Future Potential of Materials Technology in Thailand

Final Report

FUTURE POTENTIAL OF MATERIALS TECHNOLOGY IN THAILAND

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EXECUTIVE SUMMARY

In May, 1992, the Science and Technology Development Program of the Thailand Development Research Institute Foundation (TDRI) was commissioned by the National Academy of Sciences (NAS) to conduct a study analyzing research projects which had been supported by the Science and Technology Development Board (STDB) and the National Metal and Materials Technology Center (MTEC), in the specific area of materials technology. The study focuses on two aspects: case studies of individual research projects in materials technology, and the future directions which can or ought to be taken by materials technology in Thailand. This report is the outcome of the study regarding future potentials.

This project assesses the future potentials of Thailand regarding materials in the next five to ten years, dividing materials into the three broad classifications of metals, ceramics, and polymers. The current status of materials technology both in Thailand and worldwide is reviewed. The results of the case studies analysis are used to form the basis for lessons which can be learned regarding technological development in Thailand. The results of both the case study analysis and a consideration of world trends leads to recommendations for technological and industrial goals in materials technology, and strategies and recommended actions to meet those goals.

The case studies and the analysis of worldwide and local trends highlighted the fact that Thailand is fortunate to contain a large number of raw materials and natural resources, in all areas of materials, and notably in metals (ferrous and non-ferrous), ceramics, and petroleum products. However, these materials are often used only as raw materials for export or as commodity items, and their value added is not high as a consequence. For example, even though all the raw materials for traditional ceramics are located in Thailand, imported clay of high quality for bone china and porcelain production is required. In the case of rubber, a major resource of the country, 95% of the rubber produced is exported either in raw form or with little technological input. Most of the steel consumed domestically is imported. Thus, Thailand loses a significant financial opportunity to capitalize on its natural resources.

The major cause of this situation has been a lack of capability in producing higher quality and higher technology materials and products. This in turn is traced to a lack of sufficient technological infrastructure, including R&D capability, information services, technical services, linkages between the public and private sectors, and government policies. An overriding theme is that the single most crucial component necessary for Thailand at this time to achieve more of its potential in materials technology is to upgrade the quality and quantity of its technical manpower, at all levels.

If the problems associated with technological infrastructure and manpower can be addressed, there is a general consensus among all the researchers and participants in the study that the next five to ten years should see significant advances in materials technology. The steel industry will move to more integration and more state-of-the-art technology, producing 4.3 million tonnes of flat products and 3 million tonnes of long products within 5 years, and Thailand will become an exporter of machinery and tools. Non-ferrous industries such as zinc and copper will be fully established. Supporting industries in metal finishing and metal working and the export of metal products will be more advanced. The quality of ceramic raw materials will be improved to world class standards, allowing new markets to open up or expand in the developed countries. Ceramic products will move beyond traditional ceramics to more advanced applications, and within ten years Thailand should be producing catalytic converters, ceramic fibers, and ceramic composites. The polymer and rubber industries will likewise move beyond raw materials and low level products to higher technology products, such as engineering plastics, reducing the imbalances between import and export which currently exist. In many areas of materials production, for example traditional ceramics and automobile tyres, Thailand has the potential to become a world leader or a regional leader.

The recommendations for the future include a discussion of crucial measures to be addressed, general actions necessary by the public and private sectors, and as well as specific actions which ought to be addressed by NSTDA. Among those measures deemed most important are:

- the encouraging and supporting of professional societies which are the mechanism to study, coordinate and formulate the plan for the development and promotion of materials industry and technology;

- the restructuring of the tax system to encourage investment in RD&E in terms of import tax reduction for testing and measuring equipment and to attract equipment manufacturers to establish their regional operation headquarters in Thailand:

- the creation and upgrading of training institutions for technical personnel at all levels especially technicians;

- the increase of efficiency and level of support in the funding process for RD&E projects, including a loan program to facilitate the development of the materials industry; and

- the establishment of an information network to coordinate and process information from various sources to allow researchers and concerned individuals access to information on a timely basis.

The role of NSTDA in meeting the materials needs of the country is major. It, along with the NESDB, needs to set long-term policies which will promote the materials industry. It can help to develop the Industrial Parks necessary for a technological society. It can be the moving force behind upgrading information services and supporting professional societies. It can help to provide research opportunities with a minimum of red tape and a maximum level of support, and the support of full-time researchers who do not have to dilute their activities by teaching or administrative duties is proposed. One way to do this is by the establishment of a National Laboratory. Finally, NSTDA can and should devote a significant amount of its resources to the development of human resources at all levels within the country.

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ACRONYMS

ABS	Acrylonitrile-butadiene styrene
ABT	Acrylonitrile-butadiene terephthalate
AHP	Analytical Hierarchy Process
A-I-C	Appreciation, Influence and Control
Al-Li	Aluminum Lithium
AMPP	Advanced Materials and Processing Program
BB	Bureau of the Budget
BR	Butadiene rubber
BIR	Business Information and Research Co., Ltd.
BIS	British Industrial Standards
BOI	Board of Investment
CAD	Computer-aided design
CAE	Computer-aided engineering
CAM	Computer-aided manufacturing
CAT	Communications Authority of Thailand
DIN	German Industrial Standards
DIP	Department of Industrial Promotion
DMR	Department of Mineral Resources
DOH	Department of Highway
DTEC	Department of Technical and Economic Cooperation
EGAT	Electricity Generating Authority of Thailand
EIT	Engineering Institute of Thailand
EPC	Ethylene Propylene Copolymer
ETA	Expressway and Rapid Transit Authority of Thailand
FTI	Federation of Thai Industries
GDP	Gross Domestic Products
GNP	Gross National Products
HDPE	High Density Polyethylene
IEAT	Industrial Estate Authority of Thailand
IFCT	Industrial Finance Cooperation of Thailand
ISO	International Organization for Standardization
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standards
JODC	Japan Organization for Development Cooperation
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
MEA	Metropolitan Electricity Authority
MIDI	Metal-working and Machinery Industries Development Institute
MOAC	Ministry of Agriculture and Cooperatives
MOC	Ministry of Commerce
MOD	Ministry of Defence

ACRONYMS

MOE	Ministry of Education
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOI	Ministry of Industry
MOIT	Ministry of Interior
MOPH	Ministry of Public Health
MOSTE	Ministry of Science, Technology and Environment
MOTC	Ministry of Transportation and Communications
MTEC	National Metal and Materials Technology Center
MUA	Ministry of University Affairs
MWA	Metropolitan Waterworks Authority
NCGEB	National Center for Genetic Engineering and Biotechnology
NEA	National Energy Administration
NECTEC	National Electronics and Computer Technology Center
NESDB	National Economic and Social Development Board
NGOs	Non-government Organizations
NIST	National Instutute of Standards and Testing, U.S.A.
NRCT	National Research Council of Thailand
NSO	National Statistical Office
NSTDA	National Science and Technology Development Agency
ODII	Organizing for Development: an International Institute
PA	Polyamide
PAA	Polyacrylamide
PAI	Polyamide Imide
PAN	Polyacrylonitrile
PAR	Polyarylate
PAS	Polyaryl Sulphone
PAT	Port Authority of Thailand
PBT	Polybutylene Terephthalate
PC	Polycarbonate
PE	Polyethylene
PEA	Provincial Electricity Authority
PEEK	Polyethertherketone
PEI	Polyetherimide
PEK	Polyetherketone
PES	Polyether Sulphone
PET	Polyethylene Terephthalate
PI	Pohyimide

ACRONYMS

POM	Polyacetal
PP	Polypropylene
PPO	Polyphenylene Oxide
PPS	Polyphenylene Sulphide
PS	Polystyrene
PSF, PSu	Polysulphone
PU	Polyurethane
PV	Polyvinyl
PVC	Polyvinyl Chloride
PVDF	Polyvinyl Difluoride
PWA	Provincial Waterworks Authority
R&D	Research and Development
RD&E	Research, Development and Engineering
RIM	Reaction Injection Molding
S&T	Science and Technology
SBR	Styrene-butadiene rubber
SMEs	Small and Medium Enterprises
STDB	Science and Technology Development Board
TDIF	Thai Die Industry Forum
TDRI	Thailand Development Research Institute
TIAC	Technical Information Access Center
TISI	Thai Industrial Standards Institute
TISTR	Thailand Institute of Scientific and Technological Research
TMPDC	Thailand Management and Productivity Development Center
TOT	Telephone Organization of Thailand
TP	Thermoplastics
TPA	Technological Promotion Association (Thai-Japan)
TS	Thermosets
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development

CHAPTER 1 OBJECTIVES, SCOPE AND METHODOLOGY

1.1 RATIONALE AND OBJECTIVES OF THE STUDY

1.1.1 Rationale

The Science and Technology Development Board (STDB) was established with the assistance of the USAID Science and Technology Development Project as a project under the Thailand Institute of Scientific and Technological Research (TISTR) of the Ministry of Science, Technology and Environment (MOSTE)* in 1985.

In the initial conceptualization of STDB, the goal was to strive for self-reliance in science and technology for Thailand by way of enhancing the extent and effectiveness of S&T applications in support of Thailand's social and economic development. The STDB Project had as its mission to help strengthen university and government research institutes' capacities and competency in science and technology, to provide technical support to industry, and to develop strong linkages between industry and university/government research laboratories.

In line with the government policy to develop in particular three priority technology areas, STDB was to focus its effort to solve specific problems in biotechnology, materials technology, and electronics, consistent with the government's goal and objectives in Science and Technology as stated in the Sixth Five-year National Economic and Social Development Plan (1987-1991). The STDB Project was primarily designed with the following four main elements of activities:

1. strengthening the existing institutional framework,
2. review of S&T policy,
3. research, development and engineering (RD&E), and
4. industrial development support.

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* Formerly known as the Ministry of Science, Technology and Energy

According to the original STDB conceptualization plan, the seven-year cooperative initiative between the Governments of Thailand and the United States of America was planned to terminate in the latter half of 1992. The USAID, taking into account a recommendation by a mid-term evaluation team, has agreed to a further two-year extension of the Project Assistance Completion Date to September, 1994.

In addition to STDB, there are three other national centers established under the Office of the Permanent Secretary, MOSTE to function as specialized R&D agencies for each of the three priority technology areas in biotechnology, materials technology, and electronics. They are the National Center for Genetic Engineering and Biotechnology (NCGEB), the National Metal and Materials Technology Center (MTEC),[*] and the National Electronics and Computer Technology Center (NECTEC). In brief each national center acts as a funding and coordinating agency to facilitate collaboration among the government sector, universities, and private firms in developing Thailand's industrial technology and capacity in each of the three priority technology areas.

The STDB program and the three national centers have since evolved into important S&T resource institutions for the country. Their various activities provide numerous support and services, from identifying user needs and relevant S&T resources or supplies, to organizing or providing funding to address those needs. In view of its vital role for S&T development in the country, legislation of a Science and Technology Development Bill to establish a permanent institution was passed by the Parliament on 30 December, 1991. With the formal enactment of this bill, the National Science and Technology Development Agency (NSTDA) was born, and now operates freely as an independent institution. Under the Act, NSTDA will bring together under its umbrella the above four former institutions of: STDB, NCGEB, MTEC, and NECTEC.

Although an end-of-project final review of the STDB Project is forthcoming in 1994, the transformation of STDB into NSTDA, which brings under it the existing three national centers for the development of the three priority technology areas, is bound to have significant implications for the future S&T

[*] Formerly known as the National Center for Metal and Materials Technology (NCMMT)

development in the country, particularly in these three areas of technology. It is deemed necessary at this juncture to undertake a partial review of the operations so far, so as to provide policy inputs for the reorganization and the future plan of NSTDA (including of course the three national centers). This 8-week study is conceived as a component of the intended review.

1.1.2 Objectives of the Study

In view of the prominence of RD&E element of activities which takes up more than two-thirds of the financial resources of both STDB and NCMMT, this study aims to assess future potential of materials technology-related industries in Thailand, and to provide a framework and an action plan in relation to RD&E in metal and material technology to the National Science and Technology Development Agency (NSTDA) over the next five to ten years.

1.2 SCOPE OF THE STUDY

The scope of the study is as follows:

- To provide background information regarding the past and present status and the future trends of materials technology worldwide and in Thailand and past RD&E performance to a group of some 30 stakeholders.

- To seek further opinions and information from these stakeholders with a view to:

  (i) arrive at a collective opinion on the future potential of the materials technology and industry in Thailand, and
  (ii) set development goals and propose strategies to achieve the set goals.

- To draft a framework and a proposed action plan in relation to RD&E in materials technology taking into account findings of future potential of the industry and the "Case Studies of RD&E Performance in Materials technology" study.

1.3 METHODOLOGY

1. Status of materials technology in the world and in Thailand was compiled from relevant literature in terms of technological development trends, production, market and RD&E. This part of the report together with findings from interviews and lessons learned from RD&E case studies formed the background information for the stakeholders who acted as resource persons in two separate workshops.

2. The future potential of materials technology largely depend on the outcome of a two-day workshop of about 30 stakeholders comprising industrialists, NSTDA officials, researchers and policy makers. These are the people deeply involved in the present activities of the said technology and are likely to assume influential roles in any future development. Some consensus on the goals comprising production, market and RD&E was derived using a modified A-I-C (Appreciation, Influence and Control) technique as well as the strategies to achieve them.

