OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

RESTRICTED

17772

DP/ID/SER.A/1259
2 October 1989
Original: ENGLISH

ASSISTANCE IN FORMULATING A DETAILED IMPLEMENTATION PLAN FOR THE ESTABLISHMENT OF A SEMICONDUCTOR TECHNOLOGY CENTER

SI/MAL/88/801

MALAYSIA

Technical Report: Feasibility Study on the Implementation of Malaysia Semiconductor Inc.*

Prepraed for the Government of Malaysia
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

Based on the work of G.P. Fandrich
consultant in semiconductor technology

Backstopping Officer: C. Gürkök, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

*This report has not been edited.

V.89-59669

TABLE OF CONTENTS

ACKNOWLEDGEMENT

I would like to acknowledge the assistance, cooperation and advice rendered to me by the various government and statutory bodies such as MIDA, MEXPO, PNB, FMM and the local UNDP office, to mention just a few. Especially, I appreciate the guidance given by Prof. Dr. M. Zawawi Ismail of UKM as well as Dr. Tengku Mohd Azzman Shariffadeen and his colleagues of the MIMOS management team. The staff seconded me from MIMOS also contributed in no small way to the successful completion of this project study. My sincere thanks to all these people.

LIST OF FIGURES/TABLES

PURPOSE AND SCOPE OF THIS PROJECT

One of the recomendations given in a prior UNIDO - study was the 'Writing of a business-plan' for a joint venture Semiconductor Wafer Fabrication project in Malaysia.

In this respect, this draft of a business plan was written to have a base for discussions with possible technology licensor partners. The structure and outline of this plan follows the guideline of PNB(Permodalan Nasional Berhad), one of the goverment investor groups.

It will be inevitable to revise this plan together with the licensor, using his actual key figures as "average industry figures" could be used only.

On the other side, this plan was a useful tool in discussing this project with interested private Malaysian investors as well.

Furthermore, possible licensors in the US, Europe and also Taiwan have been identified and additional actions will be required as specified under Chapter V.5, "Recomendations".

INTRODUCTION

The coverpage of this feasibility study and Fig. 1, next page show the long term development of the semiconductor industry which only by 'outsiders' can be considered as 'risky'. There isn't an industry sector alike with a similar growth pattern over the last decade and thus a potential for the rest of the century.

As the Honorable Datuk Seri Rafidah Aziz, Minister of Trade and Industry stated in her opening address at the 'Internepcon Semiconductor International '89' in Kuala Lumpur on July 21st 1989:

"The Semiconductor Industry appeared as the basic bricks necessary for the whole of the Electronic Industry and its operation. Consequently, it has had an impact on the whole industry which at the same time is becoming very important in respect of all other industries. In this sense this industry can be considered as STRATEGIC. The Government realises that as the pace of electronic technology advances and expands even further into almost all aspects of economic activity, there is a need to generate a special industrial strategy for the **Age of Electronics** in order for the country to participate in the rapid development of the industry worldwide and to remain internationally competitive, as the technology of microelectronics itself is rapidly diffusing into all economic sectors."

It was concluded from an earlier study tour by a MIMOS group and a market study done on behalf of the UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION that the high investment now needed to establish a semiconductor technology facility best would be solved by a joint venture approach. This study reinforced the belief, that the set-up of a Semiconductor Technology Facility is an essential component in assisting Malaysia to become **the industrial leader** in South East Asia. The use and applications of microelectronics in practically all manufacturing industries will determine the country's competitiveness and therefore its future growth. Having access to the core technology in microelectronics will be most advantageous in supporting the National Industry.

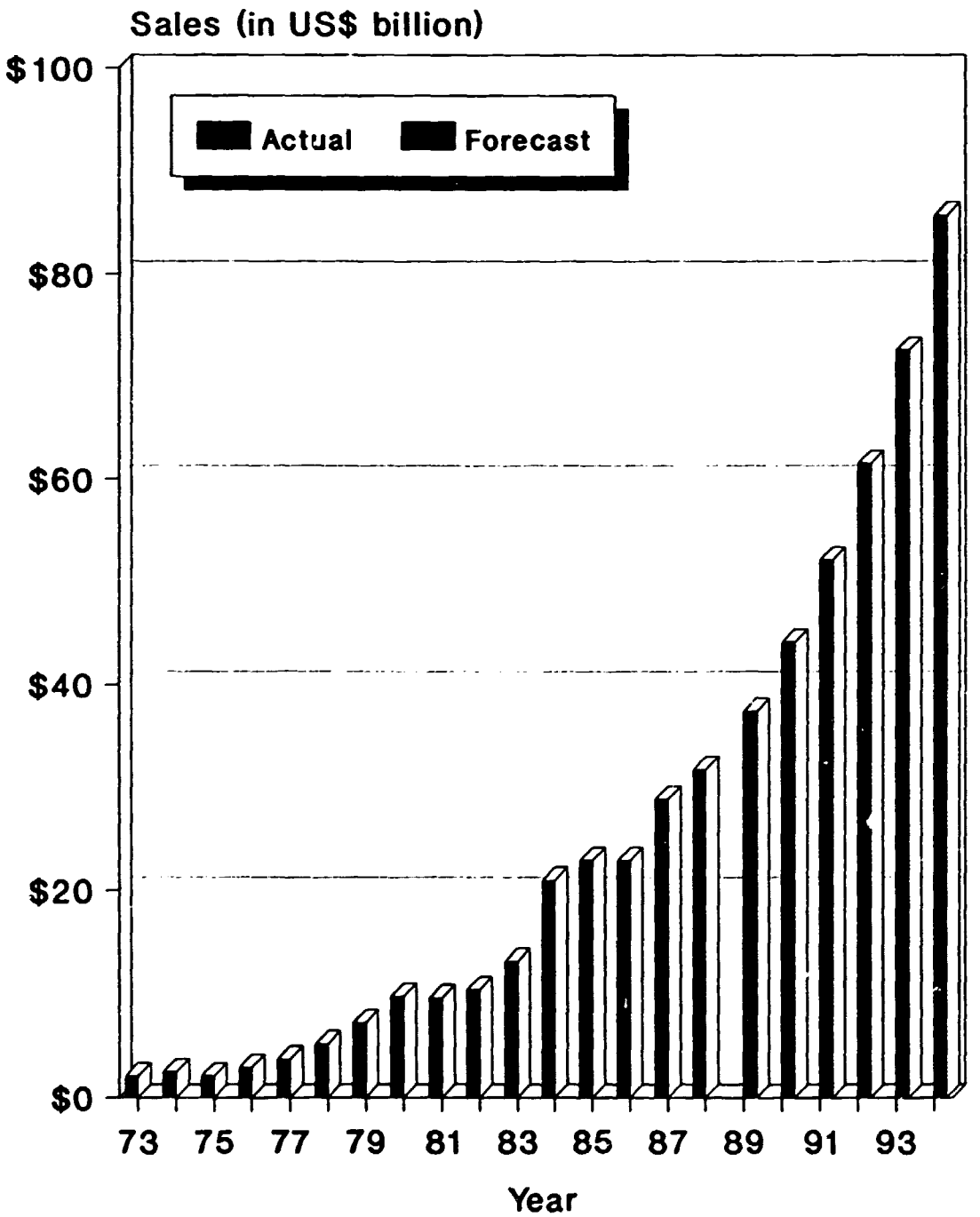
Keeping this strategic importance in mind, it is the **COMPANY OBJECTIVE** to become:

The first high technology semiconductor company in Malaysia to create, make and market 'State-of-the-Art' INTEGRATED CIRCUITS with a totally 'MADE IN MALAYSIA' label.

BUSINESS PROFILE

Primary:	New design including finished Silicon and/or packed, tested product.
Other:	Design only Silicon Foundry through unprobed or probed wafer Silicon Foundry through packaged, tested product

WORLD IC MARKET



MIMOS Aug, 1989

Fig. 1

EXECUTIVE SUMMARY

The results of a market study done on behalf of UNITED NATIONAL INDUSTRIAL DEVELOPMENT ORGANIZATION earlier this year reinforced the belief, that the set up of a Semiconductor Technology Facility is an essential component in assisting Malaysia to become THE INDUSTRIAL LEADER in South East Asia. The use and application of microelectronics in practically all manufacturing industries will determine the country's competitiveness and therefore, its future growth. Having access to the core technology in microelectronics will be most advantageous in supporting the National Industry.

In order to develop this important project without recourse to Government Funds the incorporation of "Malaysia Semiconductor" is suggested, which would be responsible for the financing and implementation of the project. Carsem, Sapura and HITI Engineering (M) Sdn Bhd as private Malaysian investors have indicated strong interest to become shareholders joining in with Permodalan Nasional Berhad or any other government investor group. To get the project under way a project team has to be set up within the 4th quarter 1989 consisting initially of members from MIMOS, the investor group and a UNIDO consultant. The first task should be the selection of a licence partner, licence negotiations and a licence agreement followed by the entire implementation of the project.

This 'business plan' covers all aspects of setting up the first high technology semiconductor company in Malaysia, which unlike all other in the country would produce and marked integrated circuits with a totally 'MADE IN MALAYSIA' label. Design, basic silicon wafer fabrication, packaging and testing till the finished product will be done in Malaysia in a joint venture effort. This joint venture company will finally give the country access to the core technology in semiconductor manufacturing, increase the value added from today's 15% towards 50-60%, substitute largely import of semiconductors and open up new export opportunities.

The 'product niche' approach selected might very well make MSC-Inc the first South-East Asia vendor offering this state-of-the-art-semiconductors.

Detailed castflow-calculations for 3 alternative investment levels (US$50, 60, 75 millions) and sales projections have been carried thru, showing a break-even as early as 3 years, 3 months after productions start.

Alternative 1 is the most likely to be pursued. Except for 3-5 positions during the start-up-phase of 2-3 years all other positions can be filled with local personnel. This high technology plant will create more than 700 jobs for professionals and highly skilled personnel.

Time is the most crucial factor in the extremely rapid changing Semiconductor Technology. It is therefore RECOMMENDED:

> **To form a project team within September, 1989 consisting of members from MIMOS, the investor groups and an UNIDO consultant with the first task being the selection of possible licence partners, concrete licence negotiations and a licence agreement concluded within the first quarter, 1990, followed by the implementation of the entire project right thereafter.**

I. TECHNICAL VIABILITY

1. CMOS (Complementary Metal-Oxide Semiconductor) Technology

In recent years CMOS has become the most pursued technology of VLSI design due to economical and technical benefits.

Comparatively, it consumes much less power with a high performance/speed and easiness in circuit design. While improvements have been made at reducing the chip area, power consumption has remained minimal which results in a lower overall costs of production.

2. Wafer fabrication process/IC manufacturing

The major steps required to fabricate wafers into chips and to produce complete Integrated Circuits(ICs) are illustrated in the following flowchart. The wafer processing steps which can be regarded as a series of repetitive process can amount to more than 150. Briefly, the operations consist of the following:

