India Electronics Sector Opportunities for Beginners

A Primer for Entrepreneurs and Strategists

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Executive Summary

This report is aimed at executives who have no previous knowledge of the Electronics Sector. The so-called Electronics Ecosystem is explored in the first section with the aim of providing all the technical knowledge necessary to understand subsequent discussions. Some forecasts for the global market in electronics are charted followed by a discussion of the East Asian experience in Electronics in order to provide both a geographical and historical context to the investment decision.

This is followed by a section on the cost economics of Electronics manufacturing in an attempt to explain the choices available to decision-makers.

Three opportunities are short-listed: Contract system Assembly (EMS), Contract Chip packaging and Analog Chip Supply.

The EMS opportunity is explored in more length with a focus on medical EMS as an example of one of the opportunities within the Contract Assembly market. The other two opportunities are looked at very briefly.

Electronics Production Chain

- **Enclosures**
- **Connectors**
- **Harnesses**
- **Batteries**

System Level

Components → **Other Parts** → **Assembly** → **End-user**

- **Semiconductors**
- **Passives**
- **Printed Circuit Boards (PCB)**
- **Displays**

- **Board Stuffing**
  Components are placed on the PCB and soldered

- **Box-build**
  Several PCBs are assembled together with electro-mechanical parts into an enclosure

- **Testing**
  Test programs using automated equipment designed to test every PCB

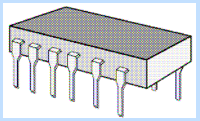
Electronic Components

Semiconductors
- Logic chips
- Processor chips
- Memory chips
- Analog
- Discretes

Passives
- Capacitors
- Resistors
- Inductors

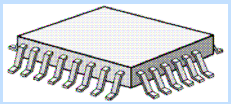
PCB
- Paper / Composites
- Rigid
- Flexible
- Microvia

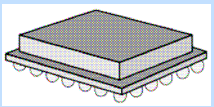
Displays
- Cathode Ray Tube
- Liquid Crystal



Pin Through Hole (PTH)
Older technology requiring holes in the PCB. The pins are inserted through the holes and the PCB is passed over a bath of solder to make joints

PTH Capacitors

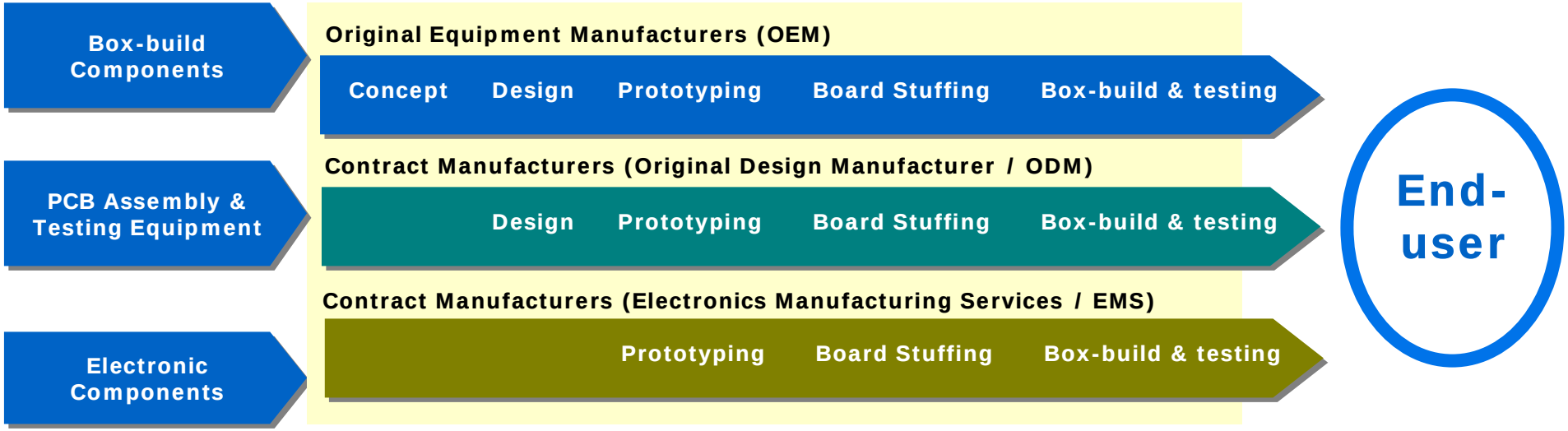




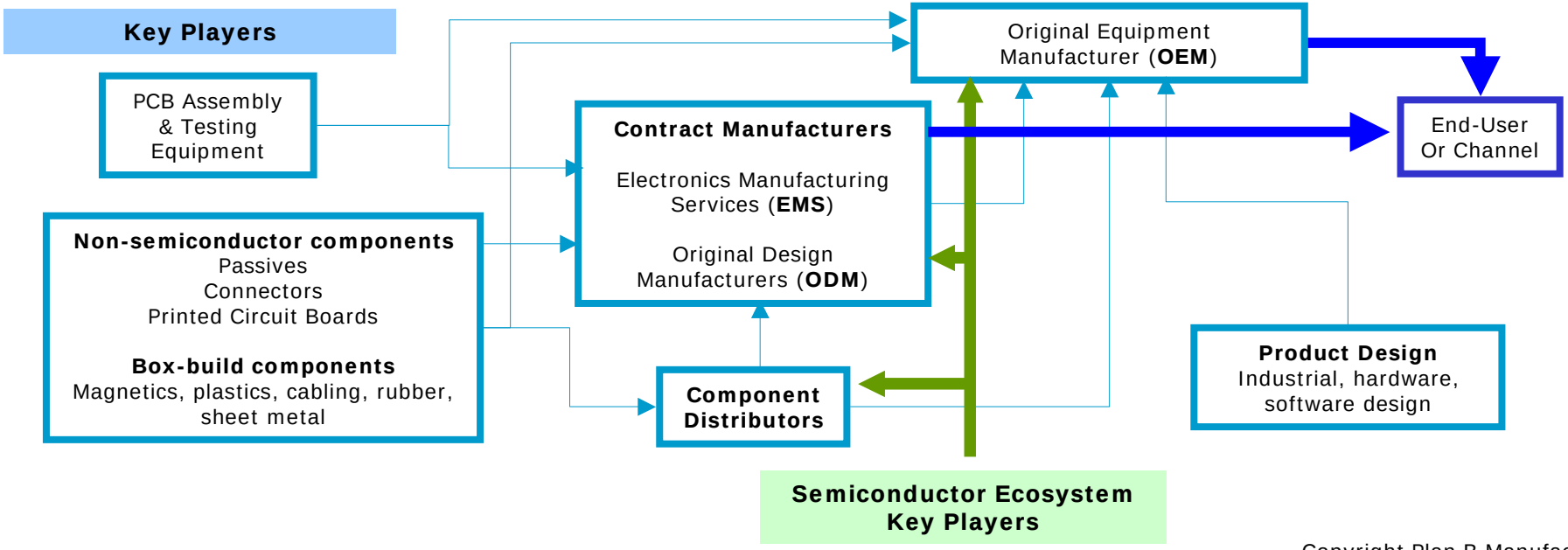
Surface Mount Technology (SMT)
Almost all Board assembly is now done by placing components directly onto the PCB. The solder is pre-applied so the components sit on the solder paste which melts to form joints when the PCB is passed through an oven. The advantage of SMT is that the components can be made much smaller, which in turn means that the PCB and the product can also be smaller.

SMT Capacitors

Electronics Value Chain – System Level



Electronics Ecosystem – System Level



What is driving the OEM companies to outsource System-build?

Large Integrated Manufacturers at System Level have seen an increase in Facilities costs for the following reasons:

Introduction of surface mount devices: Decreasing size of components to accommodate the demand for smaller and lighter products meant that accurate placement by hand would be difficult. This heralded the introduction of machinery incorporating vision systems that could accurately pick-up, measure and place thousands of components per minute to within microns on the circuit board. Costs of board assembly lines increased at least five fold within ten years .

Introduction of complex ICs: As components became smaller, for some chips with high-functionality such as Microprocessors which have a large number of leads, the spacing between the leads became smaller, requiring the accurate placement capabilities that only machines can achieve.

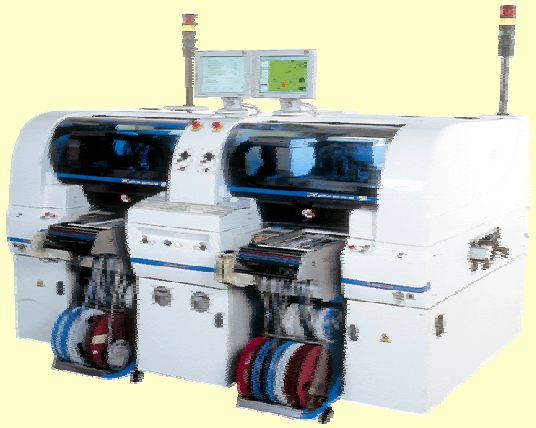
Poor capacity utilization: Volatility of market demand made capacity planning and production scheduling very difficult, which increased the costs of owning facilities dedicated to the company's limited set of products.

Costs of engineering: As equipment complexity increased, the engineering effort needed to maintain and develop the equipment increased more than the cost of labour needed to run it.

Many OEMs cannot justify the continued investment in keeping up with the process technology, especially in view of the fact that product development costs are also increasing thanks to advanced semiconductor technologies as well shorter product life-cycles. **The attractive option is to outsource the circuit board assembly to contract manufacturers (EMS companies).**

In addition there are Industry standards in circuit board layout specifications called "Gerber" files, which contain instructions for the manufacture of a Printed Circuit Board and instructions to a pick & place machine (as shown right) on what components to pick up and where to place them. This file could be generated directly by the System designer's CAD package and therefore can be very conveniently transferred to the contractor. In addition, since much of the proprietary circuit design detail is actually hidden within the ICs, there is little danger of IP theft by the contractor.

High Speed component placement machine with fast changeover capabilities



Placement speed: 50,000 components per hour

Features:
Vision system that can identify profile of component and place it within plus or minus 60 microns of accuracy – thousands of times a minute.

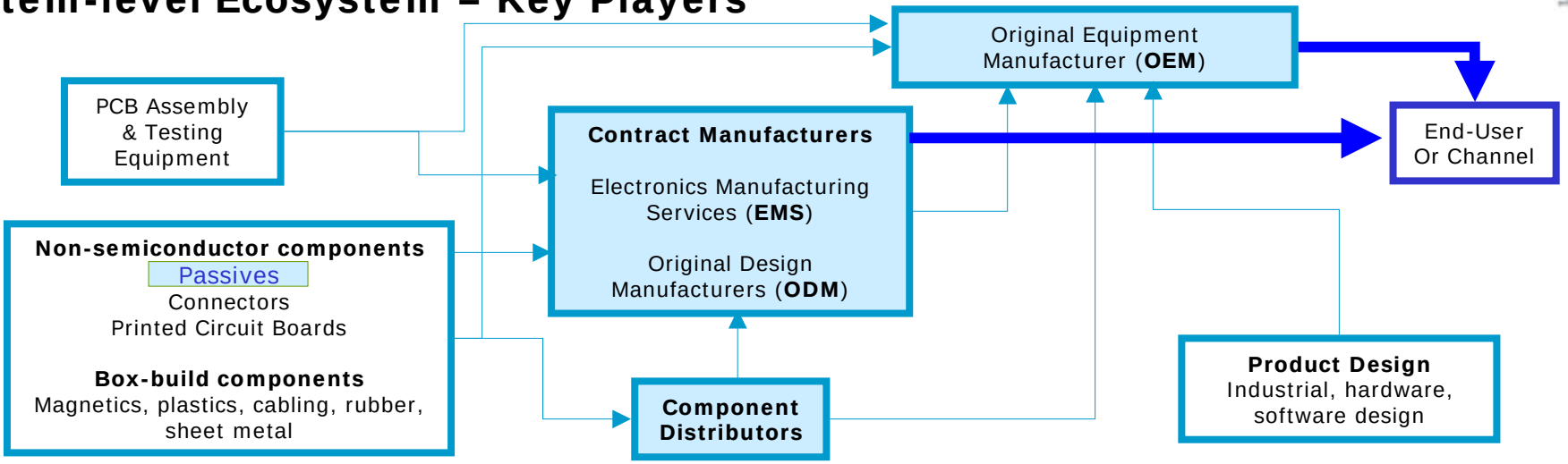
It can handle components as small as 0.5mm x 0.25 mm to as big as 50 mm x 50 mm

It can also accurately place chips that have leads with a spacing as narrow as 0.3 mm.

Changeover time: 10 to 20 mins

List Price: **$500,000** Euros for machine plus all accessories

System-level Ecosystem – Key Players



System Level Ecosystem Companies analysed in this report

Passive Components	Sales ($k) 2005
Epcos	1,490,959
Vishay	2,297,484
AVX	1,333,208
Murata	3,862,659
American Technical Ceramics	72,965
TDK Corp	6,796,410
Kemet	490,106
Yageo	504,515
Taiyo Yuden	1,609,872

Component Distribuors	Sales ($k) 2005
Avnet	1,490,959
Arrow	2,297,484
Bell Microproducts	1,333,208
Premier Farnell	3,862,659
Microcomponents plc	72,965
Richardson	6,796,410
All American	490,106
Jaco Electronics	504,515

Top EMS Companies	Sales ($k) 2005
Hon Hai Precision Ind. Co. Lt	27,353,201
Flextronics International Ltd.	15,287,976
Sanmina-SCI	11,734,674
Solectron Corporation	10,441,100
Celestica	8,471,000
Jabil Circuit	7,524,386
Benchmark Electronics	2,257,225
Venture Corp.	1,907,526
Plexus Corp.	1,228,882
Pemstar	871,500

Top ODM Companies	Sales ($k) 2005
Quanta Computer	14,376,604
Asustek	10,735,186
Compal Electronics	7,963,858
Inventec	5,961,861
BenQ Corporation	5,389,578
Wistron Corp.	4,991,873
Lite On Technology	4,933,128
Mitac International	2,514,539

Smaller EMS Companies	Sales ($k) 2005
GES International Limited	367,782
Nam Tai Electronics, Inc.	797,237
Alco Electronics Ltd.	627,177
Suntron Corporation	328,730
Surface Mount Technology (H	315,539
Nortech Systems, Inc	84,216
LaBarge, Inc	190,089
SigmaTron International	124,786
IEC Electronics	19,066
Sparton Corp.	170,805
KeyTronicEMS	187,699
Hana Microelectronics (Thai E	329,767
SMTC Corporation	228,766

Auto Assemblers	Sales ($k) 2005
General Motors	192,604,000
Daimler Chrysler	177,394,694
Ford	153,503,000
Honda	90,162,764
Toyota	182,541,386

OEM / Systems	Sales ($k) 2005
Cisco	28,484,000
Lucent	9,441,000
Motorola	36,843,000
Alcatel	14,947,355
Nortel	10,523,000
EMC	9,663,955
HP	68,945,000

Auto Parts	Sales ($k) 2005
Johnson Controls	27,479,400
Magna International	22,811,000
Lear	17,089,200
Visteon	16,812,000
TRW	12,643,000
Autoliv	6,204,900
Tomkins	5,776,000
BorgWarner	4,293,800

Auto sector companies are included for comparison

Below the System level, the Semiconductor chain is the most significant

Electronics Value Chain – System Level

Box-build Components

PCB Assembly & Testing Equipment

Electronic Components

Original Equipment Manufacturers (OEM)

Concept → Design → Prototyping → Board Stuffing → Box-build & testing

Contract Manufacturers (Original Design Manufacturer / ODM)

Design → Prototyping → Board Stuffing → Box-build & testing

Contract Manufacturers (Electronics Manufacturing Services / EMS)

Prototyping → Board Stuffing → Box-build & testing

End-user or Channel

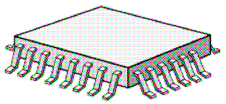
Semiconductor Production Chain

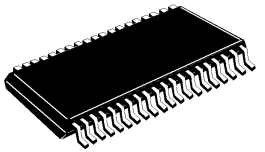
Chip Level

Materials → **Wafer Fabrication** (Front End) → **Assembly & Packaging** (Back End) → **Testing** (Back End)

Materials

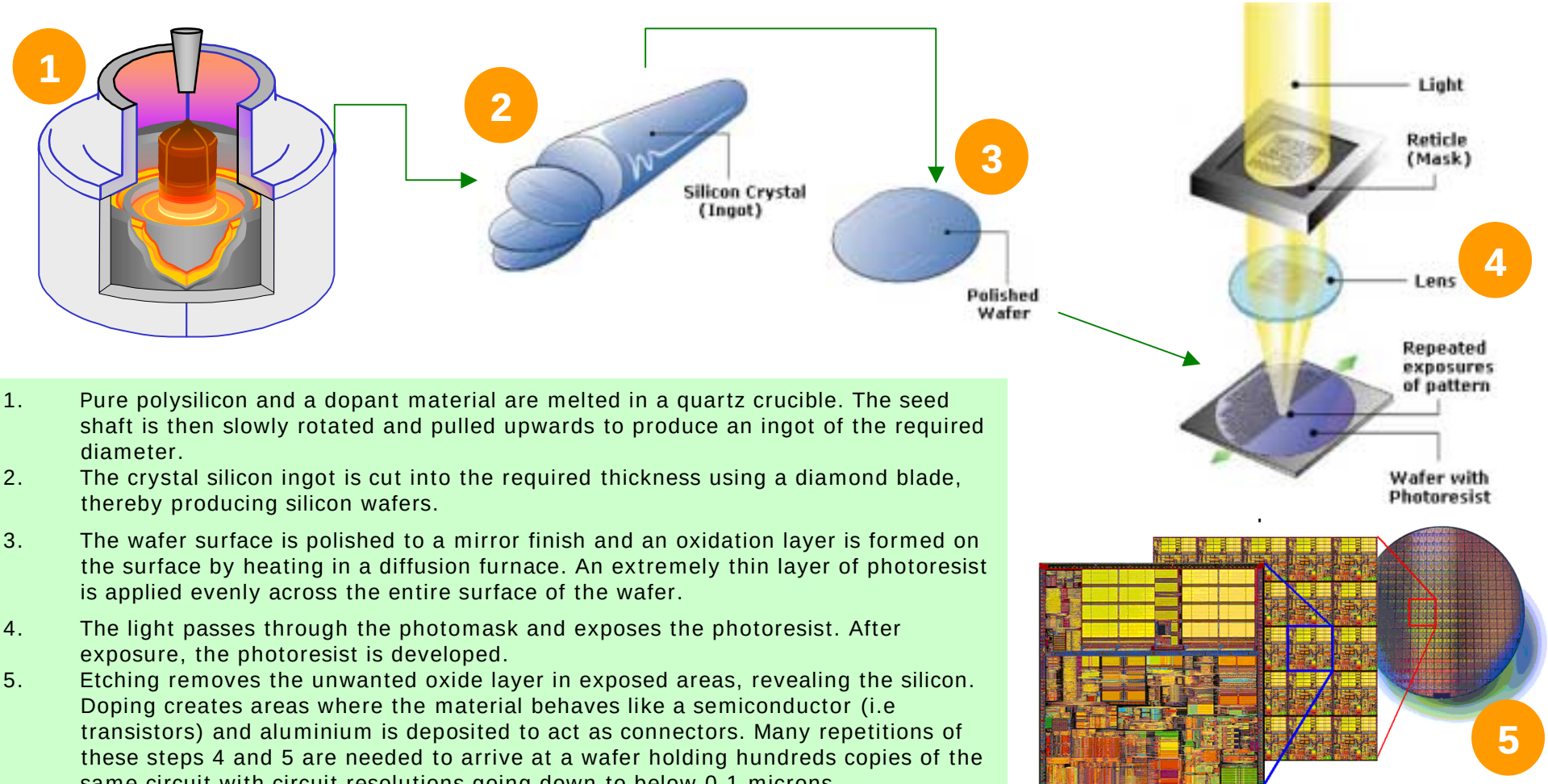
Front End	Back End
• Silicon Wafers	• Lead Frames
• Photo Masks	• Plastic Substrates
• Electronic Gases	• Encapsulation Resins
• Photo resist etc	• Ceramic Packages
• Wet chemicals	• Bonding Wire





Semiconductor front-end production process

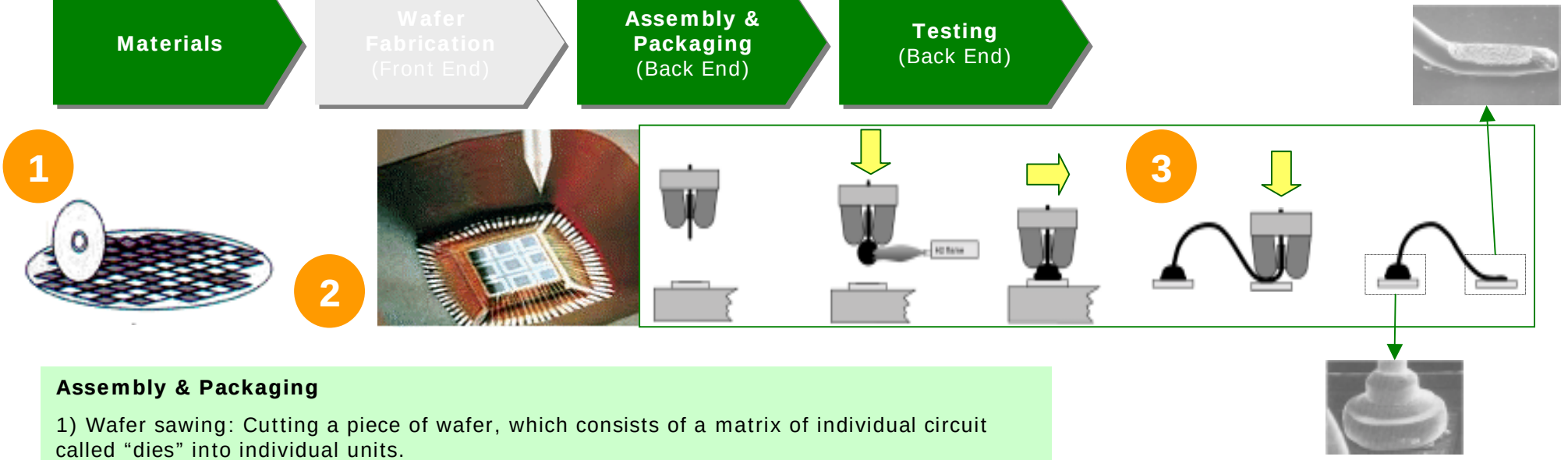
Materials → **Wafer Fabrication** (Front End) → Assembly & Packaging (Back End) → Testing



1. Pure polysilicon and a dopant material are melted in a quartz crucible. The seed shaft is then slowly rotated and pulled upwards to produce an ingot of the required diameter.
2. The crystal silicon ingot is cut into the required thickness using a diamond blade, thereby producing silicon wafers.
3. The wafer surface is polished to a mirror finish and an oxidation layer is formed on the surface by heating in a diffusion furnace. An extremely thin layer of photoresist is applied evenly across the entire surface of the wafer.
4. The light passes through the photomask and exposes the photoresist. After exposure, the photoresist is developed.
5. Etching removes the unwanted oxide layer in exposed areas, revealing the silicon. Doping creates areas where the material behaves like a semiconductor (i.e transistors) and aluminium is deposited to act as connectors. Many repetitions of these steps 4 and 5 are needed to arrive at a wafer holding hundreds copies of the same circuit with circuit resolutions going down to below 0.1 microns.

Semiconductor back-end production process

Materials → Wafer Fabrication (Front End) → **Assembly & Packaging** (Back End) → **Testing** (Back End)



Assembly & Packaging

1) Wafer sawing: Cutting a piece of wafer, which consists of a matrix of individual circuit called “dies” into individual units.

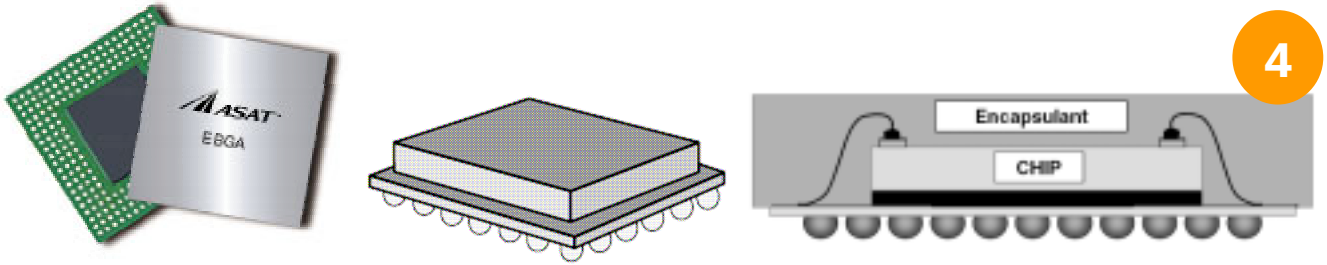
2) Die bonding/Die Attach: The die is then placed and stuck on to a piece of lead frame (usually made of copper) or substrate by conductive material (usually gold or silver epoxy).

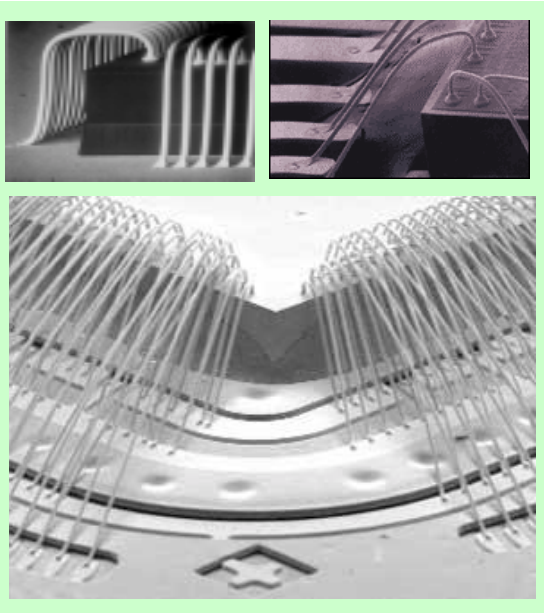
3) Wire bonding: Connecting the circuit with the leads on the lead frame or substrate using very thin (in the order of 1,000th of an inch) gold or aluminium wire.

4) Molding /Encapsulation: The connected piece of circuit is then encapsulated by molding compound (epoxy resin that can withstand high temperature in the soldering process).

Testing

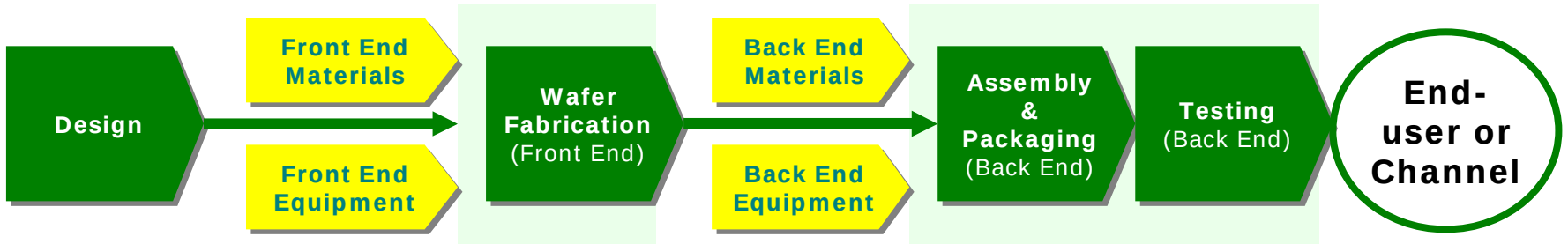
Automatic testing equipment uses programs to test key electrical characteristics of every chip produced. A number of other tests are also carried out on a sample basis.