3. This group of stakeholders was again involved in a follow up workshop to draft an action plan to achieve the set goals for the realization of future potential identified.

1.4 A-I-C TECHNIQUES

The A-I-C process is a consensus building method developed and introduced by the Organizing for Development: an International Institute (ODII)[*] to help identify all the forces or factors that affect achievement of purpose. The process evolved from a dissatisfaction with traditional models of policy planning processes which do not take into account what, in practice, appear to be the most important variables affecting performance-differences in personalities, politics, and culture. The A-I-C process, therefore, ensures that individuals who have a stake in achieving the purpose have an opportunity to

[*] Organizing for Development: an International Institute (ODII) is a non-profit organization, established in 1988 to promote and implement systematic approaches to organizing development projects.

influence decision-making. It also ensures that stakeholders become committed to an agreed course of action and take responsibility for their role in achieving the desired results.

The A-I-C concept has its origins in the work of Kurt Lewin and his student Eric Trist. The conceptual additions to Lewin and Trist's work were contributed by Dr. William E. Smith - a consultant to the World Bank in the late 70's and 80's. Dr. Smith's work contributed the key notion that project, program and policy planning processes must include the design of environmental relations. Perhaps even more significant was the discovery that environmental relationships are actually power relationships. An understanding of power relationship gave a very simple way to translate "field" concepts into practice.

The environment is in effect a power "field". In the center of the power field is an actor (or a stakeholder) with a purpose. (It is the purpose that is actually the source of power). Within the boundaries of the "self" (e.g. the internal environment of an individual, group or organization) the power is characterized by relations of control. Beyond the field bounded by the actor's control lies an area of relations to others, characterized by influence power (e.g. the transactional environment, consisting of others who provide the actor with inputs and receive his/her outputs). The outermost boundary, beyond the influence of the central actor, consists of relationships of appreciation (e.g. the contextual environment which consists of all those factors that affect the actor's purpose but over which he/she has no control or influence).

Lewin's concept of a field of forces, or power field as translated by Smith, is particularly relevant to planning policy formulation. A policy is generally initiated because of dissatisfaction with the current state of affairs expressed by various constituencies. This dissatisfaction derives from mismatches between what the constituents believe should be and what actually is. The process of becoming aware of and sorting out such mismatched signals, and relating them to "the whole" field of competing forces of differing societal norms and values is key to policy formulation.

The need to find ways to address such a generalized field of forces gave rise to a new research approach, namely action research - actors and researchers coming together to makes sense of the field of forces operating on them. These cannot be treated as "points" (individual issues, actors or units) that one can deal with singly. They provide a field of forces that have to be worked with as a whole.

However, the most important practical implication of use of the "field" concept is the recognition that one can create power fields. More particularly, one can learn how to evoke specific parts of the field - appreciation, influence or control. Thus, in designing a policy process, we can create the kind of power field that most facilitates the level of work to be carried out. One works to set up an appropriate field, rather than managing the specific "points" people, organizations, etc. within the field.

The A-I-C process, however, encourages every single stakeholder or participant (including researchers) to become the center of a power field built around their purpose (or interest) in the situation. Every actor is then "interactively" involved in the situation. Objectivity in the traditional sense is not possible. Each participant has personal responsibility for his/her relationship in the situation:

- to the self (control)
- to others (influence) and
- to the whole (appreciation)[*]

The A-I-C process employed in this research project is used as a tool to help the stakeholders and researchers understand and identify the future potential of three fields: electronics, materials, biotechnology in Thailand. The approach attempts to ensure that the power of all the stakeholders involved in or affected by the particular future program is harnessed to achieve the desired goals and that social, cultural, and other tacit variables

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[*] Details of the concepts and process are in the Organizing for Development: an International Institute (ODII), The A-I-C approach, Unpublished paper, presented at the Workshop on Leadership for Development, Bangkok, February, 1991.

that have an effect on implementation are dealt with to the extent that our current knowledge allows.

To ensure the best outcomes from these workshop, participants include NSTDA administrators, scientists, researchers, industrialists, and policy makers (from the Office of the National Economic and Social Development Board, the Bureau of Budget, Ministry of Science, Technology and Environment, Ministry of Industry, and the Office of the Board of Investment.

A series of A-I-C workshops serve the following purposes:

- to create a forum for stakeholders who are experts in each of the fields concerned to share information and experience as well as to project the future potential of the field under discussion in the next five, then ten years,

- to provide a forum for researchers to gather information which will be used to formulate recommendations to achieve optimal development of the fields concerned.

Two workshops were arranged for each of these three fields: the first was a two-day workshop in Pattaya which covered the appreciation and influence phase of the A-I-C approach. The second was one-day workshop in Bangkok in which the control phase was explained.

The methodology applied in the project's workshop is derived from experience from various workshops using the A-I-C concept and other consensus workshops.

The two workshops took participants systematically through three phases of organizing:

- an appreciative phase (A) in which an individual participant creates with others his/her own understanding of the whole situation, the realities and possibilities for improved RD&E of the biotechnology, materials, and electronics fields in Thailand.

- an influence phase (I) in which participants identify strategies, factors, people, and organizations that can influence progress in the kind of future programs that he/she envisages.

- a control phase (C) in which participants produce the plans of action he/she envisages to implement the proposed ideas for developing the potential of the three fields.

During the workshop, there are several exercises in which participants work alone, in small group or teams and as a plenary (whole group). Each of these modes is important. Individual work allows participants to focus on the issues at hand and also ensures his/her contribution is communicated to others. Small groups provide an opportunity for participants to test their ideas on others and, at the same time, to learn from others. The plenary presentation gives each participant an opportunity to see how he/she and the group relate to the whole group of participants. Through sharing and discussing experiences, debating ideas, and assisting the groups in formulating an ideal future for Thailand's technological development in the next five, then ten years, it is expected that the final recommendations will contain representing opinions from the cross-section of experts in each field.

Time is also given for participants to choose their own topics or activities and join with others those of similar interests.

To directly benefit from the strengths of the participants the methodology involves participants very actively in every phase of the process. Participants are encouraged to use visual art, acting and role-playing, debate and discussion, as well as traditional forms of discussion and planning.

CHAPTER 2 CURRENT STATUS OF MATERIALS TECHNOLOGY

The technological and developmental level of any society is intimately related to the level of development of the materials employed by that society. Historians and archaeologists have labelled various periods of human development by their outstanding materials applications, as in "stone age", "bronze age", etc. This generalization is even more applicable today. Modern society is currently the beneficiary of a myriad of advanced materials, and by observing recent trends in materials technology we have considerable reason to expect that new developments will continue at an ever increasing pace.

There are many possible ways of categorizing the status and trends in materials technology. For the purposes of this study, which encompasses both research and development aspects as well as commercial considerations, we should bear in mind two overall generalizations which can be made about technological development. These are, firstly, that considerable worldwide effort is underway to discover or create new materials, and secondly, that another considerable effort is underway to improve existing materials and the processes which produce them. Thus, even though metals have been known to man for thousands of years, improvements in metal technology and the creation of new alloys is a very important commercial undertaking today. At the same time, plastics are a major class of materials which have only been in existence for a few decades, and whose full potential is largely still unrealized. Therefore, when we examine technological developments and commercial trends, we may be referring to previously unknown types of materials, or we may be referring to new and improved ways of making a material which already has a long history, or some combination of the two.

In this study we concentrate on three broad general classes of materials, namely, metals and alloys, ceramics and glasses, and the organic materials encompassing plastics and elastomers. Within these three broad categories can be placed an incredible range of materials with diverse properties, structures, and applications. Metals and their alloys are usually defined as materials which are inorganic, have a high electrical conductivity, a conductivity which decreases with increasing temperature, a shiny or lustrous appearance, and the ability to be plastically deformed to some extent. Ceramics are frequently defined as inorganic, nonmetallic materials which are usually rendered serviceable through high temperature processing. The broad classification of organic materials encompasses the major categories of plastics and rubber; plastics can be defined as materials which contain a polymerized organic substance of large molecular weight, are solid in their final shape, and at some stage in their manufacture were shaped by flow, and rubber materials possess great flexibility, have a high elastic yield strain, and may be natural (usually from latex) or synthetic.

We consider in this section the current status of these three classes, describing both the overall worldwide situation as well as specific details pertinent to Thailand. We consider the status from the points of view of technological development trends, production, market opportunities, research, development, and engineering, and other considerations of the technological infrastructure.

2.1 TECHNOLOGICAL DEVELOPMENT TRENDS

2.1.1 Worldwide

a) Metals

Metals are a major part of our society, and even though we have witnessed major breakthroughs in the development of metal "substitutes", there are many applications which can only be served by metals. Owing to the enormous technological importance of iron and steel, it is reasonable for us to consider technological development trends in the two separate categories of ferrous and nonferrous metals.

For ferrous materials, many recent advances in both forming technology and alloy composition have helped the steel industry keep pace with ever increasing demands. Recently improved or engineered steels include high strength steels, high yield strength plate, coated plate, oxide dispersion strengthened steels, duplex steels, ultraclean steels, and clad steels. New laser finishing technologies being developed in Japan can produce mirror like surfaces on steel. The industry is also undergoing many developments relating to pollution reduction, increased energy efficiency as in the direct smelting process, and smaller scale specialty factories.

Nonferrous metals and alloys do not contain significant amounts of iron. One of the categories attracting increasing worldwide attention is that of rapidly cooled alloys which solidify in an amorphous structure. The amorphous structure permits these alloys to have excellent hardness, strength, and corrosion resistance. These alloys are primarily aluminum based, with additions of iron, chromium, manganese, and other elements. Another important technological class of metals is the shape retaining alloys, which can return to a predetermined shape after undergoing deformation. The aeronautics industry has led the way in the development of many new alloys with properties of light weight, high temperature serviceability, and other use specific properties. Among these developments are aluminum lithium alloys, some titanium materials, nickel based superalloys, and intermetallic composites.

Containing both ferrous and non ferrous materials is the classification of metals produced by powder metallurgy or powder compaction. This technology is being rapidly developed for the production of mechanical and magnetic components, such as electronic switches, vacuum tubes, cutting tools, and electric motors.[1]

b) Ceramics

The definition of ceramic previously given encompasses not only the traditional ceramics such as pottery, porcelain, refractories, structural clay products, cements, and abrasives, but also many more recently developed materials such as ceramics for electronics, magnetics, and medical applications. Glasses may also be considered a subset of ceramics, though as a general rule ceramics are crystalline whereas glasses are always, by definition, amorphous. Ceramics generally but not always contain oxide or silicate components.

Technological trends for ceramics include research and development on improvements in their properties, notably increasingly higher temperature resistance, greater pressure resistance, improved mechanical properties, corrosion protection, and novel electrical characteristics. New applications for ceramics include gas sensors, voltage regulators, electronic indicators, and substrates for hybrid or microwave integrated circuits. A major new application gaining increasing attention is that of ceramic, high temperature super conductors, which promise enormous returns in energy, computers, communications, and other applications.

Trends in the technology of traditional ceramics include increasing process efficiency, reducing environmental pollution, materials substitution to find cheaper or better components, and novel approaches to improving traditional properties such as color, glaze, formability, etc.

There is also extensive work underway in the development of cermets, or combinations of metals and ceramics, with a particular emphasis on high hardness properties. These materials include titanium carbide and nickel titanium carbide. A ceramic with similar properties is silicon carbide.[2]

c) Polymers

Plastics are valued for their excellent toughness, wear resistance, corrosion resistance, ease of fabrication, and virtually limitless color range. Plastics are often classified according to their use and level of technological sophistication. In this report we refer to "consumer plastics", which were the first products developed in the 1940s and 1950s. These materials are polyolefins, vinyls, and styrenes, and include (see list of abbreviations) PV, PS, PE, PP, and TS.

A second group of plastics contains the "engineering plastics", which began their development around 1965, and have a higher technological content and subsequently higher cost than consumer plastics. These materials include polyamides, polyacetals, polycarbonates, and polyesters. They are used in many applications in the form of structural parts, and include PA, PC, POM, PPO, PBT, PET, PC/ABS, and PC/ABT.

The highest level classification for plastics is referred to as "specialty plastics". These products were first introduced circa 1975 and are noted for high cost and very specific applications. They include PEEK, PES, PEI, PSU, PAA, and PAS.[1]

Some of the major technological trends underway now are in applications of polymeric materials. Some of the major fields utilizing polymers are electronics, instrumentation, aerospace, automobile construction, and biological applications. New conducting polymers are finding applications in antistatic environments and electromagnetic shielding. Photolithographic polymers are responsible for increasingly dense storage capacities on integrated circuits and memory chips. Pyroelectric and piezoelectric polymers are used in microphones, loudspeakers, burglar alarms, and fire detection systems. The use of polymers for membrane filters is also a rapidly growing area of development.[3,4]

In the area of new manufacturing trends, there are several major developments underway. One of these is RIM, reaction injection molding, where articles are molded directly from low molecular weight monomeric precursors at low temperatures and low pressures. Another growing technology is the use of radiation sources for both polymerization and after treatment of polymers.