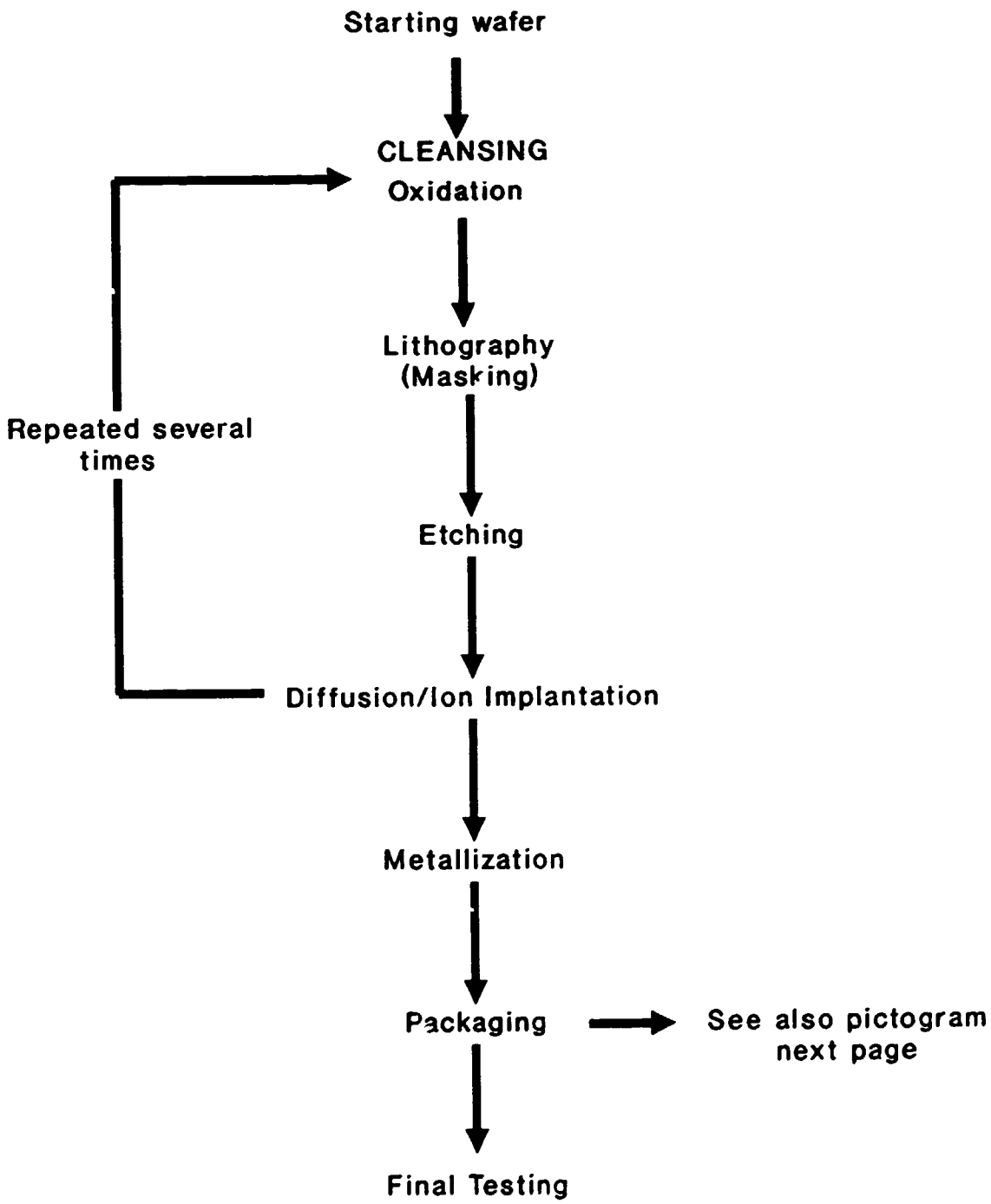
1. Cleansing of wafers. Wafers are washed by chemicals and rinsed by highly pure water. Since the wafers have to be in an ultra pure state, these operations will ensure that no contamination of sodium, heavy metals and dopant will effect device characteristics and reduce reliability.

2. Diffusion, deposition/evaporation and ion implantation are done to create new materials on or in the surface of the Silicon wafer.

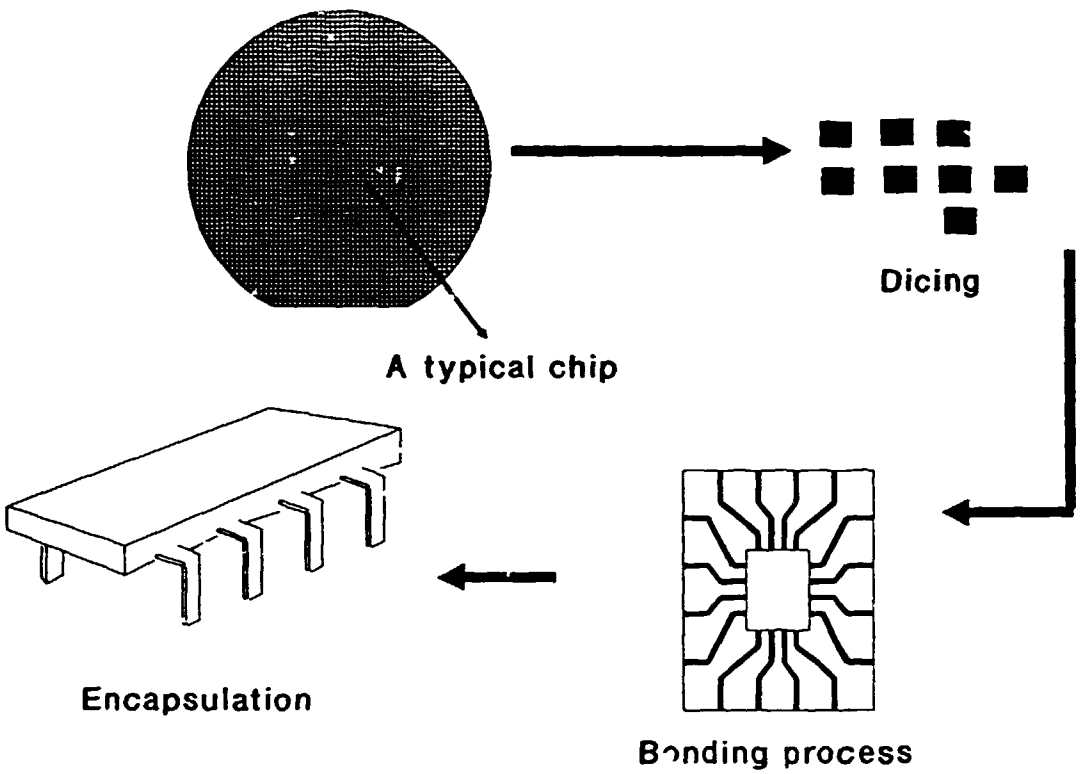
3. Photolithography is the process to transfer the pattern conceived by IC designers from a photographic mask plate onto the wafer by defining specific areas.

4. The fourth operation in the repetitive process is the removal of unwanted areas by etching. The pattern is exposed, developed and the remaining areas of photoresist material protect the wafer surface while the unwanted material is etched away. Finally the photoresist layer is removed to complete the pattern transfer.

3. IC Fabrication Flowchart



Packaging



Final Testing

4. Special Know How Requirements

All the Know How on the wafer processing steps including the operating Know How as described in the previous chapter as well as the technology itself is lacking in this country and have to be acquired.

It has to be an inevitable part of the Know How transfer arrangement that the personnel of the licensee will get the operational training at the licensors' premises.

Design, process and equipment engineers as well as wafer fabrication and assembly operators should be included in this training. Engineering staff of the licensor will have to assist this Malaysian 'start-up''group in setting up the operation facility and get it fully operational together.

A minimum five-year agreement has to be signed with the licensor to transfer and implement in Malaysia design, wafer fabrication and test technologies on an ongoing basis.

5. Need for Joint Venture

Although the necessary technology as well as the Know How involved might be obtainable without a joint venture operation it is strongly recommended to form a joint venture as:

- a partnership will guarantee an ongoing access to state-of-the-art technology for the own interest of the licensors.
- the market acceptance will be higher and a faster market penetration can be expected leading to a shorter payback period of the total funds invested.
- the funds needed will be lower.
- the costs of technology could be capitalized.
- export limitation/restrictions of a joint venture partner are most unlikely.
- risk for entire project is split.

6. Energy and Water Consumption, Ecology Effects

Energy and water consumption will be determined by the equipment used and therefore will largely depend on the licensor, however no very special requirements are to be fulfilled.

Toxic waste is produced mostly during wafer processing and some during the subsequent process such as failure analysis test. As chemicals, gases and purified water are used a permanent dumping site is critically needed. A quote from The Sectoral Task Force Report for IMP (Industrial Master Plan) should clarify this problem,

"Toxic waste disposal is a problem. No permanent dumping site exists for the semiconductor industry at the moment and all industries have to take care of their own waste. Action has been taken together with the Department of Environment to establish a permanent dumping site."

7. Labor and Skills Required

The structure of personnel for the wafer fab and the assembly line is shown on the following tables. The increasing manpower requirement is a function of the projected sales growth over the years 1990 - 1994.

Skills required:

General Manager	5 - 10 years manufacturing experience in the semiconductor industry including Fab operation and practical management experience
Senior Engineer	electronic/chemical engineers or physicists with minimum 5 years of practical experience, preferably in the semiconductor industry with expertise on either - General semiconductor engineering - Fab operation - Assembly - VLSI-design - or Quality and Reliability
Engineers	electronic/chemical engineers/physicists with 2 - 3 years practical experience, preferably in the semiconductor industry with expertise in areas as - VLSI-design - Failure Analysis - Production - Production control - Equipment maintenance - Fab operation - Quality Control - R & D
Technicians	electronic/mechanical/chemical technicians with a minimum of 3/1* years practical experience in the semiconductor industry with expertise in areas as - Assembly - Production control - Equipment maintenance - Quality control - R & D

* 3 years(highly skilled)

Structure of Personnel for Wafe. Fab.

Manpower	'90	'91	'92	'93	'94
MIN					
General Manager	1	1	1	1	1
Senior Engineers	5	5	5	5	5
Engineers	10	15	15	20	20
Technicians(highly skilled)	10	10	15	20	40
Total Engineering	26	31	36	46	66
*A&G expenses	-	1	2	4	4
Total Manpower	26	32	38	50	70
MAX					
General Manager	1	1	1	1	1
Senoir Engineers	5	5	5	5	5
Engineers	10	15	20	25	30
Technicians(highly skilled)	10	15	20	35	45
Total Engineering	26	36	46	66	81
*A&G expenses	-	2	4	4	5
Total Manpower	26	38	50	70	86

Structure of personnel for Assembly

MIN					
Engineers	5	10	10	15	20
Technicians	25	90	140	335	580
Total	30	100	150	350	600
MAX					
Engineers	5	10	15	20	30
Technicians	25	140	335	580	720
Total	30	150	350	600	750

*Adminstration & General

8. Plant Scale to Market size and Product Type / Load Factor / Operating Costs

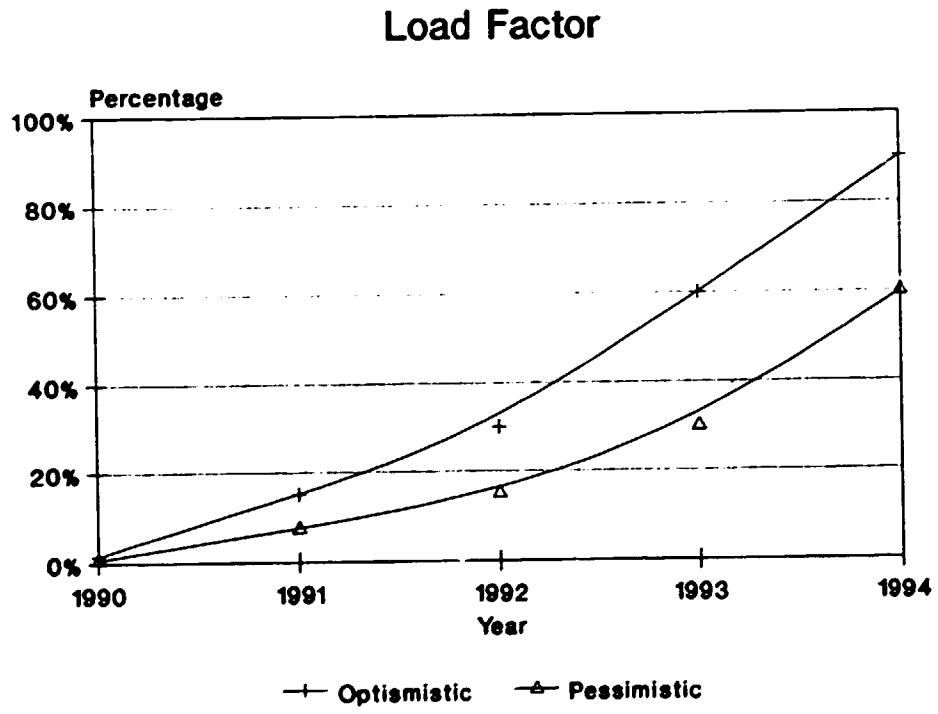
The market to be served is described under chapter III, page 17.

The size of the plant is based on these projected sales targets, see page 22 onwards. The 'nominal' capacity was set at 90% of 'design' capacity, corresponding to US$120 Million sales annually.

The load factor, operating costs and material costs are shown on the following tables, taking the necessary learning curves into account.

Operating costs for the product family in question are commonly known to be between+13X25 - 30% of sales for an established operation.