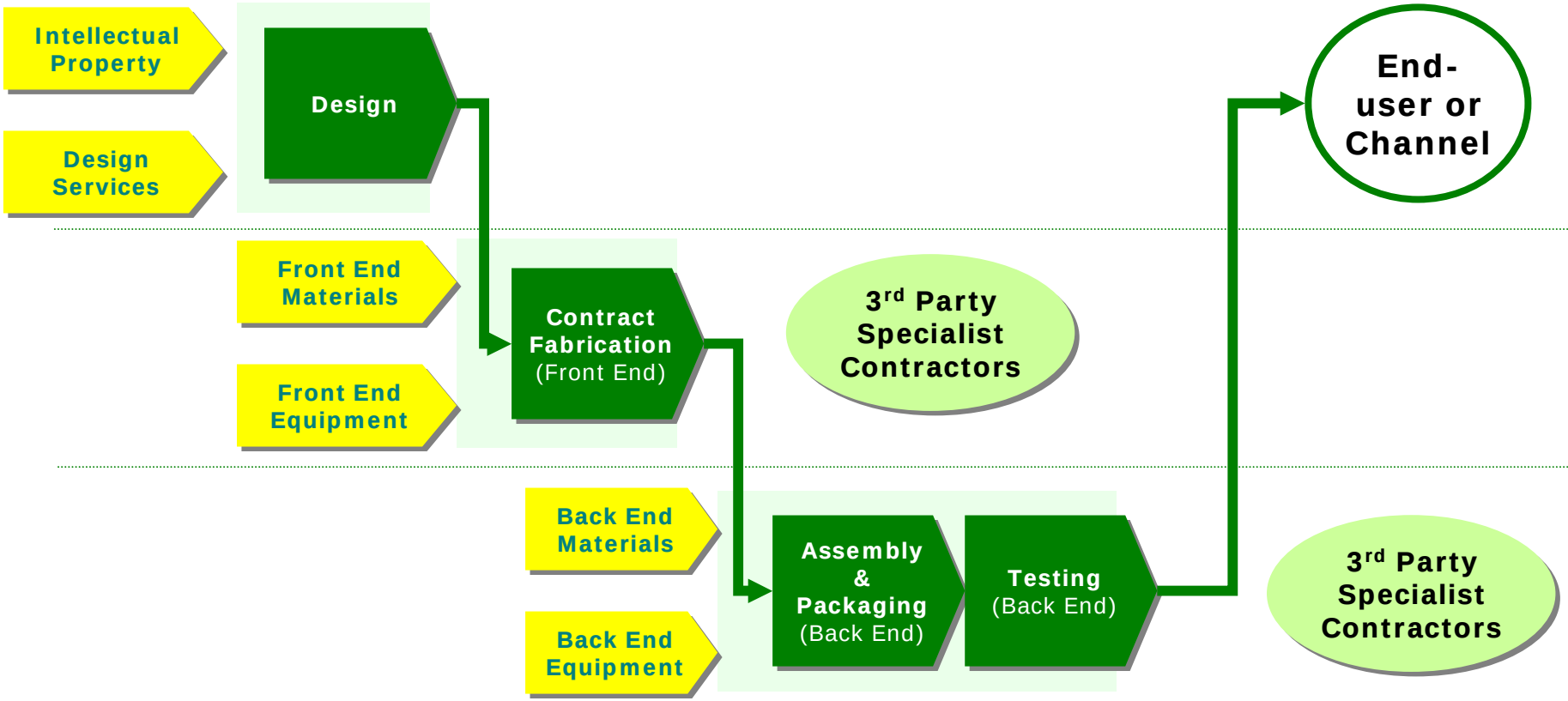


Semiconductor Value Chain

Integrated Device Manufacturers (IDMs) carry out all the steps in-house

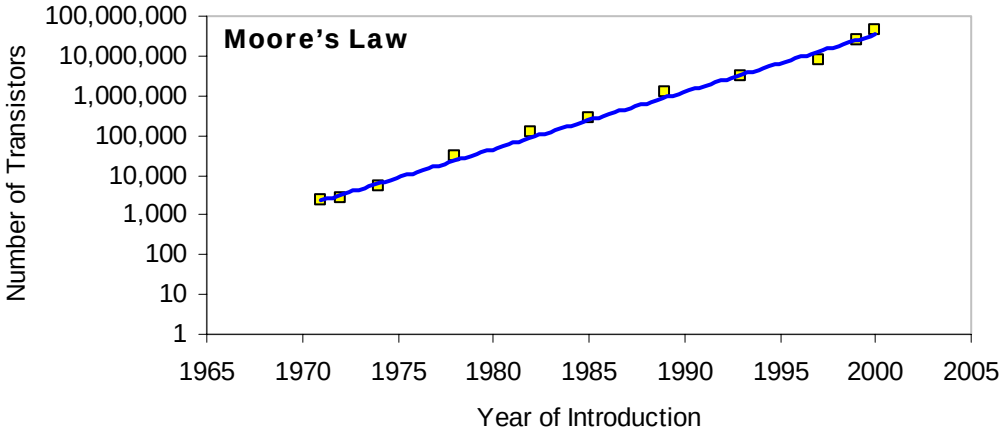


Automation of each step has seen the emergence of narrow specialists and companies that focus on design and customer relationships



Current Semiconductor Industry Issues

We may reach the limits of silicon technology by 2015

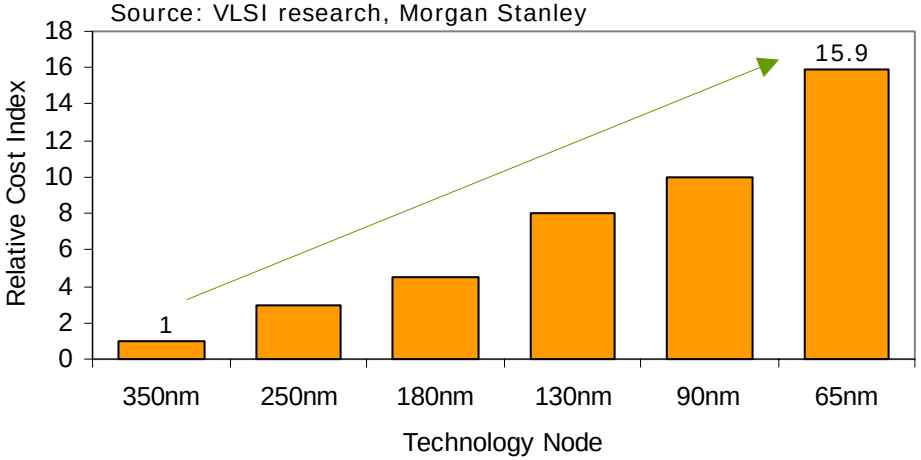


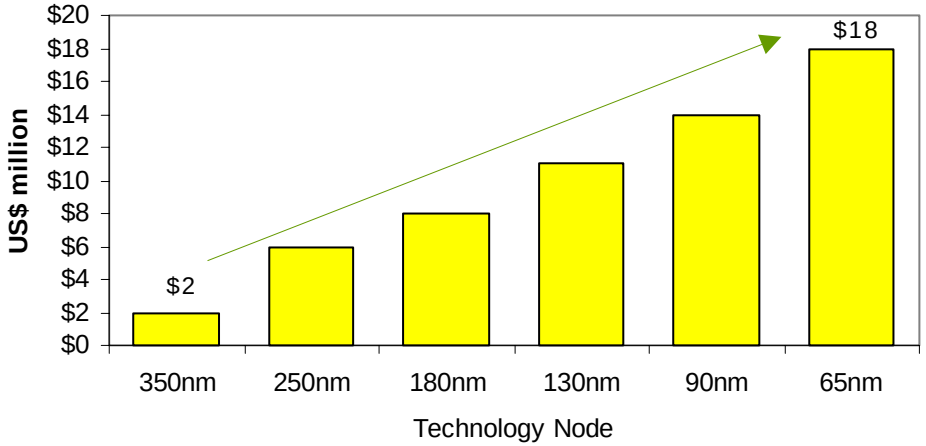
MOORE'S LAW**:** In 1965, Gordon Moore observed that the number of components on an integrated circuit was doubling roughly every 12 months with a commensurate reduction in cost per component. In 1970, he extended the amount of time to 24 months.

This characteristic of silicon technology has allowed for tremendous improvements in the speed, cost and size of electronic products over the last 40 years.

But we may be reaching the limits of this scaling and it is getting more expensive to reach each new level. Progress in semiconductors is measured in 'line widths', which is the resolution of two adjacent lines on the chip surface. Current technology frontier is at 65 nanometres. The research, development and engineering spend needed for a company to achieve this line width is estimated to have grown 16 times over 5 process nodes. The cost of developing each new chip using the new technology has also increased 9 fold.

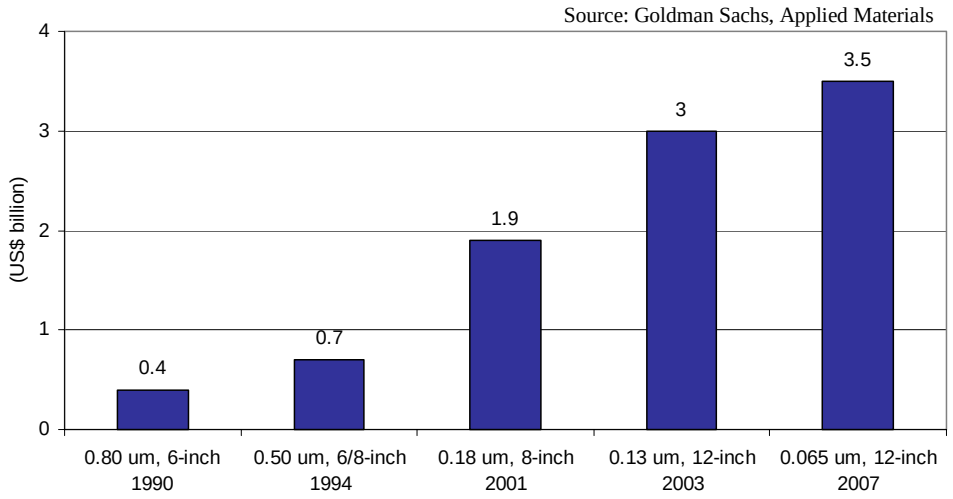
Source: VLSI research, Morgan Stanley



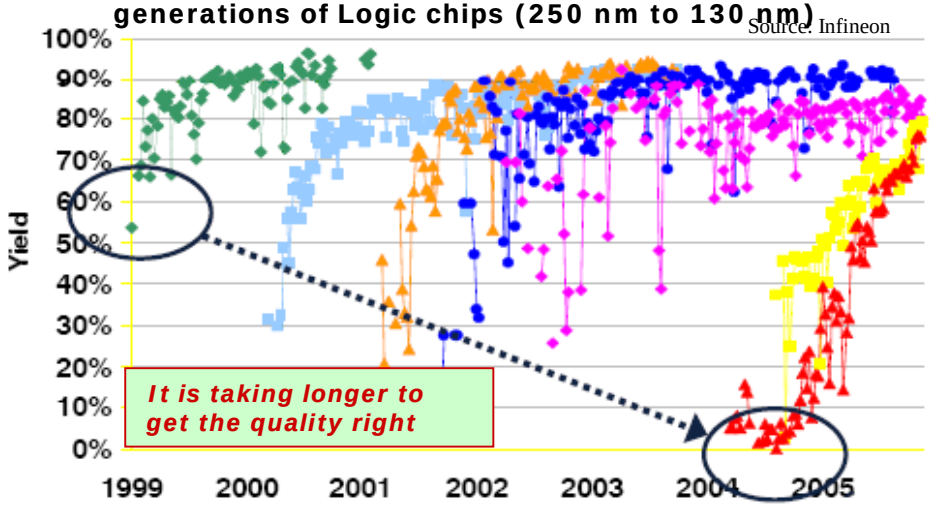


Current Semiconductor Industry Issues

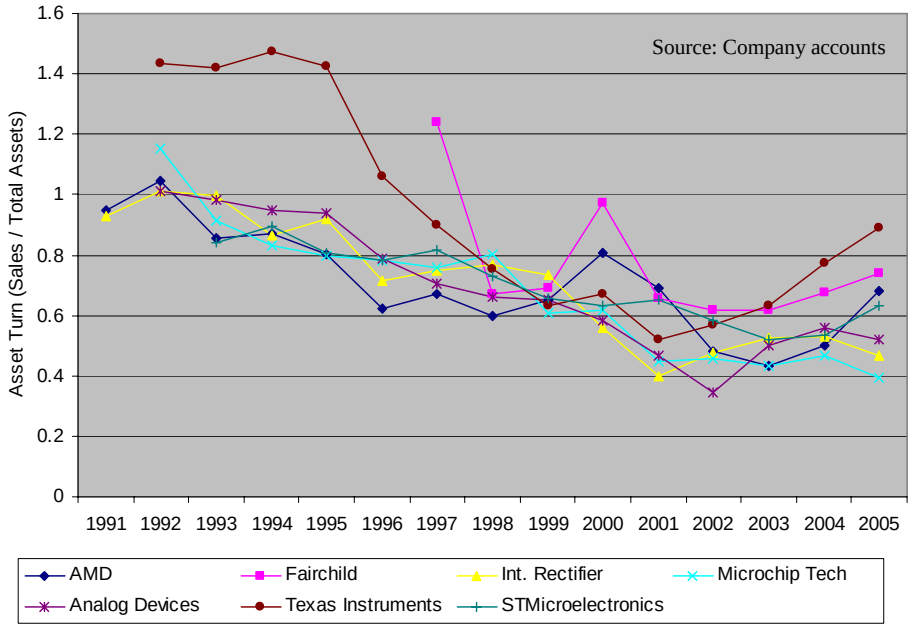
Cost of building a new Fabrication unit



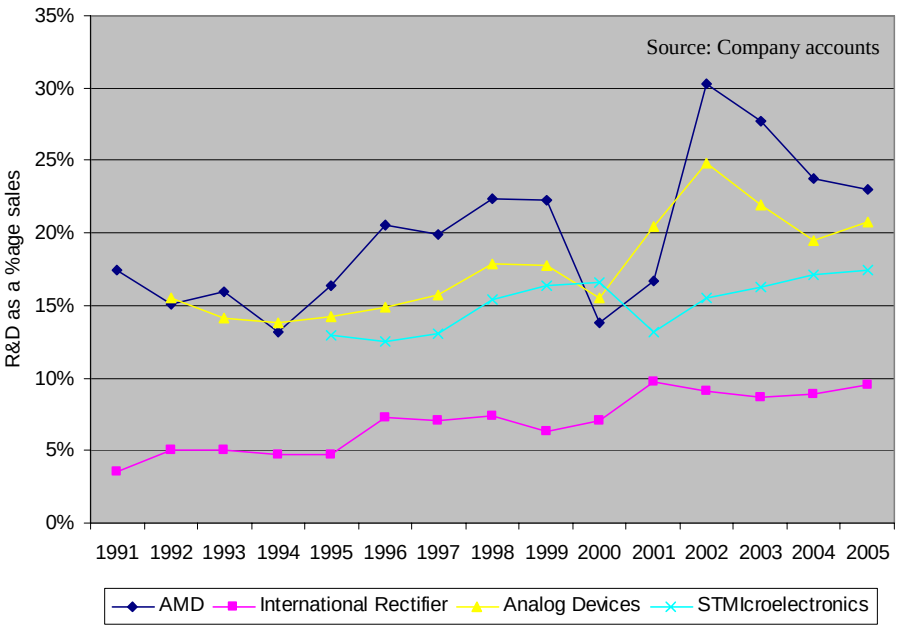
Initial production yield history for several generations of Logic chips (250 nm to 130 nm)



Chip Makers - Deteriorating Asset Turns



Chip Makers - Increasing R&D Expenditures



What is driving the break-up of the Semiconductor value chain?

The Design element of the value chain is actually a collection of a large number of activities involving the conceptualisation, design of chip layout, layout at board level, embedded software development and systems integration.

The rise of fabless companies – which specialize in design and marketing of chips, has led the way to the creation of a chip design industry. The ability to use third party foundries to manufacture chips drastically reduced the entry costs into the Chip supply chain allowing smaller companies to set up as designers.

The easy availability of Electronic Design Automation (EDA) tools, which automate many of the activities in the design process has also helped. This meant that design outputs from one team in India, for instance, could easily be integrated with the work of another team in the US.

In addition, the productivity of design engineers was also not keeping up with the increase in chip functionality and complexity, which has made it attractive for western companies to seek lower cost locations.

Huge investments are needed to keep up with Fabrication technology. This increases the fixed costs of the business and therefore the volume needed for breakeven also rises. Given the volatility of market demand for most electronics products, only those companies that are supplying standard products that are sold in their millions (Microprocessors, Memory chips) can afford in-house manufacturing capabilities.

In many cases, there is simply not enough cash to pursue both product and process innovation.

The rise of the Fabless model is also driving the demand for third party foundries.

On the pull side, the leading foundries have cutting-edge capabilities, focussed as they are solely on process improvement. These capabilities provide benefits to their customer, speeding up new product introductions when compared with having to develop in-house capabilities.

IDMs are focussing on investments in product innovation and in keeping up with fast-moving technology in Wafer fabrication. Packaging technologies are also becoming more complex and require more effort to master than many IDMs are willing to expend.

Fabless companies are driving the move to advanced packages which tend to be complex and expensive.

Foundries are also interested in forming alliances with Packagers so that they can offer the the complete packaged chip to their customers.

Increasing automation is driving costs up for each new generation of machines which in turn make it uneconomical for IDMs to try and keep up with.

On the pull side, packaging contractors have taken over product innovation by creating and patenting new low cost package designs. This helps reduce costs and gets their customers quicker to market.

Semiconductor Ecosystem

IP Companies	Sales ($k) 2005
ARM	399,051
Rambus	157,198
MIPS Technologies	61,219
Virage Logic	53,389
Mosaid Technologies	46,851
Ceva	35,636

Foundries	Sales ($k) 2005
TSMC (Taiwan)	7,996,952
UMC Group (Taiwan)	2,856,386
Chartered (Singapore)	1,032,734
SMIC (China)	1,171,319
Vanguard (Taiwan)	344,584

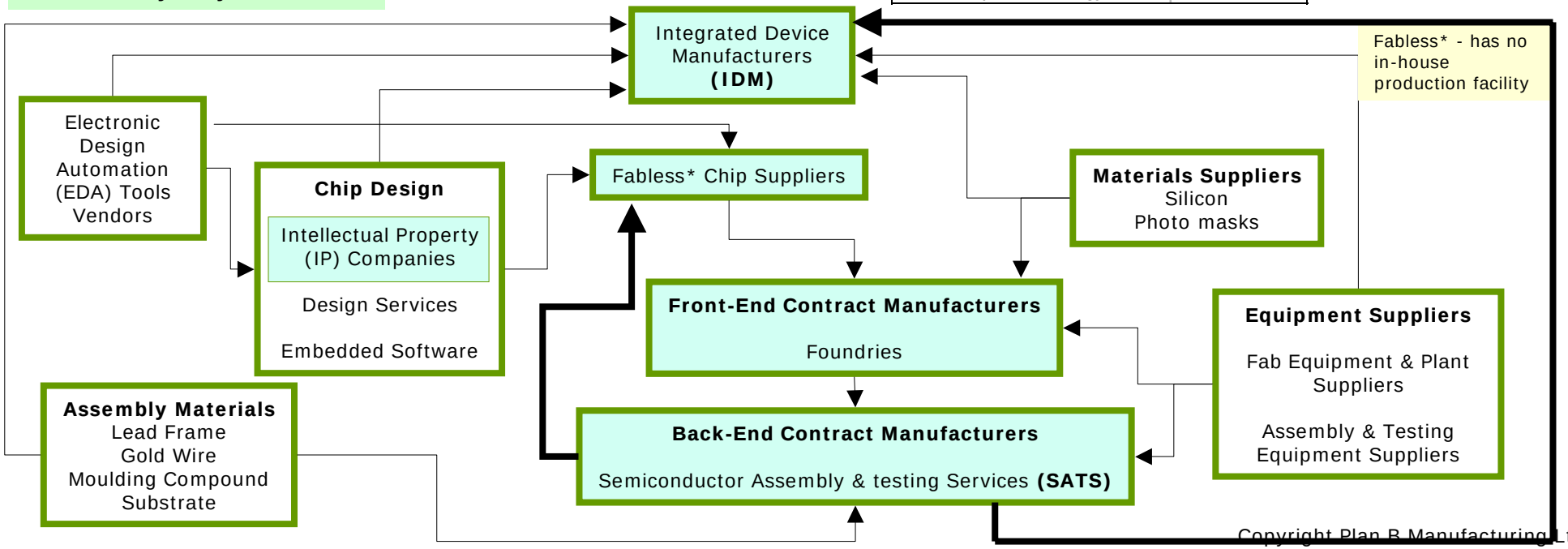
Fabless	Sales ($k) 2005
Xilinx	1,726,250
Altera	1,123,739
Lattice Semiconductor	211,060
Actel	179,397
QuickLogic	48,259

SATS Companies	Sales ($k) 2005
Amkor	2,099,949
Advanced Semiconductor	2,562,100
Siliconware Precision(SPIL)	1,325,850
STATS ChipPAC Ltd. (STTS)	1,157,253
United Test and Assembly	325,497
ChipMos	456,419
ASAT	182,115

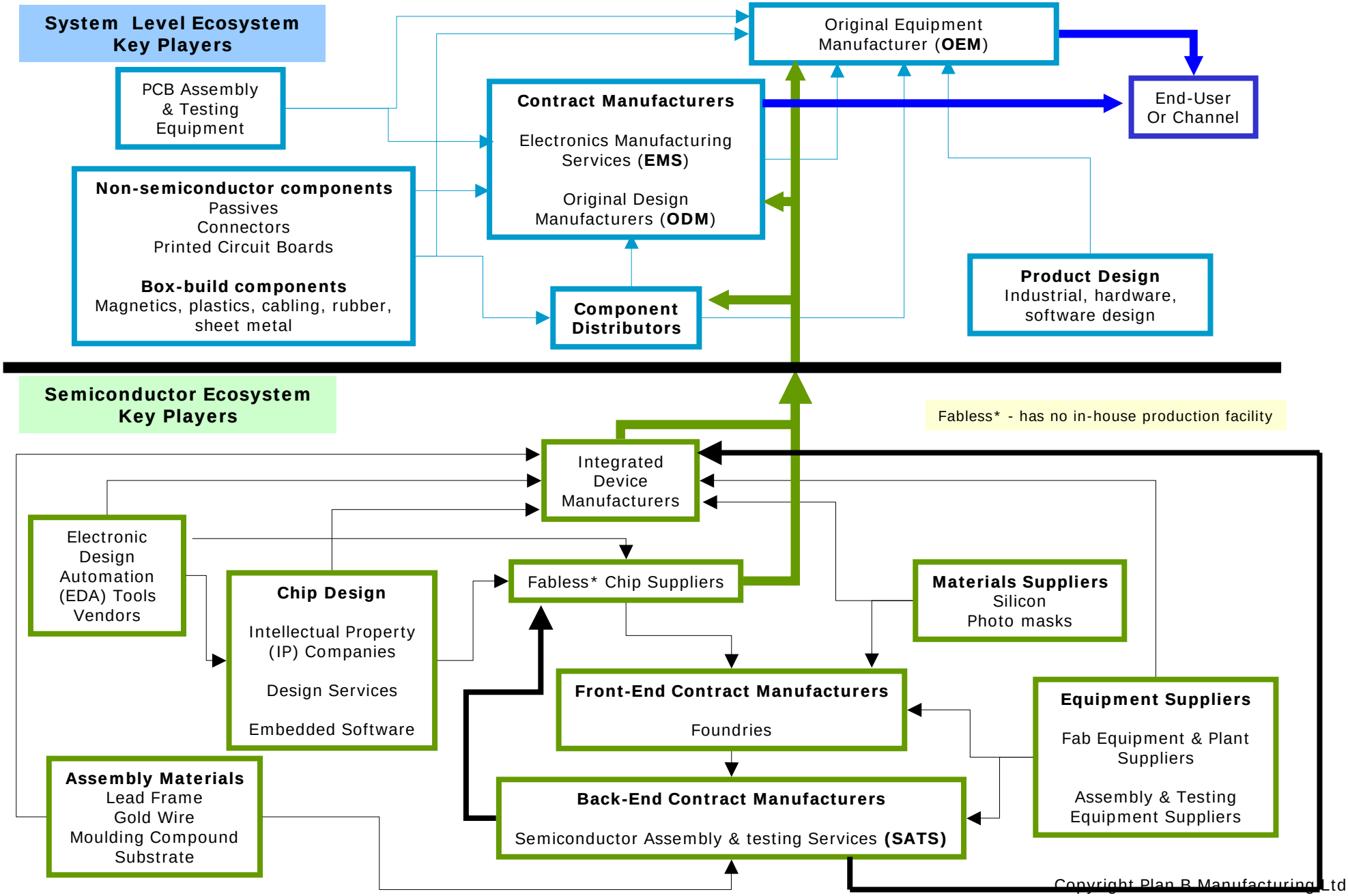
IDM	Sales ($k) 2005
Intel	38,826,000
Texas Instruments	13,392,000
STMicroelectronics	8,882,000
Infineon Technologies	8,237,193
Advanced Micro Devices (AM	5,847,577
Freescale Semiconductor	5,843,000
NEC Electronics	5,521,051
Hynix	5,362,076
Micron Technology	4,880,200
Analog Devices	2,388,808
National Semiconductor	2,158,100
Elpida Memory	2,056,304
Spansion	2,002,805
Agere Systems	1,676,000
Atmel	1,675,715
Fairchild Semiconductor	1,425,100
International Rectifier	1,171,118
Microchip Technology	927,893

Semiconductor Ecosystem Companies analysed in this report

Semiconductor Ecosystem Key Players



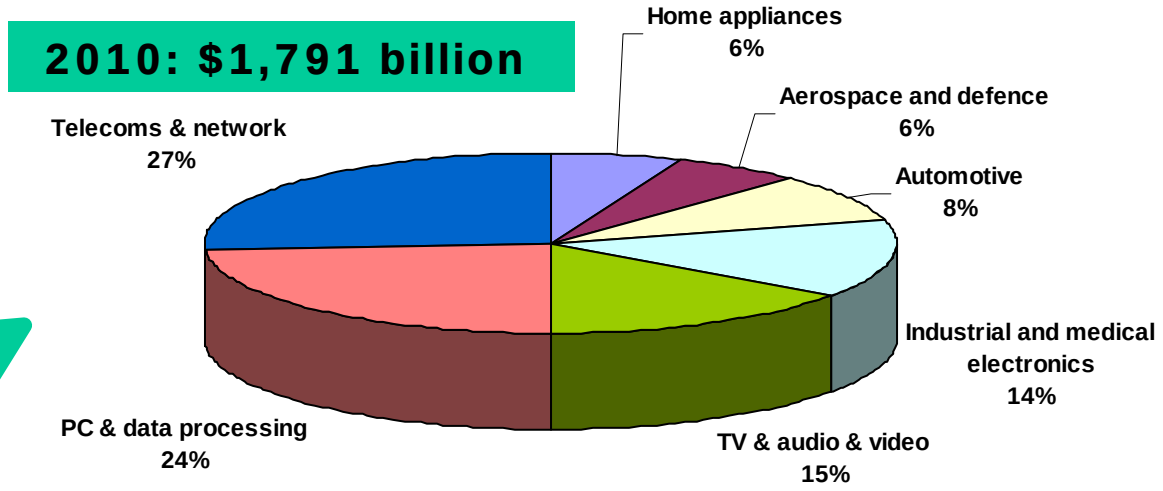
The Electronics Ecosystem



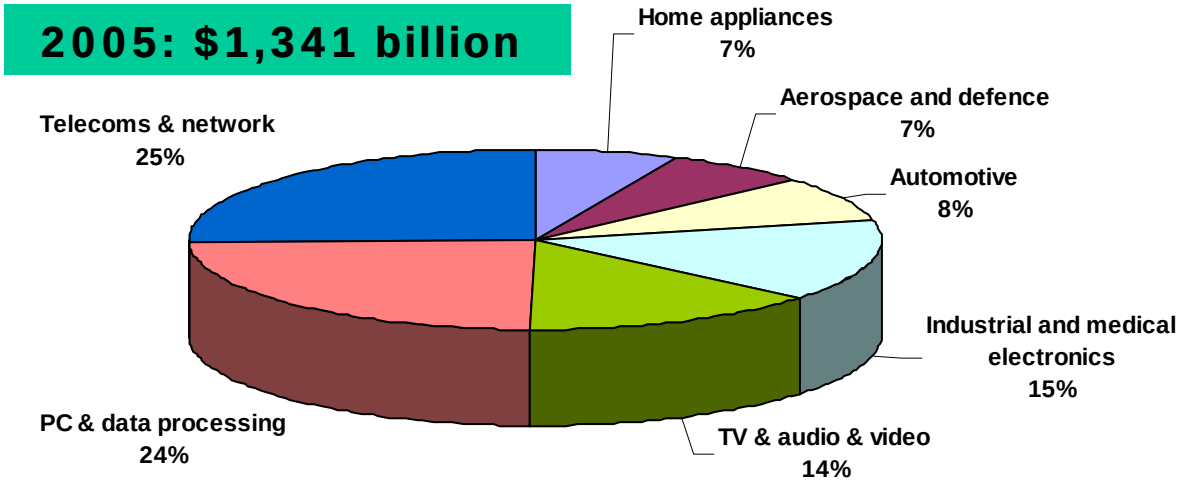
Global Market for Electronics

The Electronics Market is large and is expected grow at twice the World GDP

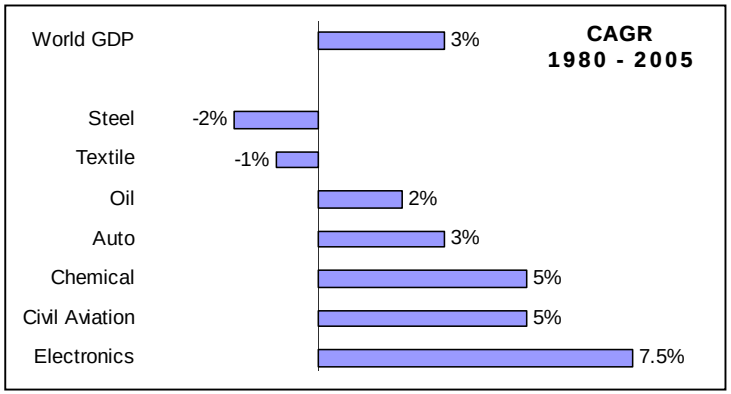
CAGR 6%



Source: DECISION – July 2006 (Euro = 1.25 US$)



Electronics is the world's fastest growing market



Global output in Electronics and Auto is migrating to China and Asia-Pacific

The percentage figures show the change in global share of production between 2000 and 2005 in Electronics and Auto sectors

North America
Electronics **−7 %**
Automotive **−5 %**

Europe
Electronics **−1 %**
Automotive **−2 %**

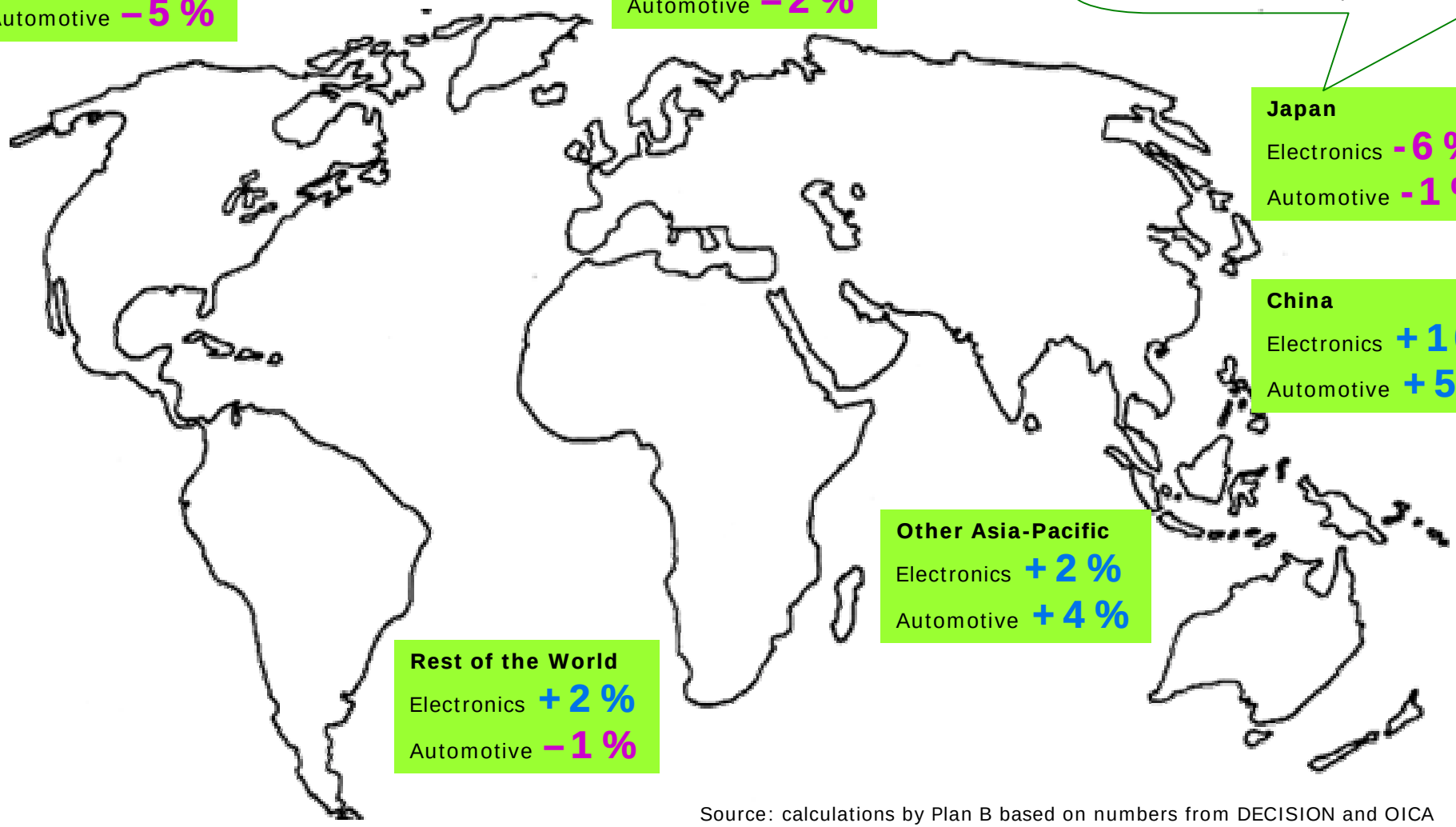
For example, Japan based units had 20% share of the 2000 global output in Electronics but only 14% of the 2005 output