2.1.2 Thailand

a) Metals

The metals industry in Thailand can be divided into 4 segments, namely:
1) extraction and refining
2) melting and casting
3) metal working and fabrication
4) metal finishing, including plating and coating

As the global prices for metal ores decrease, the economic importance of ores and refined ingots decreases. There is currently little emphasis on new developments in this area; rather, technological improvements in processing and troubleshooting are the main endeavors for the extraction and refining sector. For metal working and fabrication industries, the level of technology and the use of high precision machines has increased significantly in the past few years. This trend is the result of decreases in the cost of high precision machines and the higher standards of quality and precision demanded by the automotive and machinery parts industries. For metal finishing, the trends in steel galvanizing are for large scale semi-continuous to continuous processing, while electroplate operations tend to be small to medium size shops. All of the areas of the metals industry in Thailand suffer from some similar problems, namely lack of skilled or trained personnel, often little investment in technological improvements, and high turn over of technical employees.

b) Ceramics

There is considerable effort underway in Thailand to upgrade the traditional ceramics processing capability. At present, the country must rely on imported clays to produce the highest quality porcelains and bone china. Importation of European technology is underway to increase the level of processing.[5,6]

c) Polymers

The primary technological endeavor in Thailand at the present is to increase the production of polymers in the country, to reduce the extremely large deficit incurred in importing resin and plastic products. At the same time, the level of polymer production is shifting from low technology products to more advanced products.[7]

2.2 PRODUCTION

2.2.1 Worldwide

For all but a very few select materials (particularly certain metals and minerals which are found in only a few countries in the world), the worldwide production of materials is dominated by 3 regions: the United States, Europe, and Japan.

a) Metals

The worldwide production of steel in 1991 was estimated at roughly 713,000,000 tonnes. Of this, the breakdown by region shows:[8]

Europe	151,000,000	tonnes
Japan	110,000,000	tonnes
North America	92,000,000	tonnes
Rest of World	360,000,000	tonnes

Major other producers of steel include South Korea and the former Soviet Union.

For powder metallurgy, 1986 world production was estimated at 550,000 tonnes, of which 300,000 tonnes were used for mechanical components. The production of these components breaks down as follows:[1]

North America	160,000	tonnes
Europe	69,500	tonnes
Japan	35,000	tonnes
Rest of World	35,500	tonnes

b) Ceramics

For conventional ceramics, the worldwide volume of products produced for export in 1987, in terms of US million dollars, was:[19]

Bricks	8,105
Refractories	7,805
Tiles and Mosaics	2,747
Tableware	4,688
Sanitary Ware	453
Novelties	926

c. Polymers

Worldwide production of conventional plastics in 1987 amounted to approximately 79,000,000 tonnes, of which the major producers are:[1]

United States	22,000,000	tonnes
Europe	21,000,000	tonnes
Japan	7,000,000	tonnes
Rest of World	29,000,000	tonnes

By the year 2000 this figure is expected to increase to 95 to 100 million tonnes. In Europe the strong position of the chemical industries in Germany make it the leading producer of both polymers and ceramic materials.

2.2.2 Thailand

a) Metals

Most of the steel required for domestic use in Thailand is imported. In the country there are 8 steel mills equipped with furnaces which have a capacity of 800,000 tonnes per year. There are also approximately 40 rerolling steel mills with a capacity of 600,000 tonnes per year. There are over 450 foundries ranging in size from small scale to large operations, and which are primarily involved with sand and die casting. There are also currently about 30 forges in the country with a total capacity of 5,000 to 6,000 tonnes per year. There are no flat products produced yet in Thailand, all have to be imported.[5]

Thailand's first hot rolled and cold rolled steel mill received government approval and financial incentives in late 1989. This project is by the Sahaviriya Group, and will be located in Prachuap Khiri Khan province south of Bangkok. The project will produce hot rolled steel sheet and electrogalvanized zinc coated steel by the end of 1993, and cold rolled steel sheet by the first quarter of 1994. The project is protected from competition for a period of 10 years.[10]

The main nonferrous metal produced in Thailand is zinc, with an annual production of 435,000 tonnes of ore and 63,000 tonnes of ingot. Phadaeng Industry Co., Ltd. mines zinc ore in the northern province of Tak and is the only smelter and exporter of zinc. Other nonferrous metals smelted in Thailand include tin, lead, antimony, and tantalum. The largest tin smelter, Thailand Smelting and Refining Co., Ltd., has a capacity for 20,000 tonnes per year. The importance of tin as an export item is decreasing; in 1980 33,445 tonnes were exported but by 1990 this figure had fallen to 12,717 tonnes. The first lead refinery in the country is The Thai Metal Co., Ltd., with an annual capacity of 12,000 tonnes.[5]

There are many industries in Thailand engaged in the production of finished goods which often rely on imported raw materials. For example, there are approximately 200 foundries, usually of small to medium size, which produce brass, bronze, zinc, and aluminum cast parts. There are more than 3,600 companies engaged in the metals fabrication industry, for both ferrous and non ferrous components. Some of the major categories of products produce include frames and scaffolding, wire, rod, springs, pressed parts, and stamped parts. The metal finishing industry is another part of the production chain, with approximately 70 factories providing heat treatment facilities and a number of small factories providing electroplating and other finishing services.

b) Ceramics

Thailand produces all the major raw materials for high quality ceramic production. Traditional ceramics, such as tiles, porcelain, and stoneware are produced by companies like Thai German Ceramic Co., Ltd., and Thai Ceramic Co., Ltd. The largest number of factories involved in ceramics in Thailand produce tableware. For some of the more expensive porcelains and bone china, imported clay as a raw material is required. The 1988 value of production of all ceramic products in Thailand was 10 billion baht; of this value, approximately 90% served the domestic market and 10% was for export. By 1991, the export value of traditional ceramics had risen to approximately 5 billion baht. In 1991, the total traditional ceramic production was 967,000 tonnes, and production of some traditional products breaks down as:[11]

Mosaics	85,000	tonnes
Tiles	582,000	tonnes
Sanitary Ware	110,000	tonnes
Table Ware	80,000	tonnes
Refractories	100,000	tonnes

Abrasives, structural ceramics, ceramic insulators, alumina substrates for integrated circuits, piezoelectric ceramics, ferrites, and other electrical application components are also produced, mainly for export. In 1991, the amount of ceramic insulators produced was 10,000 tonnes. The country produces almost 500,000 tonnes of glass products yearly, using local sand, limestone, feldspar, and dolomite. Cement production is approximately 8,000,000 tonnes (1988) with a large part of this supplied by Siam Cement Co., Ltd.[5]

c) Polymers

Thailand's plastics industry has been expanding impressively for the last 2 decades. There are now 6 major suppliers of plastic resin, supporting approximately 3,000 factories of various sizes which produce plastic products.

The National Petrochemical Complex - 1 has a yearly production capability of approximately:[5]

Low Density Polyethylene	78,000	tonnes
High & Medium Density Polyethylene	155,000	tonnes
Linear Low Density Polyethylene	84,000	tonnes
Polyvinyl Chloride	140,000	tonnes
PVC Resin	60,000	tonnes
Polypropylene	125,000	tonnes

The second National Petrochemical Complex is expected to come on line in 1993, and will provide intermediate substances for manufacturers involved in plastics as well as detergents, polyesters, and solvents.

Natural rubber is one of Thailand's main agricultural products, providing a net export value in rubber products of more than 22 billion baht in 1990. 95% of Thailand's rubber is exported either in raw form or with little technological input.[5]

The figure for materials production in Thailand are summarized in Table 2.1.

Table 2.1 Production of some Major Materials Technology-Based Products. (Thailand)

Metal Industry (Unit : Million Baht)	1980	1985	1986	1987	1988	1989	1990
Basic metal products	3,732	3,833	3,290	3,515	4,188	5,244	6,194
Fabricated products	4,002	6,458	6,891	8,067	9,630	12,160	13,931
Industrial machinery	3,751	5,789	6,448	7,769	10,103	15,306	18,613
Electrical machinery	3,460	6,136	9,398	10,937	14,699	15,747	18,936
Transport equipment	11,656	11,327	12,817	18,285	29,803	39,454	52,527
Plastic Industry (Unit : tons)	**1980**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Plastic resin :							
PVC	n.a.	72,707	104,395	132,415	138,070	91,950	15,000
PE	n.a.	56,760	77,084	136,681	148,436	92,030	192,500
PS	n.a.	21,968	34,400	40,983	43,258	42,880	43,500
Rubber Industry (Unit : Million Baht)	**1980**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Rubber and rubber products	2,783	3,678	3,919	5,493	6,857	7,887	8,568
Ceramic Industry (Unit : tons)	**1982**	**1984**	**1986**	**1987**	**1988**	**1989**	**1990**
Ceramic tiles	110,400	177,839	195,000	n.a.	279,772	477,957	486,043
Sanitaryware (pieces)	969,948	n.a.	n.a.	n.a.	3,033,229	3,090,786	4,679,828
Insulator	3,292	2,932	n.a.	n.a.	n.a.	n.a.	n.a.
Refactory	32,661	48,968	n.a.	n.a.	n.a.	n.a.	n.a.

Sources : NESDB, Customs Department and Department of Business Economic

2.3 MARKET

2.3.1 Worldwide

For many materials categories, there is a close relationship between the major producers of materials and the major markets. This is quite reasonable, as the existence of a local or domestic market is a powerful incentive for local production. Thus, as in the case of production, we see that the major world markets for many products are to be found in Europe, Japan, and the United States.

a) Metals

For ferrous metals, the market share held by the rest of the world, outside of Europe, Japan, and the United States, is in fact quite significant. For high yield strength plate, the world market is estimated at 40,000,000 tones by 1995, with 48% of this demand from other countries. For coated plate, the estimated market in 1995 is:[1]

Europe	8,600,000	tonnes
United States	8,500,000	tonnes
Japan	8,000,000	tonnes
Rest of World	10,000,000	tonnes

In this case, the rest of world will equal roughly 29% of the total market.

The apparent consumption of finished steel in 1991 shows the following figures:[8]

European Community	106,000,000	tonnes
Japan	87,000,000	tonnes
United States	80,000,000	tonnes
Other Western World	124,000,000	tonnes

For nonferrous metals, the worldwide market for rapidly cooled (primarily aluminum) alloys is estimated at several thousand tonnes in 1990, with the primary demand being from the United States. The worldwide titanium market in 1995 is expected to break down roughly as:

United States	25,000	tonnes
Europe	11,000	tonnes
Japan	5,000	tonnes

with small amounts for the rest of the world. The world market for aluminum lithium alloys, primarily for aeronautic applications, in 1995 will be roughly 20,000 tonnes, with more than half of the demand from the United States. For nickel based superalloys, the major markets are again the United States, Europe, and Japan.

b) Ceramics

The situation for advanced ceramics indicates the main markets to be Japan, Europe, and the United States. Owing to the dominance of Japan and the United States in electronics, the demand for advanced ceramics in electronic applications is dominated by Japan and the US, while the dominant use of advanced ceramics in Europe is for mechanical components. In 1986, worldwide sales of advanced ceramics were approximately 5,400 tonnes, with the following breakdown:[1]

Japan	48%
United States	37%
Europe	12%
Rest of World	3%

The breakdown in worldwide demand for advanced ceramics is estimated in 1995 to be:

Electronics	21,375	tonnes
Cutting Tools	1,625	tonnes
Heat Engines	675	tonnes
Others	825	tonnes

These figures clearly show the dominant role electronics plays in the demand for advanced ceramics. The worldwide market is expected by some optimistic estimations to reach US$ 30 billion by the end of this century.

For traditional ceramics, the worldwide market sales figures for 1990 were estimated to be, in US billion dollars:[9]

Refractories	490	(7%)
Whitewares	614	(8%)
Porcelain Enamel	740	(10%)
Glass	4,124	(56%)
Ceramics	1,359	(19%)
TOTAL	7,327	

c) Polymers

For plastics, Europe, Japan, and the United States account for approximately 89% of the global demand for engineering plastics, approximately 93% of the global demand for specialty plastics, but only about 70% of the worldwide demand for consumer plastics. For 1986, the worldwide consumption of the different classes of plastics was categorized as:[1]

Consumer Plastics	70.0	million tonnes
Engineering Plastics	1.5	million tonnes
Specialty Plastics	80.0	thousand tonnes

By 1995, the consumption of engineering plastics is expected to reach 3 million tonnes worldwide. For all plastics, the per capita consumption in 1985 for some areas breaks down as follows:

United States	89	kg/head
Western Europe	63	kg/head
Japan	58	kg/head
Latin America	7.5	kg/head
India	1.3	kg/head

The percentage increase in consumption in the industrialized nations generally follows the yearly percentage increase in the gross national product.

For rubber consumption, representative per capita consumption figures are:[12]

United States	16.80	kg/head
India	0.22	kg/head

In the United States, 88% of rubber consumed is synthetic in origin.