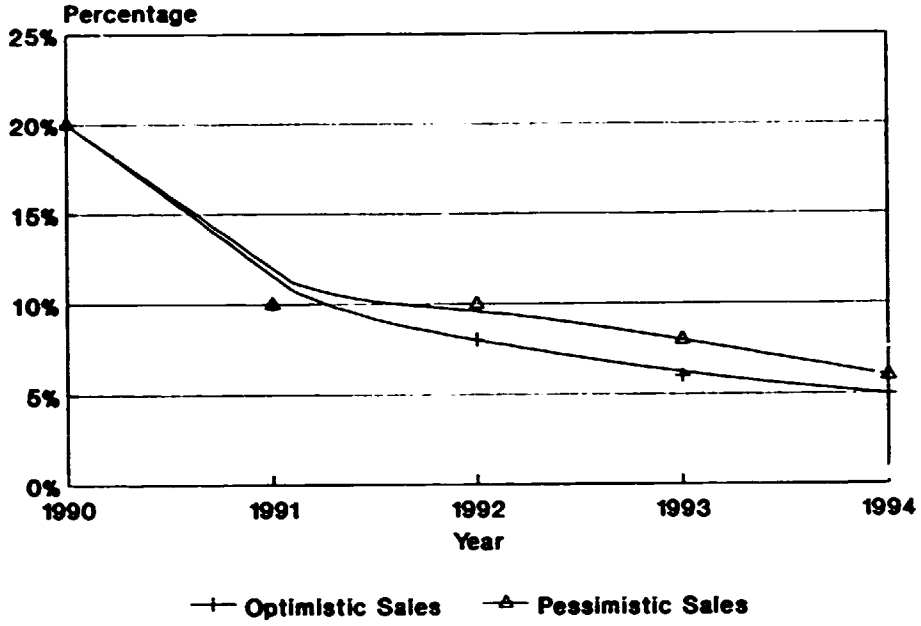
The lower yield at the beginning was taken into consideration for the material cost as well as in the operating costs.



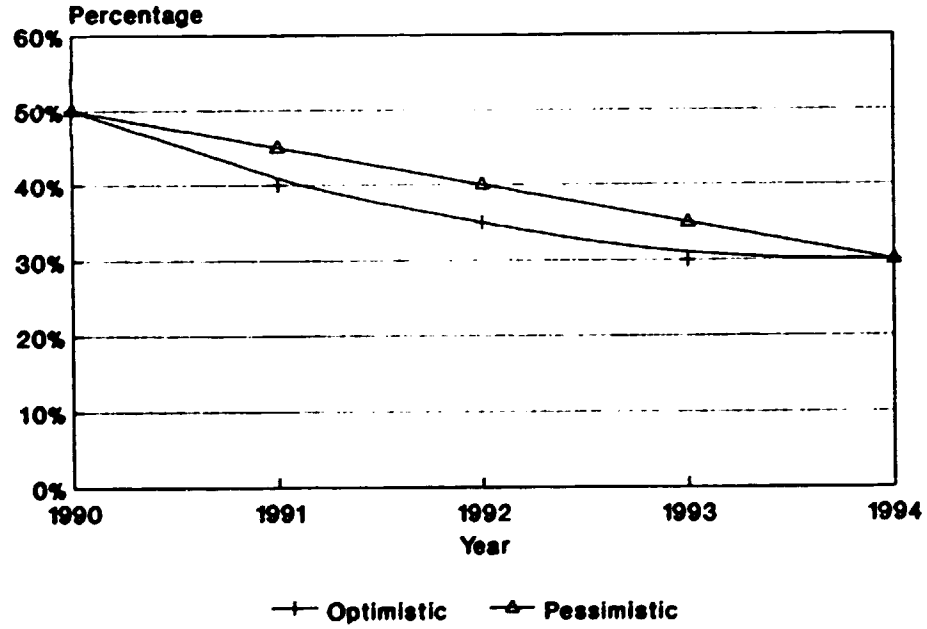
MIMOS Aug.1989

Fig. 2

Material Costs as % of Sales



Operating Costs as % of Sales



MIMOS Aug.1989

Fig. 3

II. ECONOMIC VIABILITY

The use and application of microelectronics in practically all manufacturing industries will determine the country's competitiveness and therefore its future growth. Having access to the core technology in microelectronics will be most advantageous in supporting the National industry.

1. Linkage opportunities / Value added / Import substitution

All semiconductor companies being active in Malaysia today operate 'assembly-lines' only out of Free Trade Zones. The value added is approximately 15% only, consisting mainly of wages paid, fabricated tools, operating supplies and services as well as freight.

There are practically no linkages between these FTZ companies and the local industry as they do not dispose of 2 out of 3 major company ingradients: **R&D and Marketing**. But these two missing activities are creating the spin-offs in high-tech industries.

By establishing a full-semiconductor manufacturing line in Malaysia these missing linkages not only could be closed, the 'value added' increased to 50 - [illegible]% but also all local consumptions of the output of this plant would reduce by the same amount the import of semiconductors into Malaysia, as the FTZ-produced semiconductors are reimported into Malaysia.

As the customerbase of 'MSC' in Malaysia will be the entire industry using semiconductors, see Fig 5, page 16(ASIC-usage by end-users) very close linkages with all those users will be built up in a short time. The application assistance and optimization, by nature of 'semicustom IC's' produced, will allow the user industry the important shorter time to market.

2. Required subsidies/protection

No particular subsidies/protection is required and expected for this project but it is assumed that the project will get 'Pioneer-status'.

3. Employment

The structure of personnel and the skills required were described earlier already. It can be assumed that with the exception of 3 - 5 positions during the start-up-phase of 2 - 3 years all other positions can be filled with local personnel. The licensor most likely will assist to fill the 'top-spots' on an interim basis and train successors in this period.

The total manpower requirement, including marketing will develop in accordance with the optimistic/pessimistic growth rates as follows:

Manpower		'90	'91	'92	'93	'94
Manufacturing	Min	56	132	188	400	670
	Max	56	188	400	670	836
Marketing	Min	3	15	25	40	70
	Max	4	20	40	70	100
TOTAL	Min	59	147	213	440	740
	Max	60	208	440	740	936

4. Export opportunities

The entire ASIA-Pacific area, initially the 'Rest-ASIA-Pacific' market, as described under Chapter III - not dominated by any multinational semiconductor manufacturer for the product range under discussion due to the missing R&D/Engineering, engineering application function and marketing - can be considered as the export opportunity covered by 'peer- competitors' only.

5. Inflation effects

Malaysia today is the 3rd largest producer of semiconductors in the world. These ICs exported worldwide by multinationals operating out of FTZs In Malaysia are still competitive and neither the MAEI (Malaysian American Electronics Industry) nor the JEEI (Japanese Electrical & Electronic Firms Group) see major inflationary problems for the foreseeable future, as large investments into upgrading of their assembly operations in Malaysia show.

MSC Inc., the proposed joint venture company will not face any other business environment.

III. COMMERCIAL VIABILITY

1. Product Definition

A product niche-approach is taken by selecting CMOS Semicustom ICs within the ASIC-family (see next page). As can be seen from the following market projections, this product segment is growing overproportionally compared to other semiconductor product-groups.

ASICs offer:

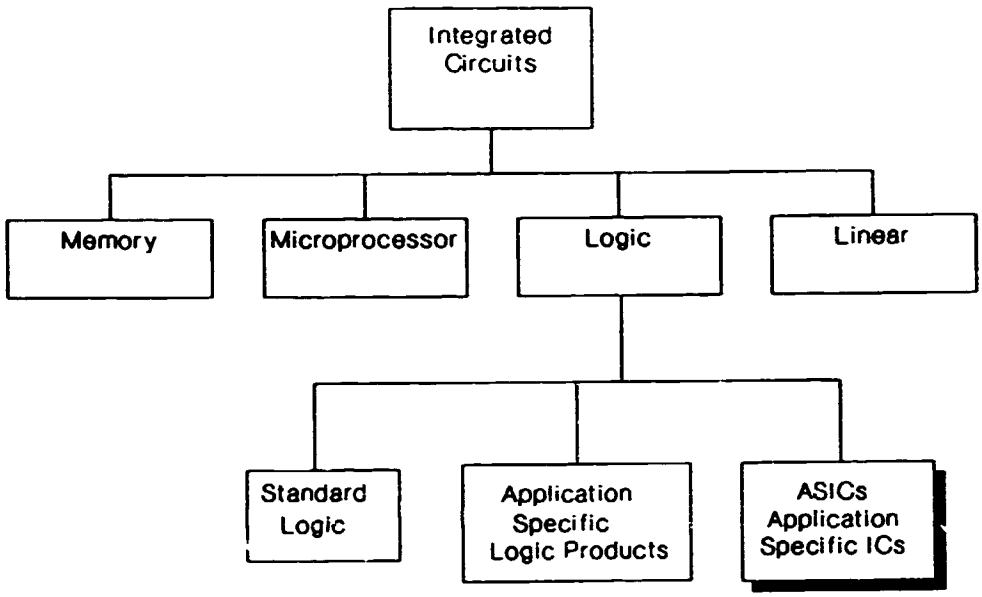
- Lower manufacturing costs
- Lower power consumption
- Smaller system design size
- Higher system reliability
- Improved design security
- Shorter time to market
- Increased functionality

It is these benefits that have helped fuel the ASIC explosion and it will be for above advantages that ASICs are going to substitute Standard Logic devices in many applications.

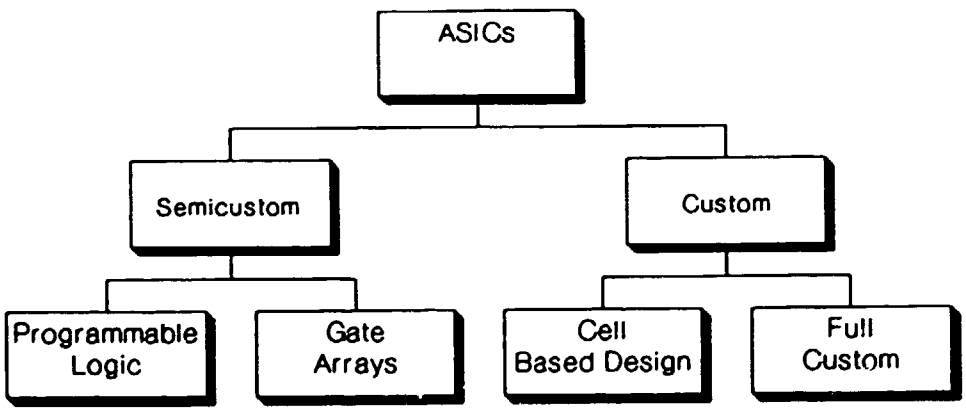
In this respect the product range selected can be considered partly as a substitute product for standard commodity ICs, partly as new.

PLDs(Programmable Logic Devices) and AGAs(Alterable Gate Arrays), further members of the product family selected have to be considered as absolutely new state-of-the-art products opening up applications which hardly can be covered with existing standard products, giving the local industry the expected 'competitive' edge on the home and particularly on export markets.

Integrated Circuits Family Tree



ASICs Family Tree



MIMOS Aug.1989

Fig. 4

2. Market Definition

As there is no limitation to specific end user groups, ASICs can be found in:

- Telecommunication
- Industrial applications
- Computer applications
- Consumer goods
- Government/military
- Automotive applications

A recent survey by 'Dataquest' shows the following distribution by end use:

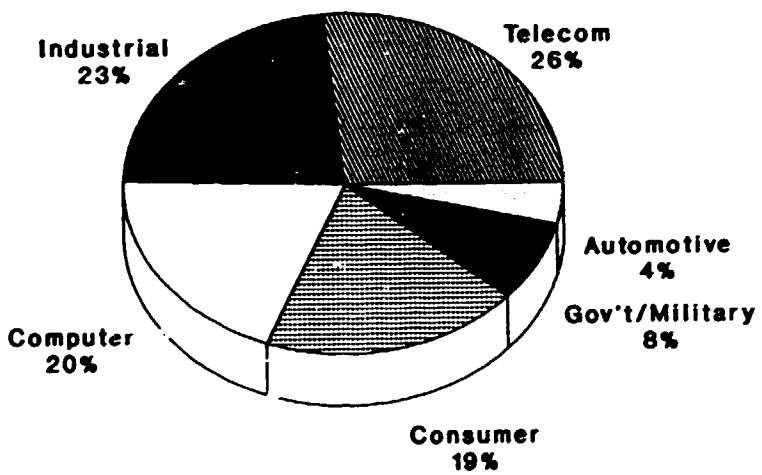


Fig 5: ASIC-usage by end user group

No major change in the user distribution is expected to take place in the forseeable future. With this user distribution it can be expected that any temporary slowdown in the one or other user group will have far less effect on a planned sales growth than being dependent on a narrow customer base.

3. Market size

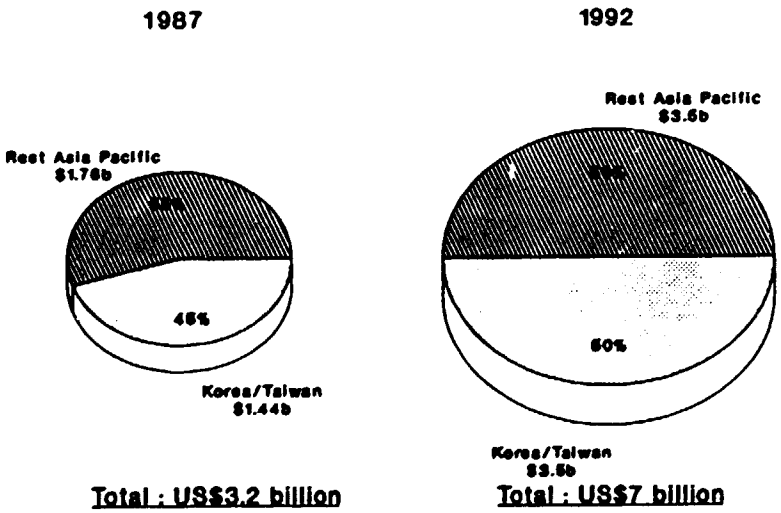
There are opinions that the semiconductor industry must be considered as a risky one due to a wide and frequent oscillation of its output. Looking into the market development of ICs over a period of more than a decade, this statistic proves this opinion wrong - and showing just in one direction : Up!