Japan
Electronics **-6 %**
Automotive **-1 %**

China
Electronics **+10 %**
Automotive **+5 %**

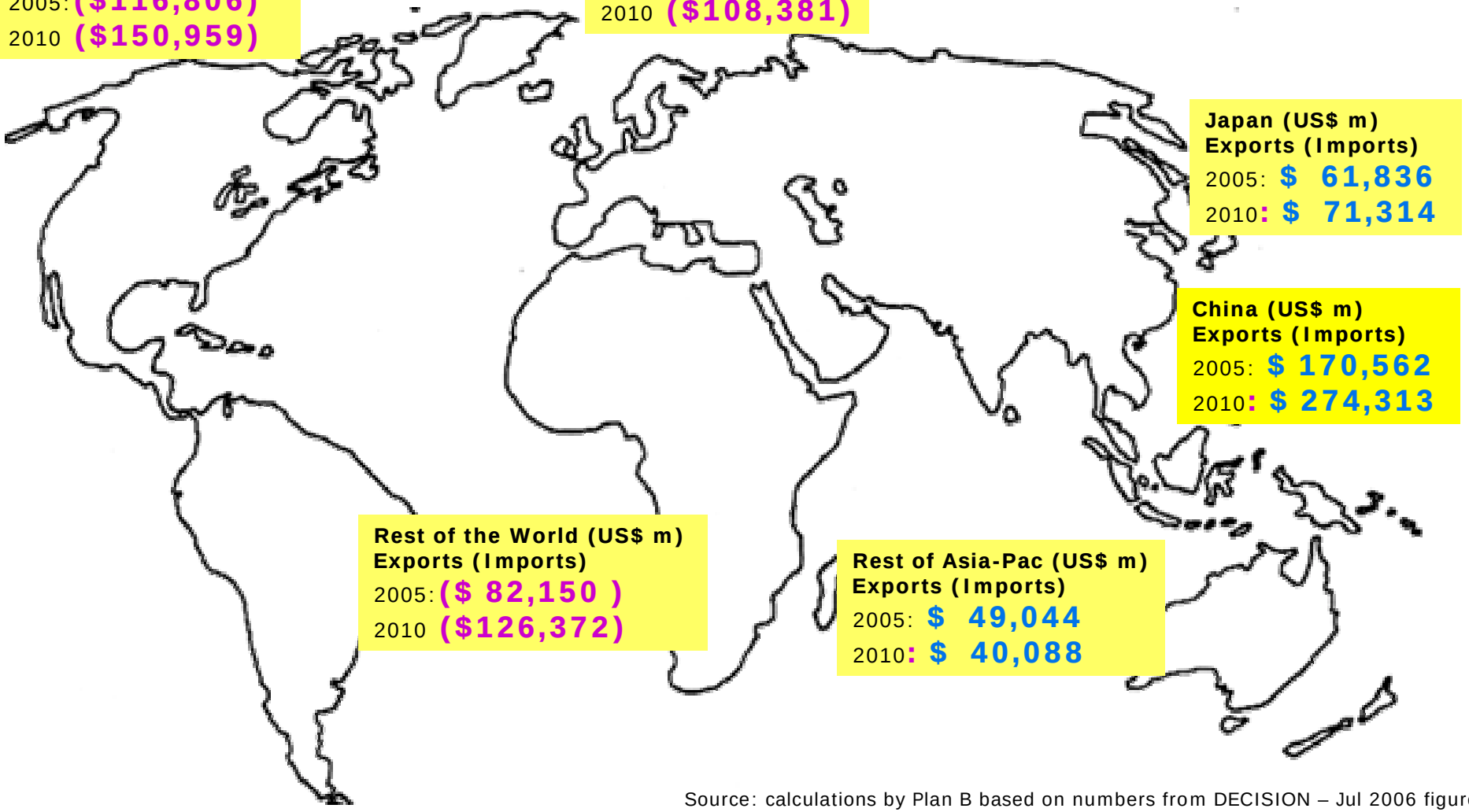
Other Asia-Pacific
Electronics **+2 %**
Automotive **+4 %**

Rest of the World
Electronics **+2 %**
Automotive **−1 %**



Source: calculations by Plan B based on numbers from DECISION and OICA

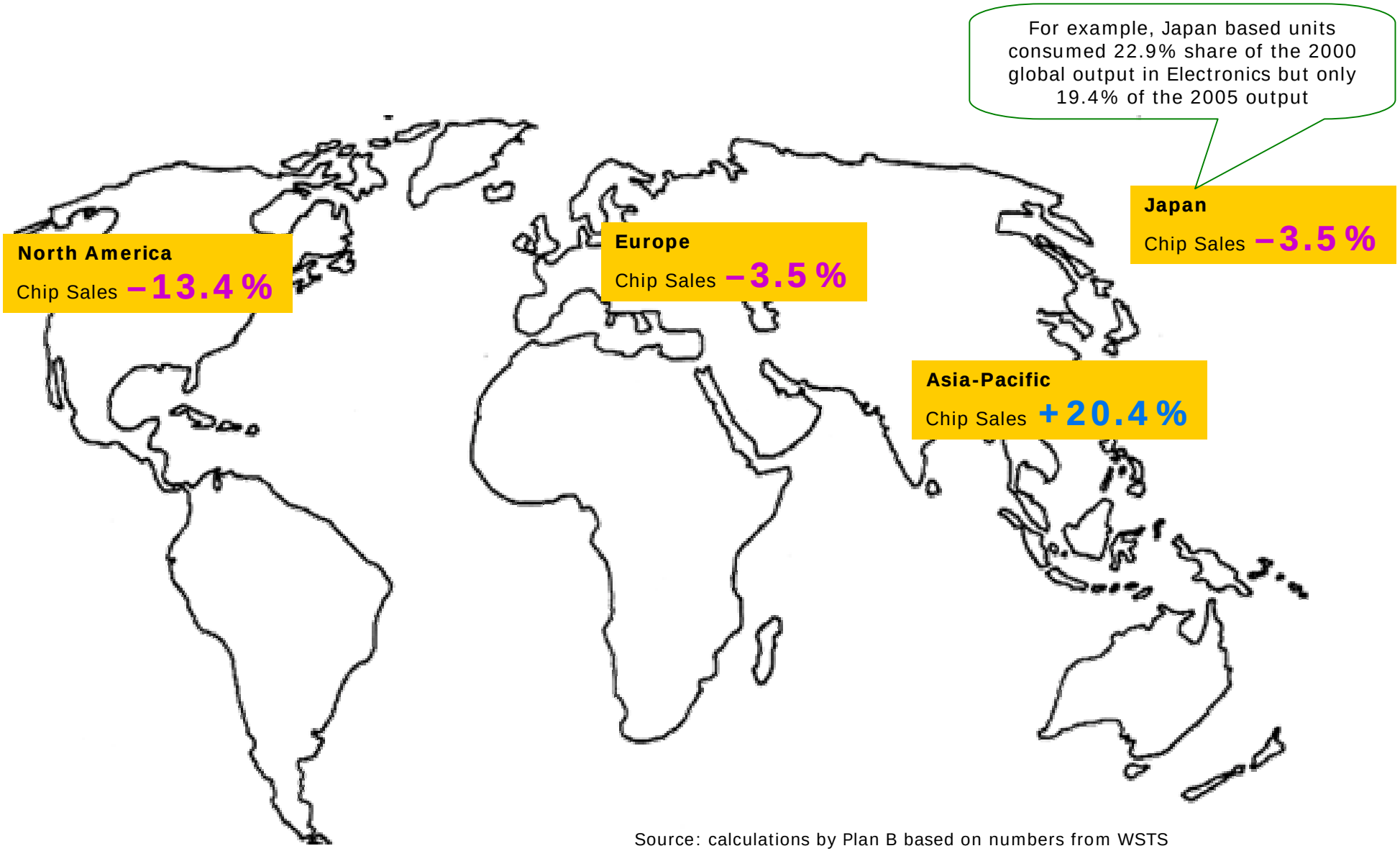
China and Asia will be supplying more of the global Electronics demand



Source: calculations by Plan B based on numbers from DECISION – Jul 2006 figures

Asia-pacific is using more Semiconductors

The percentage figures show the change in global share of Sales of Semiconductors between 2000 and 2005



Source: calculations by Plan B based on numbers from WSTS

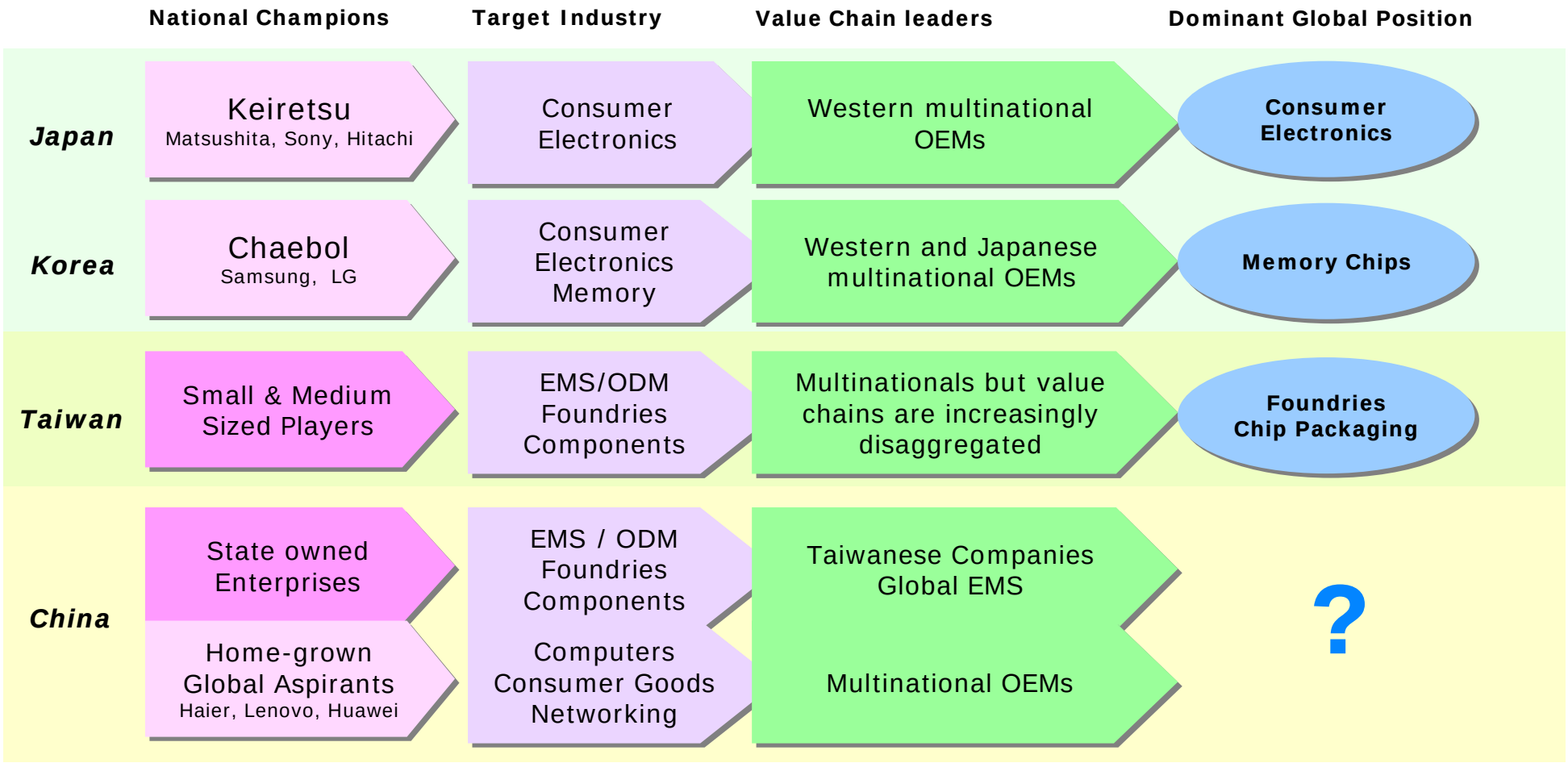
Lessons from East Asia

A brief history of outsourcing and offshoring in Electronics

1960s	1970s	1980s	1990s
Early electronics assembly was labour intensive so US and European firms operated wholly-owned facilities in low cost areas such as Mexico and East Asia. Chip assembly was moved to Singapore, Hong Kong, Malaysia and Thailand.	In Circuit board assembly, small 'board-stuffers' offering contract labour emerged in the US and Europe. The components were supplied to them in kit form (on a 'consignment' basis) and the service was limited to the supply of labour.	Brand-name electronics manufacturers making high-volume, low margin products – such as PCs and Disk drives followed the Semiconductor industry into low cost locations, especially in Taiwan.	In the US, Brand-name manufacturers started to use their contractors as more than mere providers of overflow capacity. They began to turn over more and more of the supply chain activities to the contractors, including component purchase, logistics, final product assembly etc
Japanese firms started to license Taiwanese, Hong Kong and Korean firms to manufacture transistor radios and later calculators	These services were used to supplement in-house capacity and to meet peak demand	In response to progress in European integration, American Electronics companies moved the assembly of some products to Scotland to take advantage of lower labour and engineering costs.	Manufacturing process technology was becoming more complex and more expensive, and the contractor could offer cost advantages due to economies of scale from being able to pool the manufacturing capacities.
Almost all the Wafer fabrication, circuit-board assembly and product level assembly was done in the USA, Northern Europe and Japan.	Some overseas 'board-stuffers' also emerged in Hong Kong, Singapore and Malaysia.	Increased availability of locally produced semiconductor components in Asia (thanks to previous waves of semiconductor offshoring) encouraged the growth of the Asian contract manufacturer offering 'turn-key' manufacturing services.	Other economies of scale also arose for being able to pool component purchase orders for various customers to achieve a lower cost. **The bulk of these contractors are based in the US**

Source: MIT Industrial Performance centre

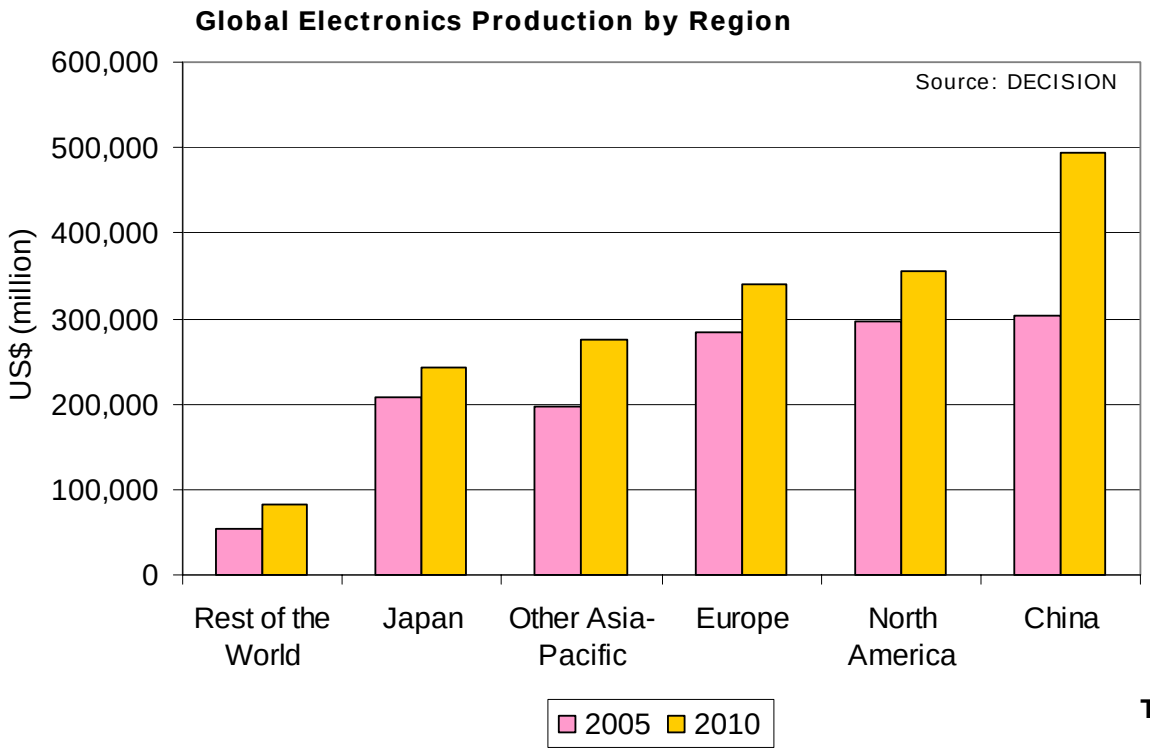
Strategies for achieving global success



Opportunities for entering and succeeding in global industries have changed over the decades. Unlike Japan and Korea where large corporations were guided by national policy into head-on competition with Western leaders, the Taiwanese used their more limited resources to provide services and components to OEMs rather than compete with them. They were aided in this by the willingness of Western companies to outsource to them. That is now being repeated in China, but many of the success stories are actually US, Taiwan and Hong Kong business who have moved their manufacturing to China. Unless the capabilities of these companies can be transferred to local Chinese companies, China cannot establish a leading global position long term. In a few years time, these factories could just as easily be moved to Philippines or Vietnam in search of lower costs

The other strand to Chinese strategy seems to be the encouragement of head on competition with US OEMs. Here the results are mixed and it is unclear whether Chinese companies will progress beyond cost arbitrage to building global brands which requires global marketing skills.

How far ahead is China?



Press coverage of the semiconductor industry often confuses the location of production facilities with control of the process

– China Economic Quarterly

China is expected to be the leading producer of electronics in the world by 2010, but as of today the bulk of the chips used in this production have been imported.

China demand is met by imports of chips by these foreign companies. Estimates vary but as much as 80% of the demand was met by imports.

The Top 10 chip suppliers in China are not Chinese

2005 Rankings	Supplier	2005 Revenue (US$ m)
1	Intel	5,774
2	Texas Instruments	2,270
3	STMicroelectronics	1,799
4	Samsung Electronics	1,741
5	Philips Semiconductors	1,720
6	Toshiba	1,435
7	Hynix	1,243
8	Freescale Semiconductor	1,239
9	Infineon Technologies	1,000
10	Micron Technology	704

Source: iSuppli Corp

How far ahead is China?

Product Structure and Self-Sufficiency of China's IC Market (US$ bn)

Product segment	Market size	Locally produced
Analog devices	7.68	1.72
ASICs	1.16	0.41
ASSPs	6.6	Very few
Logic devices	2.37	0.73
Memory	10.44	0
Computational microprocessors	6.67	0
Embedded microprocessors	1.94	Very few
DSP	1.11	Under devt
Microcontrollers	3.64	0.38
Microperipherals	5.33	Very few
IC cards	0.43	0.32
Total	**47.37**	**3.93**

Source: China Semiconductor Industry Association

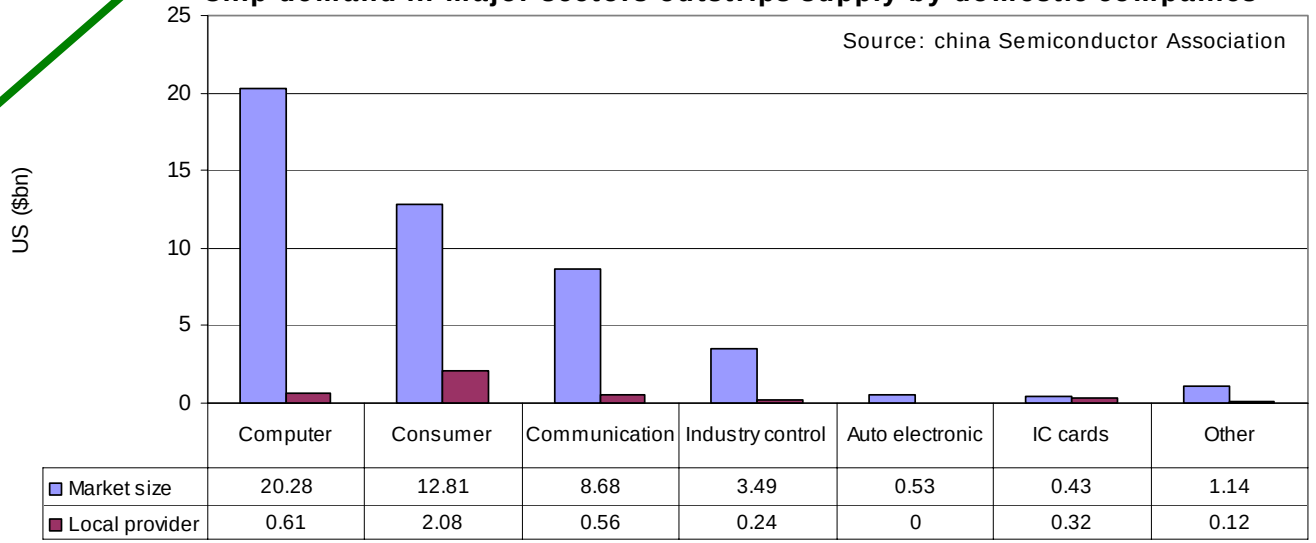
Top 10 Foundries in China - 2005 (US $ m)

2005	Company	Revenue
1	SMIC	1458.78
2	HHNEC	300.39
3	HJTC	270.24
4	SGNEC	137.05
5	ASMC	111.58
6	GSMC	106.32
7	HHMC	104.14
8	CSMC	75.09
9	JLMC	64.94
10	BCD	43.59

Source: China Semiconductor Industry Association

In 2005, domestic Chinese firms produced only around 8% of the demand

Chip demand in major sectors outstrips supply by domestic companies



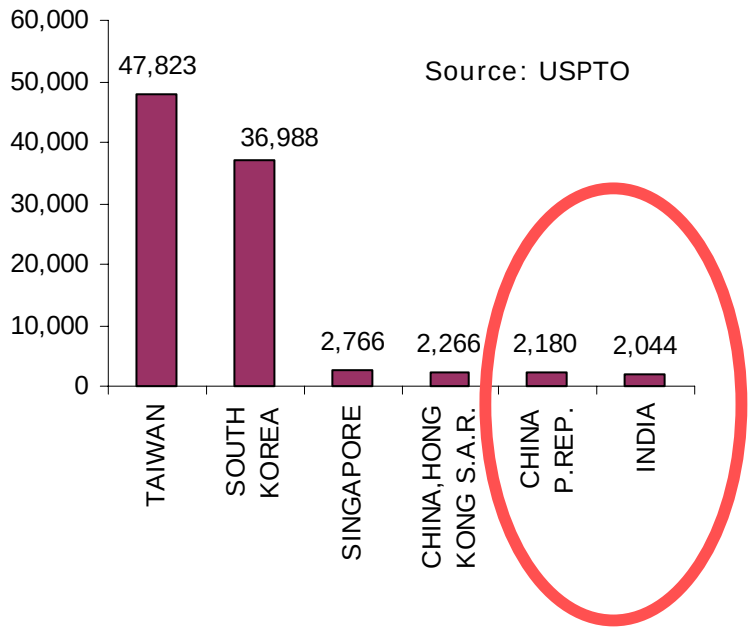
How far ahead is China?

China started on the road to reform ten years before India. Yet even on rudimentary measures of their innovative capabilities, it can be seen that they have not made progress relative to India. Some academics argue that as long as the main policy instruments are government sponsored initiatives aimed at State-owned Enterprises (SOEs) rather than at entrepreneurial businessmen a culture of innovation is difficult to foster. For instance, R&D efforts in high-tech is being directed by the government rather than by businesses responding to market opportunities.

In contrast, Taiwan started in the 70s but has been able to build a **national innovation system** that is clearly very successful.

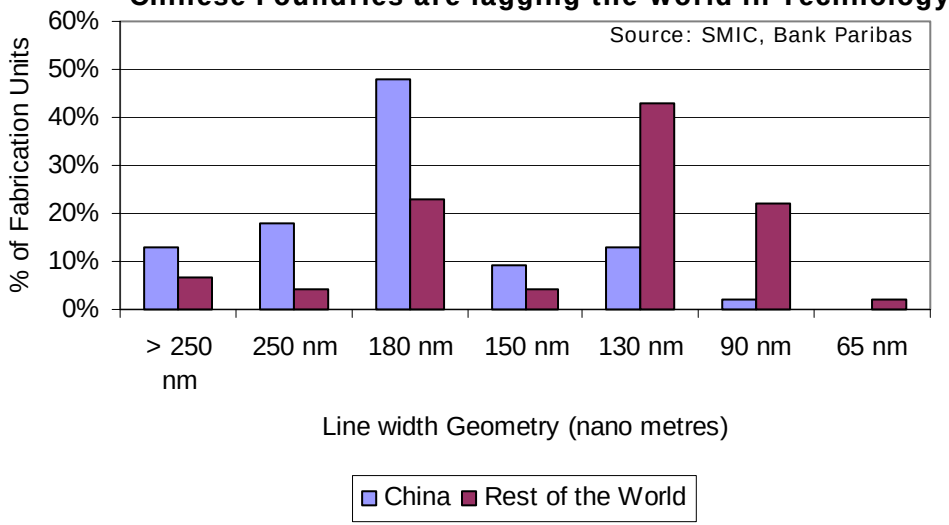
There are many lessons to be learnt from the Taiwanese.

The number of US Patents issued to each country since 1992



Chinese Foundries have older technology when compared with the rest of the world. In addition many new players are planning to build Fabs using second hand process equipment – which will invariably not have the latest technologies.

Chinese Foundries are lagging the world in Technology



What does catch-up actually mean?

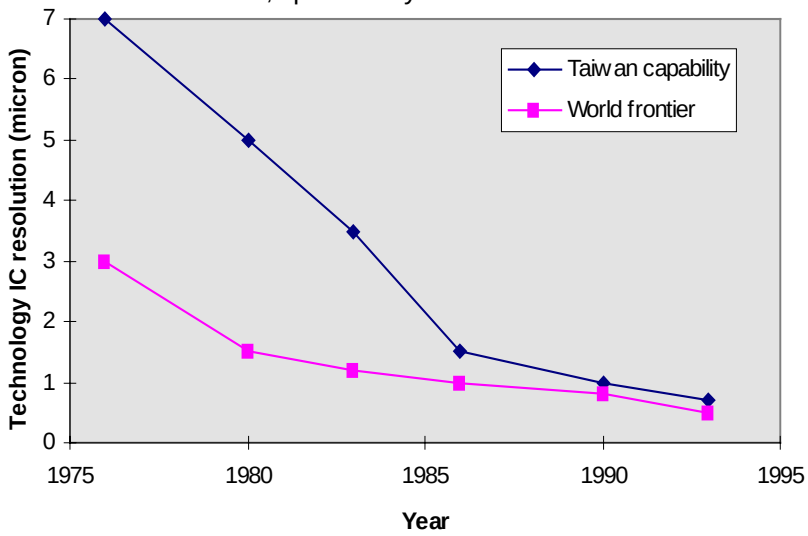
Semiconductor circuit fabrication capability is measured in line-widths – the resolution between two adjacent lines on the chip surface. The current frontier is at 65 nanometres, or 0.065 microns. This chart shows that it took Taiwan more than 15 years to go from 7 microns to around 0.5 micron, but that once the gap starts to close the process becomes faster.

Similarly, the DRAM Memory data between 1979 and 1992 and the line-width data for Korean chips shows that it took around 13 years of sustained effort for Korea to catch-up with advanced technology.

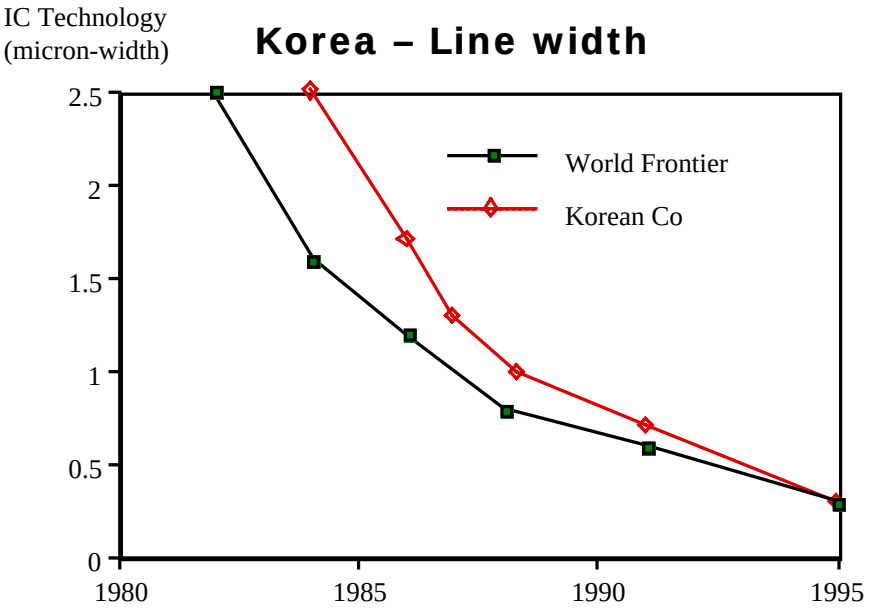
In both cases, success resulted from targeting a particular technology and allocating the limited national resources to closing the gap

Taiwan – Line width

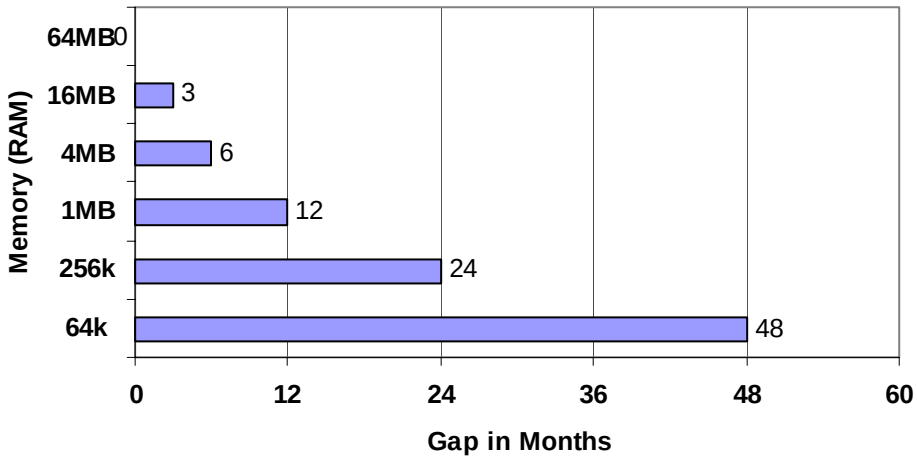
Source: ERSO, quoted by Prof. John Matthews



Korea – Line width



Korea – DRAM Memory Gap



Source: Adapted from data published by Ministry of Trade, Korea

Success in Electronics is a result of a rich local Eco-system – Taiwanese Example

Taiwan's rich ecosystem is the result of decades of concerted activity at the national level to target emerging technologies and coordinating pre-competitive research at the national level between companies (usually small and medium sized enterprises) and universities.