2.3.2 Thailand

a) Metals

In 1990, Thailand imported 70 billion baht of iron and steel materials, and 11 billion baht of articles made of iron and steel. The major categories of imports were uncoated plates, coils, iron and steel scrap, tinned sheet of hot and cold rolled steel, and galvanized sheets.[13] Also in 1990, Thailand used 1,400,000 tonnes of hot rolled steel, and the demand is expected to increase 5-6% annually.[10]

For the hot rolled and cold rolled steel complex under construction by Sahaviriya, it is estimated that the domestic market will use approximately 70% of the output, and the remainder will be exported to ASEAN countries, Japan, Taiwan, and Korea.[10]

For nonferrous materials and articles made with these materials, Thailand imported about 8 billion baht of aluminum and aluminum products. Much of the aluminum was as inwrought material, and approximately 75% of this was used domestically and approximately 25% was reexported in finished or semifinished goods. The value of other imports include:[13]

Copper and copper products	8	billion baht
Lead and lead products	420	million baht
Nickel and nickel products	320	million baht

The country exported more than 2 billion baht worth of tin and tin products, and more than 500 million baht of zinc and zinc articles. For zinc, 94% of the annual production of 63,000 tonnes is consumed domestically. Thailand consumed 34,000 tonnes of lead in 1989, 18,711 tonnes was produced locally and 15,316 tonnes was imported.[13]

b) Ceramics

The domestic market for all ceramic products in Thailand was estimated at 9 billion baht in 1988, and the export market accounted for about 1 billion baht. 30,000 tonnes of sanitary ware are produced annually, of which 20% is for local consumption and the remainder for export. Ceramic tiles account for 60% of Thailand's total ceramic export volume.[13]

For glass production, approximately 450,000 tonnes are consumed by the local market, and approximately 50,000 tonnes are exported. Major export markets are Singapore, Hong Kong, and Malaysia.[5]

c) Polymers

The domestic plastics market in Thailand is considerable. In 1990, more than 26 billion baht worth of plastics, including resin as well as finished products, were imported into Thailand, while the export value of plastics and plastics articles was roughly 8 billion baht.[13] The ambitious expansion of Petrochemical plants on the Eastern Seaboard is in direct response to the size of the domestic market as well as export potential.

The figures for materials exports and imports in Thailand are summarized in Tables 2.2 a,b, and c.

2.4 RESEARCH, DEVELOPMENT, AND ENGINEERING

2.4.1 Worldwide

The major developed countries devote significant resources to the development of new materials and new processes. Some of the major areas of

Table 2.2(a) Imports, Exports of Ceramic. (Thailand)

Value : Million Baht

Products	1988		1989		1990	
	Import	Export	Import	Export	Import	Export
Mineral Products	2,045.11	1,706.22	2,829.47	2,011.86	6,406.69	2,203.34
– Natural Sands of all kinds	3.88	1.07	8.89	0.43	12.42	3.85
– Kaolin and Other Kaolin Clays	106.65	4.04	153.55	2.64	165.34	5.27
– Gypsum; Anhydrite; Plasters	17.09	1,025.62	17.89	1,248.34	26.58	1,408.35
– Limestone Flux; Limestone and Other Calcareous Stone	0.07	7.82	0.11	7.28	0.11	3.14
– Portland Cement, Aluminous Cement	24.39	120.54	413.79	101.71	3,798.87	47.32
Ceramic Products	412.41	2,124.15	541.70	3,207.51	957.36	3,741.33
– Bricks and Refractories	276.54	55.36	404.36	59.96	768.96	55.40
– Building Ceramics (pipes, tiles, walls)	20.44	910.26	18.58	1,198.51	23.64	1,035.36
– Sanitary Ware	0.35	285.31	0.93	405.51	0.89	499.00
– Tableware	0.52	641.89	0.69	1,029.48	1.00	1,307.32
– Ornamental Ceramic	14.71	135.09	16.16	304.31	19.81	432.80

Source : Customs Department

Table 2.2(b) Imports, Exports of Polymers. (Thailand)

Value : Million Baht

Products	1988		1989		1990	
	Import	Export	Import	Export	Import	Export
Plastics and Plastics Products	17,209.43	5,465.36	20,495.12	7,604.67	25,844.72	9,114.34
– Plastics	11,784.35	887.89	12,845.24	1,429.27	15,597.44	1,695.00
– Plastics Products	5,395.65	4,567.76	7,632.99	6,164.10	10,232.40	7,399.70
Rubber and Rubber Products	2,545.38	31,823.75	3,499.46	31,952.87	5,020.67	30,160.17
– Natural Rubber	35.70	27,188.74	10.21	26,422.75	4.91	23,557.26
– Synthetic Rubber	924.68	144.34	1,168.81	21.10	1,639.24	17.96
– Rubber Products	1,585.00	4,490.67	2,320.44	5,509.02	3,376.52	6,584.95
Textile and Other Textile	26,018.30	66,036.60	34,597.20	82,696.90	39,412.20	94,001.70
– Fibers	9,950.70	512.30	13,008.90	1,829.80	15,274.60	2,033.90
– Yarns	4,805.30	4,391.80	6,179.30	4,058.50	5,470.80	5,435.60
– Fabrics	7,792.50	10,211.10	10,557.80	11,550.10	12,320.00	12,732.70
– Home Textile	104.30	1,487.60	104.30	1,912.00	186.20	2,477.40
– Clothing	58.80	45,203.60	92.90	58,723.40	182.00	66,620.40

Source : Customs Department

Table 2.2(c) Imports, Exports of Metal. (Thailand)

Value : Million Baht

Products	1988		1989		1990	
	Import	Export	Import	Export	Import	Export
Iron and Steel	48,492.04	867.15	62,409.55	967.36	73,390.20	780.94
Iron or Steel Products	7,618.12	4,816.10	9,863.81	5,335.37	12,284.78	5,393.04
Copper and Copper Products	4,749.45	224.59	8,116.80	403.80	8,732.99	637.48
Nickel and Nickel Products	231.86	16.80	381.50	12.58	324.38	2.06
Aluminium and Aluminium Products	6,141.81	1,097.15	8,064.16	2,531.36	8,667.68	3,126.43
Lead and Lead Products	327.50	6.28	420.01	2.73	445.55	2.12
Zinc and Zinc Products	149.05	390.76	181.34	706.40	295.98	434.01
Tin and Tin Products	9.71	2,408.44	6.04	2,643.00	15.20	2,010.69
Other Base Metals; Cermets; Products	94.05	1.96	100.24	1.77	109.47	45.50

Source : Customs Department

RD&E are composite materials, ceramic superconductors, processing of materials in space, ultrapure materials for the electronics industry, biomaterials including artificial implants and artificial organs, materials processing for nuclear fusion technology, electronic materials, and underwater mining. An important aspect of RD&E in the developed nations is the relative percentages of contributions to RD&E budgets by the public and private sectors. In Japan, the major share of RD&E is funded by private companies. In the US, the defense budget, other government agencies, and the private sector all contribute roughly equally to the country's total RD&E expenditure.

2.4.2 Thailand

Research and development in Thailand is heavily concentrated in the government sector, in laboratories in the universities and state institutions. The bulk of Thailand's R&D has been in agriculture, with secondary emphasis on energy, industry, social sciences, and education. The creation of MTEC could be seen as a coordinated or coherent attempt at significant RD&E for materials technology.

a) Metals

The major classifications of the metal industry in Thailand, namely extraction and refining, melting and casting, metal working and fabrication, and plating and coating, all suffer from insufficient activity in R&D and little transfer of technology. Slow industrial growth coupled with high rates of defective parts make it difficult for industry to support R&D funding. The research work being done by universities is seen as heavily weighed towards improving production processes rather than increasing fundamental knowledge of the underlying metallurgy, particularly in casting technology. In the metal finishing sector, common problems which would benefit from research and development are poor adhesion and unevenness of coatings. Also, the problems of environmental impact and waste water treatment (especially for heavy metals contamination) by the metals industry is largely ignored. This is particularly true for small to medium size industrial establishments, and also requires extensive engineering effort.

b) Ceramics

Ceramics likewise have suffered from problems of insufficient resources, and perhaps an overemphasis on process improvements rather than increasing fundamental or basic knowledge. However, given the economic importance of the ceramics industry in Thailand's development, it is not surprising that the most urgent requirements of RD&E are to support this industry.

For traditional ceramics, RD&E is called for that will improve raw materials, such as silica sand, china clay, potassium and sodium feldspar, limestone, etc. In addition, technologies need to be developed that use local raw materials, such as bone china and zircon pigments. The technological equipment and machine parts used in the ceramics industry also need to be developed and upgraded, as for example the hydrocyclone.

For new ceramics, there needs to be an effort to catch up with the progress in these materials. For example, there needs to be improvement in the chemical and physical processes to produce high purity starting materials, for example barium oxide, zirconium dioxide, silicon carbide, silicon nitride, etc. The applications of ceramics to new products away from the traditional uses needs to be addressed, for example using ceramics in capacitors, piezo-electric devices, hard and soft magnets, bioceramic applications, engineering ceramics, and ceramic composites.

c) Polymers

During the next ten years Thailand's polymer industry should advance from predominantly low technology products to medium to medium high technology products. Areas which should provide major emphasis for RD&E include the technologies of polymer blends and alloys, polymer composites, RIM (reaction Injection Molding), radiation processing, plasma technology, and polymer recycling. Improvements in natural polymers, such as latex and rubber, should also be given emphasis owing to the importance of these materials to the economy and their current relative low level of technology.[7]

2.5 OTHER TECHNOLOGICAL INFRASTRUCTURE

All of those systems which support, facilitate, or enable research, development, and engineering advances to occur can be labelled collectively as the "technological infrastructure". Infrastructure can be viewed as the basis or underpinnings upon which RD&E depends. Though often the components of infrastructure are not as obvious as the more usual workings of research and development, without a strong infrastructure as a foundation, very little in the way of solid or lasting RD&E achievement can be built. Among the most important aspects of technological infrastructure are manpower, suppliers, technical services including information services, financial institutions, laws and regulations, and government policy.

2.5.1 Worldwide

The importance of skilled personnel in materials technology, as in all areas of technology, is vital. Skilled personnel at all levels, from workers and technicians to advanced degree holders, is crucial if technical progress is desired. While the situations vary from country to country, all developed countries recognize to some extent the need for allocating significant resources to produce the trained manpower required for RD&E endeavors.

The situation in the developed countries for technical services is well established. For the maintenance of technical and materials standards, there are several worldwide recognized bodies that provide standards, such as JIS in Japan, DIN in Germany, BIS in Britain, NIST in the United States, etc. These standards are often adopted by other countries as their own. There are numerous public and private sector providers of technical and materials analysis; there are more than 1,000 private testing companies in the US alone. Databases and on line information searches are well established at both the national and international level. Other technical services such as contract R&D, consulting, private training institutions, and local sources of equipment and maintenance, are also to be found in all of the major industrialized countries.

Financial institutions are also generally well established to help in the advancement of technological and new materials technology endeavors. In particular, worldwide venture capitalists have provided major sources of funding for new start up endeavors attempting to develop or market new technologies.

One of the major driving forces for new materials technology is the increasing international awareness of safety, pollution, and environmental issues. As new laws come into effect safeguarding the health and welfare of nations, new materials are being promoted as more energy efficient, less toxic, less dangerous, renewable, cleaner, etc. Clear fiscal incentives in the form of tax rebates and government subsidies are underscoring these worldwide efforts.

In the developed countries there is increasingly greater awareness that a national materials policy should be given high priority. In the United States, the new Fiscal Year 1993 Budget includes proposed funding of 1.8 billion dollars for AMPP, the Advanced Materials & Processing Program. At the press conference announcing the program, the US government representative said the program "recognizes that materials are at the heart of essentially all of today's advanced technologies, and materials R&D thus has very broad applications". For the 1.8 billion dollar amount, 41% is allotted to synthesis and processing, 13.9% to theory, modelling and simulation, 27.6% to materials development, 1.5% to education and human resources, and 15.9% to the national facilities for materials research and other expenses.[14]

Another example, in the ASEAN region, is Singapore, which has just announced a government spending plan which will increase the total R&D spending from 1% of GDP to 2% of GDP by 1995.[15] The program will spend 2 billion Singapore dollars (US$ 1.25 billion) on the total R&D spending, of this amount more than 25% is marked for the advancement of "9 Key Technologies", identified as

1. Information Technology
2. Microelectronics
3. Electronics Systems
4. Manufacturing Technology

5. Materials
6. Energy, water, environment, resources
7. Biotechnology
8. Food and Agrotechnology
9. Medical Science

It is thus increasingly clear that materials technology is considered vital to a country's development, and that this importance is being recognized at the national level by significant policy and financial commitment.

2.5.2 Thailand

One of the greatest natural resources of a country is its people, and therefore by extension the underutilization or underdevelopment of human capital is one of the greatest wastes in a country. The situation in Thailand today has been well documented to be one of severe shortages of technical manpower, and serious cases of misallocation of scarce resources. The universities produce fewer than 4,000 engineering graduates per year, while the demand from industry is estimated at in excess of 8,000 new graduates annually. The budget per engineering student, or the cost to produce a new graduate, is estimated at US$ 1,600.00. For comparison, the figure used at the private, international Asian Institute of Technology, is US$ 40,000.00.[16]

At the vocational education level, there are insignificant programs for materials technology. For the overall tertiary education system in Thailand, approximately 15% of the graduates are in science, technology, or engineering fields, and 85% in the humanities, liberal arts, and social sciences. In Korea, for example, the ratio is 30% technical/70% nontechnical, and in Japan the ratio is even higher, approximately 40% technical/60% nontechnical. This ratio in part reflects the greater costs associated with producing technical graduates compared to nontechnical graduates.[17]

At the advanced degree level, particularly at the PhD level, RD&E manpower is heavily concentrated in government institutions, notably the university system. There is little supply or demand for RD&E personnel by private industry. The number or RD&E researchers per 10,000 participants in the work force is extremely low compared to other industrializing countries in

Asia.[18] In Thailand this figure is 1, while in Singapore the number is 28, in South Korea it is 33, and in Taiwan it is 43.[19]

One serious problem facing materials technology endeavors in Thailand is the insufficiency of local suppliers. For many processes, raw or semifinished materials must be imported, due to the fact that local supplies are not adequately exploited. The machinery, spare parts, and maintenance capability for using advanced technology is also often lacking, and large amounts of money must be spent to obtain parts or services from abroad.