For the Year 2000 there is a global projection of a US$180 Billion market. A split up of the worldwide IC market is shown in figure 7, showing the move towards the CMOS technology.

For reasons described before, the CMOS+27XSemicustom market is even growing faster, reaching in 1992 US$7 Billion or 11.9% of the entire IC market (Fig. 7). The ASIA-Pacific IC market is shown below. During the past years this market has been growing at a faster rate than the world average. This is expected to continue, reaching also US$7 Billion or 11.9% of the world IC market in 1992 after US$3.2 Billion or 11.4% in 1987.

As there still is not a technology split up available for the ASIA-Pacific region, we have concluded after a series of discussions with industry insiders in this country, that the technology split up is similar to the rest of the world. Figures 8 and 9 show the market development for the ASIA-Pacific region with and without Korea/Taiwan. The intended market to be served is the total ASIA-Pacific area (Japan is not included in this region).

Asia Pacific Market



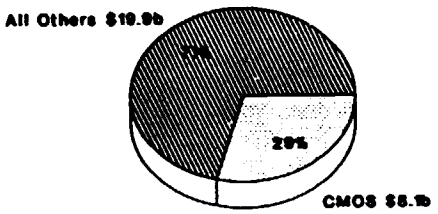
Source : Dataquest MIMOS Aug 1988

Fig. 6

Worldwide IC Market

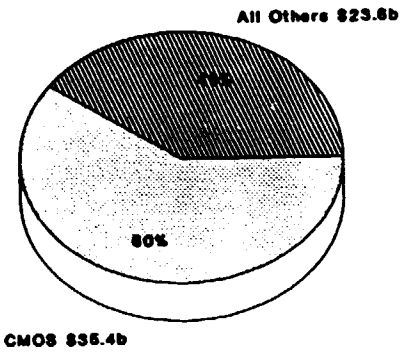
CMOS versus All Other Technologies

1987



Total : US$28 billion

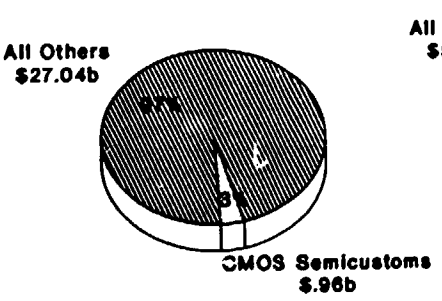
1992



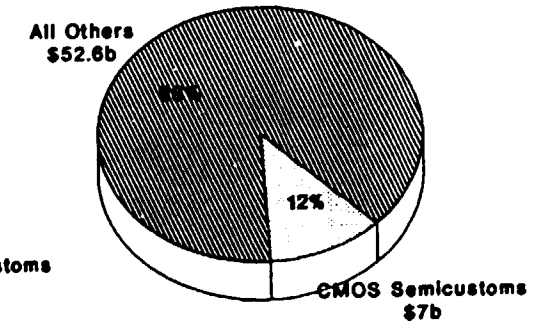
Total : US$59 billion

Source : Dataquest

Semicustom ICs versus All Others



Total : US$28 billion



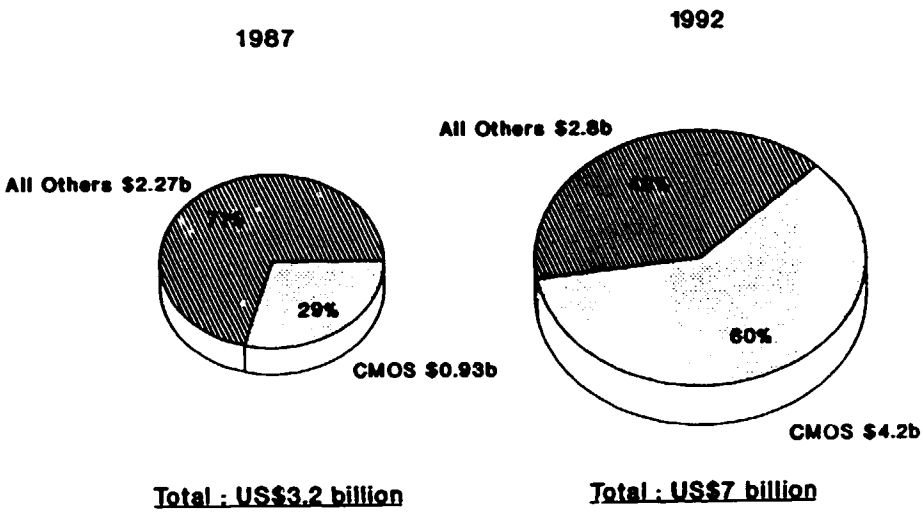
Total : US$59 billion

Source : Technology Research Group
MMOS Aug 1988

Fig. 7

Asia Pacific IC Market

CMOS versus All Other Technologies

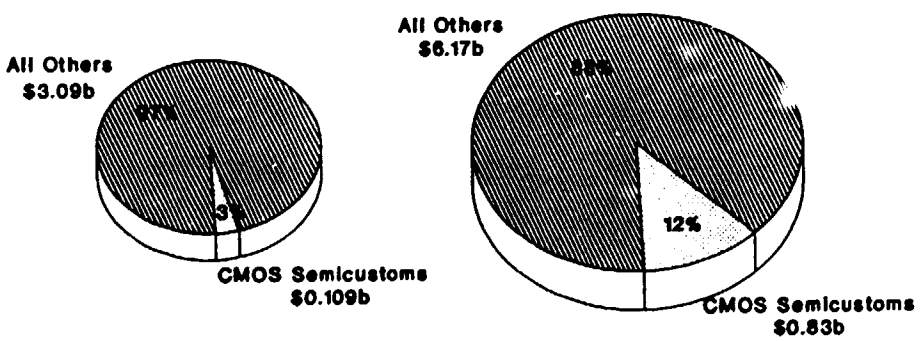


Total : US$3.2 billion

Total : US$7 billion

Source : MIMOS

Semicustom ICs versus All Others



Total : US$3.2 billion

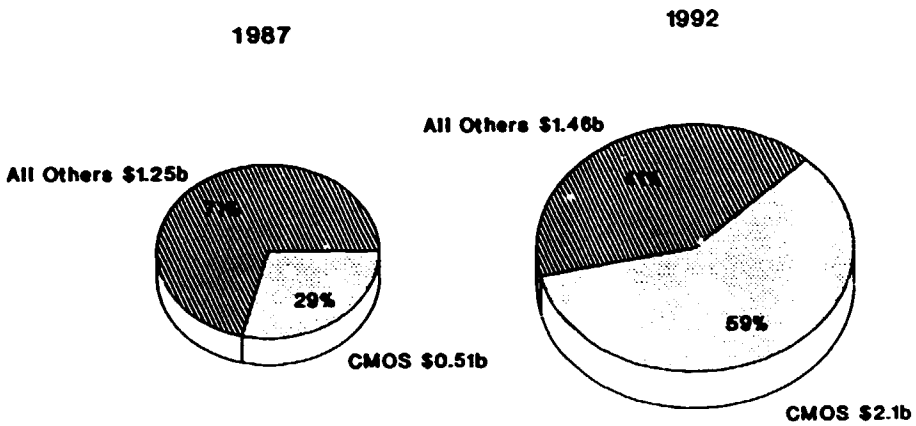
Total : US$7 billion

Source : MIMOS
MIMOS Aug 1989

Fig. 8

Rest Asia-Pacific IC Market

CMOS versus All Other Technologies

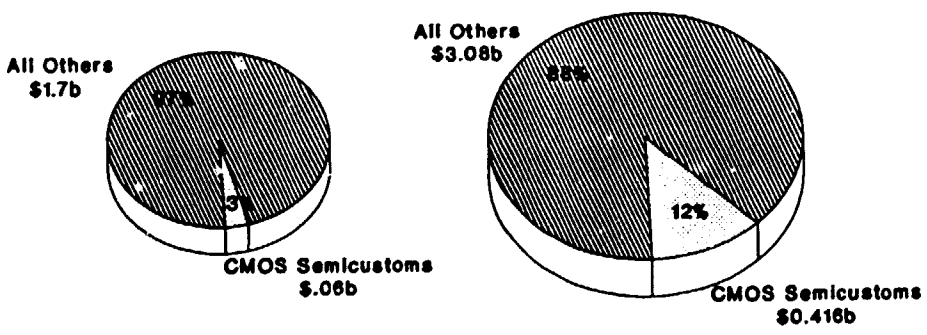


Total : US$1.76 billion

Total : US$3.5 billion

Source : MIMOS

Semicustom ICs versus All Others



Total : US$1.76 billion

Total : US$3.5 billion

Source : MIMOS
MIMOS Aug 1989

Fig. 9

Competition

As the multinational semiconductor companies do not have R&D and marketing departments at their South-East-Asia assembly plants and their existing assembly set ups here are geared for high volume commodity items only, going into the ASIC range of products for them would mean a major additional investment not only in additional plant capacity but also into engineering and marketing.

This most likely is not going to happen on a large scale as they have hugher home markets to explore with investments already made there. Semiconductor companies having wafer-fab-capabilities, R&D/engineering and full marketing in the ASIA-Pacific are most likely to become competitors - should they decide on going into the Application Specific IC market.

For the time being the following companies are engaged in ASIC production in the ASIA-Pacific region:

Hong Kong	- ELCAP - RCL
Korea	- Daewoo - Hyundai - Samsung
Singapore	- Chartered * - SGS/Thomson
Taiwan	- HMC - Taiwan Semiconductor - United Electronics

*Only 'Chartered' is concentrating its entire resources on ASICs.

Price Development

Prices can best be described in terms of 'cost per gate'. In a 1.5 - 2u technology up to 20,000 gates are packed on a single chip, averaging today probably 2,000 gates.

Today's gateprice of 0.7 - 0.8 cents will come down to 0.5 cents and level off on the long run at 0.25 - 0.3 cents at a 5 - 10K gate average per chip. So, the continous price decline will be mostly offset by the higher circuit complexity. For example :

Complexity	Price per Chip
2K gates at 0.7 - 0.8 cents	$14 - $16
3K gates at 0.5 cents	$15
5K gates at 0.25 - 0.3 cents	$12.50 - $15

4. Market entry

According to a market study conducted earlier this year by UNIDO on behalf of MIMOS, the Malaysian electronic industry showed a strong interest in not only having access to a semiconductor design center for ASICs but also to a wafer process capability. Being close to the market is the key to successful ASIC-marketing.

Looking into the ASIC-growth potential in Japan, USA and Europe (Fig. 10, page 24) it is no wonder that not one multinational semiconductor manufacturer started ASICs over here but are concentrating on their home bases respectively, as they lack the R&D and Sales-functions in their South-East-Asian's assembly operations. But both R&D(Design) and marketing will be essential for a successful ASIC market-penetration.

In respect to the planned processing capabilities, existing VLSI-design at MIMOS should be expanded and a promotional programme among the local Malaysian electronic industry should be enforced as soon as a joint venture partner has been selected and cooperation negotiation have reached a serious level.

Selling the design capabilities as early as during the 2nd quarter 1990 within Malaysia and after operating prototypes have been built and sampled successfully to Malaysian customers, export activities should be taken up immediately thereafter.

As many designs as possible should be taken up and prototypes built at the licensors' premises during the training programme for the Malaysian engineers. This 'on the job' training will not only enable the starting Malaysian engineering crew to gain immediate practical experience but also will create initial sales as soon as the Malaysian waferfab is going on stream.

To build up a customerbase already in the forefront of production will create the confidence level necessary to succeed on a larger scale. Marketing the track record of the licensor should also give a boost to the marketing entrance.

The initial sales growth will furthermore depend largely on the joint-venture partner and its sales and marketing organization as well as the coverage of the ASIA-Pacific area.