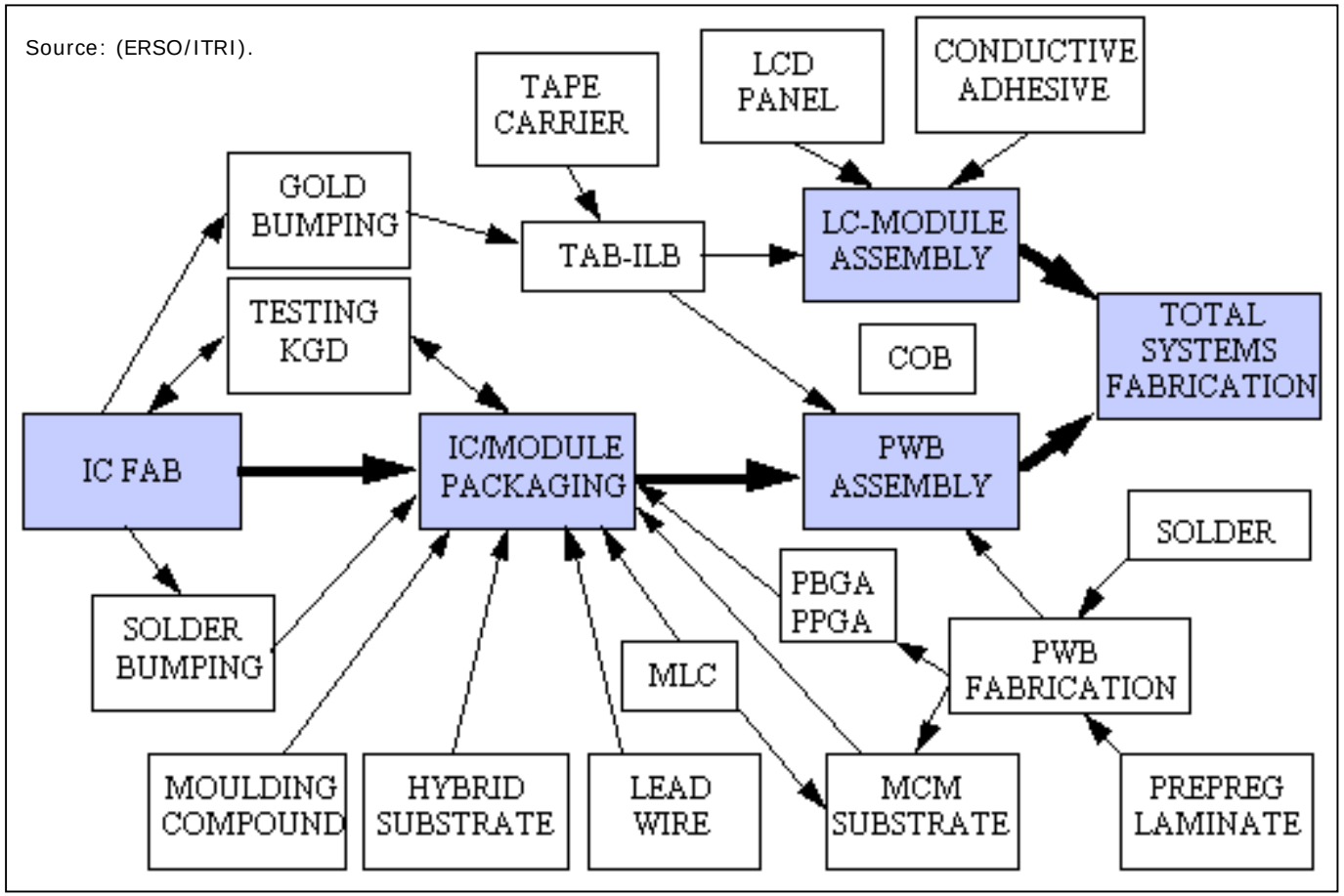
The **research is highly focussed on applying technologies to solve specific problems**. In the area of micro-machining for instance, research is in the following application areas :

-Pressure sensor
- room- temperature thermal imager
- lead frame for high pin counts for use in infra-red applications in the medical electronics field

Similarly, Materials research is being conducted in the following areas: lithium batteries, color filters, physical and chemical sensors, and aluminum foil capacitors

Source: World Technology Evaluation council

Taiwan's electronic packaging industry infrastructure

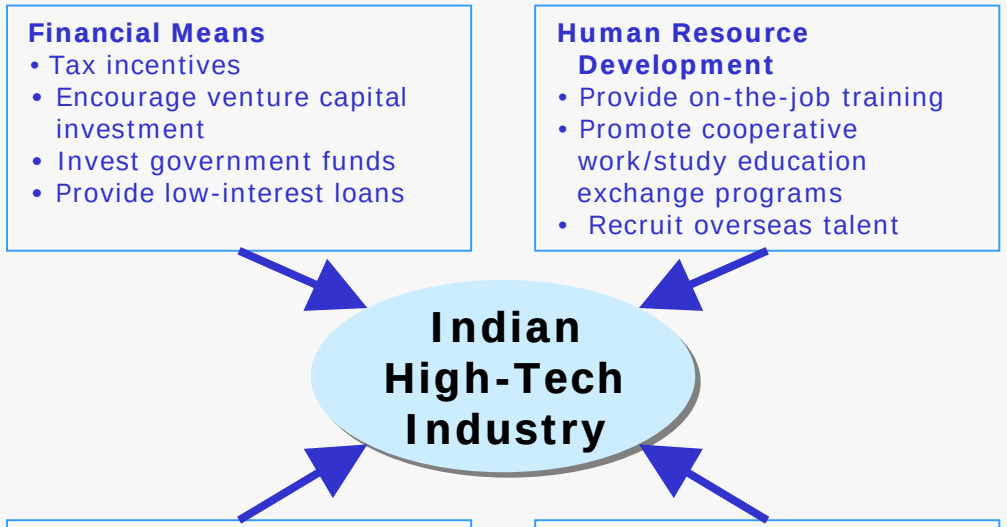


What has to happen at the national level?

Contrary to popular perception that India's success in software was a result of benign neglect by national institutions, some academics argue that the foundations were laid decades earlier by government actions. In any case, manufacturing cannot flourish without aggressive central co-ordination as demonstrated many times by the experiences of Japanese, Korean, Singaporean, Malaysian, Taiwanese and more recently Chinese national development programs.

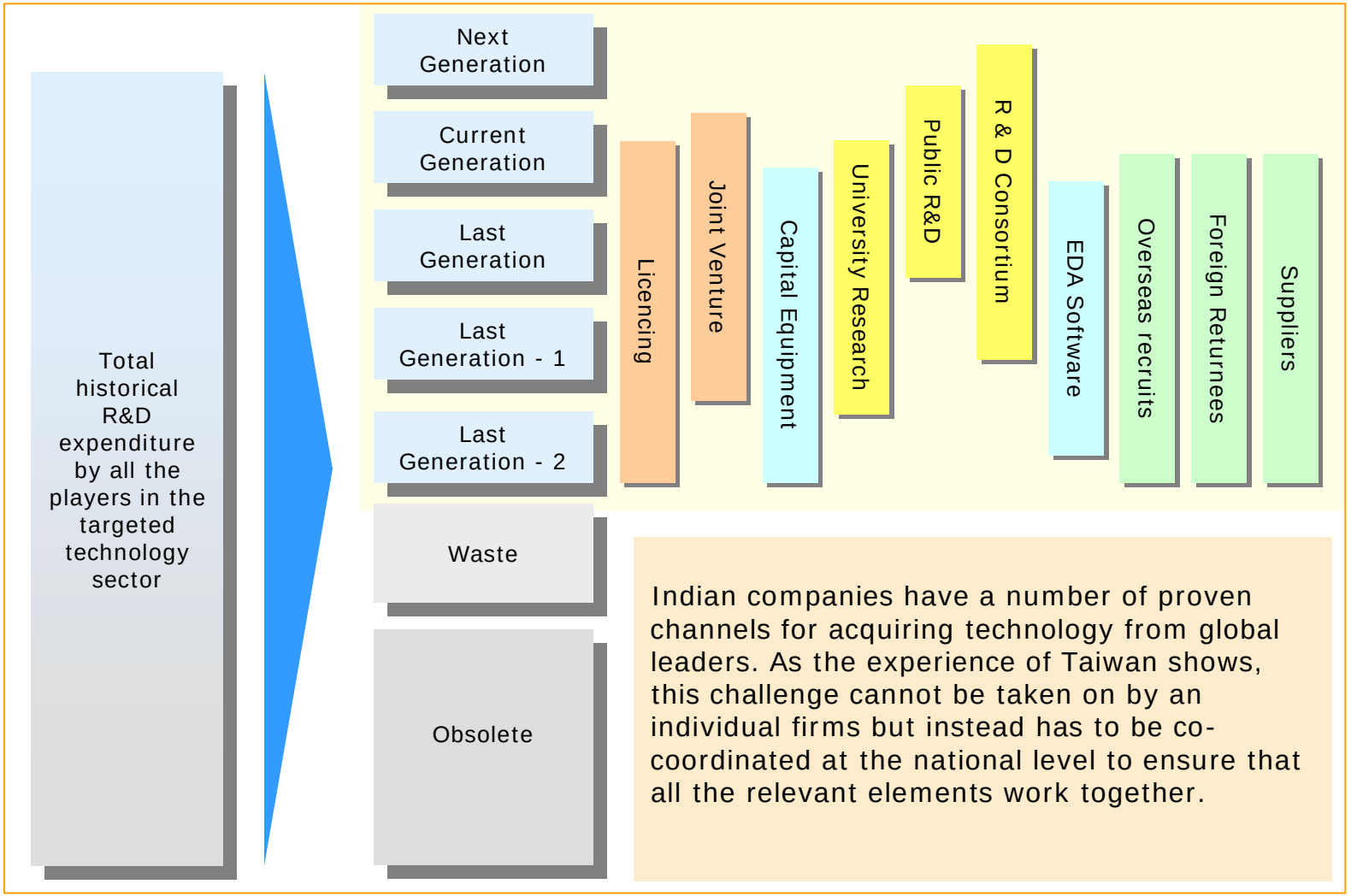
Government Development Strategies for the Hi-Tech Industry

(Adapted from Kung Wang PhD, ITRI, Taiwan)



What does India have to do to catch-up?

Conceptual breakdown of the knowledge acquired by leading companies and channels for transferring the technology to India



Indian companies have a number of proven channels for acquiring technology from global leaders. As the experience of Taiwan shows, this challenge cannot be taken on by an individual firms but instead has to be co-coordinated at the national level to ensure that all the relevant elements work together.

The Indian government's "Semiconductor policy" will therefore hold the key to the future success of Indian enterprise in the Electronics hardware manufacturing industry

The Indian Scene

In Electronics Hardware Production – India is a tiddler!

COUNTRY	GDP 2004-05 ($ Bn)	ELECTRONIC PRODUCTION	SHARE OF GDP (%)	SHARE OF GLOBAL PRODUCTION (%)
U.S.A	11750.0	634.0	5.4	44.3
Japan	4900.0	220.0	4.5	15.3
German	2100.0	174.0	8.3	12.1
China	**1650.0**	**210.0**	**12.7**	**14.6**
South Korea	681.0	103.0	15.1	7.2
Taiwan	328.0	51.0	15.5	3.5
Israel	117.0	27.6	23.6	1.9
India	**665.0**	**11.2**	**1.7**	**0.7**

Sources: InStat website; ELCINA Research

Current status of the mobile handset ecosystem in India

A comparison of the number of players in the Semiconductor manufacturing value chain

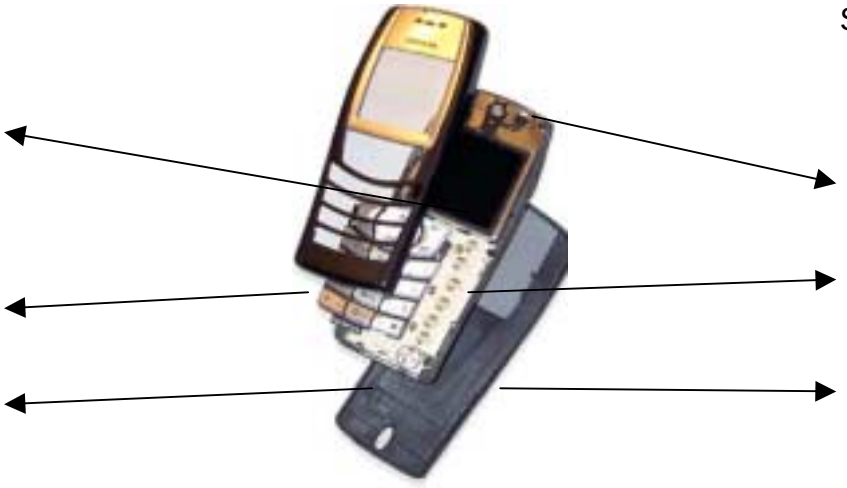
	Design Houses	Mask Units	Chemicals Vendors	Wafer Production Units	Fab Units	Substrata & Lead-frame Vendors	Packaging Vendors	Testing Firms
Taiwan	260	4	19	8	13	19	36	34
India	125	-	-	-	proposed 2007?	-	1	-

Source: Press cuttings, iSuppli

Selected Suppliers in India

Handset Chip Designers	Texas, Infineon, Conexant
Antenna	Tyco, Interplex
Keypad	Sil-Kee,
Plastic Moulding	Nypro

Source: Press cuttings, IPCA website



Selected Suppliers in India

Charger Assembly	Molex
Connectors	Tyco, HiCal
Printed Circuit Boards	AT&S (Austria)
Box Build / Testing	Flextronics, XL Telecom

Source: Press cuttings, IPCA website

Only 35% percent of the required components are available in India.

Source: Elcoteq

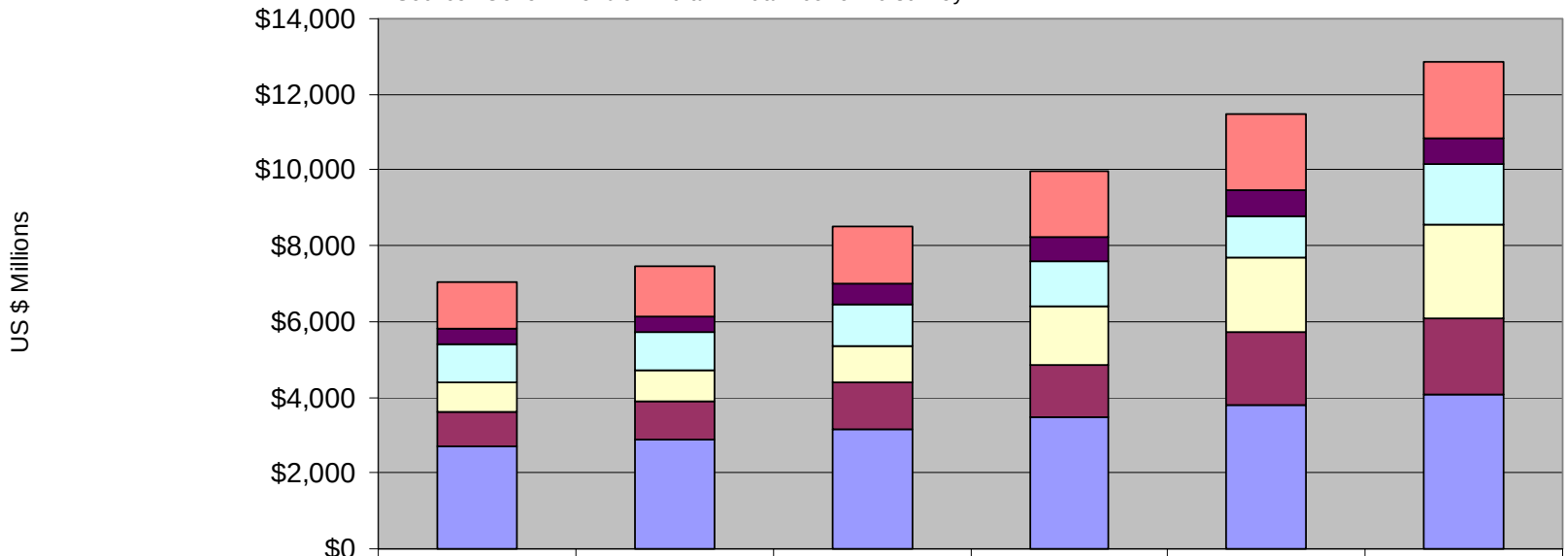
High-tech, high-value items requiring capital-intensive manufacturing are not available

Semi-conductors	LCD Panels	Chipsets	Camera Modules	Other complex sub-assemblies

India Production Volumes and Growth Rates

Indian production of Electronics has been very low by international standards. But the growth rates are high and the increased presence of EMS companies should stimulate local manufacturing by encouraging the development of an Electronics ecosystems.

Source: Government of India Annual Economic survey



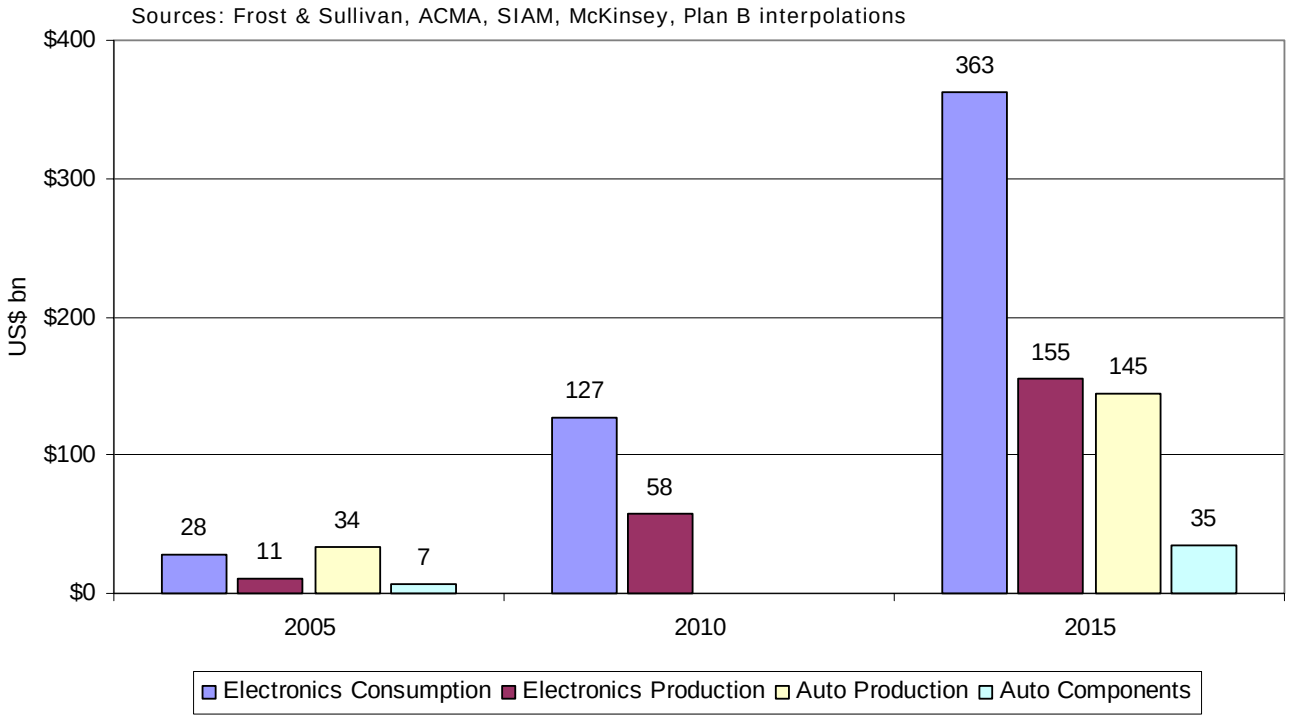
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Components	$1,250	$1,295	$1,500	$1,727	$2,000	$2,000
Strategic Electronics	$398	$409	$568	$625	$682	$727
Comms & Broadcasting	$1,023	$1,023	$1,091	$1,216	$1,091	$1,591
Computers	$773	$807	$966	$1,545	$2,000	$2,455
Industrial Electronics	$909	$1,023	$1,261	$1,386	$1,886	$2,000
Consumer Electronics	$2,716	$2,886	$3,136	$3,455	$3,818	$4,091

Comms Electronics 2006 Growth Rate
46 %

Computers 2006 Growth Rate
23 %

Total Production 2006 Growth Rate
15 %

Indian Manufacturing in Electronics and Auto are expected to grow fast



Indian Manufacturing output in Auto and Electronics is expected to grow to 10% and 12% of GDP, respectively within 10 years which, even at half the rate, should provide some excellent opportunities for investment. We expect that 80% of the Electronics manufacturing will be carried out by big name EMS providers (Flextronics, Jabil etc) and OEMS (Nokia, Samsung etc) whilst a healthy 20% will be up for grabs by Indian players. The last major Indian EMS company – Celetron – was purchased by Jabil earlier in 2006, leaving very few independent pure play EMS provider of any size. A list of most of the players in various fields is given in this report.

Current India opportunities

Fast growing Domestic demand: In this respect, India is very similar to China of ten years ago.

Emerging alternative to China : Much of the market projections shown elsewhere in this report seem to be based on the assumption that India will focus on Design and Knowledge based services whilst China focuses on manufacturing. This situation is likely to change rapidly in the next few years. The government's long-awaited semiconductor policy could be enlightened enough to kick start the Electronics manufacturing sector and provide some serious competition to China as a manufacturing destination.

Availability of low cost skills: Much of Electronics manufacturing has migrated to the use of automated machines that need considerable engineering support. This is available in greater quantities and at a lower cost in India.

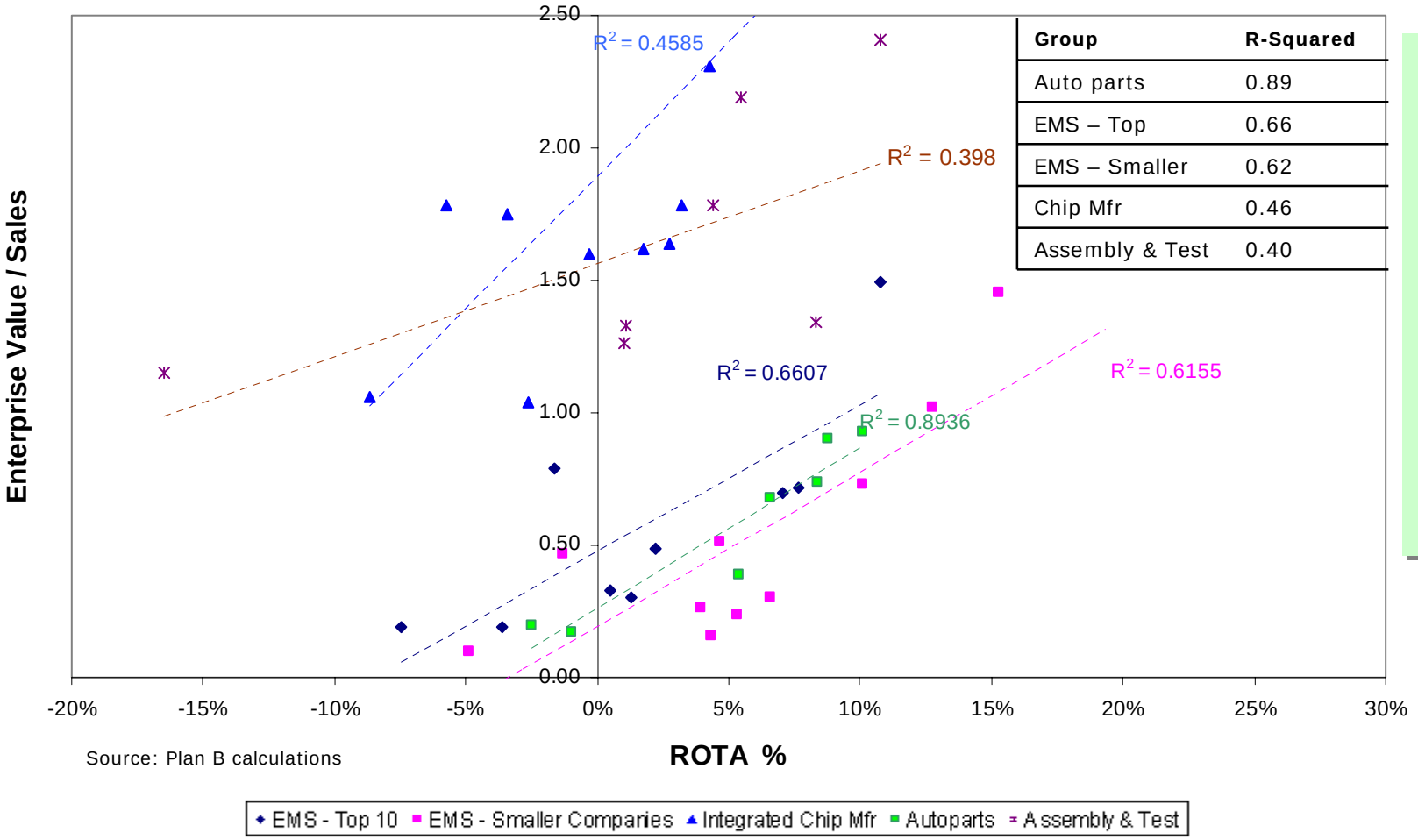
Ecosystem is likely to grow fast: Companies such as Flextronics and Nokia are setting up large SEZs and encouraging their suppliers to move into the zones. This should help create an ecosystem of suppliers from which others will also benefit.

Large Domestic Demand + Low-cost Labour + Low-cost Engineering + Innovative Management > China Advantage

The Economics of Electronics Manufacturing

What drives Electronics company valuations?

This chart shows market value variations against a variable very familiar to Auto Execs – Return on Assets – in an attempt to understand how Electronics companies may be valued by the stock market. The best fit lines show the rate at which the valuation changes for changes in the return on total assets. As expected, Auto parts valuations pretty much follow the return on total assets (89% of the time) but Semiconductor company valuations are less attributable to this single variable, leaving us to ask what the other variables might be. Common sense tells us that the expected growth rates of companies might be one such variable, and another might be defensible assets such as patents and control of technology standards. **Further work is needed to determine value drivers for each group**.



Group	R-Squared
Auto parts	0.89
EMS – Top	0.66
EMS – Smaller	0.62
Chip Mfr	0.46
Assembly & Test	0.40

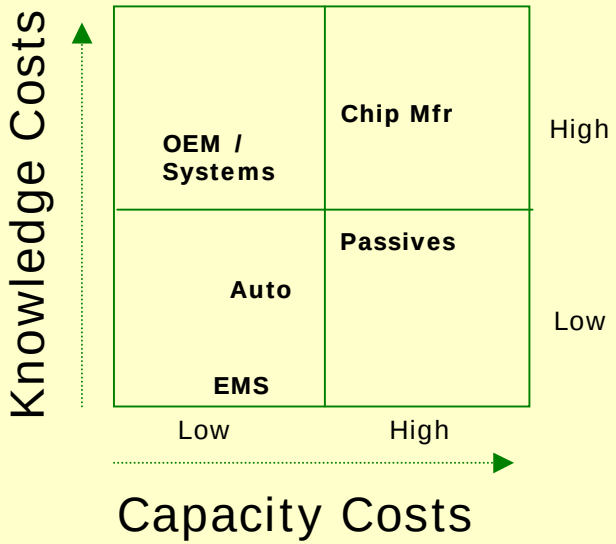
Source: Plan B calculations

R-Squared
The closer R^2 is to 1, the better the fit of the trend line and more we can be sure that the line can be used to predict the Enterprise value given any ROTA figure. For instance, in the case of the auto line we can attribute 89% of the change in valuation to changes in the ROTA. We need to find some other variables to explain the remaining 11% of the change.

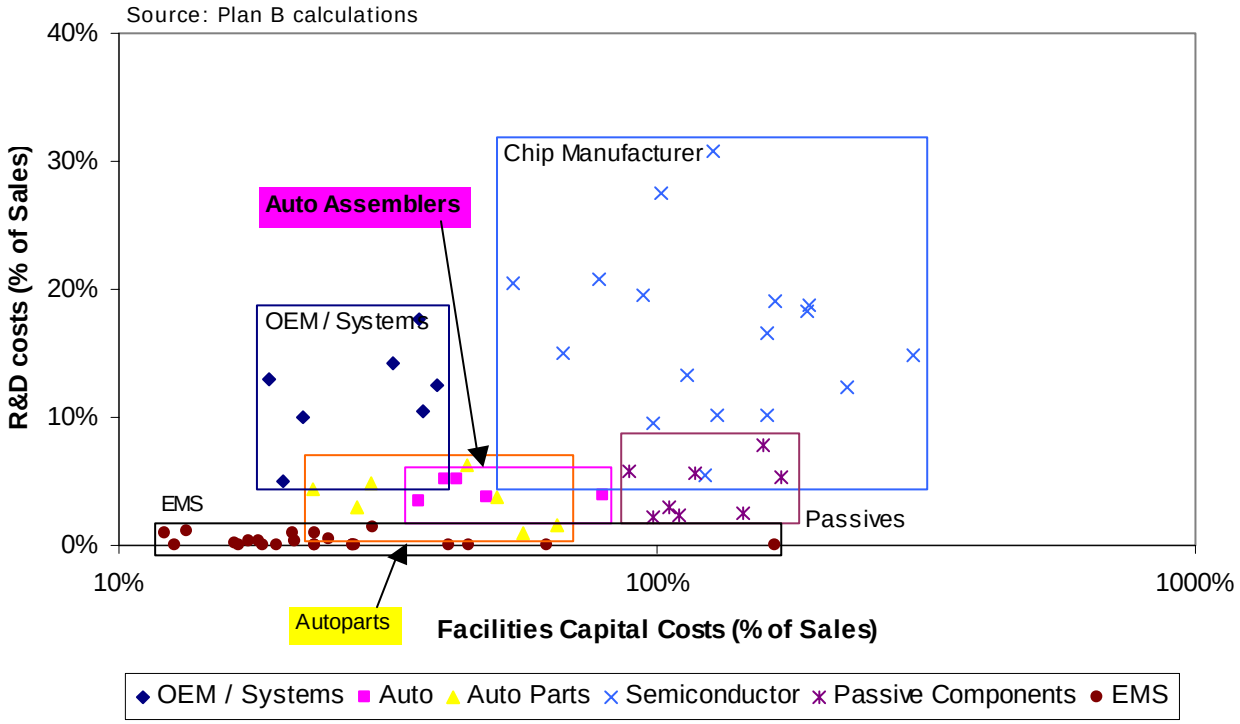
Another comparison with Auto companies

To gain further insight into the nature of Electronics businesses, the facilities costs (gross block) of businesses in both Auto and Electronics were compared with the R&D expenditures. The Electronics OEMs have to spend more on R&D but are comparable to Auto companies as far as facilities capital costs are concerned, perhaps because much of the manufacturing is now outsourced and they are merely "screw-driver" assembly plants. Clearly Semiconductor manufacturing businesses spend large amounts on both R&D and facilities compared to other businesses. So what is the incentive to enter the semiconductor business?