Technical services in Thailand are primarily provided by the government, though as time goes on private sector companies are beginning to recognize the economic opportunities available in providing technical services. The maintenance of standards in the country is not well defined, with different organizations responsible for maintenance of different standards, and often no clear system of international traceability has been established. Calibration services have been recently upgraded by the construction of two centers for calibration and testing in Samut Prakan, for TISI and TISTR. Information services, particularly access to international databases, is still in its beginnings, and there is yet no country wide linkage of the library systems to enable rapid dissemination of information.

The number of private sector providers of technical services is growing, though still quite small for a country the size of Thailand. A Summary of public and private suppliers of technical services in provided in reference.[20]

The banking system is well established, and private sector endeavors which show a solid financial potential are capable of finding investors. For example, the new plants engaged in steel, ceramics, glass, and polymers are all being funded by combinations of various financial sources, some private, some public, and at both the national and international level.

The laws are gradually changing to reflect the growing awareness that technological advances are crucial in the country. For example, the import duties on machinery imported for industrial production have been lowered to 5%. However, the import duty for testing and measuring equipment remains many times higher. The details of the patent laws are undergoing revisions to help bring Thailand more in line with worldwide positions regarding patents on new products and intellectual property rights. And, the policies regarding recruitment of foreign technical manpower for work in Thailand are being eased to streamline the process of obtaining visas and work permits for foreign nationals who can help in the transfer of technology to Thailand and relief of the manpower shortage.

There has not been a strong leadership shown by the government, particularly as it relates to a national materials technology policy. Part of this is due to the pressing international and national situation, which has given higher priority to other government concerns.

There is little government direction for RD&E; for example 97% of the RD&E carried out in Thailand is done through the public sector, but the total amount spent on RD&E amounts to less than 0.17% of GNP, compared to 2.0% for Korea and more than 3% for Japan and the United States. One encouraging note in government policy is the increased emphasis by the Board of Investment on backward linkages in the industrial sector. This is a policy aimed at encouraging many of the support industries, which are often heavily materials related, to develop in Thailand and reduce local dependence on imported raw or semifinished materials.

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CHAPTER 3 LESSONS LEARNED FROM RD&E CASE STUDIES

3.1 PRODUCTION

The cases* highlighted the fact that Thailand contains a wide variety of natural resources, and that many of these natural resources, such as rubber, metal ores, minerals, petroleum, etc., are being used by Thai industry. However, all too often these materials are used only as raw materials and commodity items, or at most they are used in low technology, often low quality and low value added, industry. Thus, for example, ceramic novelty items can be produced with satisfying results, but higher quality and technical ceramics still need more research and development. Consumer plastics can be produced locally, but higher level engineering and technical plastics are still some time away in the future. Likewise, high grade steel is not locally produced, and as a consequence many special types of steel must be imported.

All these factors indicate that Thailand is a long way from reaching the fullest value of its resources, and that further benefit will only occur as the technological content and quality of materials and products rises, and the losses from scrap, waste, and defective items decrease.

3.2 MARKET

The cases have shown that there is frequently an insufficient or undeveloped market for the results of Thai RD&E efforts. In some cases the researchers do not have the time or desire to establish a commercial market for their results, preferring instead to work more specifically for the advancement of knowledge or to aid the efforts of another research project. And, the people who are capable of doing a good job at RD&E may not have the best skills necessary to communicate with the business and commercial community.

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* TDRI (1992), "Case Studies of RD&E Performance in Materials Technology", Thailand Development Research Institute, July 1992.

For the situation where there is a clear and strong linkage between the development of a prototype or new process and a commercial user, the results of the work can be quite satisfactory. It is important to note that such linkages require market information concerning the size, needs, and restrictions of markets, both international and domestic. This information must be available to RD&E planners and workers, and suitable schemes must be undertaken to reach these markets.

3.3 RD&E

From the cases studied we have seen that RD&E can produce concrete results, and that researchers can be held accountable for the results of their efforts. The results may take many forms, including publications, patents, licenses, processes transferred to or adapted by industry, textbooks or manuals prepared, standards written, seminars and training programs presented, etc. In some cases economic gains may be obtained in a relatively short time, within two to three years, while in other cases ten years may be required before there are any appreciable gains. And, in some cases there will never be any real commercial gains for a project, but the results in terms of people trained and experience gained will still be considerable.

The calibre of RD&E often depends on the calibre of the project leader, and such a project leader may need ten to twenty years of experience before he or she will be in the position to lead an RD&E team to produce creditable results.

3.4 OTHER TECHNOLOGICAL INFRASTRUCTURE

The technological infrastructure is a crucial component in the success of an RD&E project. Without sufficient support no project can be expected to achieve its goals.

The most pressing need at the current time in Thailand is the lack of sufficient manpower at all levels. This includes the technical manpower of researchers, instructors, technicians, and skilled workers, as well as the administrative manpower for project management, executive planning, and administrative support. The support systems necessary to maintain the manpower that does exist is insufficient. Researchers frequently feel they are isolated, and have no way of feeling fully integrated into the technical community on the local or international level. Continuing education or specialized training to upgrade people's skills in new areas is also not given a very high priority.

Another pressing concern of the technological infrastructure is insufficient funding or unnecessary difficulties in obtaining available funds. Researchers are discouraged by the low rates of remuneration and the additional burdens for administrative and teaching requirements placed on them. Laboratory assistants, equipment maintenance technicians, machine shop operators, etc., cannot be hired because the private sector pay scales are much more attractive. The budgets allocated for research do not accurately reflect the high costs of equipment, standards, spare parts, high quality materials, information, communications, etc.

Information is often not available, or there is no easy access to it. Researchers spend a lot of time trying to find information, and such efforts are not very productive or efficient.

Technical services are required for calibration, standards testing, and analysis of properties. If projects are to be commercially successful and meet product export expectations, they must be capable of being tested to international standards, such as ISO 9000 or JIS or DIN or whatever. Often an individual researcher or project cannot justify the cost of a major instrument, but the equipment needs to be available within the country so that occasional users can benefit from it. Technical testing services of a high calibre are a prerequisite for having the results of Thailand's RD&E efforts be accepted commercially both here and abroad.

Linkages between the providers of RD&E and the users of RD&E are vital. This means that for commercially viable projects, the end users such as factories or commercial manufacturers must be connected with the RD&E workers, they must have some input as consultants or supporters or providers of direction to the RD&E workers, and they must be agreeable to helping to bring a product to the marketplace. One of their most important functions is to provide feedback as to how well a particular process or product satisfies their needs, and what improvements or changes would they like to see.

Finally, the overall framework within which RD&E projects are carried out must be set by the policies of the National Centers and ultimately the National Government. Without the security of long term planning and long term commitment, it is difficult to pursue RD&E efforts effectively. For Thailand to make real and long lasting improvements in its RD&E structure, and thereby to provide benefits which can extend throughout the society, the government must take the initiative and show real leadership in the key area of materials technology.

CHAPTER 4 FUTURE POTENTIAL FOR THAI MATERIALS

This chapter describes the future outlook of technology pertaining to materials production and research in Thailand for the next 5 and 10 years. It is based on the outcomes of A-I-C workshops held at the Siam Bay Shore Hotel on June 15-16, 1992. The participants were invited from both the government and private organizations and included university lecturers, administrators, policy makers and industrialists.

Some of the technological goals and targets and RD&E levels of achievement which appear in this chapter may seem unrealistic and unreachable. However, they do not represent absolute goals; rather, they are set up so that means and mechanisms by which the targets could be reached could be accurately defined.

The future outlook and strategies are not a result of present status and past development evaluations. The participants were asked to visualize an ideal case where they were not restrained by the present situations. They were asked to work backward from the "future present" to see what would have been needed to establish such a state. Once the goals and the strategies have been well defined then action plans could be formulated in chapter 5.

4.1 PRODUCTION

4.1.1 Metals

Five year targets: Steel production will reach the level of 4.3 million tonnes of flat products and 3.3 million tonnes of long products. The government policy for basic steel industry and other metallic industries will be concrete. Various non-ferrous industries such as zinc and copper will be fully established. The metal industry will invest more in state-of-the-art technology so as to improve productivity and quality. Furthermore, computer-aided production will become more important, and effective data bases must also exist.

To support the metal production industries and upgrade the technology level of other industries, metal working industries such as forging, machining, and welding will be highly developed. Thailand will be a machinery exporting country of low to medium technology, particularly for agricultural machineries and tools. About 20% of industries will attain the level of world-class manufacturing. The output per head of employee in small and medium scale industries will be at least 1,000,000 baht.

Ten year targets: Thailand will be able to develop some materials for industrial use. The steel industry should be fully developed through the process of backward integration. Thailand can produce steel directly from iron ore. The supply of raw materials for steel industries such as iron ore, scrap, coke, etc. will be secured. High quality products can be produced effectively through process development by the industry in cooperation with research institutes.

Downstream industries of non-ferrous metal are fully developed. Thailand can export high quality finished products produced from local metals and materials.

Supporting industries such as metal working industries are fully developed to serve as a basis to propel the development of other major industries. Reliable local engineering and consulting firms are available sufficiently to facilitate the development of materials industries. Export of high precision and high technology machinery is also possible. Overall metal products will be of high quality. 20-30% of local industry should be able to export and 30-40% of the firms will have attained world class level. Output per head of employee will be 1.5-2 million baht per year for most small and medium scale industries.

4.1.2 Ceramics

The future outlook of Thailand's ceramics industry in the next 5 years will be as follows: The production value of ceramics products will reach 100,000 million baht annually of which seventy percent are traditional ceramics and thirty percent new ceramics. Basic ceramics raw materials can be produced with quality up to world standards and can be exported. Ceramic materials such as silicon carbide, alumina, optical glass, optical fiber, electronic ceramics, low cost building materials and technical ceramics phase I can be produced locally. Productivity of traditional ceramics will be highly improved through total quality control and total productive maintenance methods.

In the next ten years: Production value of all ceramics products will reach 200,000 million baht annually. Catalytic converters can be produced locally. Ceramic fiber, ceramics composites and technical ceramics phase II can also be produced. Production technology for glass will be fully developed.

4.1.3 Polymers

In five year's time the polymer industries will increase their production significantly. The plastics industry will produce products worth 90,000-100,000 million baht per year, with a growth rate of 15-20% annually. Natural rubber production per year will be 35,000 million baht while rubber products will be 50,000 million baht with growth rates of 5% and 8% respectively. Fiber and textile production will be 400,000 million baht with a growth rate of 15% annually. In the textile industry garment production will be worth 300,000 million baht and synthetic fiber will be 40,000 million baht. To achieve these levels of production, the technology for the production and processing of engineering plastics, polyester for film and bottles, multilayer films for packaging, high quality natural rubber, styrene-butadiene rubber and butadiene rubber, fiber used for reinforcing rubber, dyes for textile, textile technology printing, and high value fiber will be fully developed.

In the next ten years production of those polymeric materials mentioned above will be further increased. Some products will become world leaders such as automobile tyres. Some high technology products such as carbon fiber and aramid fiber for composite materials can be produced locally together with industrial fiber. Specialty fiber such as flame-retardant fiber, high modulus fiber and chemically resistant fiber can also be produced. In order to speed up production development joint investments with well-established foreign firms should be promoted.

4.2 MARKET

4.2.1 Metals

There will be more competition and more globalization in trade in the future. So, the metal industry in Thailand should be ready and more competitive in order to survive and sustain its growth locally and worldwide. Markets for steel products will increase not only in volume but also in type of products. New markets will include p.c.wire rods, high quality wire rods, stainless steels, alloy steel for structural applications, high quality coated steels, etc. Markets for non-ferrous products, particularly aluminum and aluminum alloys, and copper and copper alloys will increase in volume and range of products. The quality of these products will reach world standards and can be exported to markets in the developed countries. Thailand will also be a machinery exporting country. Agricultural machinery and tools can be exported worldwide. High precision and high technology machinery can also be exported in the next 10 years. Metal products that are exported will be high value products or finish products while external markets for raw materials and primary forms of metals will decrease. Such materials will be used locally instead.

4.2.2 Ceramics

In the future Thailand would be able to export basic ceramic raw materials to world markets and become the leader in the ASEAN market. Such materials will be of high and consistent quality. Sales value of ceramics product will increase at the rate of 20% per year and will reach 200,000 million baht in 10 year's time. Export of traditional ceramics will increase tremendously and Thailand will achieve world ranking as a ceramic exporting country. For new ceramics, Thailand will become a leader among ASEAN countries. These new markets include bioceramics, electronic ceramics and engineering ceramics.

4.2.3 Polymers

The future outlook of the polymers market can be summarized as follows: As production of various polymeric materials will increase drastically, there are needs to improve the quality of products and to develop various new products so as to expand the markets both locally and worldwide.

In the plastics industry, engineering plastic products for automobiles and electrical appliances will be one of the major targets for the industry, along with polyesters for film and containers. As the packaging industry is becoming more and more important the development of multilayer films for packaging will also need attention. Certain engineering plastics can also be produced, primarily for local consumption.