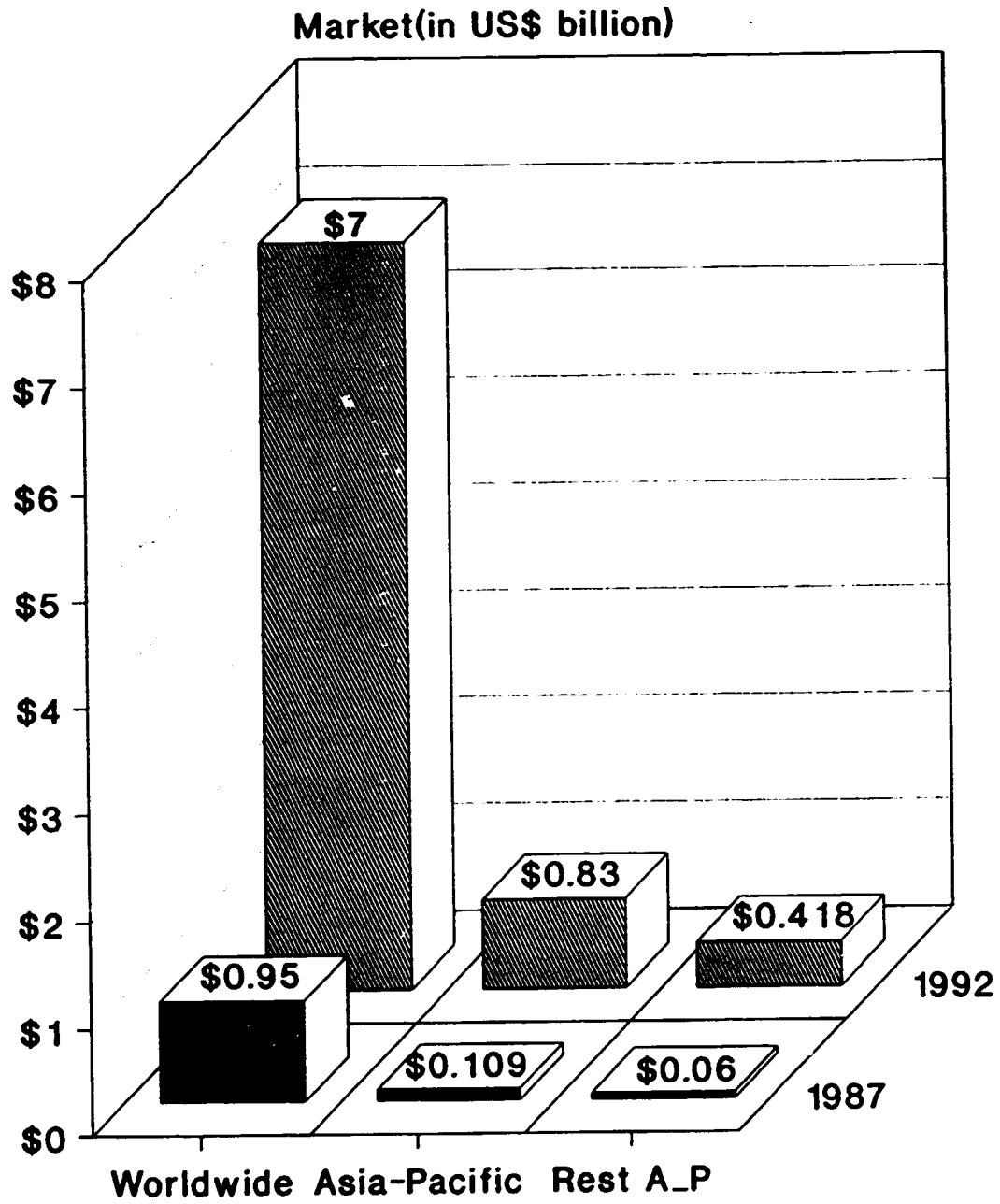
Sales projections have been made anticipating the possible use of an existing ASIA-Pacific sales organization (with AP-Marketing) or without such an organization.

A final sales strategy will have to be determined with the licensor but most likely the telecom/industrial sector should be approached first to open up a broad customer base with relatively low volume per product, meeting better the necessary 'initial' learning curve of a start-up-production. The sales projection 1990 - 1994 for MSC as shown in Fig. 11, page 25 do represent a market share in 1994 of 9.6% respectively 14.4% of the ASIA-Pacific region. As today's market is not dominated by any single manufacturer, these benchmarks should be achievable in an evolving industry.

It has to be stated very clearly, that the quality of the marketing/sales-force will determine the sucess of MSC Inc. Also marketing/sales is not a key-issue of this study, major emphasis should be put on this side of the business as soon as the technological side is solved by choosing the right technological joint venture partner. (IBM has proven that you can become a market leader with a technically third class product if the marketing is right, as they have done with their PC-line of products.)

Semicustom IC Market

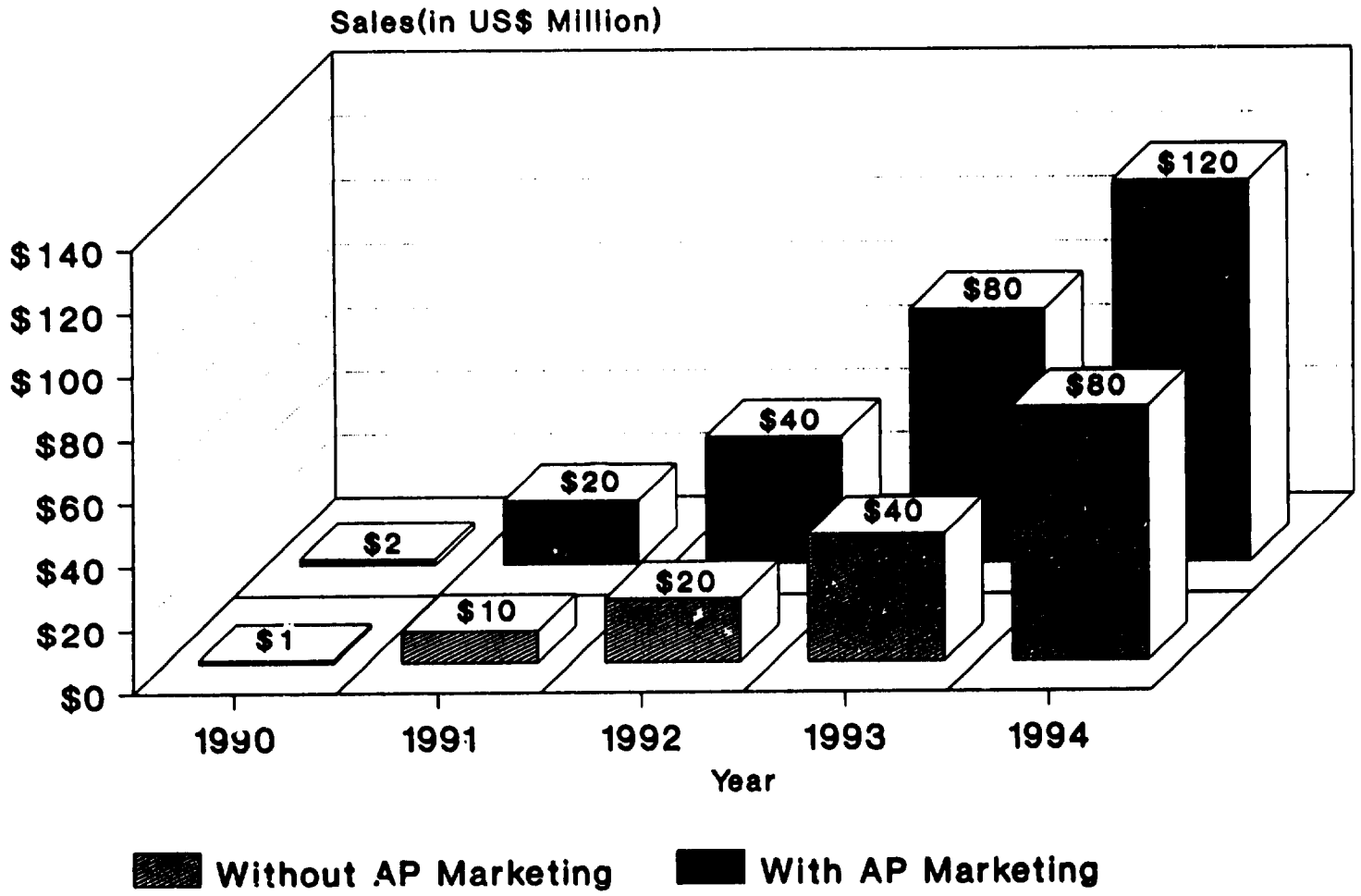
(Source: Dataquest & Electronics)



MIMOS Aug.1989

Fig. 10

Growth MSC Inc. Sales



MIMOS Aug.1989

Fig. 11

5. Product demand/Product opportunities

For reasons described earlier the growth rate for ASIC-family type products has been higher than for other ICs. According to industry forecasts this growth rate will be even accelerating over the years to come. As the product features of PLDs will offer additional, not yet availiable comfort and flexibility to equipment manufacturers, extended market opportunities will materialize.

Application and design assistance will be an essential ingredient for a fast market penetration as MSC Inc. might well be the first South-East-Asia vendor offering this state-of-the-art semiconductors.

6. Sales and distribution costs

To cover the ASIA-Pacific area a combination of an own sales force with application engineering, regional representatives and distributors will be used. The set up of the marketing force will depend largely on an eventually existing organization of the licensor.

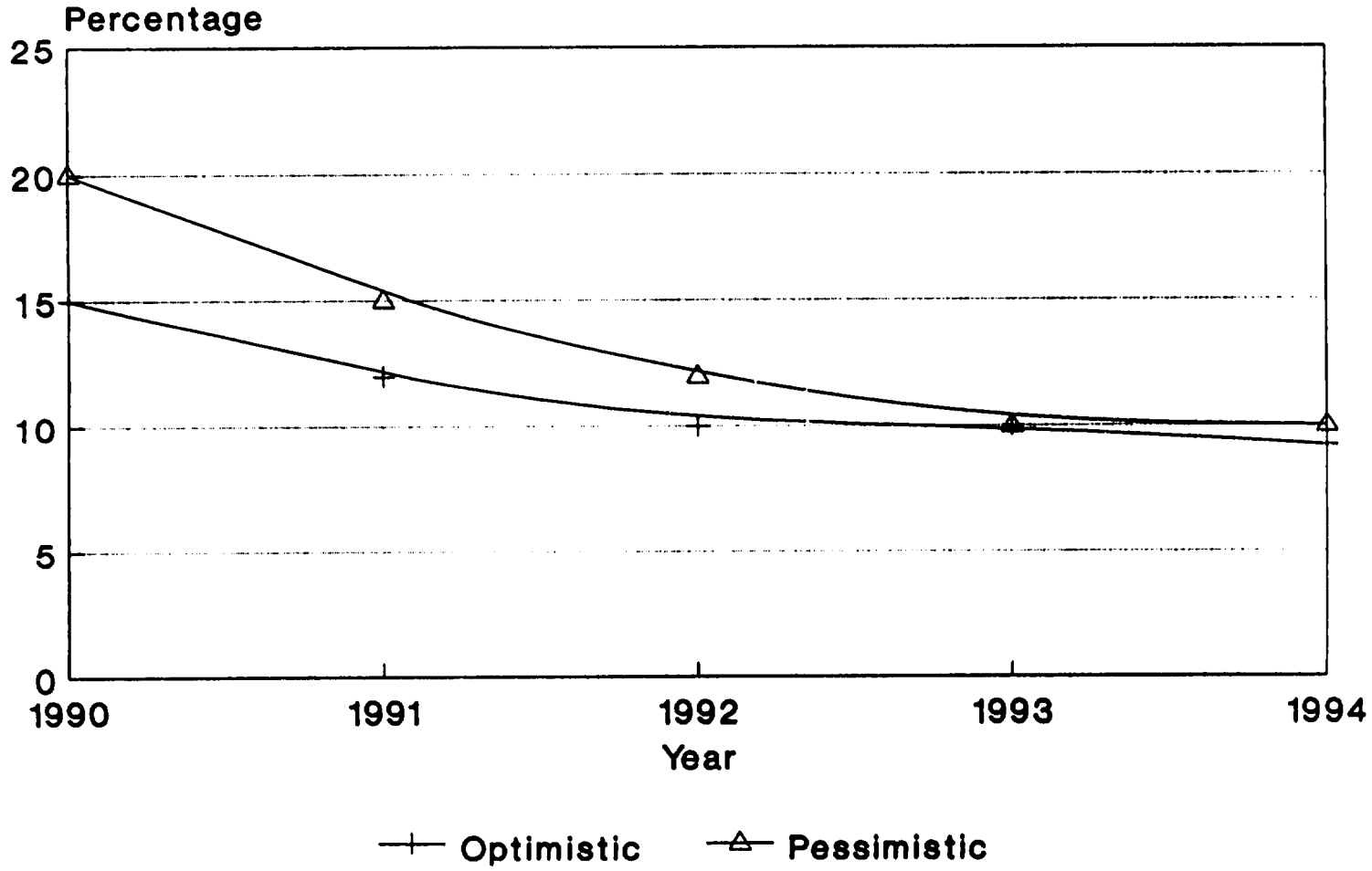
The cost of sales and distribution as function of sales are shown on the following table and will reach the industry 'below 10% mark' for an established production volume during the 3rd year of operation.

