の商品別シェア		石油及び同製品 ・・・	25.3%
		電気機器 ・・・	11.9%
		通信器機 ・・・	6.2%
		オフィス・データ機器・・・	5.2%
		天然ゴム ・・・	4.2%
国産品輸出の割合		64.4%	
輸入の商品別シェア		石油及び同製品 ・・・	27.7%
		電気機器 ・・・	10.4%
		輸送用機器 ・・・	4.1%
		一般機械 ・・・	3.8%
		通信機器 ・・・	3.8%

主要外国投資残高シェア（83年央）	米　　国 ・・・・	1.601百万ドル（33.1%）
	日　　本 ・・・・	966百万ドル（20.0%）
	英　　国 ・・・・	760百万ドル（15.7%）
	オランダ ・・・・	699百万ドル（13.8%）
	西　　独 ・・・・	109百万ドル（ 2.2%）

3 物価・雇用・賃金

消費者物価上昇率	83年　1．2%　84年　2．6%　85年上期　0．4%
卸売物価上昇率	83年　△3．7%　84年　△0．6%　85年上期　△1．5%
労働力人口	1，207千人（うち就業者数　1，175千人）
産業別労働力構成	製造業・・・・27．4% 商業・・・・22．5% 地域・社会・個人・サービス・・・・20．6% 運輸・通信・・・・10．4% 金融・保険・・・・8．6% 建設・・・・8．5% 農水産業・その他・・・・1．9%
失業者数	32．5千人
失業率	2．7%
平均実収賃金（週当り）	約116．3ドル（＝252．7シンガポールドル）
賃金上昇率	平均9．2%　（84年勧告はS$27＋4%－8%） （参考：85年勧告は3%－7%）
労働生産性上昇率	82年　1．1%　83年　5．0% 84年　6．7%　85年上期　3．6%
労働組合員数	192千人（組織率　16．3%）
ストライキ件数	0件（労働損失日数0日）<1978年以降>
日系企業の雇用労働者数	約7万人（推定）

4 財政・金融

予算額（84年度）	8，724百万ドル
歳入構成	直接税・・・・25．6% 間接税・・・・11．9% 借入金等・・・・23．7% その他・・・・38．8%
歳出構成	国防司法・・・・14．9% 社会公共サービス・・・・45．2% 経済サービス・・・・20．5% その他・・・・19．4%
通貨	シンガポール・ドル（変動相場制） 1US$＝2．1725S$（84年12月平均）
マネーサプライ（M1）	4．081百万ドル
アジア・ダラー市場規模	1，326億ドル　（85年6月末現在）

（5）運　輸　・　通　信　・　観　光

年間寄港船舶数 （75NRT以上）	26，468隻　（内、日本国籍1，457隻）
年間港湾貨物取扱い量	104．2百万トン
年間寄港航空機数	35，327機
登　録　船　舶　数	1，555隻　　　6，860千総トン
登録自動車台数	491，322台（内、私用車217，119台） （約5．2人に1台保有）
電　話　台　数	1，002，631台（約2．5人に1台保有）
年間観光客数	82年　2，957千人　83年　2，854千人　84年　2，991千人 （85年上期現在の対前年同期比　2．8％増）
年間主要観光客数	日　本　370千人 インドネシア　304千人 オーストラリア　291千人 米　国　177千人 英　国　150千人

（6）建　設　・　住　宅

建　設　投　資　額	5，242百万ドル（対前年6．7％） 公共部門　48．9％（対前年　9．1％） 民間部門　51．1％（対前年　4．6％）
目的別建設投資額	住　宅　建　築　2，854百万ドル（対前年　16．1％） 非住宅建築　1，865百万ドル（対前年　△6．1％） その他建設工事　524百万ドル（対前年　12．0％）
公共住宅居住 人口比率	78％（84年3月）

（7）日本からの経済協力

有償資金協力	127．4億円　（累計　70年－73年）
無償資金協力	29．4億円　（67年）　　12．1億円　（83～84年）
受入研修員数 （JICAベース）	1，401名（累計1954年度－83年度実績）
派遣専門家数 （JICAベース）	377名　（　同　上　）
技術協力費合計	86．9億円（累計1954年度－84年度実績）

ＩＶ．在留邦人関係

日本人会会員数 （85年７月25日現在）	個人会員	２，７１５人（その他家族　４，６２８人）
	法人会員	５６２人
	会　友	４５３人
日本商工会議所会員数	４６７社　（８５年９月１０日）	
日本人学校児童・ 生徒数	２，０３５人　（うち、中学生　４２３人、　小学生　１，６１２人） （８５年９月　２日現在）	
日　系　企　業　数	６５５社　（含、駐在員事務所、８４年１０月１日現在）	

（注１）　シンガポール・ドルのＵＳドルに対する換算率は、１９８４年１２月平均レート（１ＵＳ＄＝２．１７２５Ｓ＄）

（注２）　計数については、特に注記のない限り、１９８４暦年末現在である。

JICA