In the rubber industry, there are needs to improve the quality of natural rubber and to develop synthetic rubbers such as SBR and BR. As Thailand will become a world leader in serving the tyre market, the development of synthetic fiber for reinforcing tyre eg. polyester fiber, nylon fiber etc. is also necessary for full integration in the tyre industry.

In the future, competition in the textile industry will become more severe, and quality improvements and high value products will be more emphasized. Dyes for fiber and printing technology will be more developed. The market for fiber will focus on high value fiber that have good properties, particularly high gloss fiber, multicolored fiber, microfiber flame-retardant fiber, high modulus fiber and chemically resistant fiber. Apart from these markets composite materials will become more important and the development of fiber such as carbon fiber is also important.

4.3 RD&E

Responses from the four groups in the Workshop (1 polymer, 1 ceramics and 2 metals) were strikingly similar. The participants visualized Thailand's future potential as laying in being able to improve the quality and increase the quantity of the existing products and pursue production of high-tech materials. For example, in the area of polymers new materials such as styrene-butadiene and butadiene rubber, new types of synthetic fiber, and polyester were suggested. In the area of ceramics, new materials such as silicon carbide, optical glass, optic fiber and electronic materials were mentioned.

High quality products such as PC wire, stainless steel and alloy steels were recommended by the metal groups.

RD&E is necessary to meet the ambitious goals for production envisioned by the groups. The metal groups suggested that exports of the metal industry should reach the level of 10-15% of the total national export level. Domestic steel production should reach the level of 3 million tons of flat products and 2.5 million tons of long products within five years. Similarly, the ceramics group envisioned a strong growth and extrapolated that the national annual sales of ceramics would reach 100,000 million baht in 1997. The polymer group was equally ambitious in its prediction of the growth of the polymer industry: the sales volume was expected to double in 5 years. The participants from all four groups agreed that to pursue such targets the RD&E in Thailand needs:

a) Clear policy on RD&E by the government which, at present, is unsatisfactorily defined.

Areas of shortcomings are long term commitment and direction from the government. Programs to promote RD&E in private sector must be launched.

RD&E has not been on the list of top professions in Thailand mainly due to unattractive salaries, as most positions are offered by the government agencies. As a result, it fails to recruit top quality graduates and has difficulties in maintaining staff. Brain-drain and high turn-over are common occurrences in the government institutions. RD&E personnel do not receive adequate status and recognition in the society. The government must commit to a long term policy to rectify this situation. It should also include RD&E in pre-university education so that students will be properly introduced to the RD&E concept and can appreciate its challenges and rewards.

b) Adequate funding and incentives.

Funding for RD&E research needs to be increased to be comparable to other countries as mentioned in section 2.5.2.

c) Promotion of RD&E and industry linkages with researchers.

A strong consensus opinion of the participants was that our RD&E activities did not generally satisfy the nation's needs. The country suffers severely from the lack of or ineffective linkage between the two parties to facilitate exchange of information. The researchers, in general, are not in communication with end users, and at the same time, the users are not aware of what is being done and what is available from the researchers. The participants agreed that the promotion of the linkages is an important goal for the future.

d) Excellent data base services.

Every researcher voiced grievances regarding the inadequacy and incompetence of the existing system. Presently, the information retrieval system is inefficient and rather outdated. Fast, accurate, and readily accessible methods of information retrieval are needed so that literature searches by the researchers can be carried out conveniently, and vital and pertinent information for RD&E can be quickly located.

It was, however, suggested that the problem at the moment is how to fully utilize what is available. The weakest area in the data base services is the lack of linkages between libraries. Thailand has invested substantial amounts of man-hours and money to improve its data base system. Nevertheless, the attempts have largely been individual efforts. Large resources of literature are left with their existence unknown. A fuller utilization of our data base resources can be facilitated by setting up a central body to integrate the whole system into a single network whereby computer searches, electronic transmission of data, and inter-library loans are common practices. Lastly, an integrated data directory and catalogue at the national level must be established.

e) Better qualified personnel and facilities.

The government should invest more heavily in graduate level education. RD&E can be best conducted in universities, as part of the learning process in higher degree education. The research will generally be of good quality and economical. The outcome will also be obtained in a more timely fashion as a result of the universities' readiness in personnel and facilities.

f) Fast and convenient supplies of consumables and equipment.

The participants and researchers agreed that one of the more serious problems facing RD&E in Thailand is the procurement of supplies. Most research labs in the world do have dependable supplies. Most universities abroad maintain their own supply stores where their staff can get orders filled. It would be wise for Thailand to follow these good examples.

g) Promotion of exchanges among RD&E research staff.

This is also a vital mechanism in initiating and accelerating the pace of research, and reducing the feeling of isolation among researchers. This mechanism has long been administered by the more developed nations. It helps facilitate the exchange of information. The exchange of the researchers can be conducted between government agencies or between government and private organizations.

4.4 INFRASTRUCTURE

The consensus of the participant was unanimous that infrastructure is a major problem undermining the development of industry and RD&E. The infrastructure both in hardware investment and management needs urgent and rigorous attention. Thailand's attractiveness for investment is now suffering as a result of infrastructure bottlenecks.

The following are conclusions regarding infrastructure taken from the A-I-C meeting during the present and future potential sessions from all 4 groups. Since the conclusion were similar in nature they are described here as a single section rather than truncating them into 4 sections according to their sources.

a) Long term government policy.

The participants felt strongly about the lack of direction and coordination by the government which causes Thailand's industry to be unable to capitalize on trade opportunities and strengthen its production capacity. The government can help by laying down clearly its trade and industry policy. It can also monitor the global market and trends and inform the proprietors of pertinent information. New policies in technology transference such as setting up industrial parks and training centers need to be formulated.

b) Manpower.

Thailand at present is seriously short of qualified technical personnel. It was reported that there are at least six to eight thousand vacancies for engineers now. This is a pressing issue for the government. Universities and technical colleges must increase the number of their graduates. Also the cost per head of student must be greatly increased to a respectable level (see section 2.5.2) so that the graduates are properly trained and are an able work force.

c) Public utilities.

Public utilities such as roads, water supply, electricity, telephones, railway services etc. need to be improved extensively. Large development projects have been delayed or suffered from inadequacy of utility supply. The frequent black-outs of the electricity, especially in the provinces, is another pressing problem which deters large and high technology investment. Water is now a growing concern, as the nation is pushing for growth in both agriculture and industry. Both sectors will be competing for this limited resources more vigorously in the near future. One good example to illustrate the seriousness of this problem is a public announcement by a petroleum refinery in Sri Racha that it is constructing a desalination plant to produce its own supply of fresh water. Therefore, the outlook calls for rigorous expansion and development of the needed utilities by the government.

d) Reform of laws and regulations.

A number of laws and regulations were quoted as being out-dated and inflexible. Reformation, and new laws and regulations such as lower import duties (for RD&E equipment), export custom clearances, tax incentives etc. should be invoked so that they will act as a platform to propel growth in new industries and RD&E.

e) Finance institutions.

The finance and banking institutions were said to have been an important element in development. Long term soft loans are highly welcomed by the industrialists. Thailand's interest has been higher than most developed countries despite our ability to contain the inflation rate to well under 10 percent. Lower interest rates will help facilitate importation of new technology into Thailand which in turn will prompt activity and research in new areas.

f) Supporting technical services.

Supporting technical service such as analytical testing labs, product standards, patents and codes of production were cited as the things that need to be developed further by the government.

Specification of supplies needs to be improved. Procurement of supplies is often untimely and expensive. The government should encourage a system of open cataloging and pricing.

g) Information.

Market and technology information is often slow and out-dated. The government should help the industry and RD&E people to keep abreast of recent global changes. This problem can be highlighted when comparing our country with Singapore.

h) Small and supporting industries.

Most small and supporting industries in Thailand generally must rely on themselves. Therefore, they are often struggling and unguided. It is important that this sector should be well taken care of as it represents the domestic market demand for raw materials and intermediate products which will create potential for the local production of materials by larger corporations.

CHAPTER 5 RECOMMENDATIONS AND ACTION PLAN

5.1 GOALS

After the discussion on the current status of the materials industry and technology, and forecasts on the future potentials for the next five and ten years, this chapter will explain the goals, strategies and action plan recommended in order that the materials industry and technology can achieve the stated future potentials.

In the same manner as the determination of current status and future potentials, the participants representing policy makers, academics, researchers and industrialists were divided into four groups, namely two for metals, one for ceramics and one for polymers. Each group discussed and found its consensus for the goals of each materials industry and technology. A representative from each group then presented the findings and the results were summarized as industrial goals and technological goals.

5.1.1 Industrial Goals

For the metals group, various industrial goals were discussed as follows:

- Marketing, demand requirements and mechanisms to facilitate marketing;
- Industrial policy and planning, for small and medium enterprise, incentive plans, planning agency, linkage of industrial and technology;
- Infrastructure, manpower, waste treatment, tax exemptions, supplier bases, supporting industries;
- Production processes, learning, importing, acquiring of know-how;
- Data bases;
- Raw materials;
- Productivity;
- World-class level of company operation;

For the ceramics group the goals discussed were:

- Manpower, adequate and qualified, university and college graduates in all aspects of ceramics business;
- Infrastructure, energy, communications, industrial estates;
- Taxes, government support in equipment and materials purchasing;
- Quality products, productivity, consistency of products, R&D, process improvement, competitive cost, quality raw materials;
- Information, information centers for marketing, production, and raw materials;
- Policy, steady and certain, export promotion, buy Thai policy, quality awards;
- Industrial promotion by BOI on new ceramics and glass;
- Cooperation among industries, education and government;
- Technical services and assistance;
- Technical acquisition through joint-ventures and licensing.

For the polymers group, the discussions emphasized the government policies with priorities on:

- Information;
- Infrastructure;
- Incentives;
- Technology management;
- Product and process development;
- Raw materials development;
- Productivity and joint-investments.

Numerous goals from each group were then discussed and summarized by the researchers with the consent from participants to include the targeted production quantities for each material.

The industrial goals for materials in the next five years were summarized as:

1. Increase production

Ceramics - 100,000 million baht per year with the growth rate for traditional ceramics as 15% per year and for new ceramics as 25% per year.

Metals - Steel production of 3 million tonnes of flat products and 2.5 million tonnes of long products. Non ferrous production of zinc and copper.

Polymers - Plastics 100,000 million baht per year.
Rubber 35,000 million baht per year of raw materials and 50,000 million baht per year of rubber products. Fiber, textile and garments 40,000 million baht per year of synthetic fibers and 300,000 million baht annually of textiles and garments.

2. Improve productivity for the materials industry, to have: a significant percentage of the firms attain world class level.
3. Attain 60% of the necessary supply of technical manpower.
4. Process and quality development.

5.1.2 Technological Goals

For the metal groups, various technological goals were discussed and summarized as follows:

- RD&E and design;
- National laboratory;
- Funding support;
- Efficiency;
- Professional societies;
- Standardization, testing centers, and industrial standards;
- Tax exemption and financial motivation;
- Code of practice;
- Linkage promotion between government and private sector;
- Promotion privileges;
- Raw materials, surveys, supplier association, tax relaxation;
- Environmentally cleaner processes.

For the ceramics group, technological goals were determined with the emphasis of supporting the ceramics industry as:

- Technology for quality improvement and higher production yield, particularly in the traditional ceramics;
- Technology for high potential new product development for industrial use, particularly engineering ceramics for the electronic industry, technical or engineering ceramics for the metals and automobile industries, insulation and glass fiber optics for the communication industry, transportation, etc.;
- Technology for raw materials exploration, especially in the Asian region;
- Technology for the creation of certain domestic traditional ceramics.

For the polymers group, the technological goals were established as a flow from policy toward standardization as follows:

- R&D policy;
- Personnel development, RD&E funding and incentives;
- RD&E with linkage to industry;
- Establishment and development of RD&E organization and reformation of government supporting mechanism for RD&E;
- Information, acquisition and transfer of appropriate technology with consideration on environmental effects;
- Standardization development.

In the same manner as the industrial goals, the various technological goals from all of the groups were summarized by the researchers with a certain number of priority materials products that need technological development in the next five years.

The technological goals for the materials for the next five years were summarized as followed:

1. Quality products development, namely,

    Ceramics - Electronic ceramics
    Engineering ceramics
    Glass fiber optics

    Metals - PC wire
    Stainless steel
    Alloy steel
    Structural steel
    Agricultural machinery
    Industrial machinery
    Machine tools

    Polymers - Multilayer films
    Engineering plastics
    PET
    Fiber for reinforced rubber
    Dyes and printing for textiles
    High value fiber
    Rubbers engineering

2. Raw materials development, new resources, quality improvement.
3. Sufficient technical manpower, attaining 60% of the level of technical manpower necessary to supply local demand.
4. Sufficient funding (in infrastructure for RD&E) to be supported by 0.1-0.5% of sales from private sector and 1% from government budget of each fiscal year.

5.2 STRATEGIES

To ensure the best possible strategies for achieving the goals stated in the previous section, the four groups of participants then reconvened in the next session to determine the strategies for the industrial and technological goals. In order to emphasize and focus the efforts of the participants, the goals for industry and technology were reduced with the consent of the participants to one for industrial goals and two for technical goals.