7. Outlook

The CMOS technology and the ASIC-design capability acquired as well as the ongoing Know How Transfer during the contract period will allow MSC-Inc to build up an own Know-How-Pool, which will lead to own, more advanced designs and new state-of-the-art products.

The increasing operating profit from the plant operation will allow MSC-Inc to spend on a continous basis the necessary funds for R&D and the upgrading of equipment, ensuring not only the semiconductor core-technology acquired is getting upgraded but also spread over the country by spin-offs which naturally are going to follow as they did elsewhere - having by then created the entrepreneural spirit of a high-tech-industry.

Sales & Distribution Costs as % of Sales



MIMOS Aug.1989

Fig. 12

IV. FINANCIAL VIABILITY

1. Fixed capital

Three alternatives for the project investment have been calculated:

- US$50 Million (alternative 1)
- US$60 Million (alternative 2)
- US$75 Million (alternative 3)

The latter figure is based on the investment made by Chartered Semiconductor, Singapore in their ultramodern waferfab in 1988, spending US$35 Million for highly automated manufacturing equipment and US$33 Million on the building with 14,500 square meters thereof 5000 square meters Class 10 cleanroom. (Nominal capacity: US$325 Million). Investigations have shown in the mean time that the wafer fab building including cleanroom can be done by a local contractor with a track-record in building cleanroom areas at a much more favorable price.

Approximately 95% of the total project investment will become fixed asset. Practically all the fixed capital will be invested in the wafer fab and assembly building (approx. 40%), the remainder in cleanroom equipment, wafer fab line, assembly and testing equipment, as well as land. The grade of automation will depend on the licensor, but it can be assumed that alternative 1 will be most likely the one to be chosen. Alternative 3 should be considered as a reference calculation only, showing that even at such a high investment level a break even point can be reached within 4 years.

2. Cash flow/working capital requirements

The cashflow for the three alternative investment levels including all detailed calculation over a 5 year period are shown on the following graphic illustrations and tables. For each investment level an 'optimistic' and a 'pessimistic' approach is shown, based on an optimistic, respectively pessimistic sales growth over the 5-year-plan period (with or without existing ASIA-Pacific Marketing).

An estimated US$0.75 - US$1 Million will be needed between the time of signing the contract and the start up of production to cover a possible licence down down payment respectively costs involved with the licence transfer (eg : training, documentation, licensor's manpower, technical assistance).

The ongoing working capital needed is shown under the line 'Total Funds applied' in the corresponding tables. The year end figure 1991 does not show that there will be a short term requirement in the first two quarters due to full operating and marketing costs during this period, but slowly picking up sales in this time frame only. A break even is reached for:

	Optimistic	Pessimistic
Alternative 1(US$50 Mil) after	3 yrs, 3 mths	4 yrs, 3 mths
Alternative 2(US$60 Mil) after	3 yrs, 5 mths	4 yrs, 10 mths
Alternative 3(US$75 Mil) after	3 yrs, 10 mths	5 yrs, 5 mths

Not included in the cashflow calculation is the percentual licence fee, which most likely will be between 3% - 5% of net sales with probably a fixed minimum amount to be paid for the starting years, when agreed upon sales volumes will not be met.

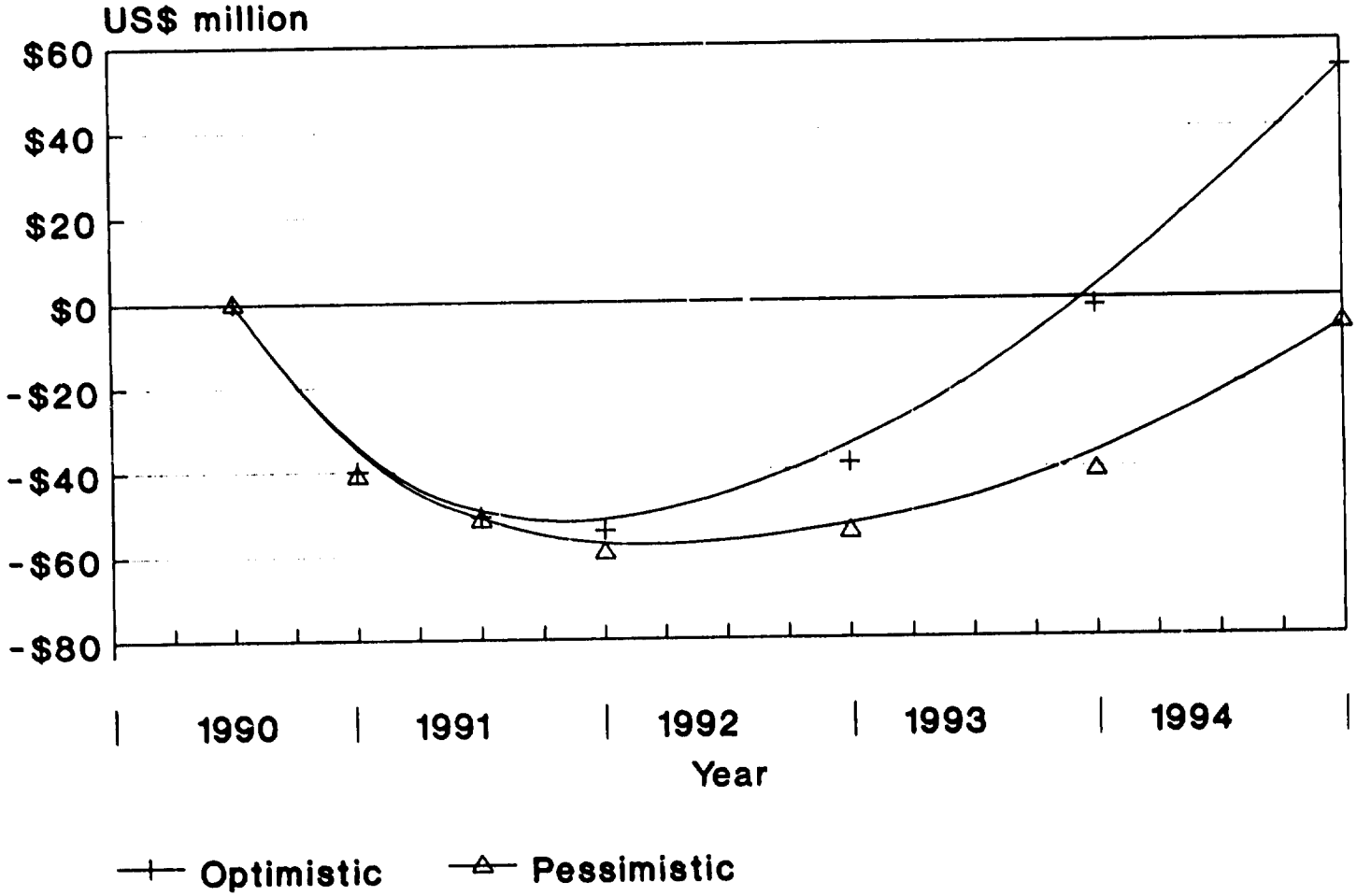
Starting approximately in the 3rd year of operation, additional own R&D activities should be taken up and a gradual increasing percentage should be reserved for that. In a high-tech-industry as semiconductor, in the long run 8 - 10% of sales should be reserved for R&D. A part of these funds will come from paid customer designs.

Even though the equipment bought initially will last longer than the planning period described, reserves for upgrading the equipment respectively new equipment should be built on an ongoing basis. Two percent of the initial capital expenditure are reserved for this purpose, starting in year three and the following ones.

Alternatively to setting up a complete own assembly line including testing, the use of a semiconductor subcontract assembly line could be considered, as offered by CARSEM, an independent assembly operation under Malaysian management.

In case of such a cooperation, the investment for the assembly line including testing could be saved.(See also capital structure, page 36)

Cashflow - Investment US$50 million



MIMOS Aug.1989

Fig. 13

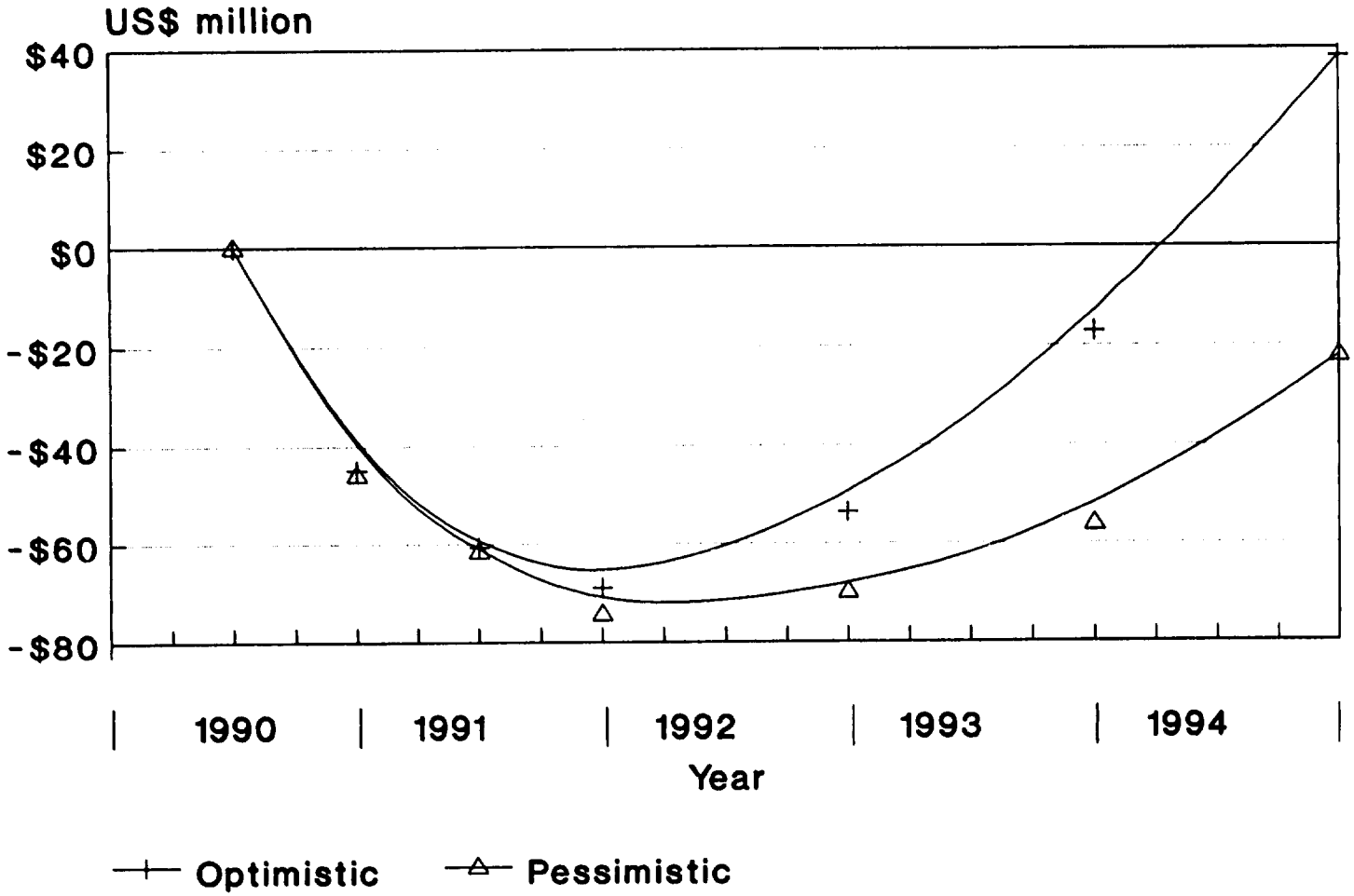
CASHFLOW CALCULATION MSC Inc.