A Simplified Model

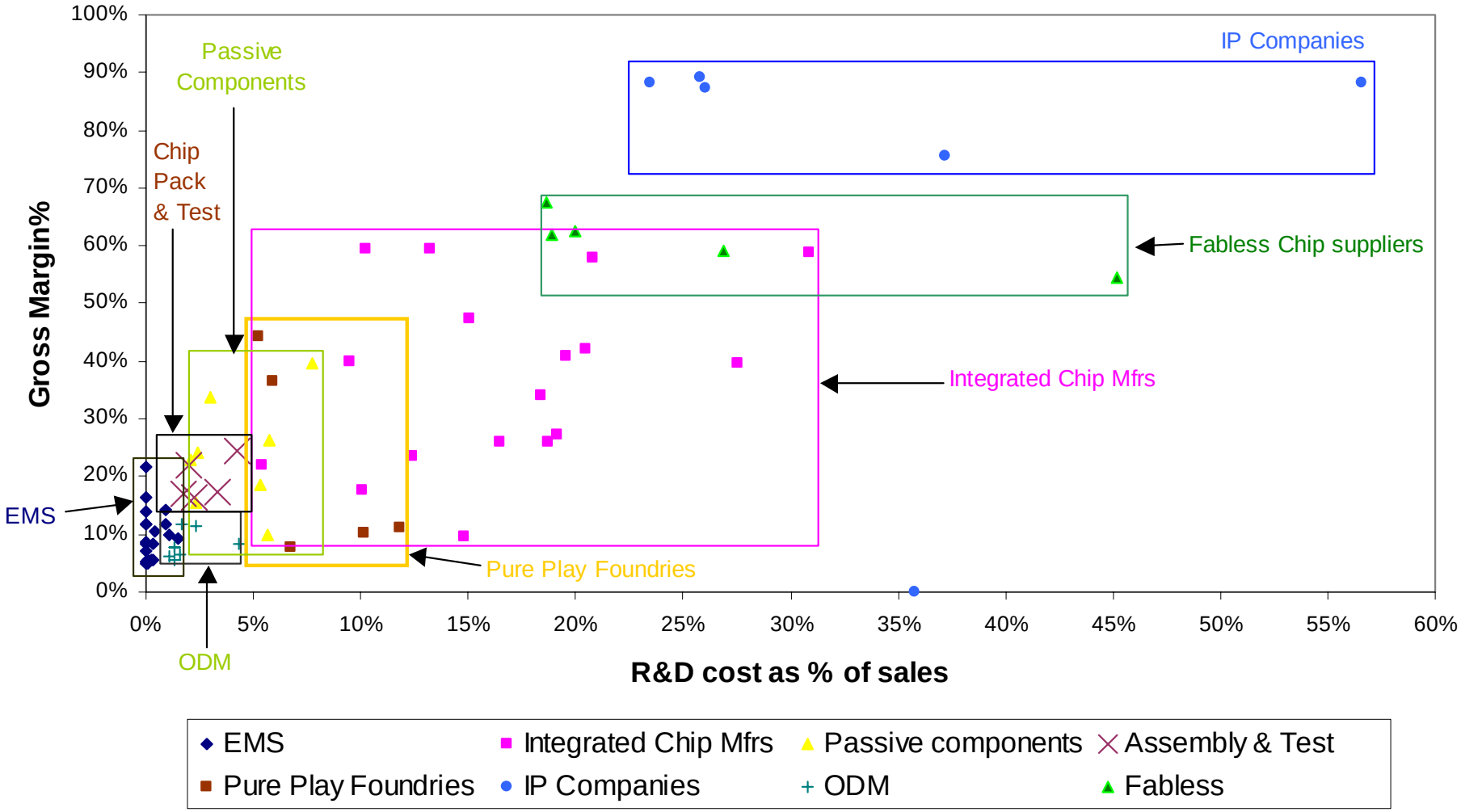


Our research shows that there are two major dimensions of costs in Electronics manufacturing. Apart from the costs of building manufacturing capacity, there is also the costs involved in generating product and process knowledge.



The customers are willing to pay for the R&D

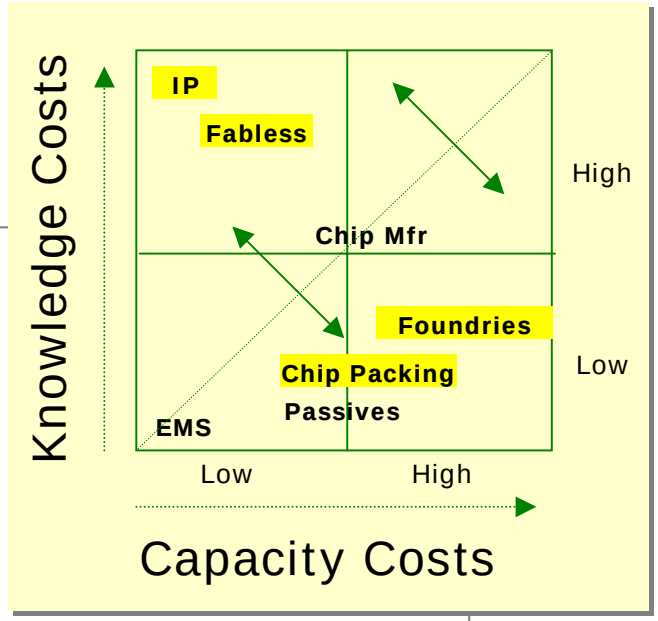
This busy chart shows at a glance that there is a **knowledge ladder** in the Electronics ecosystem starting with EMS companies and rising through to IP companies. Roughly speaking, companies spend relatively similar amounts on R&D as their peers and enjoy enough gross margin to cover these expenses. The more R&D intensive their business model, the more the gross margin they can expect. Many East Asian countries have taken 15 to 20 years to move up this ladder.



Source: Plan B calculations

The Knowledge-Capacity model yields more insights

A look at the distribution of ecosystem companies along the knowledge – capacity dimensions shows what has been happening in Electronics Manufacturing. The availability of automated machines for each step of the process and standardised ways of communicating product specifications along the supply chain has made it possible for new entrants to pursue narrow specializations in the chain. For instance, the Taiwanese set up the first contract wafer fabrication units ("foundries"). This in turn enabled many US design companies ("fabless") to go to market without having to invest in expensive facilities. New entrants have to choose what to specialize in, since not many companies have the cash resources to do both

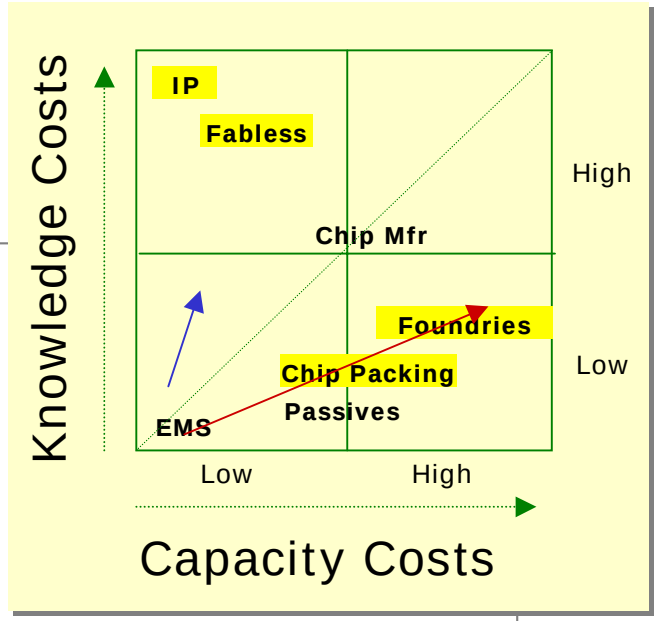


Source: Plan B calculations

EMS | Integrated Chip Mfrs | Passive components | Assembly & Test
Pure Play Foundries | IP Companies | ODM | Fabless

China thus far has been following the classic route to progress

In China, there is a proliferation of contract services companies: EMS, Chip Assembly & Testing and Foundries. It is easier for them to take this route because the skills / knowledge needed to provide these services are already incorporated in the machinery that are easily available. This gives rise to two insights: first, the consensus view that India can specialize in designs whilst China manufactures will lead Indian companies into smaller more specialist markets, even whilst India has exactly the same advantages that China has, not only as a supplier but as a high growth consumer of Electronic products. Secondly, it may be much harder to go from providing services to chip designers to developing a fabless sector without the rich ecosystem enjoyed by Taiwan and increasingly by China.



Source: Plan B calculations

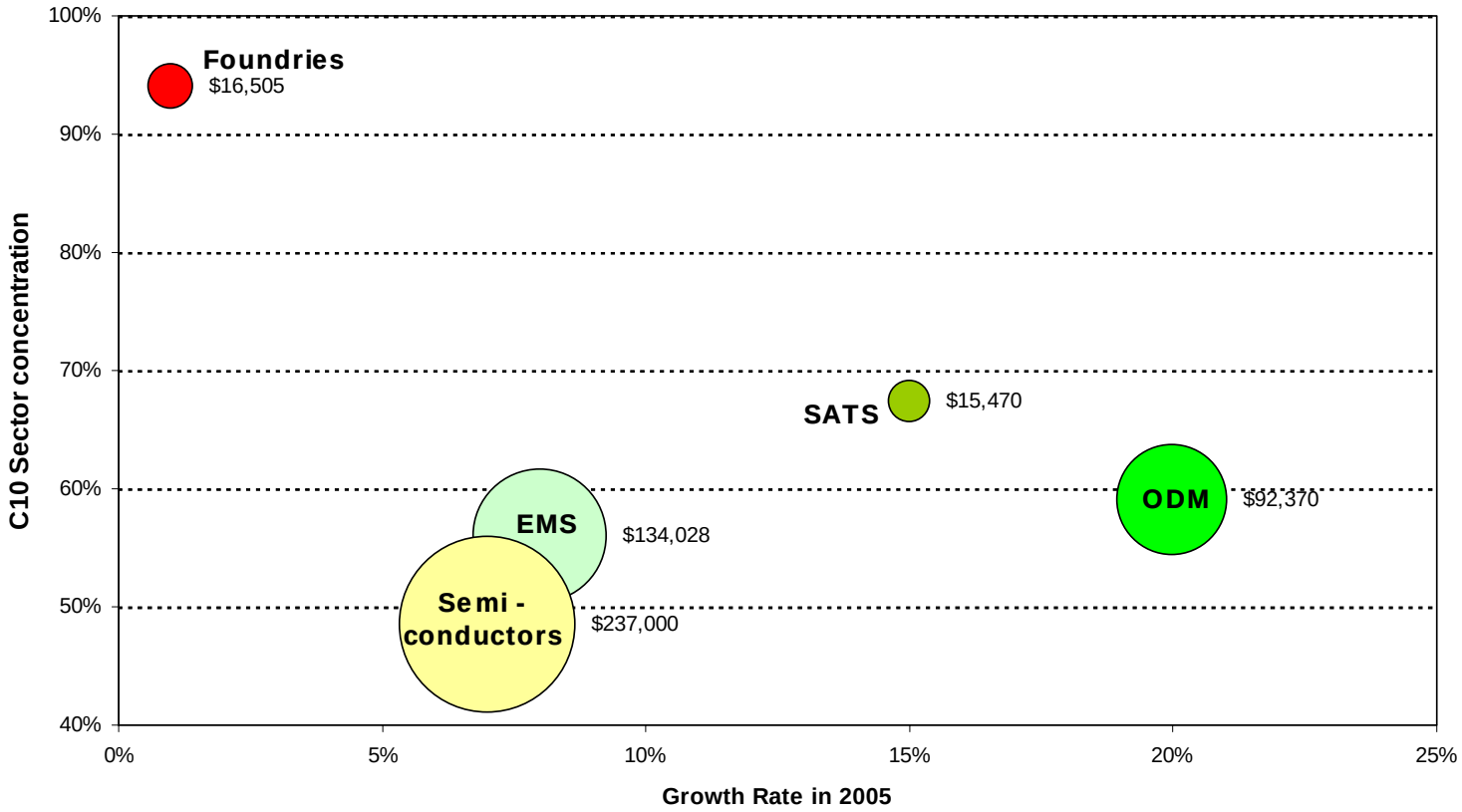
EMS | Integrated Chip Mfrs | Passive components | Assembly & Test
Pure Play Foundries | IP Companies | ODM | Fabless

Short-listing the Opportunities

Contract Product Assembly and Chip Packaging seem to be good entry points

Steps in the Manufacturing Process	IC Design	IC Fabrication	Chip Packaging (SATS)	Product Assembly (EMS / ODM)
Main area of Cost **Typical entry costs**	Software and Engineers **$1m - $5m**	300mm/65nm Foundry **$3 bn**	Chip Assembly and Test lines **$20m - $100m**	PCB Assembly lines **$5m - $20m**

Source: Plan B calculations

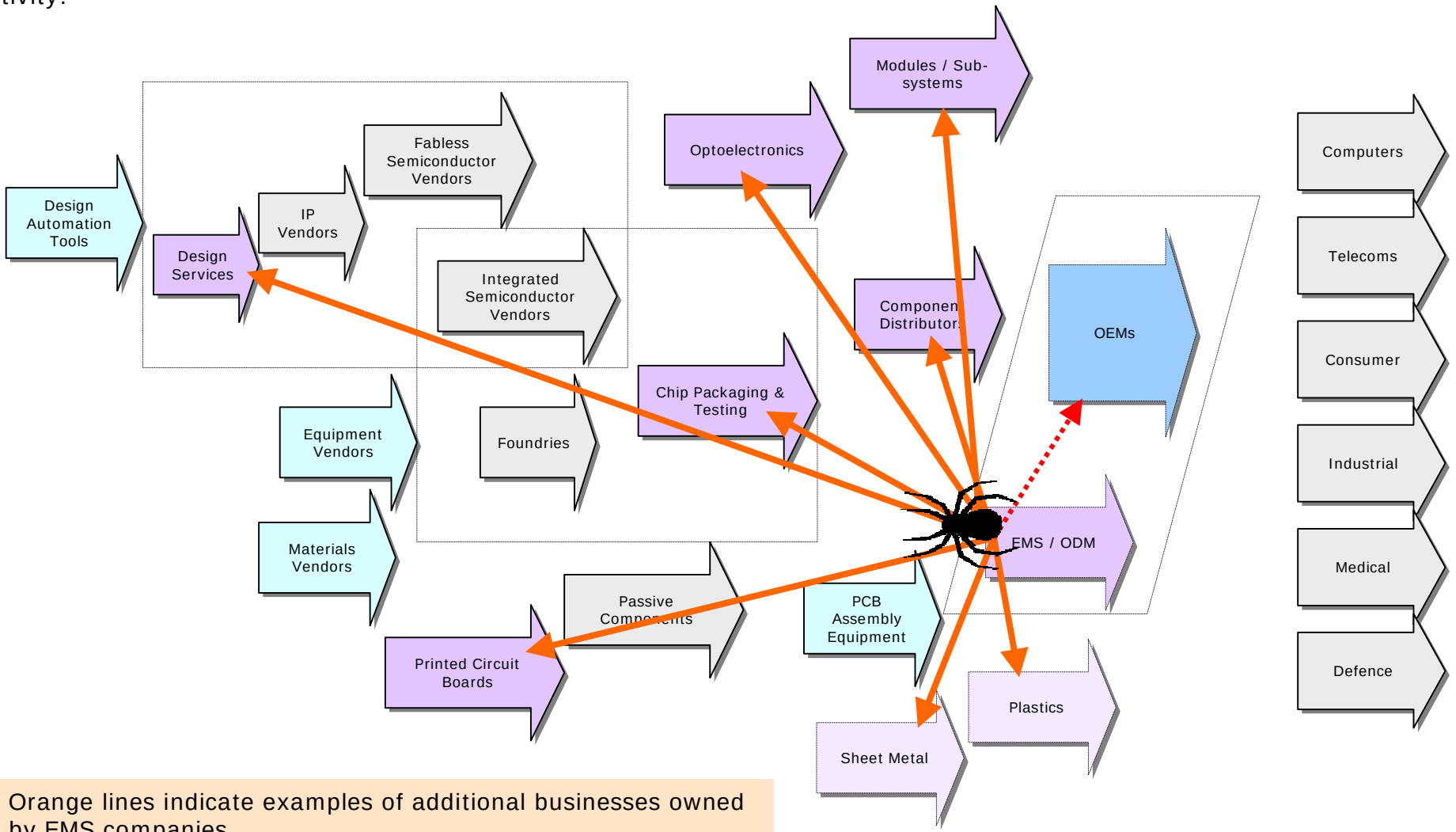


This chart shows the market share held by the Top 10 companies in their respective markets against the sector growth rates last year. ODM companies and Chip Packaging companies grew the fastest, whilst foundries the slowest. Semiconductor sector was less concentrated than the others. The conclusion we can come to is that there is room for new-comers in all the areas except perhaps for foundries, where more than 90% of the market is held by the top players.

The flow chart above indicates once again that **Product assembly and Chip Packaging would be the lowest cost entry points** into the Electronics supply chain

Spider's stratagem – a key listening post

Setting up as EMS contract manufacturer provides a central role in the electronics industry supply chain which could be leveraged to spot trends and opportunities ahead of other non-EMS players. Almost all EMS companies have complementary operations in other parts of the supply chain, which in some cases makes up for underperformance in their contract EMS activity.



Orange lines indicate examples of additional businesses owned by EMS companies

Understanding the Semiconductor Market

Whereas a 'chip' can contain millions of transistors, a discrete semiconductor holds a solitary device such as a diode, thyristor or a transistors that performs basic signal amplification and switching functions in electronic circuits.

They are also used in power management, where they are used to control, convert and condition electric power, as opposed to signals.

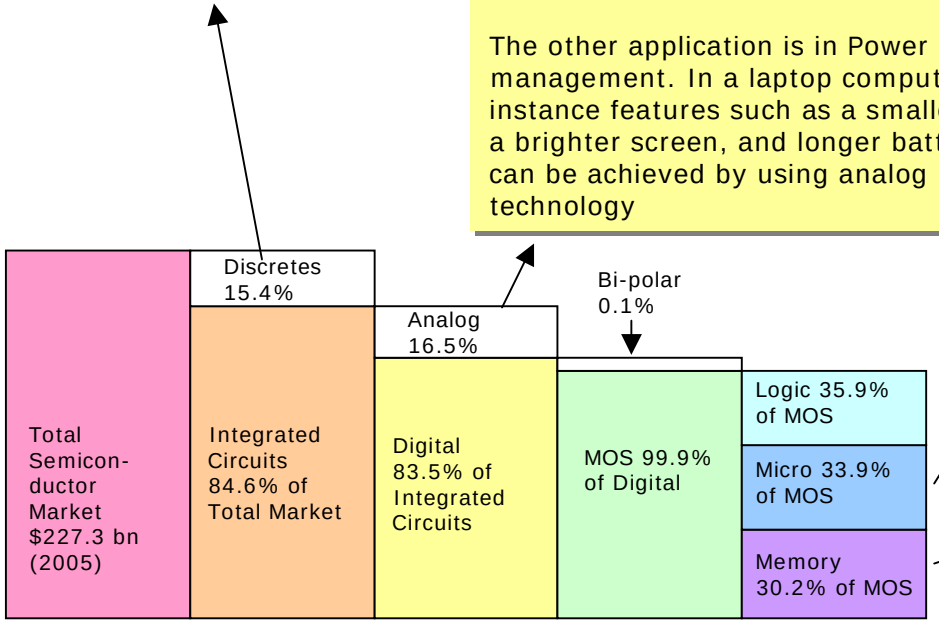
Analog chips work with continuously varying signals such as Heat, Light, Voltage and Current etc. Digital Chips would have limited applications without analog chips.

There are two important application areas – mixed signal chips sit on the interface with the real world converting the signals into digital ones that the digital chips inside the device can process and converting them back into analog ones. For example, a song can be recorded onto disk by converting continuous signals into 1s and 0s and can be played back by reconstructing the original sounds from the digitally stored data.

The other application is in Power management. In a laptop computer, for instance features such as a smaller size, a brighter screen, and longer battery life can be achieved by using analog technology

Logic chips come in two main forms: Application Specific IC (ASIC) or Programmable Logic Devices (PLD). **ASIC**s are designed for one specific customer and one specific application. The variation on these are known as Application Specific Standard Products (ASSPs) which are designed for one application but may be sold to many different customers. ASIC / ASSP logic is hardwired and are the most cost effective way to produce chips in volume. However for low volume applications, it is more cost effective to use a programmable device that can be configured for a particular application and can if necessary be reconfigured later.

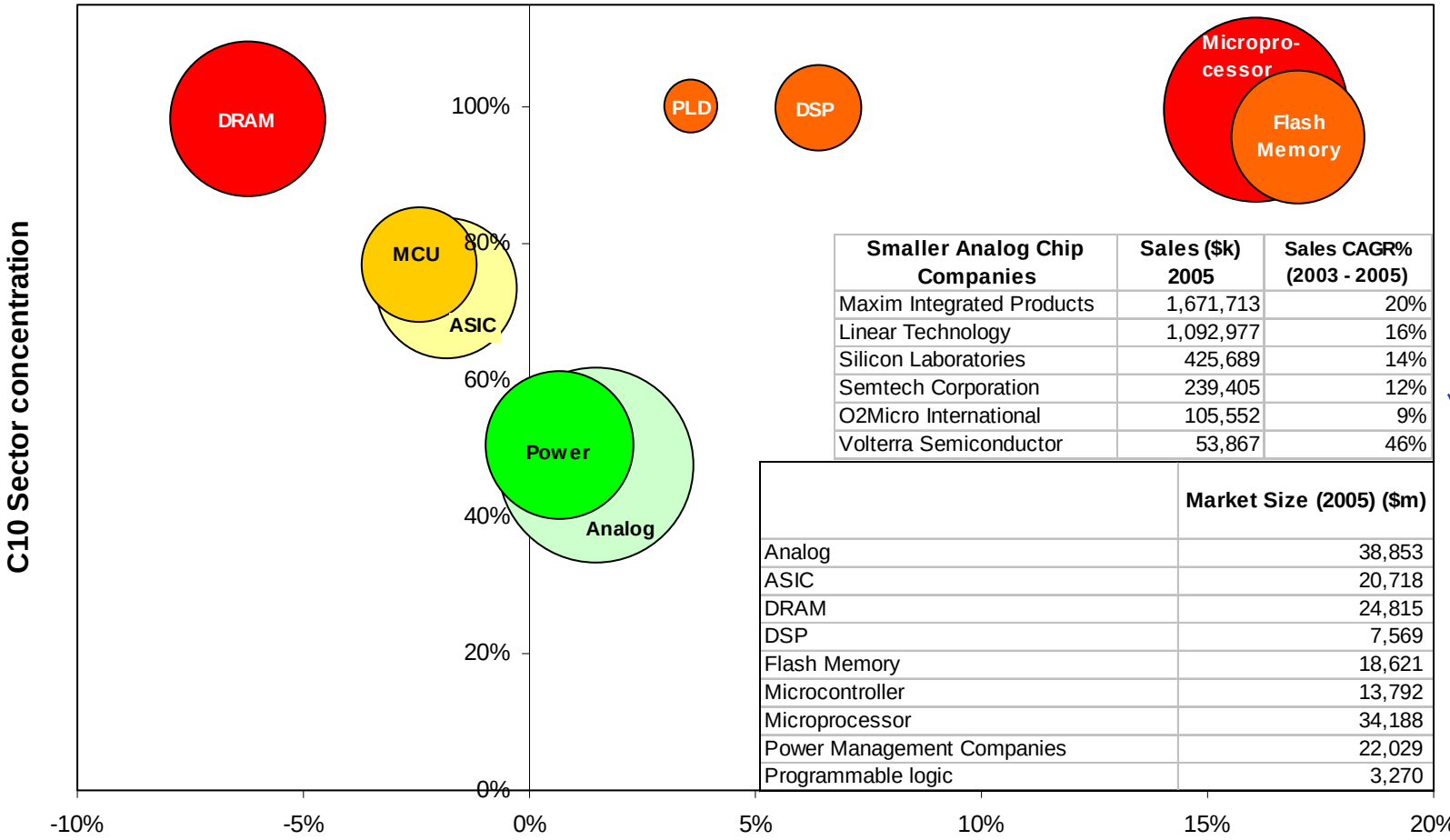
The most widely known application for **Microprocessors** is in Computers, but they also appears in different versions as **Microcontrollers** (MCU) and **Digital Signal processors** (DSP). In a new automobile for instance, MCUs can appear in their 32-bit version as an engine controller, two 16-bit ones for transmisssion control and anti-lock braking, and up to 30 8-bit versions controlling air-bags, speedometer, climate control, automatic windows etc. DSPs on the other hand, are microprocessors that are designed with the aim of processing digital signals (say filtering of noise, conditioning of the signal).



PCs are the biggest users of memory chips although almost all electronic circuits are likely to have at least one memory chip. The two most popular types of memory chips are DRAM and Flash Memory. **DRAM** chips are the most cost effective way to store a lot of data, but the data disappears when the power is turned off. **Flash Memory** chips are now being used with MP3 players and digital cameras to store music and images, because they continue to store the data without an external power source, but can easily be erased and 'refilled' with new data by the user.