For the industrial goals, various strategies were determined to achieve the increase in production (goal number one), and for the technological goals, the strategies were determined to achieve quality products development and raw materials development, and new resources and quality improvement (goals number one and two).

5.2.1 Industrial Strategies

Eleven strategies were established to achieve the stated industrial goals as follows:

- Infrastructure
- Manpower
- Policy
- Technology acquisition assessment
- Quality products
- Information
- Taxation
- Technical services
- Cooperation
- Joint-ventures
- Industrial promotion.

5.2.2 Technological Strategies

Twelve strategies were established to achieve the stated technological goals as follows:

- Manpower
- RD&E policy and management
- Finance of RD&E
- Information
- Cooperation
- Technology acquisition
- Tax incentives
- Organizations
- RD&E activities

- Investment promotion
- Environment
- Standards.

Due to the common nature of the strategies for industry and technology, and to concentrate on a few vital strategies, the participants with facilitation from the researchers then discussed and prioritized each group of strategies. The number of strategies was then reduced to six major strategies for industry and six major strategies for technology.

5.2.3 Major Strategies

The major strategies to achieve the industrial goals are:

1. Infrastructure
2. Manpower
3. Policy
4. Technology acquisition assessment
5. Quality products
6. Information

The major strategies to achieve the technological goals are:

1. Manpower
2. RD&E policy and management
3. Finance of RD&E
4. Information
5. Cooperation
6. Technology acquisition

It can be clearly seen that the need for manpower, a concrete and consistent policy for RD&E promotion, and an adequate supply of information concerning RD&E for industry are the common strategies stated for both the industrial and technological sides.

5.3 ACTION PLAN

A common concern of participants and researcher was the lack of serious action on the part of corresponding organizations to pursue the strategies which were discussed. There are numerous studies which have been done in the past in a similar manner to the present one but no concrete action has been taken so far. So, an action plan which specified tasks for each party concerned was discussed, with the emphasis on the role of government and private sectors alike, to pursue the stated strategies during the specified period. For the convenience of the establishment of the action plan, the time frame was divided into:

- Long term of 5-10 years,
- Medium term of 3-5 years,
- Short term of 1-3 years;
- Immediately and/or continuously.

Each strategy was then discussed to determine the organization concerned and the role and responsibility for the task involved in the specific strategy. The detailed listing of strategies, institutions concerned, and functions will be included in the appendices. The following explanation will focus around the action plan with the time-frame and the relationship between the institution/organization concerning each action.

The summary of questionnaires from the participants on institutions concerned and function of each strategy to achieve industrial and technological goals is presented in Appendix 5.1. That on major measures, responsible units, time-frame, budget and resources is in Appendix 5.2.

5.3.1 Manpower

The action plan for the strategy of manpower will be discussed first due to the similar nature of the actions and organizations concerned. The discussion about this strategy emphasized survey and projection, planning, education, training and re-training, policy, and institution building.

Short-term and continuous action: NESDB will have to do the surveys and projections of manpower requirements for the materials technology and industry. The outcome should include the qualifications and quantity of the technical manpower required. Policy making and planning will be done with the cooperation of the Ministry of Science, Technology and Environment (MOSTE), the Ministry of Education (MOE), and the Ministry of University Affairs (MUA). The Ministry of Interior (MOIT) and various non-government organizations (NGO) such as the Technological Promotion Association (Thai-Japan) (TPA), the Engineering Institute of Thailand (EIT) and the Federation of Thai Industries (FTI) will take a role of training to up-grade the existing manpower in the private sector with respect to the demand projections of NESDB.

The Board of Investment (BOI) should have a concrete and consistent policy concerning technology transfer in joint-venture companies and companies which buy technology from overseas. These companies should submit action plans which outline the technology transfer process and the specified period in which the local operators/technicians/engineers would be able to gain sufficient knowledge required for the industry concerned. This should be done before receiving investment privileges. Work permits should be given to expatriate technicians/engineers who will be responsible for training and educating the local people in the industry.

The training and education of technical manpower could be speeded-up by the establishment of training institutions. After planning and policies are established by NESDB, the institution(s) for education and training in the immediately needed technologies, e.g. mold and die, CAD/CAM/CAE, machine tools, etc, should be established using the budget set aside by the government with the cooperation with the FTI. Foreign experts could be recruited through the overseas cooperation organization, i.e. JODC, UNIDO, etc. These experts could take responsibility in the training and education of local personnel, including the instructors, in various technical colleges with a multiplying effect in mind. Sufficient machines and equipment suitable for training should be provided. The curriculum for training and education should be arranged in a sandwich-like manner i.e. theoretical training in the institution for one to two years and practical training in the factory for one year before returning to theoretical training and graduation within another year.

The New University Acts should also be established with emphasis on flexibility and freedom in the routine operation of the educational institutions. Attractive salaries should be provided to prevent braindrain of the instructors and researchers/technical supporting personnel. Various appropriate curricula could be provided without the red-tape which presently delays the development of new programs. Sufficient budgets should also be provided for the existing universities to support routine operations, the acquisition of RD&E equipment, and research funding.

Medium term action: MOE and MUA through cooperation with the industrial societies such as FTI should also provide the "sandwich curriculum" as stated in the short term action plan in addition to the normal curriculum. The sandwich courses can be used to educate technical manpower who concentrate on the practical aspects while the normal curriculum should aim to produce RD&E personnel for public and private research institutions, together with the technical personnel to supervise and manage the operations in the factory. MOSTE should also help to provide scholarships for domestic and overseas education of technical manpower with the aim to produce instructors and/or researchers for the universities, technical colleges and research institution.

Long term action: NESDB through the cooperation with MOSTE/NSTDA, FTI, MOI/MIDI, and other research institutions such as TDRI or Chula Unisearch should try to establish long term plans and targets for each materials industry. These long term plans and targets should be used as a master plan for the education and training of personnel and also for requesting the assistance from overseas organizations such as UNIDO, JETRO, JICA, UNESCO, etc. The tri-party relationship or linkages between government, university and industry should be promoted to facilitate cooperation in manpower development and other aspects as well.

The Ministry of Defence (MOD) should also assist in the production of technical manpower especially in the science and engineering disciplines due to the existence of the educational institutions and infrastructure (equipment, instructors, etc.) for army, navy, and air-force personnel at the undergraduate level.

Next, the action plan concerning industrial strategies will be discussed, with the technological strategies following.

5.3.2 Infrastructure

Lack of sufficient and effective infrastructures has plagued Thai industry for many decades. Even though the government has tried to promote the development of numerous industrial estates which are operated by the government and also by the private sector, the problems are still not solved. The major obstacles impeding the investment and development of various industries are lack of transportation facilities, telecommunications, insufficient supply of electricity and water, and red-tape in the granting of permission for the establishment of a factory or receiving promotional privileges. Strong cooperation between various government organizations is seriously needed.

Short term and immediate action: NESDB, BOI and other sections in the Office of the Prime Minister should establish concrete and consistent plans for industrial promotion with the emphasis on infrastructural development. Plans and policies should aim to coordinate the efforts and mechanisms of the public enterprises under the supervision of the Ministry of Transportation and Communication (MOTC) namely, the Port Authority of Thailand (PAT), the Telephone Organization of Thailand (TOT), the Communications Authority of Thailand (CAT), and the ones under the supervision of the MOIT, namely, the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), the Metropolitan Waterworks Authority (MWA), the Provincial Waterworks Authority (PWA), the Express-way and Rapid Transit Authority of Thailand (ETA) together with the Department of Highways, the Department of Lands, etc. This cooperation could be done through the setting-up of a committee responsible for the development of infrastructure for industry based on the plans and policies of NESDB and BOI.

Medium term and continuous action: The Industrial Estate Authority of Thailand (IEAT) under the supervision of MOI should develop more industrial estates for small and medium size industries. NSTDA and the other sections under the supervision of MOSTE should develop the so-called Industrial Science Parks with the cooperation of MOI and the Office of the Prime Minister. These science parks should be situated in various strategic locations throughout the country which have a high density of materials industries such as Saraburi, Chonburi, Chiangmai, Songkhla, etc. The science parks would be a place where industry and research institutions co-exist to promote strong cooperation between government and private sectors.

Long term and continuous action: The Ministry of Finance (MOF) with cooperation from FTI and other NGOs in the private sector should establish long term plans and policies for tax incentives, tax clearance, etc. to promote higher investment in the materials industry. The step-by-step reduction of import taxes for raw materials, equipment and machines should stimulate the expansion and up-grading of the industry.

Recently, environmental problems have generated strong concern and activities for environmental conservation in the public and private sectors. The conservation of energy is also a major concern of various government organizations. These two problems were addressed seriously by the government with the establishment of the Office of the Conservation of Energy and the New Environmental Acts which provides funds for environmental conservation. Authority is given to the corresponding government organization to order the shut-down of violating factories. Numerous strong measures and regulations are also established. However, motivations for the industry to conserve the environment and energy should also be promoted via tax mechanisms e.g. tax exemption for environmental control and energy conservation equipment.

5.3.3 Policy

There was a consensus in the discussion concerning the policy for industrial development, namely, the policy was rather inconsistent and frequently changed in the past. The appropriate atmosphere for industrial development necessitates a concrete and consistent industrial policy from the government.

Short term and continuous action: NESDB, BOI and MOI should cooperate to establish a development scheme for the small and medium size industries. An incentive policy which promotes investment in up-grading machines and equipment should also be established with the cooperation of MOF and FTI.

NSTDA should promote RD&E in the quality development and quality assurance systems of raw materials and products in the materials industry. Alternative uses of waste, scrap and pollutants from the materials industry should also be investigated through RD&E promotion by NSDTA.

Long term and continuous action: The long term plans, policies and targets for the materials industry should be established by NESDB,BOI and other organizations concerned as stated in the action for manpower. The policies should also encourage an awareness of the contributions of S&T development in industry and public organizations.

5.3.4 Technology Acquisition Assessment

Technology acquisition has resulted in the depletion of foreign reserves. Additionally, acquisition usually resulted in the failure to absorb foreign technology by the local industry. The vicious cycle of continuous buying of technology then led to more depletion of foreign reserves. Without properly addressing this issue, Thailand will be continuously buying foreign technology without ever achieving the capability for its own domestic technological development.

Short term and continuous action: The Department of Industrial Promotion (DIP) under MOI should organize study tours for small and medium industry to observe and investigate the materials industry in foreign countries. These study tours should include programs on the observation of technology and trade exhibitions. At present, study tours are arranged by NGOs such as TPA, the Thai Die Industry Forum (TDIF), the Thai Foundrymen Forum, and government organizations such as TMPDC. But, appropriate planning, guidance and preparation are needed for systematic technological assessment and technology transfer. Seminars or workshops and presentations and publications regarding the observed information should be organized to obtain the utmost benefit from study tours and to facilitate their assessment. With the intervention of government organizations, the study tours could be organized with the assistance of overseas organizations such as UNIDO, JETRO and JICA.

TIAC, under the supervision of NSTDA, should provide the transfer of information concerning patents of materials technology. Consultancy services should also be provided by TIAC and NSTDA.

BOI should promote contract joint-ventures which emphasize technology acquisition for the materials industry.

Medium term and long term action: The MUA and MOE can be other mechanisms which provide assessment on technology acquisition in the long term through RD&E in materials technology, with the funding provided by MOF, NSTDA and FTI. The banking institutions with research facilities should also assist investors in the assessment of technology and loan supports. FTI could also assist through the activities of various materials chapters through direct contact with overseas counterparts.

5.3.5 Quality Products

The improvement in product quality in the materials industry is vital for export promotion and the development of local industry. Recently, there is a strong trend to adopt ISO 9000 in various industries to gain acceptance of exports to the EC group of countries.

Short term and continuous action: DIP should establish a grading system for factories according to the product's quality level in order to motivate the improvement of quality in the materials industry. MIDI should assist in quality improvement and TISI should establish national standards for materials products. Calibration services for measuring and quality control equipment should be provided by TISI and TPA.

The Ministry of Commerce (MOC) with the cooperation of MOF should promote tax reductions and/or exemptions for measuring and quality control equipment. The marketing information concerning a product's quality level required by overseas buyers should also be provided by MOC.

NGOs such as FTI, TPA, EIT, etc., should promote quality control, improvement and assurance through public relations and training and education about the quality management process required for quality development in the materials industry.

Medium term and long term plan: The universities and RD&E institutions such as TISTR and the Department of Science Service should provide technical services for small and medium industries which cannot acquire expensive measuring equipment. RD&E for quality development should also be promoted by NSTDA.

5.3.6 Information

Information is a scarce resource greatly needed by the private and public sectors. Lack of sufficient, up-to-date, and correct information is a major obstacle for long term planning for both private and public sectors. Recently, the establishment of information centers in some government and private organizations has slightly improved the situation. But more work needs to be done to correct the problems for industrial development.

Short term and continuous action: A feasibility study concerning materials industry projects should be done by DIP, DMR, and TDRI to provide the information to local entrepreneurs. Various government organizations should provide data bases and assume the role of information centers for industry e.g. a metal industry data base in the metallurgy division of DMR, technological data bases in NSTDA and TIAC, import and export statistics with appropriate categories of materials products in the Department of Customs, general information concerning production, markets, and imports and exports in the Bank of Thailand.