Project Investment : US$50 million
(in US$ million)

	1990	1991	1992	1993	1994
Sales 'Optismistic'	2.0	20.0	40.0	80.0	120.0
Material Costs	0.4	2.0	3.2	4.8	6.0
Depreciation & Amortization	1.25	5.0	5.0	5.0	5.0
Operating Costs	1.0	8.0	14.0	24.0	36.0
Marketing and A&G expenses	0.[illegible]	2.4	4.0	8.0	11.0
R&D/Equipment Upgrading	0.0	0.0	1.8	4.2	8.2
Net Income before Tax	-0.95	2.6	12.0	34.0	53.8
N.I. after Tax(Pioneer Status)	-0.95	2.6	12.0	34.0	53.8
Return on Sales(%)	-47.5	13.0	30.0	42.5	44.8
FUNDS PROVIDED BY PROJECT					
Net Income(Pioneer Status)	-0.95	2.6	12.0	34.0	53.8
Depreciation & Amortization	1.25	5.0	5.0	5.0	5.0
Total Funds Provided	0.3	7.6	17.0	39.0	58.8
FUNDS REQUIRED BY PROJECT					
Capital Expenditure	40.0	10.0	0.0	0.0	0.0
Current Receivables, inc(dec)	0.1	0.4	1.1	2.0	2.5
Inventories, inc(dec)	0.1	0.5	0.5	0.5	1.0
Other Current Assets, inc(dec)	0.0	0.0	0.0	0.0	0.0
Trade Payables, dec(inc)	-0.02	-0.08	-0.1	-0.2	-0.4
TOTAL FUNDS APPLIED	40.18	10.82	1.5	2.3	3.1
NET CASH SURPLUS	-39.88	-3.22	15.50	36.70	55.7

Sales 'Pessimistic'	1.0	10.0	20.0	40.0	80.0
Material Costs	0.2	1.0	2.0	3.2	4.8
Depreciation & Amortization	1.25	5.0	5.0	5.0	5.0
Operating Costs	0.5	4.5	8.0	14.0	24.0
Marketing and A&G expenses	0.2	1.5	2.4	4.0	8.0
R&D/Equipment Upgrading	0.0	0.0	1.4	2.6	5.8
Net Income before Tax	-1.15	-2.0	1.2	11.2	32.4
N.I. after Tax(Pioneer Status)	-1.15	-2.0	1.2	11.2	32.4
Return on Sales(%)	-115.0	-20.0	6.0	28.0	40.5
FUNDS PROVIDED BY PROJECT					
Net Income(Pioneer Status)	-1.15	-2.0	1.2	11.2	32.4
Depreciation & Amortization	1.25	5.0	5.0	5.0	5.0
Total Funds Provided	0.1	3.0	6.2	16.2	37.4
FUNDS REQUIRED BY PROJECT					
Capital Expenditure	40.0	10.0	0.0	0.0	0.0
Current Receivables, inc(dec)	0.1	0.4	1.1	2.0	2.5
Inventories. inc(dec)	0.1	0.5	0.5	0.5	1.0
Other Current Assets, inc(dec)	0.0	0.0	0.0	0.0	0.0
Trade Payables, dec(inc)	-0.02	-0.08	-0.1	-0.2	-0.4
TOTAL FUNDS APPLIED	40.18	10.82	1.5	2.3	3.1
NET CASH SURPLUS	-40.08	-7.82	4.7	13.9	34.3

Cashflow - Investment US$60 million



MIMOS Aug.1989

Fig. 14

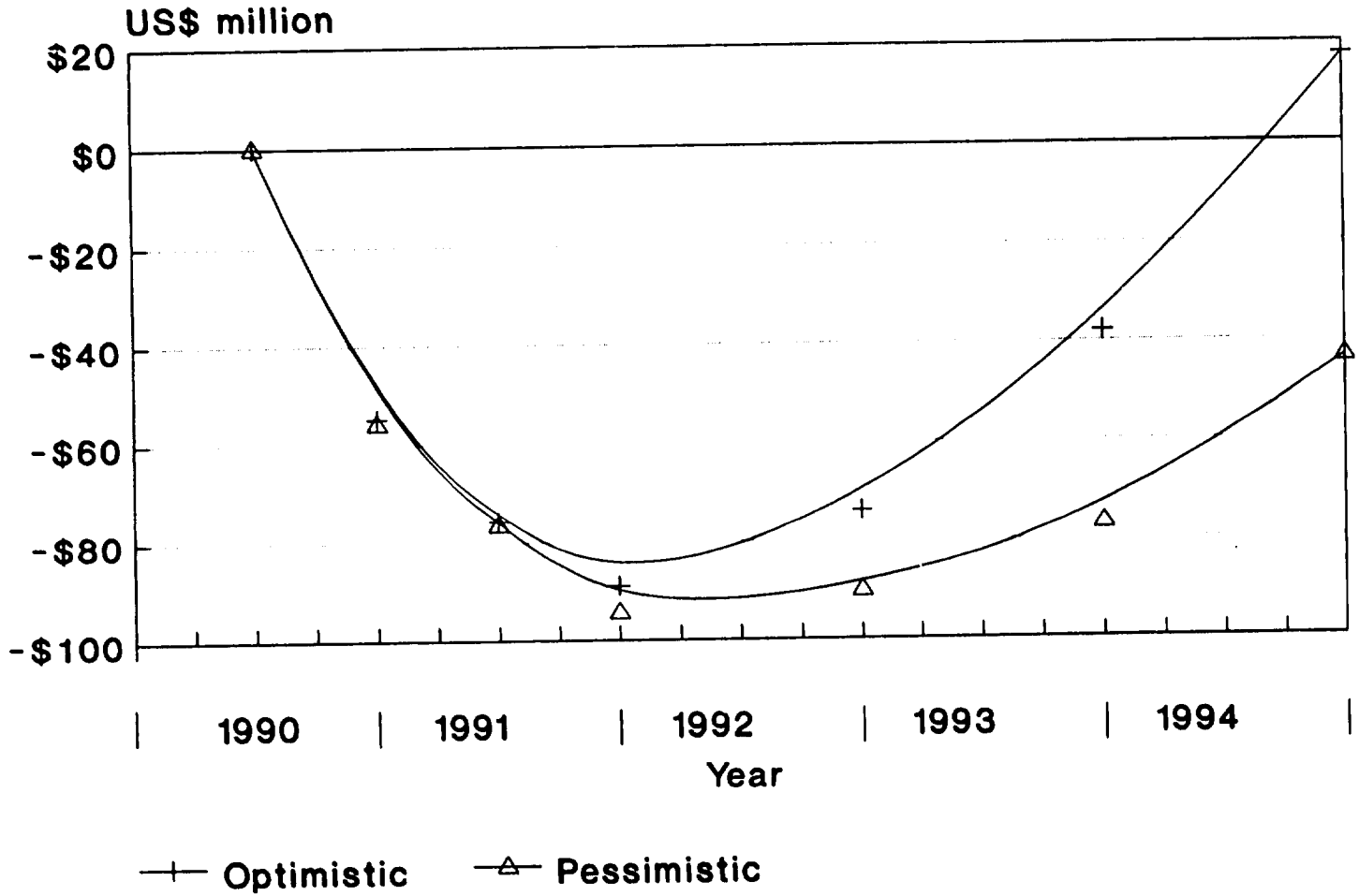
CASHFLOW CALCULATION MSC Inc.

Project Investment : US$60 million
(in US$ million)

	1990	1991	1992	1993	1994
Sales 'Optismistic'	2.0	20.0	40.0	80.0	120.0
Material Costs	0.4	2.0	3.2	4.8	6.0
Depreciation & Amortization	1.5	6.0	6.0	6.0	6.0
Operating Costs	1.0	8.0	14.0	24.0	36.0
Marketing and A&G expenses	0.3	2.4	4.0	8.0	11.0
R&D/Equipment Upgrading	0.0	0.0	2.0	4.4	8.4
Net Income before Tax	-1.2	1.6	10.8	32.8	52.6
N.I. after Tax(Pioneer Status)	-1.2	1.6	10.8	32.8	52.6
Return on Sales(%)	-60.0	8.0	27.0	41.0	43.8
FUNDS PROVIDED BY PROJECT					
Net Income(Pioneer Status)	-1.2	1.6	10.8	38.8	52.6
Depreciation & Amortization	1.5	6.0	6.0	6.0	6.0
Total Funds Provided	0.3	7.6	16.8	38.8	58.6
FUNDS REQUIRED BY PROJECT					
Capital Expenditure	45.0	15.0	0.0	0.0	0.0
Current Receivables, inc(dec)	0.1	0.4	1.1	2.0	2.5
Inventories, inc(dec)	0.1	0.5	0.5	0.5	1.0
Other Current Assets, inc(dec)	0.0	0.0	0.0	0.0	0.0
Trade Payables, dec(inc)	-0.02	-0.08	-0.1	-0.2	-0.4
TOTAL FUNDS APPLIED	45.18	15.82	1.5	2.3	3.1
NET CASH SURPLUS	-44.88	-8.22	15.30	36.50	55.5

Sales 'Pessimistic'	1.0	10.0	20.0	40.0	80.0
Material Costs	0.2	1.0	2.0	3.2	4.8
Depreciation & Amortization	1.5	6.0	6.0	6.0	6.0
Operating Costs	0.5	4.5	8.0	14.0	24.0
Marketing and A&G expenses	0.2	1.5	2.4	4.0	8.0
R&D/Equipment Upgrading	0.0	0.0	1.6	2.8	6.0
Net Income before Tax	-1.4	-3.0	0.0	10.0	31.2
N.I. after Tax(Pioneer Status)	-1.4	-3.0	0.0	10.0	31.2
Return on Sales(%)	-140.0	-30.0	0.0	25.0	39.0
FUNDS PROVIDED BY PROJECT					
Net Income(Pioneer Status)	-1.4	-3.0	0.0	10.0	31.2
Depreciation & Amortization	1.5	6.0	6.0	6.0	6.0
Total Funds Provided	0.1	3.0	6.0	16.0	37.2
FUNDS REQUIRED BY PROJECT					
Capital Expenditure	45.0	15.0	0.0	0.0	0.0
Current Receivables, inc(dec)	0.1	0.4	1.1	2.0	2.5
Inventories, inc(dec)	0.1	0.5	0.5	0.5	1.0
Other Current Assets, inc(dec)	0.0	0.0	0.0	0.0	0.0
Trade Payables, dec(inc)	-0.02	-0.08	-0.1	-0.2	-0.4
TOTAL FUNDS APPLIED	45.18	15.82	1.5	2.3	3.1
NET CASH SURPLUS	-45.08	-12.82	4.5	13.7	34.1

Cashflow - Investment US$75 million



MIMOS Aug.1989

Fig. 15

CASHFLOW CALCULATION MSC Inc.

Project Investment : US$75 million
(in US$ million)

	1990	1991	1992	1993	1994
Sales 'Optismistic'	2.0	20.0	40.0	80.0	120.0
Material Costs	0.4	2.0	3.2	4.8	6.0
Depreciation & Amortization	2.0	7.5	7.5	7.5	7.5
Operating Costs	1.0	8.0	14.0	24.0	36.0
Marketing and A&G expenses	0.3	2.4	4.0	8.0	11.0
R&D/Equipment Upgrading	0.0	0.0	2.3	4.7	8.7
Net Income before Tax	-1.7	0.1	9.0	31.0	50.8
N.I. after Tax(Pioneer Status)	-1.7	0.1	9.0	31.0	50.8
Return on Sales(%)	-85.0	0.5	22.5	38.75	42.33
FUNDS PROVIDED BY PROJECT					
Net Income(Pioneer Status)	-1.7	0.1	9.0	31.0	50.8
Depreciation & Amortization	2.0	7.5	7.5	7.5	7.5
Total Funds Provided	0.3	7.6	16.5	38.5	58.3
FUNDS REQUIRED BY PROJECT					
Capital Expenditure	55.0	20.0	0.0	0.0	0.0
Current Receivables, inc(dec)	0.1	0.4	1.1	2.0	2.5
Inventories, inc(dec)	0.1	0.5	0.5	0.5	1.0
Other Current Assets, inc(dec)	0.0	0.0	0.0	0.0	0.0
Trade Payables, dec(inc)	-0.02	-0.08	-0.1	-0.2	-0.4
TOTAL FUNDS APPLIED	55.18	20.82	1.5	2.3	3.1
NET CASH SURPLUS	-54.88	-13.22	15.0	36.2	55.2