Analog Chips sector is the least concentrated and therefore most interesting

The Semiconductor market has differing growth and concentration characteristics for different families of chips. Devices that are supplied in standard forms such as Microprocessors and Memory are concentrated in the hands of a few large players. The Top 10 companies in these sectors have nearly all of the market. But for chip families that are tailored to end-use, the concentration decreases with level of customisation required for end-use applications. **The analog and power chip markets stand out as interesting areas of study.**



Smaller Analog Chip Companies	Sales ($k) 2005	Sales CAGR% (2003 - 2005)
Maxim Integrated Products	1,671,713	20%
Linear Technology	1,092,977	16%
Silicon Laboratories	425,689	14%
Semtech Corporation	239,405	12%
O2Micro International	105,552	9%
Volterra Semiconductor	53,867	46%

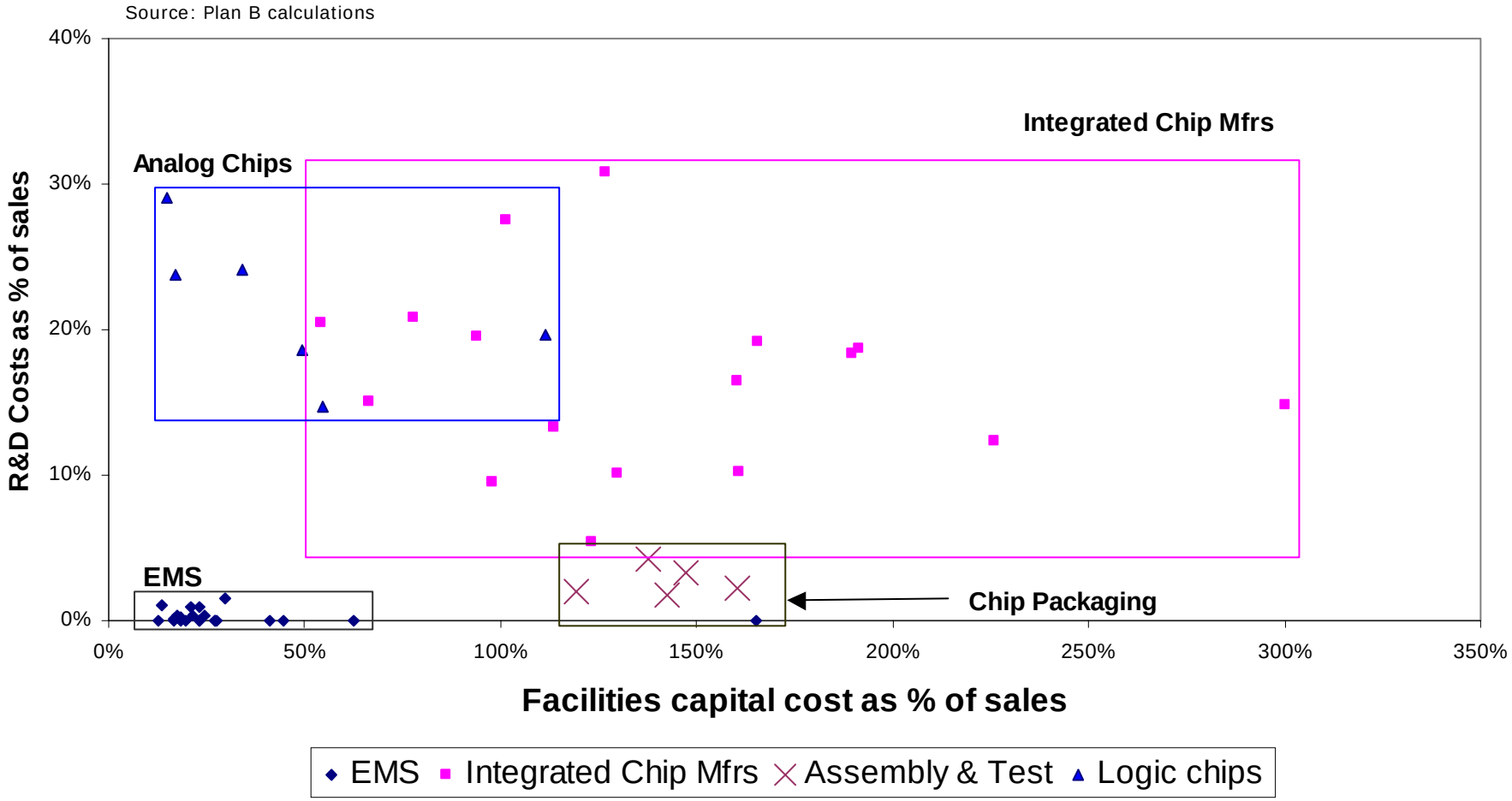
	Market Size (2005) ($m)
Analog	38,853
ASIC	20,718
DRAM	24,815
DSP	7,569
Flash Memory	18,621
Microcontroller	13,792
Microprocessor	34,188
Power Management Companies	22,029
Programmable logic	3,270

Smaller Analog Chip companies are growing much faster than the overall market

Source: Plan B calculations

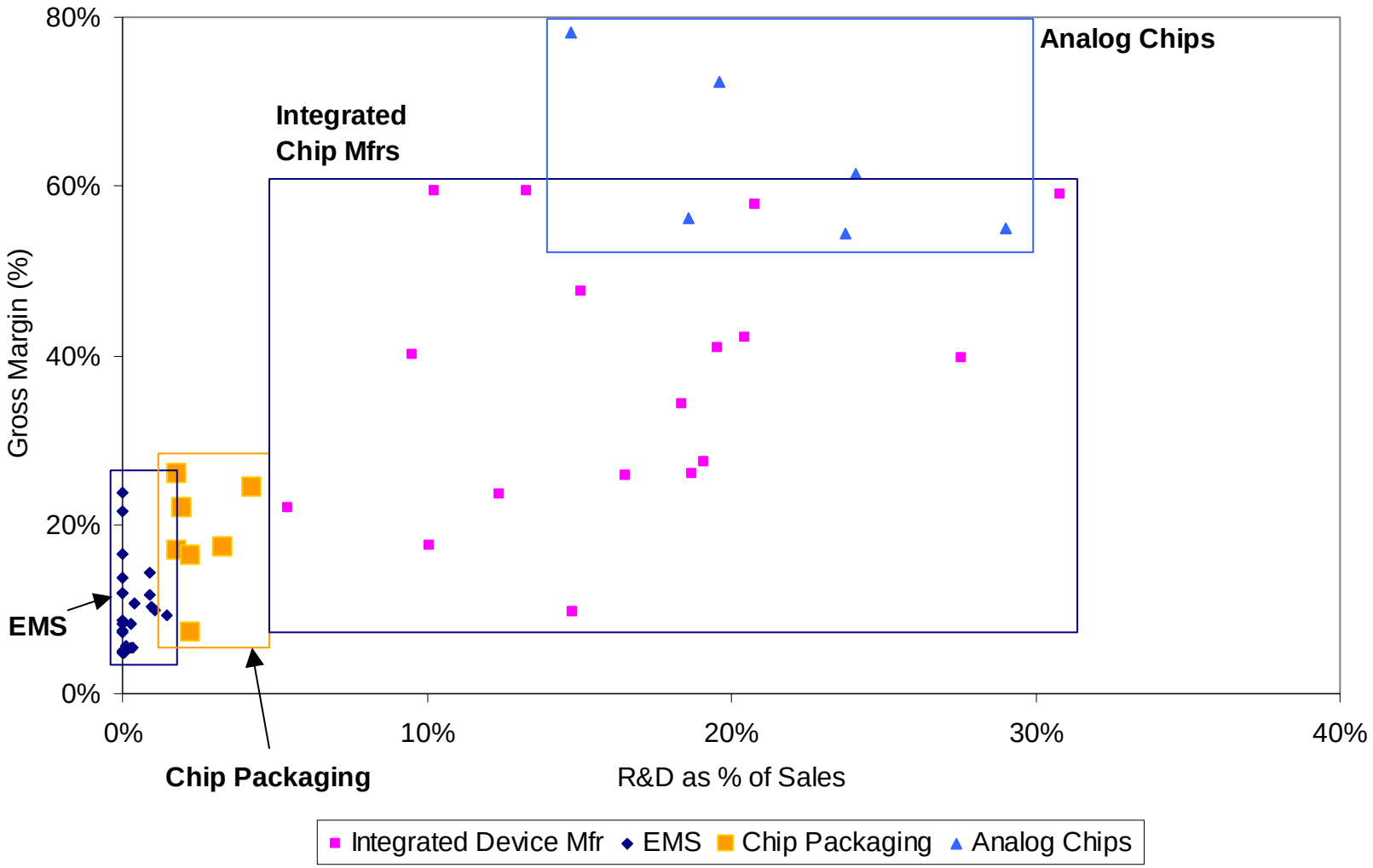
Analog Chip companies have to spend less on Facilities

Analog chip companies spend less than Chip Packaging companies on facilities. Analog chips do not require the latest manufacturing technologies.



Analog Chip companies have higher gross margins

Source: Plan B calculations



Analog Chip business has some important differences

1) Analog chips tend to be highly tailored for a particular application and for particular customers, which allows them to command higher prices, leading to healthier Gross and Operating Margins.

2) Diversified products and customer base – Analog companies tend to be more diversified with many different products and customers. Analog companies can have as many as 50,000 active customers buying a few hundreds to thousands of products. This allows Analog companies to be better diversified and less subject to individual customers or design wins.

3) The key barrier to entering the Analog sector is the difficulty in finding engineers skilled in Analog design. This follows from the nature of Analog design which tends to be more individualistic than team-based, since the work cannot be standardised and split between several individuals as in the case of Digital chip design. There are no software tools which can automate aspects of it and thus make the job easier. The individual designer has to concern himself with all aspects of the design and so has to be of a higher calibre than a typical Digital designer.

4) Analog chip performance benefits from using older, larger line-width chip technology so companies in this space spend significantly less on Capital Expenditures. Capex to Sales ratio in this segment usually ranges from 7% to 17 versus an average of 15% to 25% for Microprocessors, Foundries, and Memory semiconductor companies.

5) Customers also tend to have limited Analog design skills, which provides an opportunity for Analog companies to provide technical support during the pre-sales phase which can be crucial in winning business.

6) Analog chip designs don't change very frequently and customers continue to use older designs, which provides long term steady revenues for each successful design, lasting many years.

Stages to becoming a major player in Electronics: One possible scenario

Having looked at the Electronics Industry, we can put together the potential opportunities as follows:

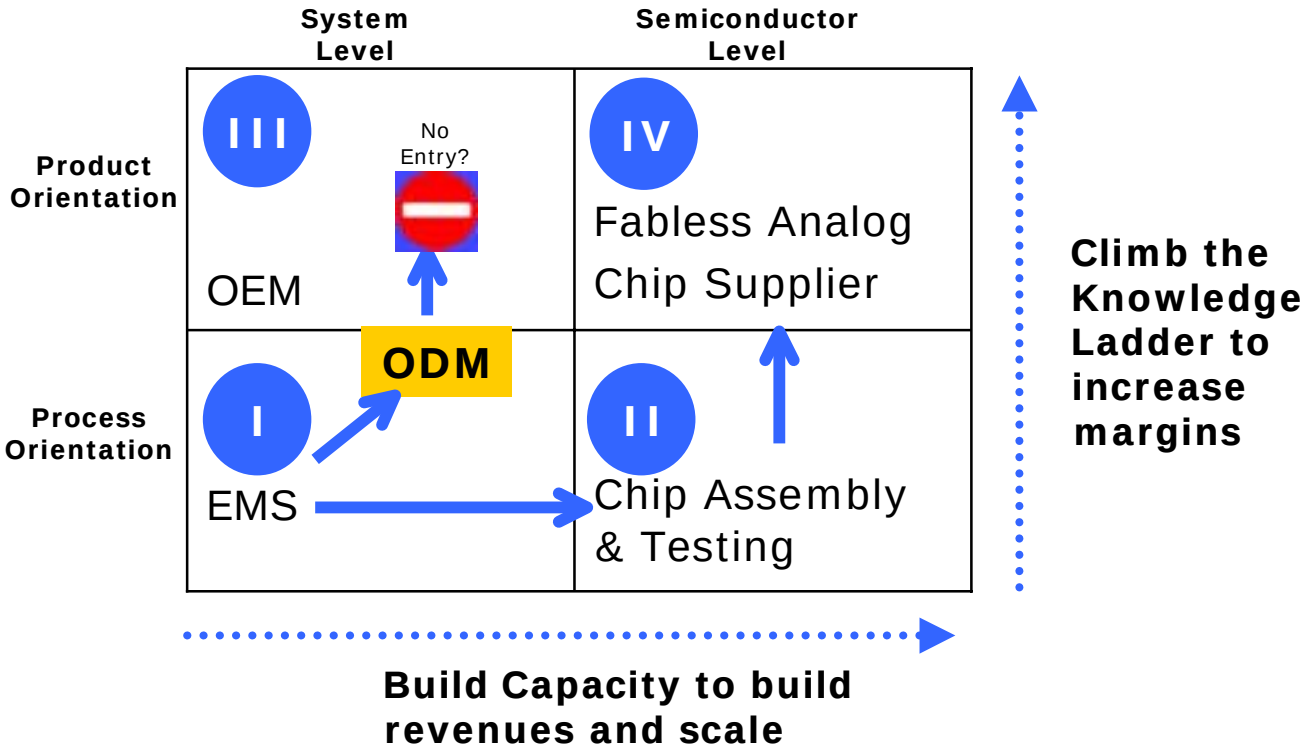
EMS is clearly a low cost entry point which allows the build-up of a global network of niche manufacturing businesses and forms the foundations for other businesses.

Chip Assembly is a low cost entry point into the Semiconductor industry.

Both of these businesses can be used to build revenues and to form a foundation for more ambitious moves at a later stage.

One such move is to consider becoming fabless chip supplier or IDM in the analog chip sector.

The rest of this report looks at the EMS sector in some detail.



Ideal Qualifications for success

- Experience of attracting global players as customers
- World-class manufacturing facilities set-up and operations capabilities
- Experience of managing capital intensive projects
- Brand has potential to attract global managerial and technical talent
- Clean Room expertise (useful for Chip Assembly)
- Interest in and experience of technology and product development

Challenges for Indian Companies

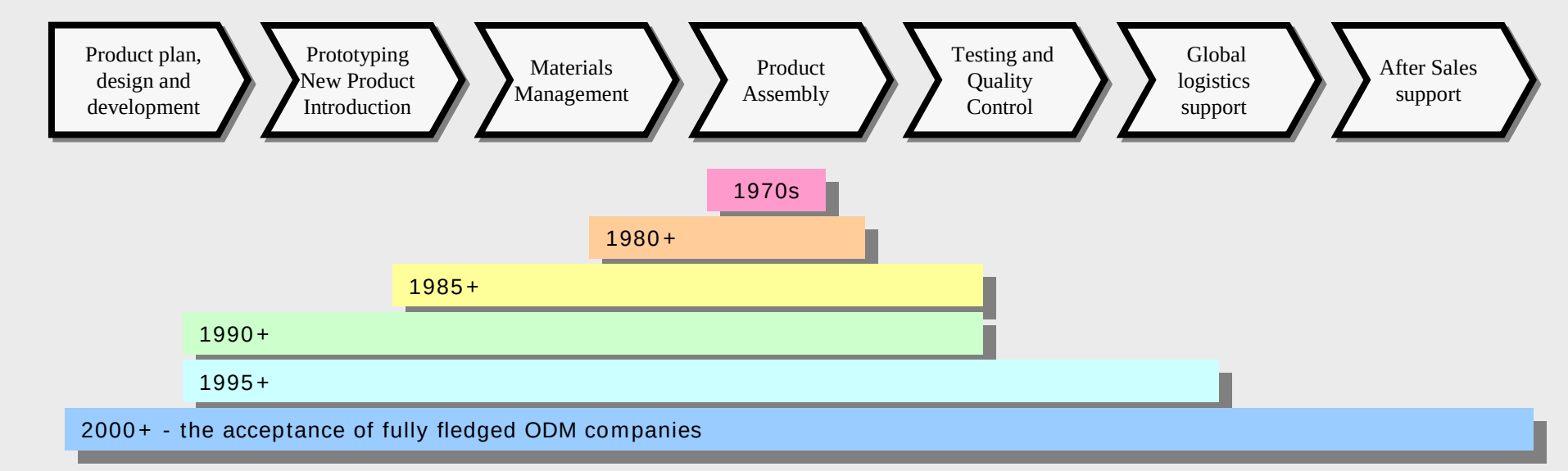
Understand the nature of the global production network in Electronics and work out how to become a network member at the lowest entry cost

Create strategies that exploit India's engineering skills – in other words focus on cost-effective knowledge generation and exploitation rather than only capacities

Most importantly learn how to manage innovation

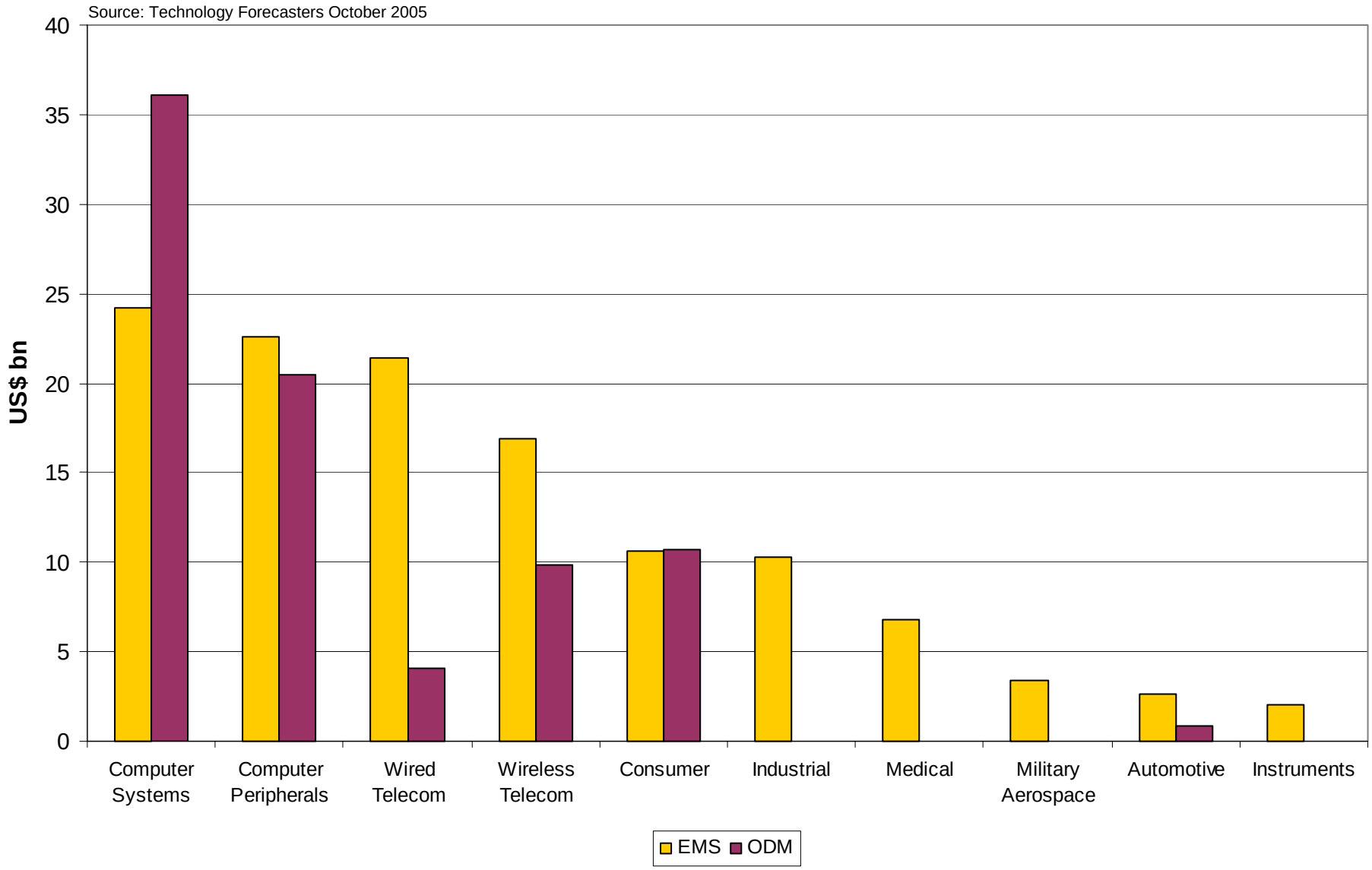
Contract Electronics Manufacturing
A Closer Look

The evolution from Board-stuffer to Original Design Manufacturer

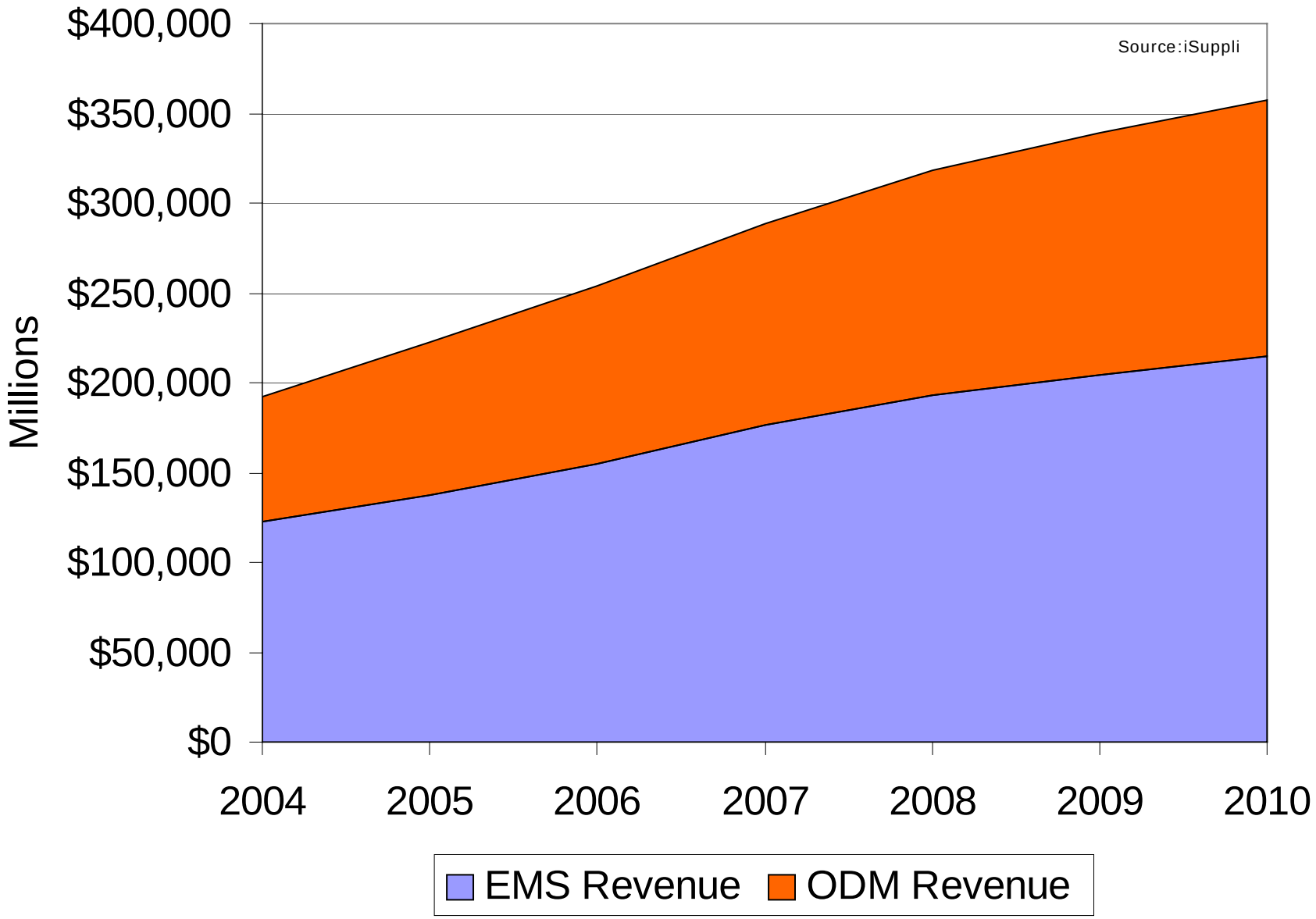


	ODM (Original Design Companies)	EMS (Electronics Manufacturing Services)
Design/ Intellectual Property (IP)	New product design -Electrical, mechanical, and industrial engineering - Proprietary IP	Contract design - Principally PCB layout - Customer owns IP
Bill of Materials (BOM)	Ownership of BOM and can optimize the Approved Vendor List (AVL) for mutual benefit	Less control over BOM
Inventory Risk	Takes the risk of having unsold goods but can sell “white boxes” to lower risk	Small inventory risk
Mix	More than 50% of sales derived from computing (mostly desktop / notebook / peripherals) Top customer can account for 40% plus of revenue	75% of revenue from communications and computer sectors Largest customer typically represents less than 20% of sales
Competition with OEM	Via “white box” sales (sell the same technology to others as a cheaper unbranded version)	Does not compete with customer
Manufacturing Footprint	Concentrated in Asia (Taiwan and China)	Global footprint but with higher percentage of production in US and Western Europe

But ODMs operate in mass market categories

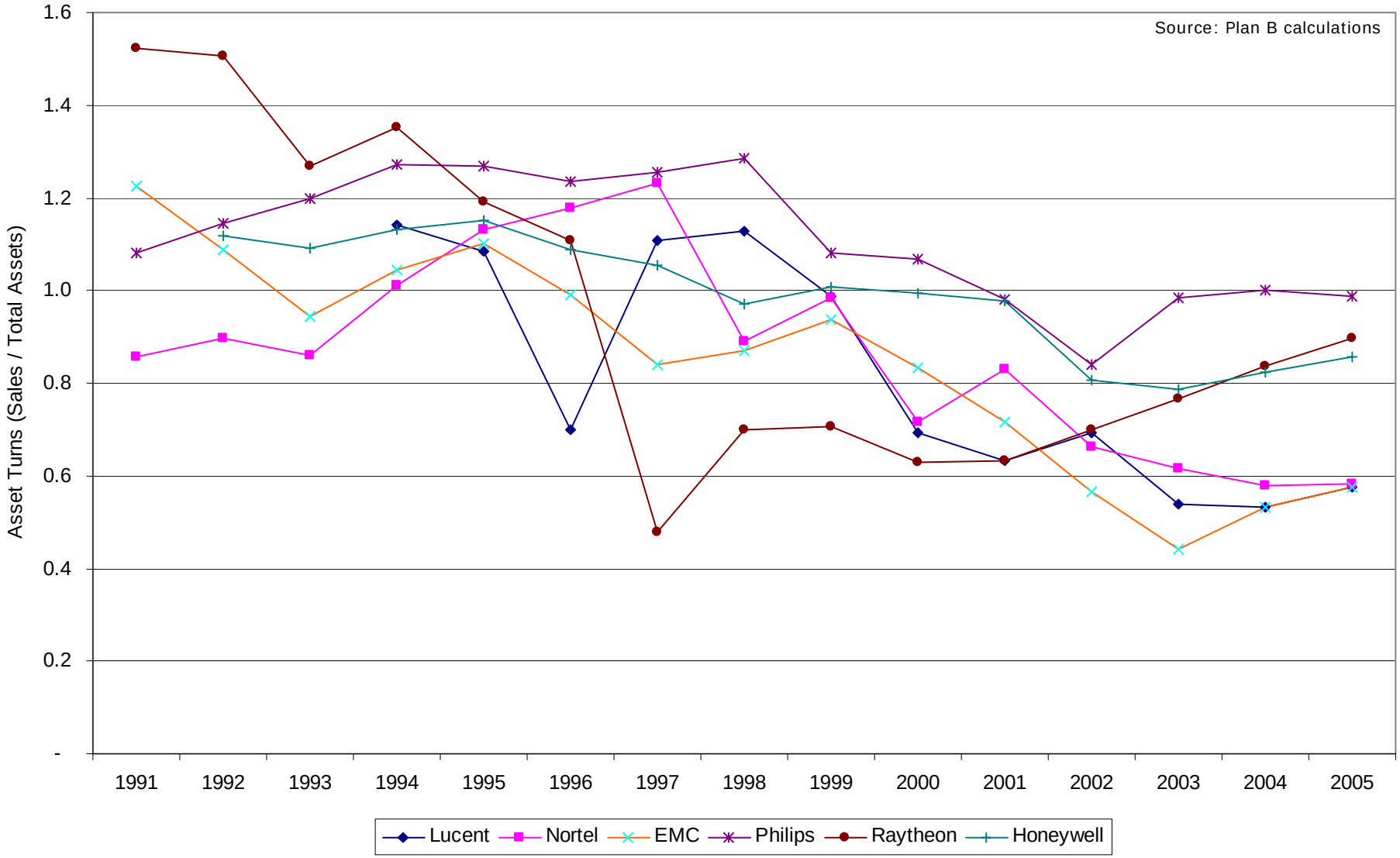


Both EMS and ODM is expected to grow with the global electronics market



Declining Asset Turns should maintain pressure to outsource

This chart shows the reduction in asset turns (sales / total assets) of leading OEM / Systems companies which should maintain the pressure to be rid of assets which are not core to their business. The expanding global reach of the contract manufacturers and their ability to achieve scale economies in manufacturing and the supply chain should increase their attractiveness.



The potential for outsourcing is far from fully tapped

Telecom & Networks
LAN Switches
LAN Routers/Hubs
NICs (Wireline)
Dial-Up Modems
DSL/Cable Modems
Wireless Terminals
Other Phones
Wireless LAN NICs
Wireless LAN BTSs
Cellular BTSs
PBX/Other CPE
Carrier-Class Switches
Carrier-Class Routers
Other Telecom

PC & Data Processing
PCs/Notebooks
Servers
Workstations
Enterprise Storage
Monitors
Printers
Handhelds
Keyboards
Accessories
Other Computer

Medical
Medical Diagnostics
Therapeutic
Monitoring and Surgical
Other medical

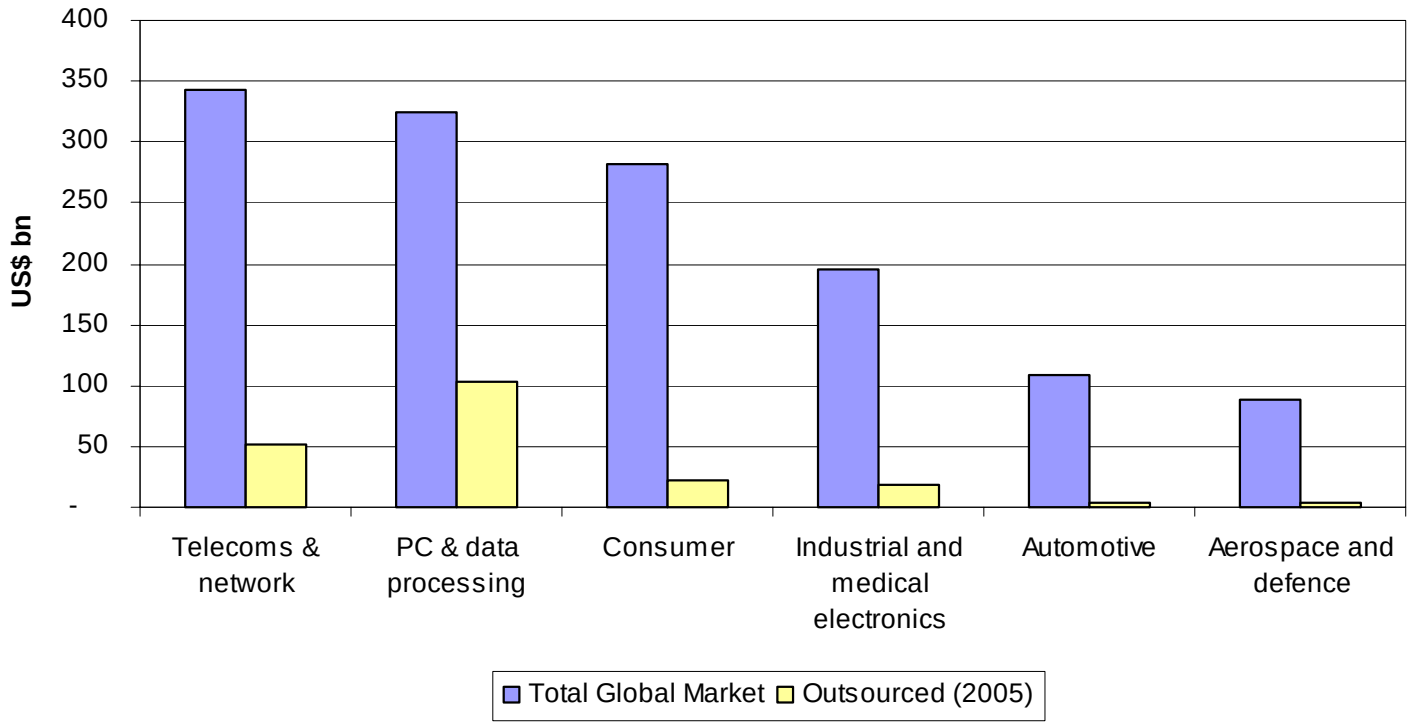
Industrial
Control Processing
Test and Measurement
Other Industrial

Aerospace & Defense
Flight Navigation
Weapons/Combat
Other Defense

Consumer
Analog TVs
Digital TVs
Audio Systems
Game Systems
Digital Set-Top Boxes
Camcorders
VCRs
DVD Players
Digital Cameras
Smart Cards
Other Consumer

Automotive
Engine Control
Instruments
Safety
Entertainment

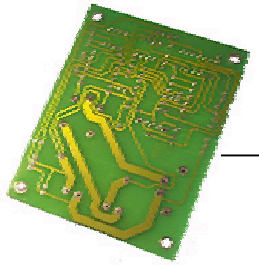
Source: Technology Forecasters October 2005



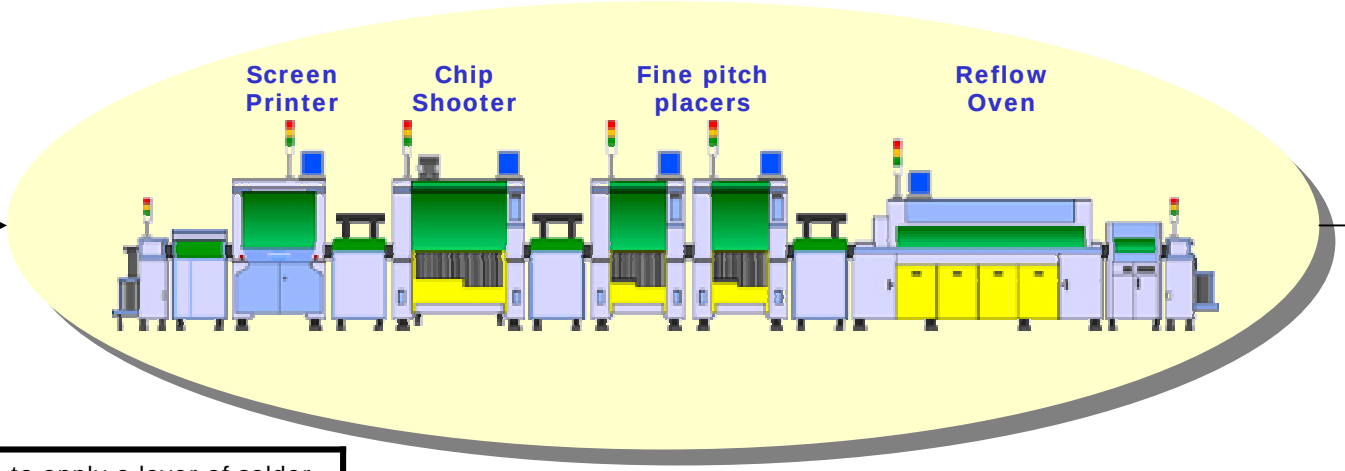
Product Assembly is the core activity

In earlier days, contract manufacturers were required only to supply labour to place components on printed circuit boards. The introduction of surface mount technology, which allowed component sizes to be reduced, led to increasing automation of the assembly process. Most of the PCB assembly capabilities claimed by EMS companies are in fact built into the machines that they purchase and require little effort on their part.

Product plan, design and development → Prototyping New Product Introduction → Materials Management → **Product Assembly** → Testing and Quality Control → Global logistics support → After Sales support



Printed Circuit Board



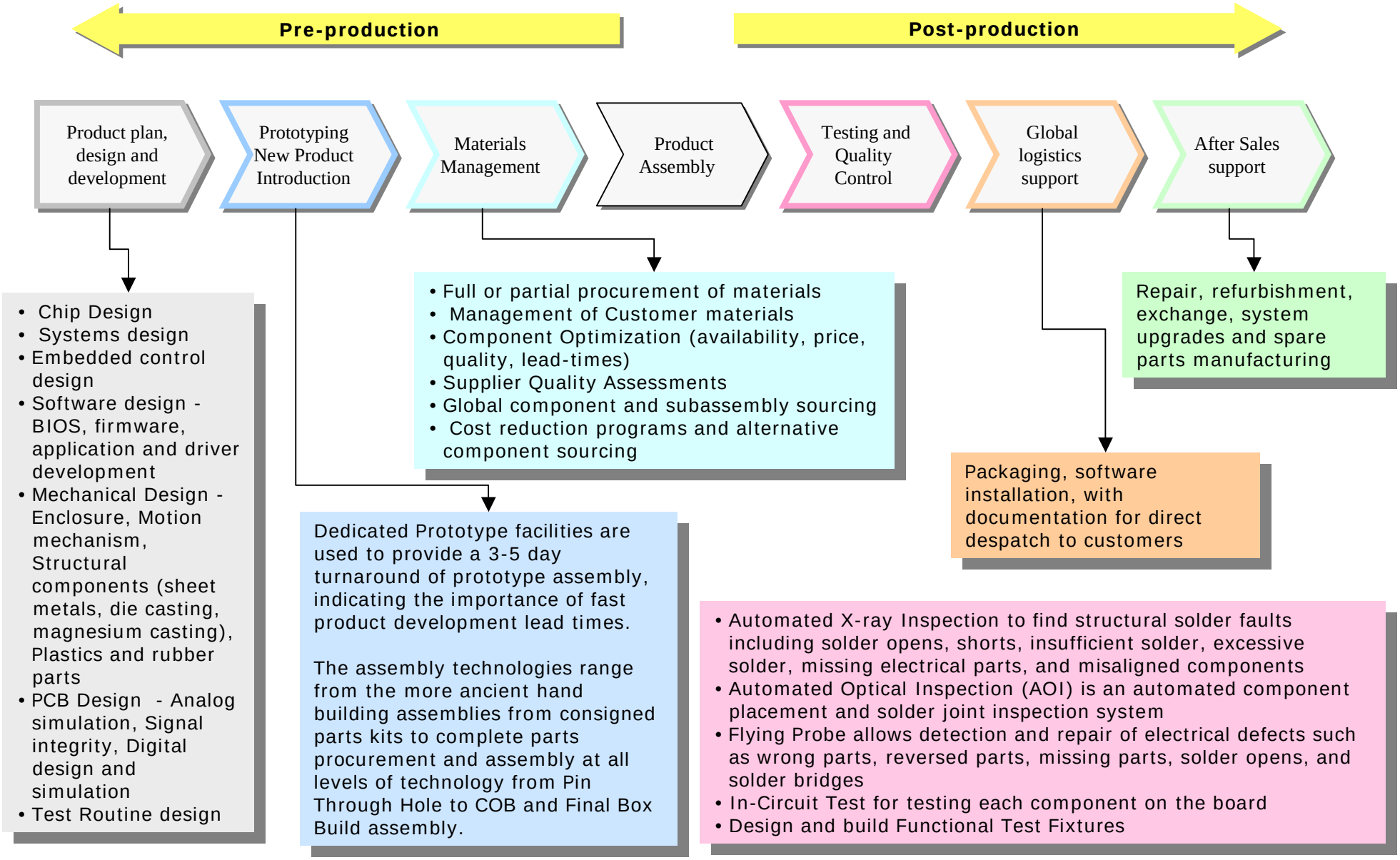
Screen Printer	Uses a stencil to apply a layer of solder paste to the PCB wherever a component is to be placed
Chip Shooter	Fast machine that can pick components from feeder reels and place up to 50k per hour. Solder paste hold them in place.
Fine pitch Placers	As chip packages become smaller, the leads become closer together. Uses cameras to recognize and place complex components
Reflow Oven	The solder paste melts and forms permanent joints as it passes through the oven

Box-build

Backplane Assembly

Through-hole assembly of larger odd shaped components – usually manual but can be automated

OEM customers are willingly outsourcing more than just assembly



Top EMS companies are expanding globally

Given that the major benefits of using EMS companies are related to costs and access to global markets, they are motivated to expand their global footprint not only in search of low cost labour, but as in the case of their entry into India, to provide their brand-name OEM customers with access to fast growing markets.

Major Advantages of using EMS contractors

- EMS companies offer lower wages and fewer benefits to their employees than large brand-name OEM companies that outsource to them
- They make much more use of a temporary contract labour. This can range between 10% to 50% of the work force in big contractor firms.
- They have better plant utilization since they can balance the load between many customers.
- They can pool orders to achieve component purchase economies. As their buying power increases, distributors have created specialized sales teams to cover them. They are also able to go direct to the manufacturer to get even better deals.
- They provide the OEM customer with the ability to ramp production up or down without having to install or idle in-house capacity.
- Given their presence in many locations around the world, they provide even their smaller customers with the ability to manufacture and supply products anywhere in the world without the risk of entering the market themselves.

Large players have global operations

Each of the largest electronics contract manufacturers has established a global network of plants that consist of

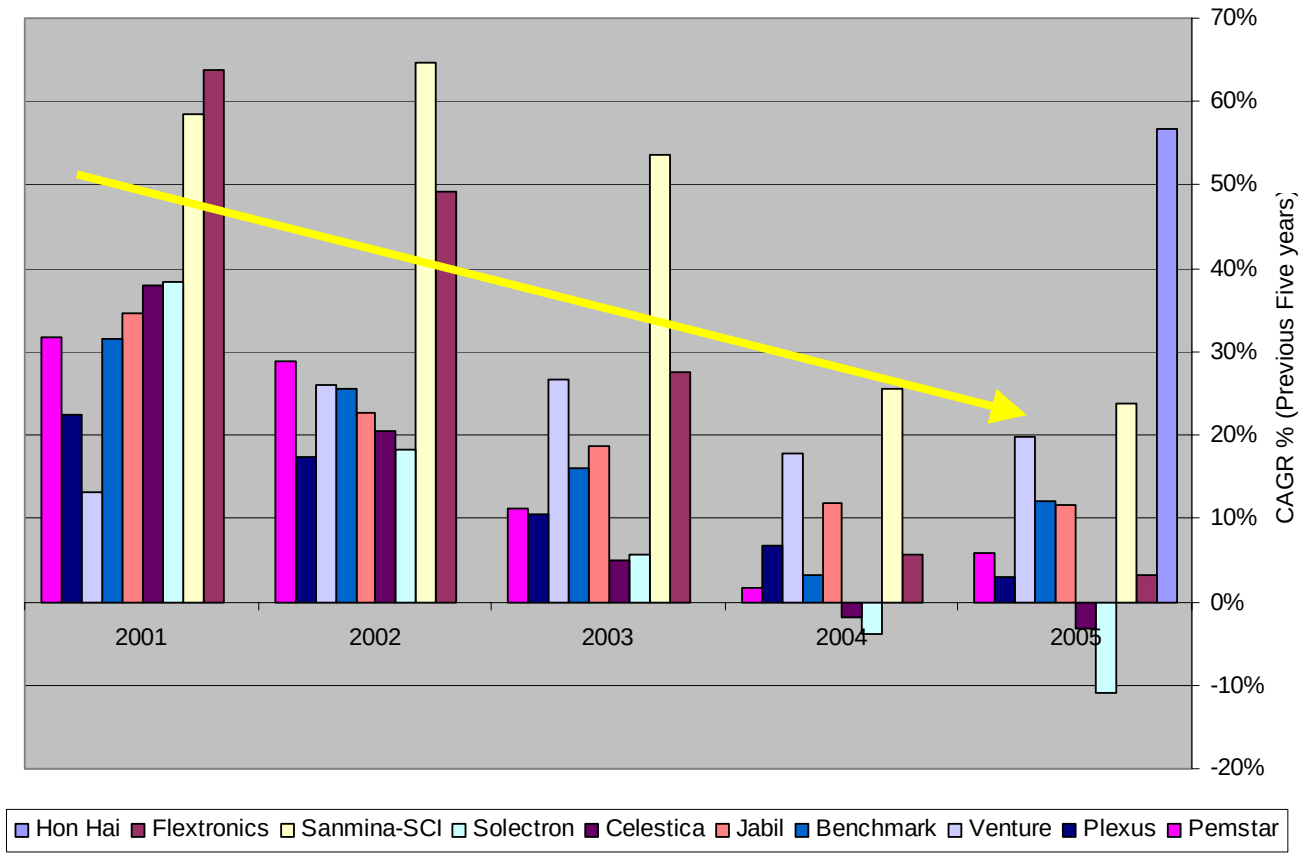
- low-product-mix, high-volume production sites, mostly in Asia, Mexico, and East Europe;
- high-product-mix, medium-to-high volume production sites in the United States, Canada, Western Europe, and now Japan;
- engineering-heavy “new product introduction” centres, often located near an important customer’s design activities; and
- facilities that perform final assembly and product configuration to order and/or provide after-sales repair service, often located near major transportation hubs, such as Memphis, Tennessee and Amsterdam.

All have large-scale investments for high volume production in East Asia, especially in South East Asia and increasingly in China.

But growth of the larger companies seems to be slowing down

Declining Growth rates of most of the Top EMS providers (CAGR for preceding 5 years)

Source: Plan B calculations



The anticipated CAGR for the EMS sector for the next five years is around 10%.

As our analysis shows, growth is slowing down and the growth rates are uneven and some are faltering.

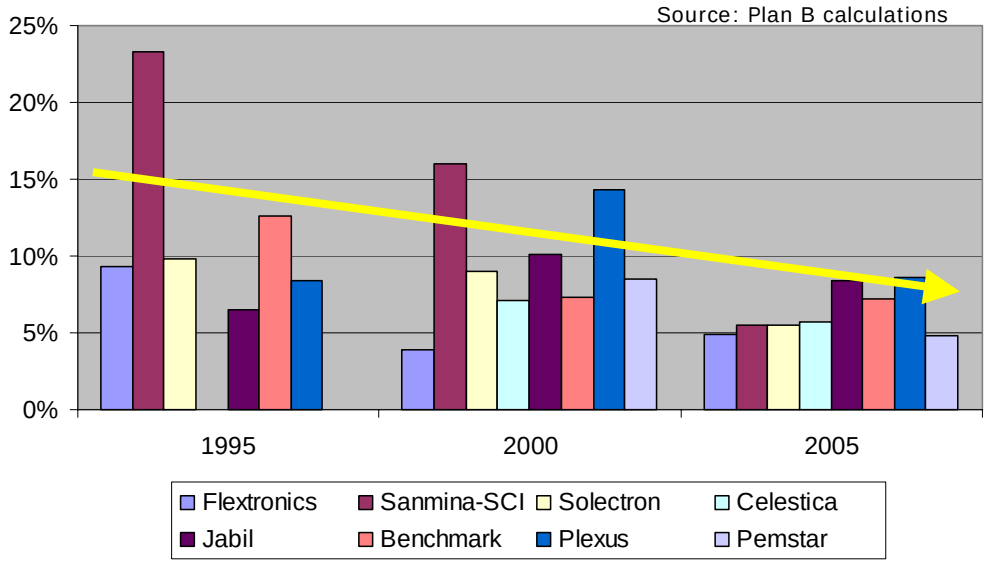
The situation at the top is therefore dynamic and changeable.

And their margins are dropping

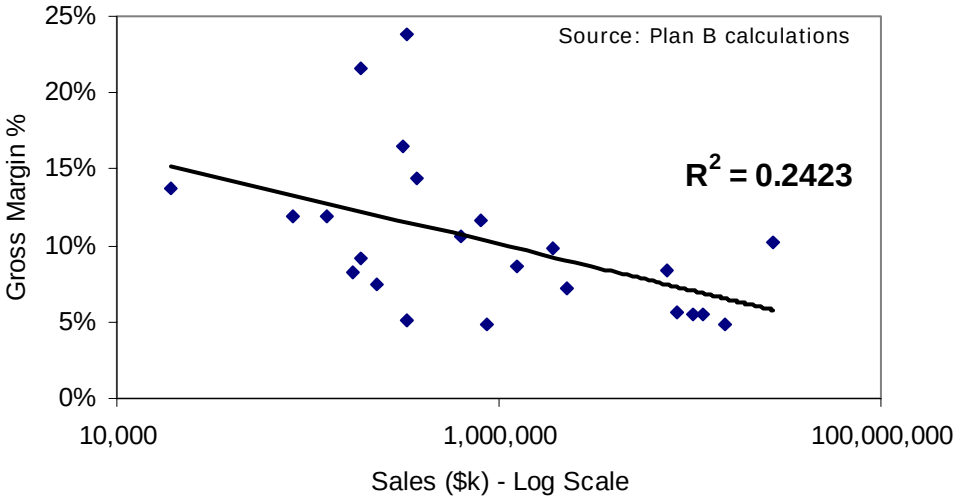
Over the years, the top EMS companies have grown at a furious pace. But they have also seen their gross margins fall significantly.

Our analysis of the returns in 2005 of all the 30 EMS companies in our sample shows that there is a relationship of sorts between the size of the business and its gross margin

Gross Margins of the Top EMS companies have declined

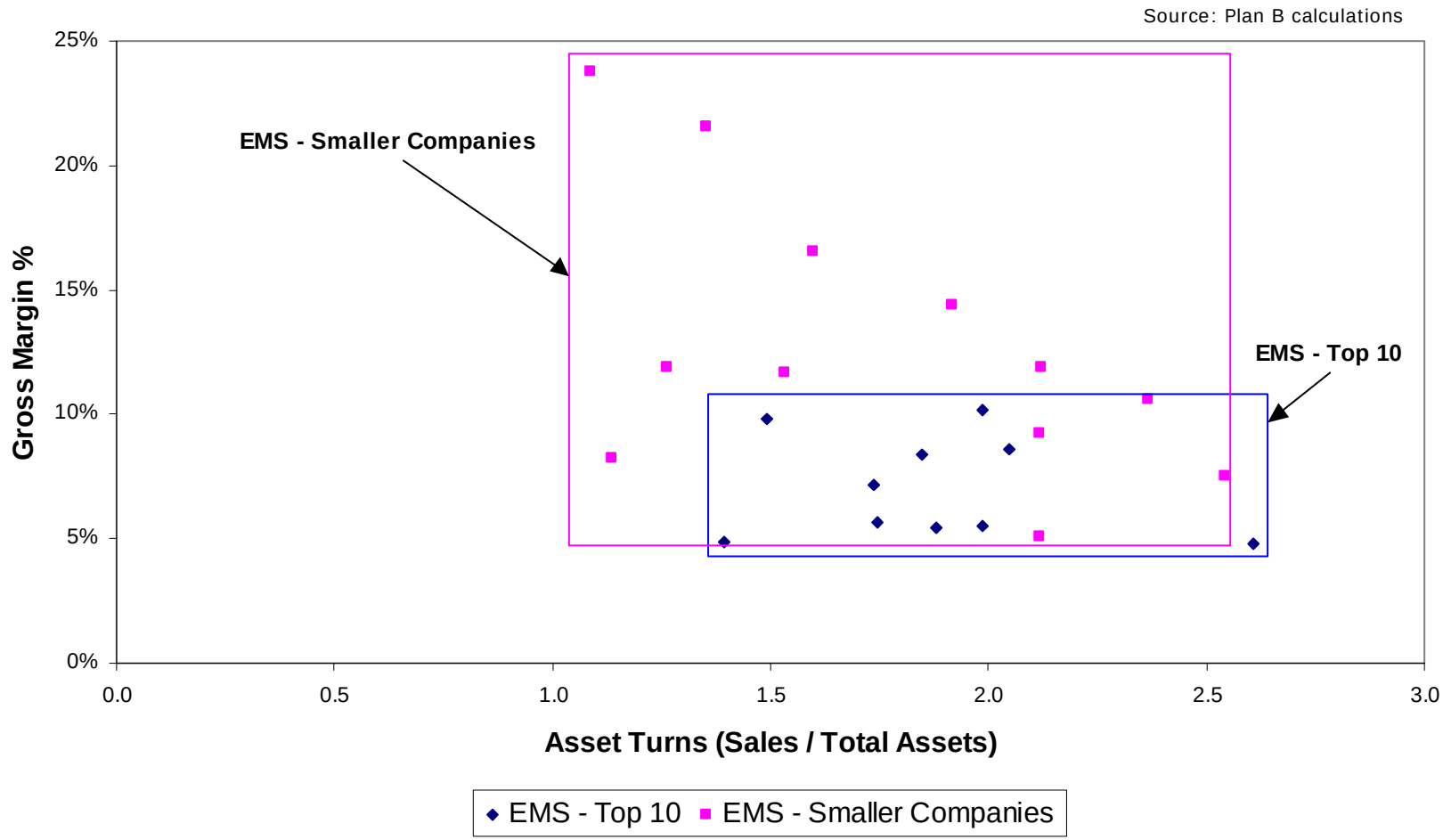


A link between size and gross margins?



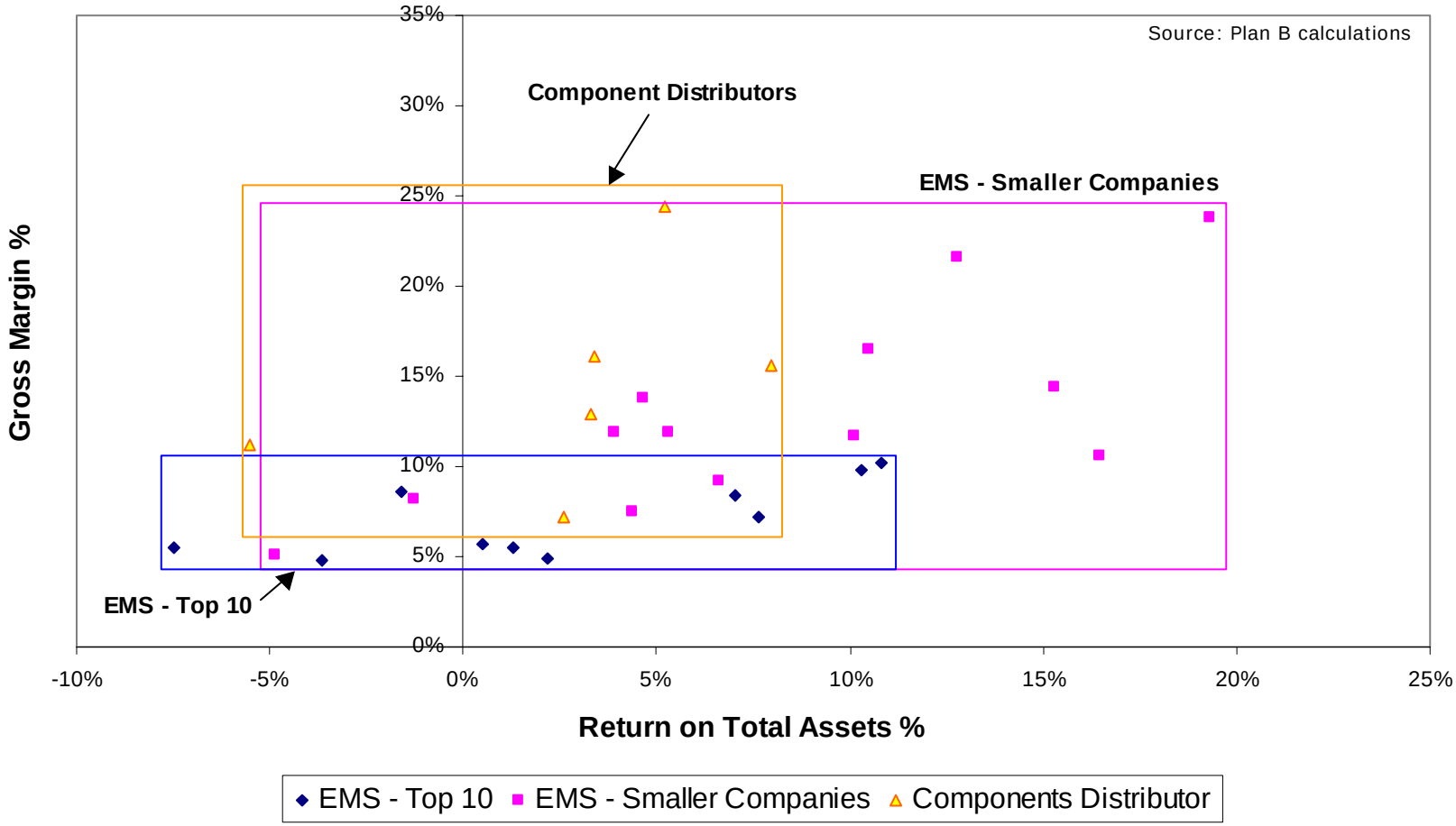
Is this a consequence of the way the speed with which they have grown? In other words is it due to an inability to manage the growth?

But as a group larger EMS companies are no worse at managing their assets



When judged by their asset turn figures, the larger companies seem to be as good if not better at managing their assets when compared with all the EMS companies in our sample. In other words, their global networks of recently acquired factories, component supply flows and finished product flows are not necessarily as unwieldy and inefficient as some commentators have suggested. This implies therefore that the lower margins are either due to an increase in other costs or more likely due to a decrease in selling prices.

EMS companies are not capturing the value from their assembly services



Our research shows that the returns of Top EMS companies resemble those of the Component distributors. Both buy components and sell them to a End user. In the case of the EMS company however, the components are all assembled together into a product and then shipped out. If their returns are similar then it raises the question what return if any is the EMS company getting for their investment in factories and equipment?

Profitable Business Models

Return on Total Assets, Percentage of revenues and Facilities location	ROTA % (2005)	Telecoms	Computers	Consumer	Industrial	Medical	Automotive	Defence	Factory Location
Surface Mount Holdings	11%	0%	**41%**	**11%**	**26%**	0%	**23%**	0%	China
LaBarge	13%	0%	**10%**	0%	**38%**	0%	0%	**40%**	USA
Alco Electronics	16%	0%	0%	**100%**	0%	0%	0%	0%	China
Nam Tai Electronics	10%	**50%**	**50%**	0%	0%	0%	0%	0%	China
Venture Corp	10%								Asia

Source: Plan B calculations

Of the 30 companies analysed, these 5 EMS companies stand out in terms of performance. Whilst a bigger sample would be necessary before critical investment decisions can be made, we can make some initial assertions about the nature of the industry

1. Large US based EMS companies are suffering declining margins. They earn more than two thirds of their income from three fast growing, competitive markets: Telecom, Computers and Consumer electronics. A number of factors might be depressing returns:
   - These high volume segments are price sensitive and customers may be reluctant to pay for the additional services that they are expecting
   - These segments tend to require global distribution / supply chain management and the companies may be incurring more costs than anticipated
   - The large players may not be as good at managing the global supply chain as they were at manufacturing

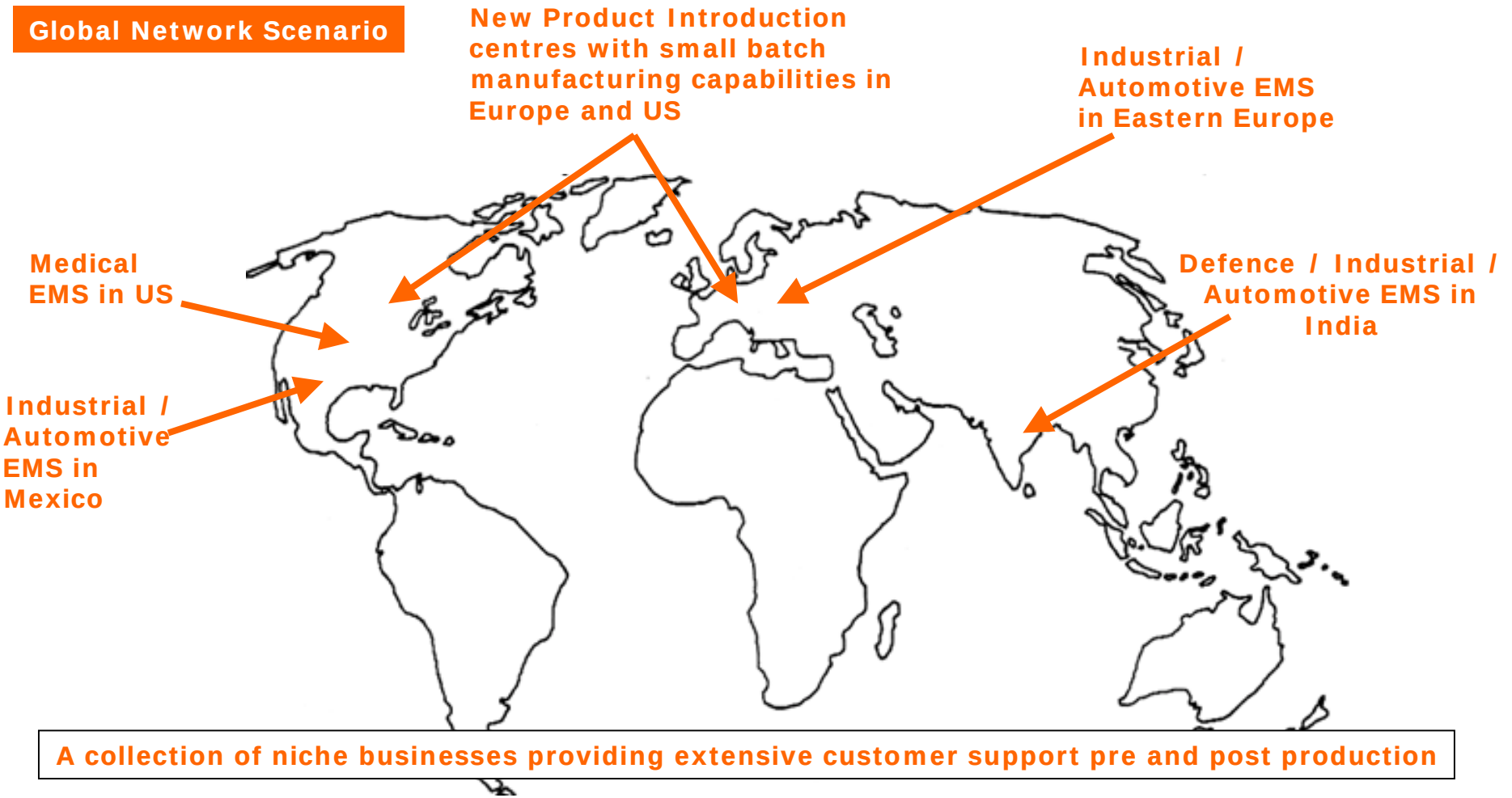
2. To be based in China/Asia seems to provide better returns. Companies based out of India should also be able to see the same benefits.

3. Although there is only one US company in the sample above, it is interesting to note that the bulk of this company's revenues come from Industrial and Defence sector, where margins may conceivably be higher, in part due to smaller volume – high value product mix.

What are the opportunities for an Indian Company in EMS?

Selection of emerging sectors that require high support and where Indian technical resources can be leveraged to add value at lower costs: Medical, Defence, Automotive. The real value in EMS is added not at the product assembly stage, but in the pre-production and post-production stages. In addition a global presence is required to be considered a serious player.

Global Network Scenario



A collection of niche businesses providing extensive customer support pre and post production

Possible opportunity: Medical Electronics EMS

The Medical Devices market is made up mostly of low volume – high mix assembly work. A large number of regional niche manufacturers have a strong presence in the medical EMS market. According to Frost & Sullivan, Medical OEMs prefer to outsource to local participants rather than to low cost regions, but this is changing.

Rhythm management devices

Pacemaker

Implantable cardioverter -defibrillator

High growth is expected in audiology, imaging, therapeutic and monitoring devices. Increasing trend towards electronic healthcare and telemedicine is expected to increase the total available market.

Increasing average age of Western populations is driving the overall market for medical devices. The total addressable market for 2005 was $52.2bn of which only 8% has been outsourced (TFI / Halpern Capital)

DSP Programmable hearing aids

BP and Diabetes monitors

Ear Digital Thermometers

Patient monitoring systems

Consignment v Turnkey Business

In Medical Electronics and other sectors where some of the components have been specially designed for the OEM by the component manufacturer, the OEM may prefer not to delegate the purchasing of components to the EMS companies – commonly known as “turnkey” business. He may see information regarding these components as a trade secret and may prefer to purchase the components himself and have them delivered to the EMS. This arrangement is known as “consignment” business.

	Consignment	**Turnkey**
Revenue	**$5,000**	**$28,750**
Cost of Goods Sold (COGS)		
a) Labour and Overhead	$4,350	$4,350
b) Materials	0	$21,500
Total COGS	**$4,350**	**$25,850**
Gross Profit	$650	$2900
Gross Margin	13.00%	10.10%

Source: Analyst’s report

Advantage of Consignment business: As this illustration shows Gross margins are higher for the same job.