Sales 'Pessimistic'	1.0	10.0	20.0	40.0	80.0
Material Costs	0.2	1.0	2.0	3.2	4.8
Depreciation & Amortization	2.0	7.5	7.5	7.5	7.5
Operating Costs	0.5	4.5	8.0	14.0	24.0
Marketing and A&G expenses	0.2	1.5	2.4	4.0	8.0
R&D/Equipment Upgrading	0.0	0.0	1.9	3.1	6.3
Net Income before Tax	-1.9	-4.5	-1.8	8.2	29.4
N.I. after Tax(Pioneer Status)	-1.9	-4.5	-1.8	8.2	29.4
Return on Sales(%)	-190.0	-45.0	-9.0	20.5	36.75
FUNDS PROVIDED BY PROJECT					
Net Income(Pioneer Status)	-1.9	-4.5	-1.8	8.2	29.4
Depreciation & Amortization	2.0	7.5	7.5	7.5	7.5
Total Funds Provided	0.1	3.0	5.7	15.7	36.9
FUNDS REQUIRED BY PROJECT					
Capital Expenditure	55.0	20.0	0.0	0.0	0.0
Current Receivables, inc(dec)	0.1	0.4	1.1	2.0	2.5
Inventories, inc(dec)	0.1	0.5	0.5	0.5	1.0
Other Current Assets, inc(dec)	0.0	0.0	0.0	0.0	0.0
Trade Payables, dec(inc)	-0.02	-0.08	-0.1	-0.2	-0.4
TOTAL FUNDS APPLIED	55.18	20.82	1.5	2.3	3.1
NET CASH SURPLUS	-55.08	-17.82	4.2	13.4	33.4

3. Capital structure/Payout period

Capital Structure	US$Million		
	Alternative 1	Alternative 2	Alternative 3
Land	1	1	1
Building with clean room	18	20	25
Wafer fab line	23	28	32
Assembly line including testing	5	8	13
Licence(partial)	1	1	2
Project team	0.15	0.2	0.2
Reserve	1.85	1.80	1.80
Totai	50	60	75

Alternative 1 (US$50 Million)

Payout period	1989	1990				1991		Total
	4 Qtr	1	2	3	4	1	2	
Land		1						1
Building with cleanroom			5	5	6.5	1.5		18
Wafer fab line			2	5	11	2	3	23
Assembly line including testing				1	2	2		5
Licence (partial)			0.5		0.5			1
Project team	0.02	0.02	0.02	0.03	0.03	0.03		0.15
Reserve					0.35	1.5		1.85
Total quarter	0.02	1.02	7.52	11.03	20.38	7.53	3	50
Total year	0.02				39.95		10.03	50

Alternative 2 (US$60 Million)

Payout period	1989	1990				1991		Total
	4 Qtr	1	2	3	4	1	2	
Land		1						1
Building with cleanroom			5	5	7	3		20
Wafer fab line			3	7	10.5	2.5	5	28
Assembly line including testing				2	3	3		8
Licence (partial)			0.5		0.5			
Project team	0.03	0.03	0.03	0.03	0.03	0.05		0.2
Reserve					0.3	1.5		1.8
Total quarter	0.03	1.03	8.53	14.03	21.33	10.05	5	60
Total year	0.03				44.92		15.05	60

Alternative 3 (US$75 Million)

Payout period	1989	1990				1991		Total
	4 Qtr	1	2	3	4	1	2	
Land		1						1
Building with cleanroom			5	6.5	9	3.5		24
Wafer fab line			5	10	11	4	5	35
Assembly line including testing				2	4	5		11
Licence (partial)			0.5		0.5	0.5	0.5	2
Project team	0.03	0.03	0.03	0.03	0.03	0.05		0.2
Reserve					0.3	1.5		1.8
Total quarter	0.03	1.03	10.53	18.53	24.83			75
Total year	0.03				54.92		20.05	75

V. INSTITUTIONAL VIABILITY

Legal requirements concerning the company form, the joint venture structure and ownership should be subject to a detailed discussion between the Malaysian investment group and the legislature.

1. Organization structure

An organizational chart of the manufacturing part is shown on the next page. Not included is the marketing side, as the set up of this department will depend on the marketing and sales structure of this licensor.

2. Licence conditions/agreements

- Topics to be covered in a contract:
  i) transfer of knowhow and technology on CMOS
  ii) ASIC design
  iii) process technology
- documentation on technology and knowhow
- technical assistance before, during set up and during operation at licensor's premises and at MSC
- a minimum 5-year agreement on technology exchange and ongoing updating with licensor's latest technology
- agreement on the use of name and trademark of licensor
- buy-back arrangement and/or marketing assistance

3. Management requirement/Project management

The skills and the expertise required for the management team are listed under Chapter I, section 5 'Labor and skills required' and cover the technical and manufacturing team.

Additional one marketing executive will be needed, who should have at least not only 5 years experience in International Marketing Management, but also of having set up an International Marketing and Sales Organization in the electronic component field.

To get the project underway, a project team should be set up within the 4th quarter 1989 consisting initially of members from MIMOS, the investor group and an UNIDO consultant. The first task should be selection of licence partners, concrete licence negotiations and a licence agreement followed by the implementation of the entire project.

Organizational Chart

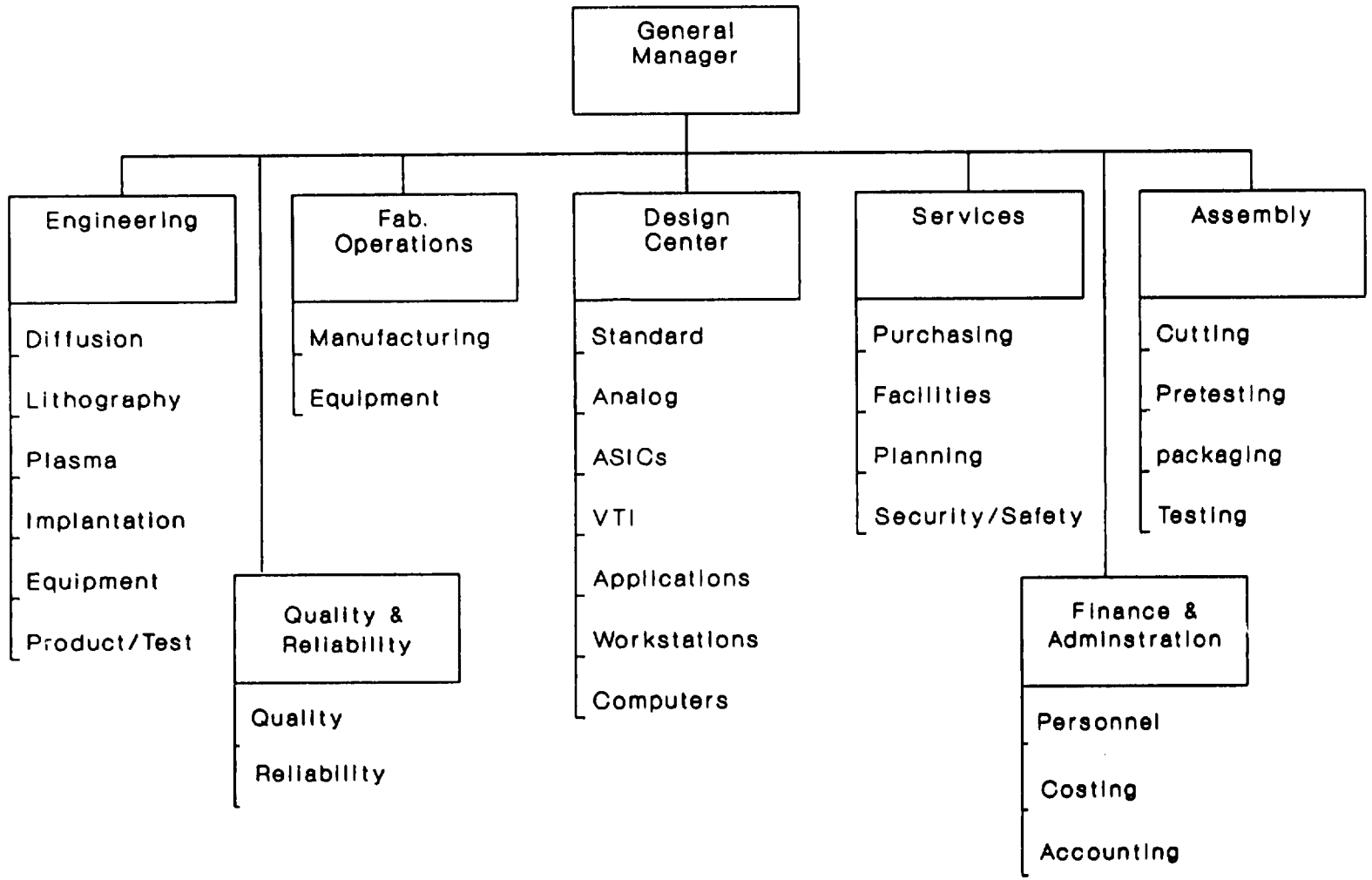
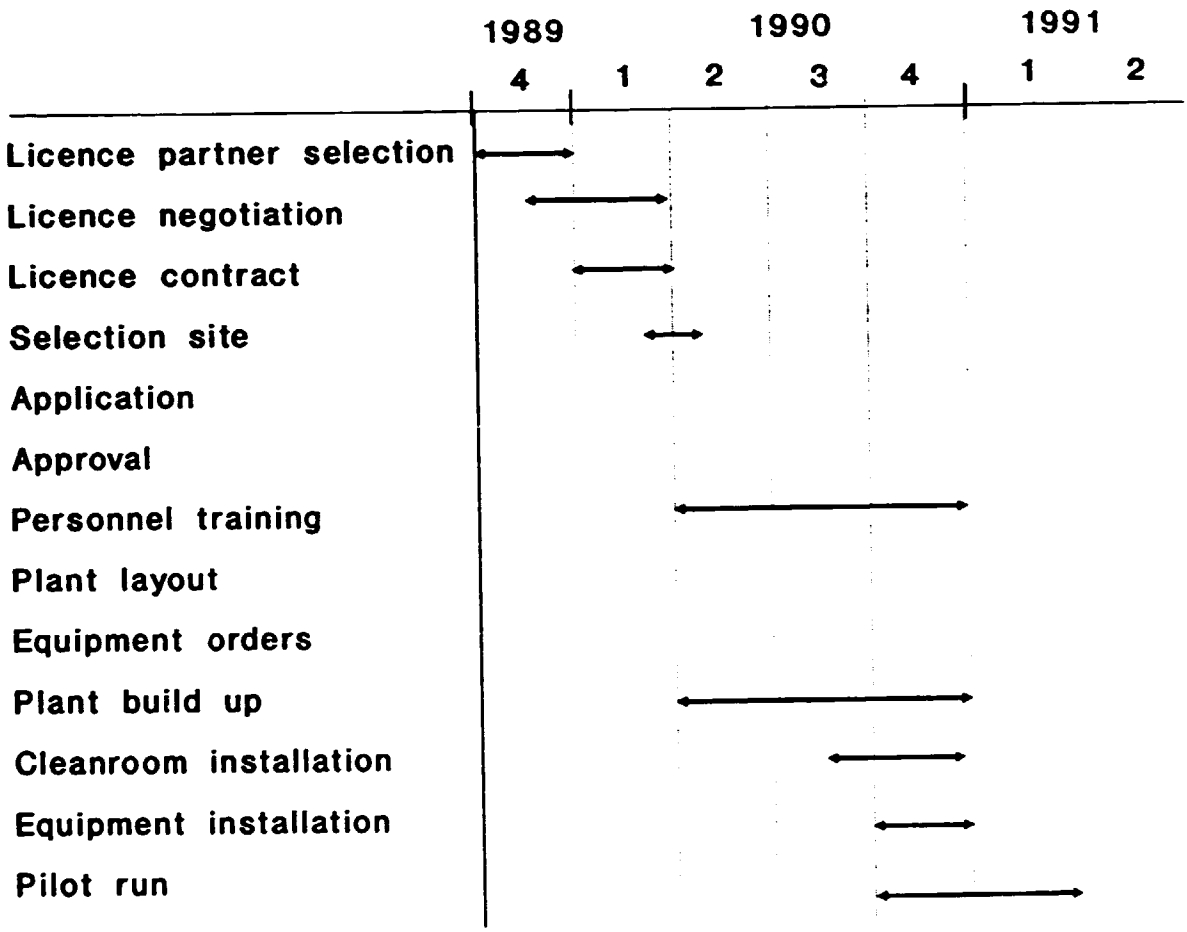


Fig. 16

4. Time Frame Implementation



MIMOS Aug,1989

5. Recommendations

Recommendation 1 :

Form a project team within September, 1989 consisting of a MIMOS representative, each one representative from the goverment investor group and the private investors as well as an UNIDO consultant.

Recommendation 2 :

Identify additional possible technology licensing and joint venture partners, start corresponding negotiation with them within the 4th. quarter, 1989(USA, Europe and Taiwan).

Recommendation 3 :

Close a licence contract within the 1st. quarter, 1990.

Recommendation 4 :

Incorporate MSC Inc. within the 1st. quarter, 1990.

Recommendation 5 :

Review and finalize business plan within the 2nd. quarter, 1990.

Recommendation 6 :

Incorporate the 'Semiconductor Technology Division of MIMOS', to get it involved in the operational activities of MSC. Inc.

Recommendation 7 :

Start operational activities of MSC. Inc. within the 2nd. quarter, 1990.