Disadvantage: If the EMS company is adding no value beyond the supply of labour for assembly, making the relationship weak and vulnerable to price pressure and constant threat of switching to other suppliers.

The Indian Scene for EMS

Activities of Top 10 global EMS companies in India

Company Name	2005 Sales (US$m)	2004 Sales (US$m)	% Change	India activities / plans
Foxconn / Hon Hai	27,315	15,811	62%	Plans to set up a SEZ near Chennai
Flextronics	15,582	16,062	-3%	Chennai SEZ to go live in Nov 2006 (56,000 sq metres)
Sanmina-SCI	11,343	12,484	-9%	Land ear-marked near Hyderabad
Solectron	10,207	11,630	-12%	Acquired Bangalore company Centum, a component mfr
Celestica	8,471	8,839	-4%	Acquired Hyderabad EMS firm – Ramnish Electronics
Jabil Circuit	8,057	6,575	23%	Facilities in Mumbai, Pune, Ranjangaoan and Chennai
Elcoteq	5,179	3,899	33%	Invested $100 million in its Bangalore facility
Benchmark	2,257	2,001	13%	No plans announced
Venture	2,007	1,945	3%	No plans announced
Universal Scientific Industrial	1,621	1,613	1%	No plans announced
Top 10 Total:	86,936	80,859	11%	

Source: Company Reports

It is likely that large global companies will dominate up to 80% of the Indian Electronics manufacturing sector. This arises from the simple fact that global OEMs dominate the largest electronics sectors: Telecoms, Computers and Consumer and they would prefer to use the larger players with whom they already have relationships around the world.

Telecommunications Sector

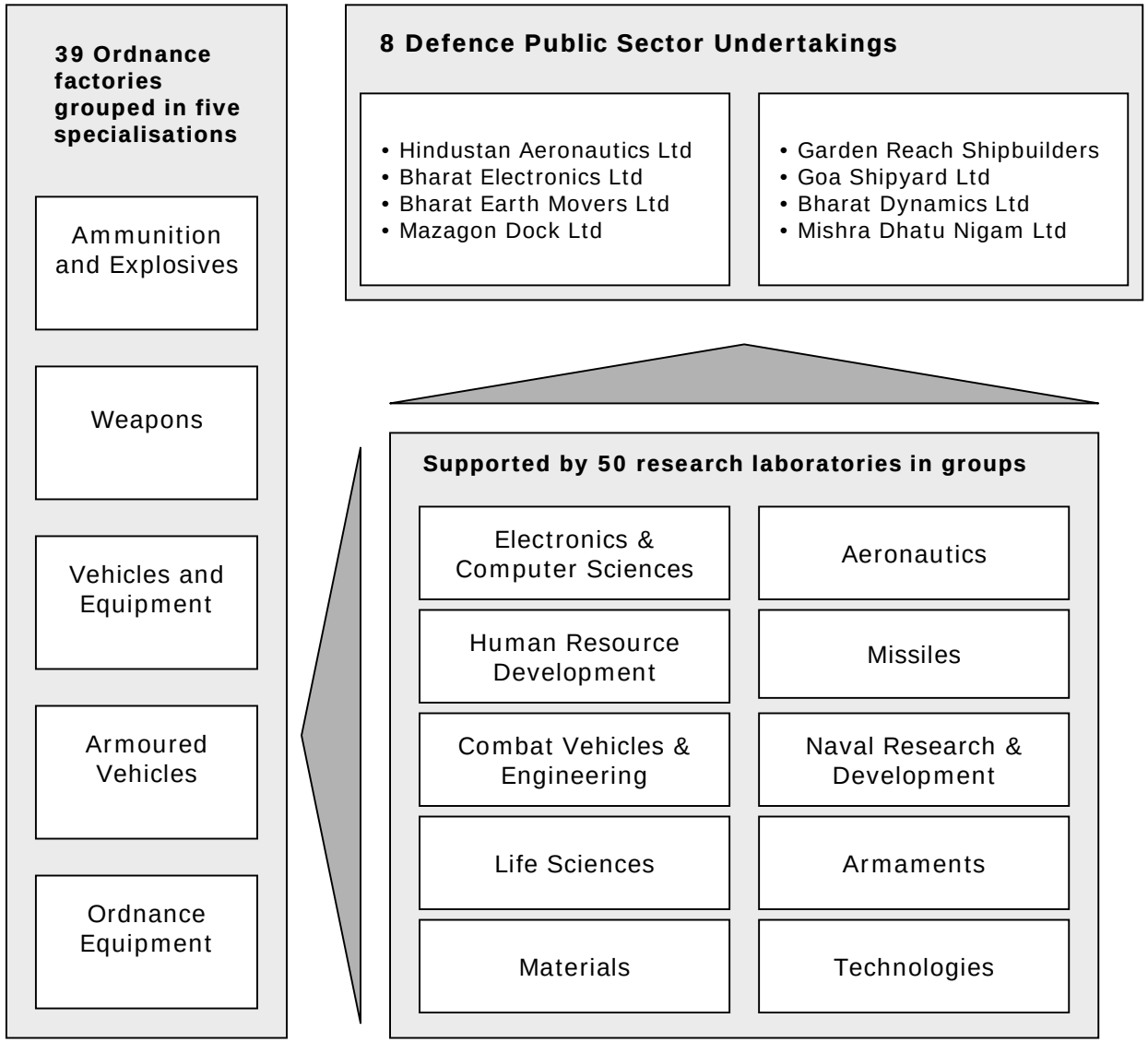
Manufacturers	Investment	Focus areas	Location	Time
Foxconn	$1bn over 3 yrs	Mobile Handsets, Electronic goods	Chennai	Planned 2006 – delayed
Nokia	$150m over five yrs	Mobile Handsets, Base stations	Chennai	In operation
Flextronics	$100m over 3 yrs	Mobile Handsets, Base stations, Electronic goods	Chennai	will start Nov 2006
Elcoteq	$100m over 3 yrs	Mobile handsets, Base stations	Bangalore	since Apr 05
Ericsson	$50m	Base stations, Mobile switching centres	Jaipur	since Mar 05
Alcatel / ITI*	$20m	Base stations	Rae Barelli	since Jul 05
Samsung	$15m	Handsets	Manesar	Planned 2006
LG	$12m	Handsets	Pune	since Jun '05
BPL*	$10m	Handsets	Palakkad	In operation
XL Telecom*	-	Handsets	Hyderabad	In Operation

***Indian companies**

•Source: Press clippings

The largest Indian company here is ITI, which is the favoured child of the Government. After many years of underperformance it received a £130m bailout recently and up to 30% of the telecom order placed by the government via BSNL is reserved for ITI which assures the future of the organization. Alcatel is providing the technology and ITI the over-manned factories. The two other Indian companies in this sector are BPL and XL Telecom.

Defence Production Sector in India



India is increasing Defence spending significantly and plans to invite private companies into the sector

Bharat Electronics is the most significant player in this sector.

The bulk of hi-tech electronics – up to 70% of total demand - is imported. There is increasing pressure to manufacture more defence hardware in the Indian Private sector.

Bharat Electronics Profile: The Government of India holds 75.9 percent stake in Bharat Electronics Ltd (BEL). BEL earns 75 percent of its revenues by selling electronic equipment to the Indian defence forces.

It designs, develops and manufactures surveillance and communication equipment, radar equipment and electronic warfare systems.

In the civilian market products include set top boxes for cable television (TV), electronic voting machines, solar cell power plants and wireless equipment for the police.

BEL had revenues of £417m in 2004-2005.

Consumer Electronics

This sector is clearly dominated by large OEM companies, but a sizeable chunk is outsourced to these EMS companies.

Source: Press Clippings

Market Share (Aug 2004)	
LG	25.5%
Samsung	17.3%
Onida	12.0%
Sansui	7.5%
Videocon	7.4%
Philips	6.7%
Others	24.6%

Source: Press Clippings

Indian EMS Companies	Turnover £m		Installed Capacity ('000s)			
			Air Con	TV sets	DVD Players	Microwave Ovens
Bigesto	£	91	200	3,000	500	300
Hotline	£	52		3,000		
Dixon Utlities	£	39	360	840	720	
Evershine	£	39	100	360		
Noble (Airvision)	£	34		1,800		
Oscar	£	26		360	360	
Relan	£	21	140			
Intec	£	15	100	60		
Calcom	£	12		750		
Adventech	£	6.5	600			
Bhujri Supertek	£	6.5	360			
Kinger	£	6.5		300		
Clearline	£	5	65			
Genus	£	0.4		500		

These OEMs outsource in the following categories

Market Players			
Air Con	TV sets	DVD Players	Microwave Ovens
LG	LG	LG	
Carrier	Videocon		
Hitachi	Onida		
Haier	BPL		
Voltas	TCL		
Samsung	Daewoo		
Emerson	Haier		
	Samsung		
	Philips		

* Indian companies are marked in Blue

** Chinese companies are marked in Orange

Source: Press Clippings

Computers and Office Equipment

Source: Press Clippings

Company	2004-05 Desktop Units	% of total	2004-05 Laptop Units	% of total
HCL	473,445	14%	23,073	1%
HP	427,620	13%	75,088	34%
IBM/Lenovo	195,750	6%	57,750	26%
Zenith*	126,699	4%	7,200	3%
PCS*	110,030	3%	2,539	1%
Acer	109,065	3%	21,539	10%
Dell	105,000	3%	23,300	11%
LG	95,600	3%		-
Wipro*	86,434	3%	2,294	1%
Apple	25,000	1%	500	0.2%
Others and assembled	1,628,124	48%	7,327	3%
Total	**3,382,767**	100%	**220,610**	100%

*** Indian Companies**

Source: Press Clippings

Motherboard manufacturers in India
Mikrotek
Cerebra
BEL
D-Link
Gigabyte
Vintron
Krypton
Micro-Star International
-
Manufacturers planning to start
Pro Team
TVS Electronics
XL Telecom

Industrial / Automotive / Others -1

This is a partial list of smaller independent EMS providers in India.

Source: Plan B Survey

Pure Play EMS Provider	City	Region	Website
Power Services	Kolkata	East	-
PCP ELECTRONICS PVT LTD	Delhi	North	-
SGS Tekniks Pvt. Ltd.	Gurgaon	North	http://www.sgst.com/tekniks/
XO Infotech Ltd	Gurgaon	North	http://xoinfotech.com/
Samitech	Gurgaon	North	-
Genus Overseas Electronics Ltd	Jaipur	North	http://www.genusoverseas.com
Basant India Ltd	New Delhi	North	http://www.blscomputer.com
Deltron Ltd.	New Delhi	North	http://deltronindia.com
Sahasra Electronics Pvt. Ltd.	New Delhi	North	http://www.sahasraelectronics.com
MR Technologies	Noida	North	-
Cerebra Integrated Technologies Ltd	Bangalore	South	http://www.cerebracomputers.com
Militronics	Bangalore	South	-
Peninsula Electronics	Bangalore	South	http://www.peninsulaelectronics.com
Pro Innovative Technologies	Bangalore	South	http://business.vsnl.com/proinnovative/
Digital Circuits	Bangalore	South	-

Industrial / Automotive / Others -2

Source: Plan B Survey

Pure Play EMS Provider	City	Region	Website
Avalon	Chennai	East	http://www.siennagroup.com
Riskguard Assurance Services	Chennai	North	http://www.riskguard.co.in
Shree International	Chennai	North	-
Srikrishna Designs & Technologies Pvt. Ltd.	Hyderabad	North	-
Veratroniks	Hyderabad	North	http://www.veratroniks.com
Neulite Products Pvt. Ltd.	Mysore	North	-
PCP Electronics Pvt. Ltd	Mysore	North	-
Rangsons Electronics Pvt. Ltd.	Mysore	North	http://www.revc.com/
Vin Electronics	Mysore	North	http://www.vinelectronics.com/
Vinyas Innovative Technologies	Mysore	North	http://www.vinyasit.com
Kaynes Technology	Mysore	South	http://www.kaynestechnology.com
Terra Electrosoft.	Mumbai	South	http://terraelectrosoft.com
Vital Electronics & Manufacturing Co	Mumbai	South	http://vitalelectronics.org
Frontline Electronics Ltd.	Pune	South	http://www.frontlineelectronics.com/
Consolidated Dynamics Pvt Ltd	Thane	South	http://www.consolidateddynamics.com

Industrial / Automotive / Others -3

Source: Plan B Survey

Product plus EMS Provider	City	Region	Website
Punjab Communications Ltd	Chandigarh	North	-
CEDA	Delhi	North	-
Estovir Controls	Gurgaon	North	-
Grantex	New Delhi	North	-
Automated Circuit and Systems	New Delhi	North	-
Rinky Electronics	New Delhi	North	-
Elcomponics Sales Pvt. Ltd.	Noida	North	http://www.elcomponics.com
Goldwyn Ltd.	Noida	North	-
Uniword Telecom Ltd	Noida	North	http://www.uniwordtelecom.com
Avanti Components	Bangalore	South	-
CCube Systems	Bangalore	South	-
Essen Electronics	Bangalore	South	http://www.essendeinki.com
Leo Circuit Boards Pvt. Ltd.	Mumbai	West	http://www.leoelectronics.com
Lipi Data Systems Ltd	Mumbai	West	http://www.lipidata.com
Ratnaparkhi Electronics Industries	Nasik	West	-
Thuse Elektronics Pvt. Ltd.	Pune	West	http://business.vsnl.com/thuseelectronics/

A quick look at Chip Assembly and Analog Chips

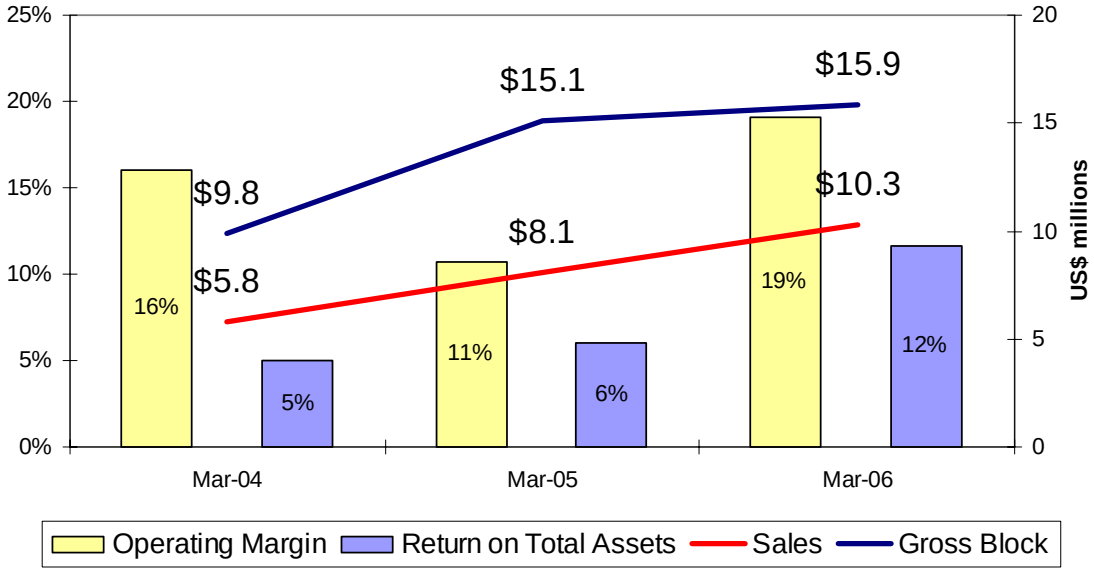
India's largest chip packaging company is doing well

100% EOU near Chennai

Promoted by SPIC (Southern Petrochemicals Industries Corporation Ltd)

Claims to have some big name customers such as Alliance, Vishay and Fairchild

At $10m sales the company is valued at $18m on BSE



Source: Company Report

Business Standard

Spel to invest $250 mn
12 September 2006

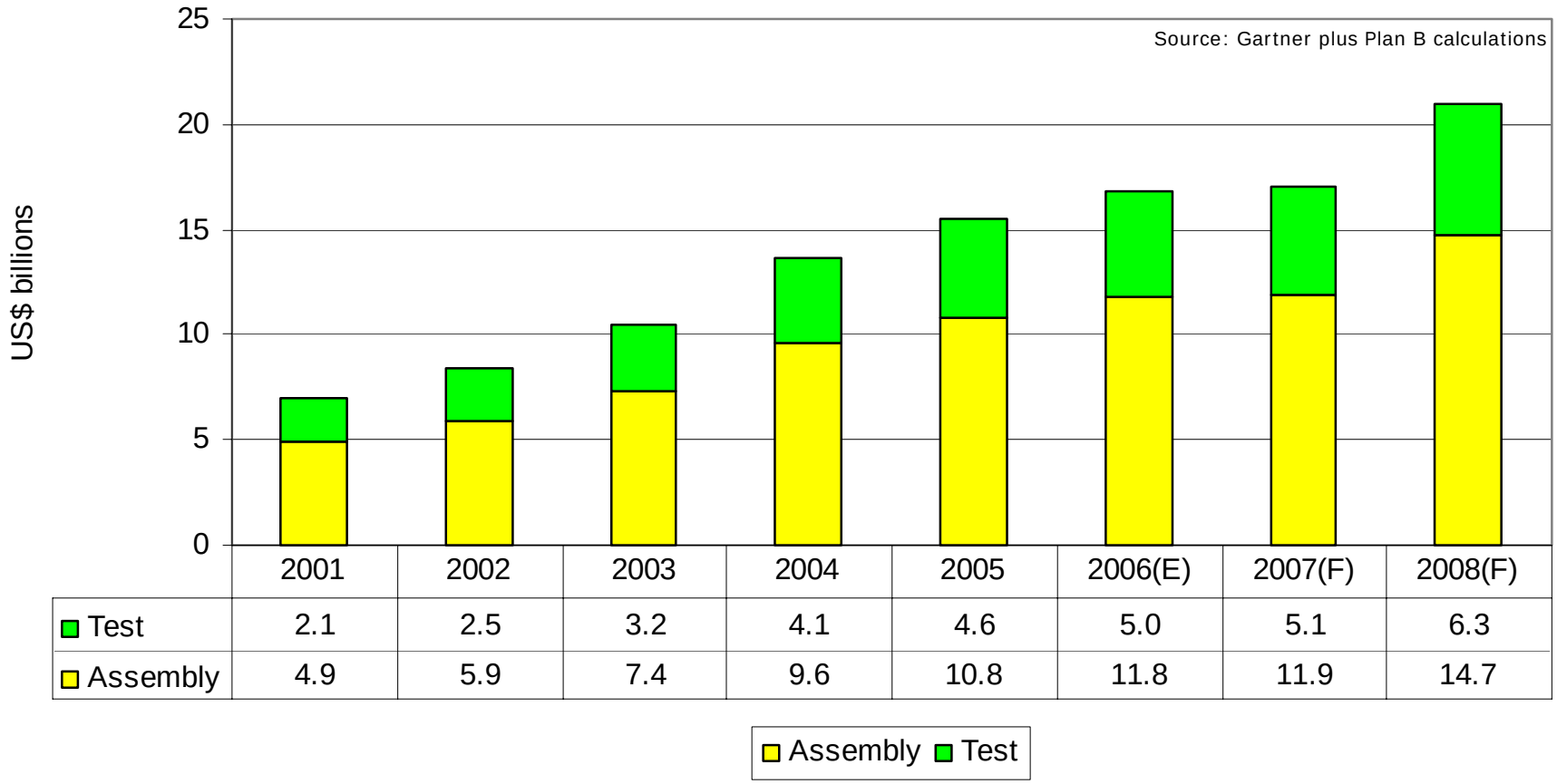
Spel Semiconductor, integrated chip (IC) assembly and testing company, has chalked out an investment budget of $250 million (about Rs 1,150 crore), spread over five years to increase its advance packaging capabilities, its existing capacities and to fund acquisition from 2-3 years from now.

The company's new leadless molded package (LMP) facility at its plant in Maraimalai Nagar, near Chennai was unveiled yesterday by the union finance minister P Chidambaram. The company had invested $5 million in this new facility.

Of the $250-million investment, most of the part would be raised through debt, convertibles and and preference capital. It is also planning overseas listing after 2-3 years.

Global demand for Chip Packaging and Test Services will continue to rise

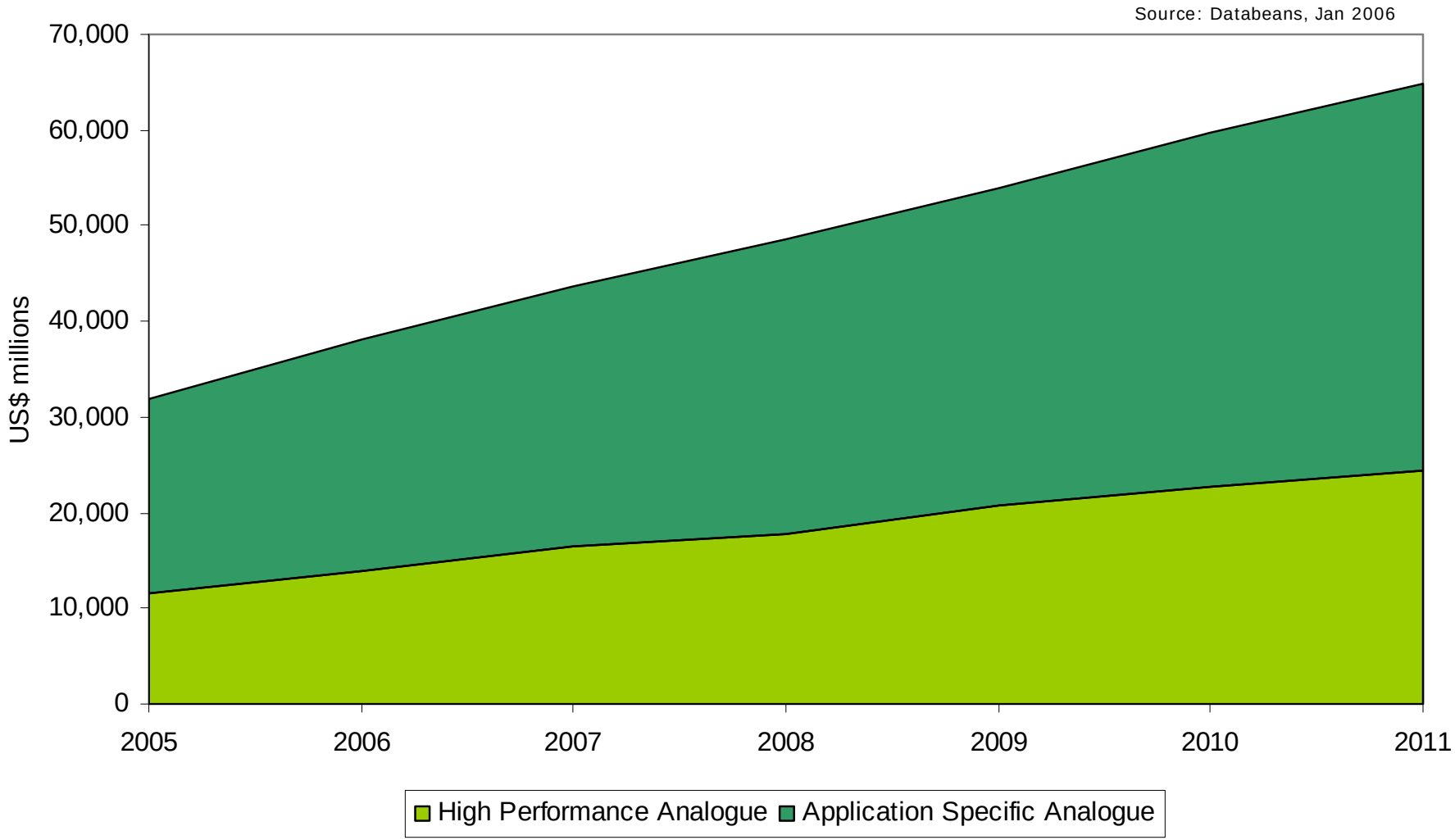
Gartner estiimates that only around 40% of the total demand for this service has been outsourced which puts the total global market in 2005 at $37 billion.



	2001	2002	2003	2004	2005	2006(E)	2007(F)	2008(F)
Test	2.1	2.5	3.2	4.1	4.6	5.0	5.1	6.3
Assembly	4.9	5.9	7.4	9.6	10.8	11.8	11.9	14.7

MORE ON THIS IN A LATER REPORT

Analog chip demand is to double to $64 billion in the next five years



Speculative Scenarios in Analog Chips

The key to succeeding in Analog is access to Analog Design engineers who are said to be in short supply all over the world.

There are more job opportunities in Digital chip design. Whereas digital design can be standardised to such an extent that a team of designers can work together even when thousands of miles apart, Analog design cannot be so easily standardised and a single individual will have to take on the responsibility for working through all the inter-relationships within the design. Thus it may take several years for a newly trained engineer to fully mature as a designer.

The Indian Semiconductor Association estimates that there are only around 400 Analog designers in India with more than three years experience compared to 10,000 Digital design engineers.

This is a road-block AND an opportunity since acquiring these skilled engineers through recruitment and in-house training can create guaranteed revenue opportunities in a fast growing market. We estimate that each designer can add an estimated $1m to $2m of high margin revenue.

One possible scenario: Sponsor a training program or a Masters degree in IIT Madras which is known for its Analog prowess, recruit and groom several engineers over a few years, letting them cut their teeth in a specially set up design company run by experienced designers poached from the top Analog companies. The design company should be profitable in its own right or at least be able to cover the cost of the engineers. In a couple of years, make an acquisition of a Analog chip supplier / manufacturer specially selected for the skills constraint they are facing.

China's IC Production by Local Foundries in 2005 (US$ bn)

Product segment	Market size	Locally produced
Analog devices	7.68	1.72
ASICs	1.16	0.41
ASSPs	6.6	0
Logic devices	2.37	0.73
Memory	10.44	0
Computational microprocessors	6.67	0
Embedded microprocessors	1.94	0
DSP	1.11	0
Microcontrollers	3.64	0.38
Microperipherals	5.33	0
IC cards	0.43	0.32
Total	**47.37**	**3.93**

Chinese foundries produced more Analog than Digital chips in 2005.

Analog chips tend to require older process technology and low-cost second hand equipment is available. This makes the analog market more attractive for the Chinese.

Could an Indian company follow this route and become one of the first Analog foundries in India?

MORE ON THIS IN A LATER REPORT

Appendix

Typical Equipment List for a small EMS company

I. COMPONENT PREPARATION
3 – GPD CF-8 Radial Prep
3 – GPD CF-9 Radial Prep
3 – GPD CF-10 Radial Prep
Hepco DIP Lead Former
Hepco Radial Lead Former
Axial/Radial/SMD Component Counters
4 – A.P.S. Radial Lead Cutters
2 – Technical Devices Mark V Axial Formers
ATC-210 Taped Radial Cutter/Former
Hepco 8000-1 Axial Former
Data I/O Universal Programmer
2 – Q-Corp. Component Taper for SMT Devices
Amistar Automated Labeling Machine

II. SMT EQUIPMENT
11 – Auto. Vision Screen Printers
2 – Cyberoptics LSM3 Paste Measurement Systems
9 – Universal High Speed Chip Shooters
2 – Universal Genesis HSC Chip Shooters
1 – Universal Genesis FJ/FJ Pick n' Place
6 – IRSI Automated Optical Inspection Systems
10 – Universal GSM-1 Fine Pitch Pick n' Place
10 – Electrovert Convection Reflow Ovens
1 – Conceptronics Convection Oven
2 – Glenbrook Jewel Box 90C X-Ray for BGAs
2 – ERSA Scopes/BGA Inspection
1 Agilent 5DX 3-D X-Ray Series II
6 – Yestech AOI Systems

III. AUTOMATIC THRU-HOLE ASSY
1 – Universal Instruments 6284 VCDs with Rotary Table and BEC
2 – Universal Instruments Sequence Inserter 100 Stations
2 – Universal Instruments Dip Inserters
1 – Universal Instruments 40 Station, Radial 8XT Lead Inserter
Automated Label Applicator

IV. SOLDERING/CLEANING
4 – ERSA-VERSA Flow Automated Selective Solder System
1– Technical Devices 18" Dual Waves with Finger Conveyor
6 – Electrovert Dual Wave Solder Machines
6 – Trek Triton SMT Wash
2 – Q-Corp. Q2G Mass Lead Trimmer
Q-Corp. P.C. Brush
3 – Baking Ovens
1 Reverse Osmosis System

V. HAND SOLDERING EQUIP.
Utilize Single and Dual Station Metcal Power Units throughout the Manufacturing Line
4 – Air Vac Soldering/Desoldering Stations
2 – BGA-3000 Rework Station
Pace Micro-Bench Top Desoldering Station
Conceptronic Model Pulse-R2 SMT Rework Station

VI. LOADED BOARD TEST
4 – Genrad TS-128
12 – HP3070 In-Circuit Test Systems
4 – Innovate 9100 In-Circuit Test Systems
2 – Teradyne Z1880 In-Circuit Test Systems
1 – Teradyne Z1890 In-Circuit Test System
2 – HP5315B Universal Counter
BK1823 Universal Counter
HP53131A Universal Counter
3 – Tektronix 2235 2-ch 100 MHz Scopes
Tektronix 475 2-ch Scope
4 – Tektronix 2445 2-ch 150 MHz Scopes
Tektronix 465B 2-ch Scope
2 – Tektronix TDS784D 4-ch Scope
2 – Tektronix TDS 380 Scopes
6 – Tektronix TDS3012 100MHz Scope
Tektronix CFG253 Function Generator
HP1631D Logic Analyzer
5 – Fluke 45 Bench Multimeters
2 Huntron Tracker 1000 Shorts Tracker
Corelis Boundary Scan Test Station

VI. LOADED BOARD TEST (contd)
2 – Asset-Boundary Scan Test Stations
2 – Tektronik TD53032 2-Ch 300 MHz Scope
2 – Polar ToneOhm 950 Multilayer Shorts Locators
2 – Agilent 34401A 6-1/2 Digit Multimeters
2 – Agilent E3634A Power Supplies
8 – TDS 1012 60 MHz Scopes
ONTAP Boundary Scan Test Station

VII. BURN-IN CHAMBERS
Tenney Model TTRC
Blue M Model DC-1406F-H.P.
Blue M Model C-4717-Q
Tenney T64C-15
Tenney T5-20S
Thermotron F-62
Thermotron F-84
Cincinatti Sub Sero SP-32

VIII. CONFORMAL COATING
Nordson "Select Coat" In-Line System with In-Line Cure
Manual Touch-Up/Inspection Booths

IX. MANAGEMENT INFORMATION SYSTEM
Fourth Shift MSS Release 7.4
Demand Stream Rel. 1.2

X. PROCESS CONTROL
3 – Omega Meter 600
Microscopes/Halo
Digital Thermal Instrumentation
ECD SuperMole