Medium term and long term action: Central computerized data bases concerning the materials industry should be established with the funding provided by both the government and the private sector. Information should be gathered through the cooperation of corresponding government organizations and NGOs such as FTI, TPA, EIT. Information from overseas should also be accessed and gathered by this center.

Next, the action plan for the technological strategies will be discussed.

5.3.7 RD&E Policy and Management

Policies concerning S&T development had not previously existed until the Fifth National Economic and Social Development Plan, which led to the establishment of MOSTE. At the present time, the National Research Council of Thailand (NRCT), TISTR and the universities under the supervision of MUA are the primary organizations concerned with RD&E. The discussions regarding this aspect of the action plan emphasized the role of the government in establishing guidelines to prioritize the fields of materials technology to be researched and developed by technical personnel. A center for materials which is not combined with machinery should also be established by MOSTE. It is important that the distinctive and differing natures of materials development and machinery development be recognized. The requirements of the two areas are not the same. The supporting mechanisms should be reformed to provide more flexibility in research activities. An integrated plan combining the mission and the financial plan should be established by the organization concerned.

Short term and continuous action: NSTDA and NRC should provide S&T indicators concerning materials technology. Cooperative efforts among various RD&E organizations should be promoted through the funding mechanisms of NSTDA and NRC. Planning for strategic RD&E which emphasizes strong linkages with industry to define needed technology should be established.

Medium term and long term action: NESDB and BOI should establish policies in the same manner as stated in the manpower action. Coordination of the S&T plan for the country should also be established by NESDB. The S&T policy should be concrete and consistent with an emphasis on self sufficiency in materials technology in the long term.

The Office of Industrial Economics and DIP under the supervision of MOI should promote policies for tax incentives through the cooperation of MOF in order to stimulate RD&E in the materials technology in the public and private sectors. Tax exemption for importation of RD&E equipment and tax reduction for RD&E spending coupled with tax free revenue from RD&E activities should promote strong RD&E activities in the industry.

The RD&E activities should evidently be actively promoted in the universities and technical colleges. Red-tape in purchasing and acquisition of equipment and materials for RD&E should be eliminated. Full-time researchers in these institutions could exist provided that there is funding support from government and private sectors. NGO activities in RD&E support would be very effective for the promotion of strong linkage between researchers and end-users.

5.3.8 Finance

The financial support actions for RD&E activities in materials technology need to be done immediately, continuously, in the short-term, the medium term and the long-term.

Firstly, NESDB should establish a clear policy for S&T support in materials technology to facilitate the funding support from the Bureau of the Budget.

Secondly, the Department of Technical and Economic Cooperation (DTEC) should assist in the requests for funding support from overseas governments based on the policy provided by NESDB.

Long term and continuous action: MOSTE with the aid of NSTDA and NRCT should establish a long term research fund for materials technology. Many more scholarships should also be provided for competent students to acquire RD&E knowledge from abroad. The graduated students can be put to work for various government RD&E institutions such as industrial parks and research centers.

Loan and funding support for RD&E activities in the industry should also be provided by the government and NGOs alike to assist the RD&E activities in the private sectors.

MOF should provide special tax incentives to promote RD&E in small and medium size firms. The funding support for RD&E from the government budget should be 0.5% of GDP with about 0.25% of GDP provided by private sectors as stated in the 7th Plan with appropriate allocation for RD&E activities in materials technology.

Strategic research topics should be selected through careful planning by NSTDA and adequate grants and funds should be provided for two to three research teams to work in the same field to promote research competition and speed-up the time for the achievement of results.

5.3.9 Information

The discussion of the actions concerning an information strategy for technological goals was nearly the same as for industrial goals. The explanation here includes those actions which differ from the previous discussion.

Long term and continuous action: Information centers for study and research regarding people, researchers, raw materials, marketing, and forecasting should be established through the cooperation of government and private sectors. The members should consist of personnel from academic, research, and industrial institutions. Contributions from the patent offices, both domestic and overseas, should be requested through the activities of the information centers. There should be an adequate information supply for small and medium firms for materials technology development. S&T statistics indicators should also be distributed through periodic publications of the center.

5.3.10 Cooperation

Short term and continuous action: MOI should stimulate small and medium sized firms and industries to use S&T as tools for productivity improvement, through policy measures and motivation. NESDB should establish an advisory board with the members consisting of industry, university, and government personnel to plan and implement overall strategies for materials technology. This board should act as a cooperative body for academic institutions and private industry in RD&E activities for materials technology.

Regular meetings between private/private & private/government sectors should be organized by various NGOs through cooperation with the corresponding government organizations to discuss the matters concerning policy, planning and implementation of RD&E.

Medium, long term and continuous action: Tri-party relationship among government, NGO and academic institutions should be promoted to facilitate the technology transfer and development in the materials field. The law and regulations which prevent funding support of the private sectors by the government budget should be reformed. The development of professional societies with funding support by the governments of Japan, South Korea, Singapore and Taiwan should be studied and applied for wherever appropriate. Examples of tri-party cooperation in Japan and in Thailand are presented in Appendix 5.3 a,b.

5.3.11 Assessment of Technology Acquisition

The explanations in this section will include only those that differ from those previously stated in the industrial strategies.

Medium, long term and continuous action: MOF should provide tax incentives for technology transfer in the private sectors. BOI should establish a plan for technology transfer through joint-venture activities and aim to create technology domestically. MOI should try to investigate and provide appropriate technology for the materials industry.

Teams of students and researchers should be sent overseas to become "ninja teams" and transfer technology from abroad as has been done continuously and effectively by Japan, South Korea, Taiwan and China.

A technology assessment center should be established by NSTDA to provide assistance for the private sector in technology acquisition. The service fees could be paid back after a profit is made by the industry. The activities of the technology transfer center were also emphasized in the discussions to assist in technology acquisition by the private sector.

The MUA should originate and develop domestic technology through RD&E activities of the university.

The government policy concerning free technology assistance should be reformed to promote careful selection of technology by the private sectors.

5.4 RECOMMENDATIONS

Researchers and stakeholders reconvened on July 4, 1992 to discuss the results of the brain storming sessions and to propose measures and recommendations to achieve the desired goals. Five key measures were identified by the participants as crucial. This section will summarize these measures and the general actions which should be taken by the public and private sectors and the specific actions which should be taken by NSTDA.

5.4.1 Important Measures

Among the numerous activities proposed in the action plan, five important measures were selectived to be actively pursued in order to assure the success of the other activities. These measures are:

- Professional Societies
- Taxes
- Training Institutions
- Funding
- Information Centers

Professional Societies: This measure is seen as the most important of the five because societies can be used as central points to gather data and information regarding the other measures. The government should try to promote existing societies and establish new ones in cooperation with the private sector. Funding support is needed from the government initially until societies gain enough momentum to be supported by the private sector. Professional societies will be gathering places for researchers, industrialists, and end users. They could help establish strong linkages among the concerned parties to promote the materials industry and improved technology. The tri-party relationships between the government, universities, and industry, proposed in the action plan, would be made possible through the mechanism of societies.

At present there are only a few professional societies in the materials field, such as the Thai Foundrymen's Forum, the Thai Electroplating Forum, the Thai Die Industry Forum, the Welding Society, and the Materials and Corrosion Society. All these organizations face the same problems, i.e. lack of funding, lack of private and public sector awareness about their existence and function, and lack of linkages with the government, the universities, and industry. They, therefore, are not very active and cannot assume the role of technology promoters. Funding support from the government and the private sector would help these societies in achieving their goals.

Various activities to be pursued by societies, as suggested by the participants, include:

- Studying the policies and measures of the government concerning the appropriate materials industry, and proposing suitable new policies.
- Studying materials laws and regulations and where appropriate suggest changes and reforms.
- Studying various industrial indices such as energy consumption, productivity, etc. This data could be processed and distributed to society members to be used as a means of helping to improve their operations.
- Acquiring the help of retired government officers in order to properly draft plans and proposals which will more easily gain approval and acceptance from the government sectors.

An example of an effective relationship between government, universities, industry, and a technical society in Japan is shown in the Appendix 5.3.

Taxes: The participants from the private sector stated that taxation is a major obstacle for the development of materials and other industries. The import taxes for scientific equipment range from 20% to 50%, and even higher in some cases for quality control equipment. Some changes in the tax structure have recently been announced by the Board of Investment,* but he feeling

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* The Nation Newspaper, page B1, July 9, 1992.

is that this should go even further. The tax system is one of the major reasons that many equipment manufacturers have established their Far Eastern branches in Singapore or Hong Kong. The technology of scientific instrumentation has accumulated in these countries while users in Thailand have to wait a long time for maintenance and must pay a high import tax for spare parts. Thus, reformation and overhauling of the tax structure for the materials industry is an urgent need for the government to address.

Training Institutions: Lack of personnel at all levels is the most serious problem facing the materials industry in Thailand. There should be enough manpower, funding, and support for acquiring RD&E equipment in a coherent policy for training institutions in Thailand. On-the-job training is also an effective way to provide skilled technicians for the materials industries, and should be promoted.

Funding: The importance of funding support for RD&E was stated many times in the proposed action plan. Loan policies from financial institutions for the materials industry should be reformed in order to facilitate the growth of the industry. Interest rates should be reduced, grace periods of 3-5 years should be granted, and loans should be more easily obtained through the backing and support of the government.

Information Centers: Recently, various information centers have been established in Thailand, which is a welcome event. Considerable information also exits in various government sectors such as the Department of Science Service. However, some of the data from the government sectors is out of date or inconsistent. So, efforts to coordinate the activities of the information centers and to update their information are needed. Networks which coordinate information from government sources, financial institutions, newspapers, etc., is an effective means for providing information to enhance the development of the materials industry.

5.4.2 General Recommendations for Public and Private Sectors

- Long term plans and targets should be established in cooperation between the public and private sectors for each materials industry, with NESDB to act as a coordinating body. This plan will be a basis for the development of the materials industry and technology.

- Professional societies concerning materials technology should be established through the tri-party relationship. These societies will be the mechanism for technology transfer, information exchange and RD&E activities in materials technology.

- Tax structure should be reformed to facilitate technology acquisition, transfer, and development in both the public and private sectors.

- Investment promotion through joint-ventures in the materials industry should aim for the absorption of the transferred technology and self-sufficiency in technological development in the near future.

- Industrial Parks as technology incubators should be established in various strategic locations to promote strong linkages between researchers and end-users.

- A promotional policy for the results of industrial development and S&T activities in developed countries should be investigated and applied where appropriate.

- Cooperation with overseas government and private sector organizations for technology transfer and acquisition, as through study tours and educational or training scholarships should be requested and pursued continuously.

- Computerized data base centers concerning materials technology and industry should be established.

5.4.3 Recommendation for NSTDA

The New Science and Technology Development Act has outlined the goals for the RD&E support system, RD&E implementation and technical services, technology investment, and the activities to achieve these goals of NSTDA. In this section specific recommendation for further actions of NSTDA will be summarized.

- NSTDA should cooperate with NESDB in the establishment of long term policies and plans for the promotion of the materials industry and technology.

- NSTDA should help to develop the so-called Industrial Parks with the cooperation of other public and private organizations.

- Information centers and data bases for materials technology should be established by NSTDA to provide technical data services for researchers in both the government organizations and industry.

- NSTDA should assist in the development of professional societies through funding support. It should suggest the reformation of laws and regulations which would allow for governmental budgetary support of NGOs.

- NSTDA should seek to create an atmosphere for active research activities in materials technology. Flexibility in funding should also be aimed for.

- Strategic selection of research topics and promotion of competitive research should be promoted by NSTDA.

- NSTDA should establish a National Laboratory as a place where full time researchers can do research work independently and in cooperation with public and private organizations. Full time research is a means for acquiring knowledge, experience, and skill, and will also cultivate the working relationship between industry and research. This in turn will facilitate the selection process in research fund granting by NSTDA in the future, as the grantees will be familiar with the needs and requirements of technology in industry.

- RD&E organizations with a role similar to NSTDA's have been established in the past, such as NRCT and TISTR. A thorough study should be done about the development of such organizations, from their beginning philosophy, and goals or objectives in their establishment, to their strong and weak points in operation and output. Information obtained from this study will be very helpful and important for the long term planning and running of NSTDA. The possibility of cooperation, mutual promotion, or merger of the operations of these organizations with NSTDA should also be explored.

Appendix 5.1 Institutions Concerned and Function of Each Strategy to Achieve Industrial and Technological Goals (Summarized Questionnaire Results from Stakeholders)

Appendix 5.1 Institutions Concerned and Function of Each Strategy to Achieve Industrial and Technological Goals

Technological Goals

1. Manpower

Institution	Function
# OFFICE OF THE PRIME MINISTER	
- NESDB	1. Survey projection 2. Set policy and planning to serve and link
- BOI	1. Permit for foreign workers 2. Technology transfer to local workers
# MUA	1. Produce graduates and researchers 2. Training
# MOE	1. Produce Technician 2. Skilled workers
# MOSTE	1. Scholarship 2. Training 3. Produce researchers 4. Planning
# MOIT	1. Skilled worker 2. Training (technical management, skilled entrepreneurship)
# MOD	1. Produce Engineers
# NGO	
- TPA, EIT, FTI	1. Training for Technicians and Engineers

-: notes

1. Build-up of training institutions
2. Recruit foreign experts/ domestic experts as instructors
3. Establish technical training school through cooperation of industrial societies
4. Support existing universities or institutions comparable to developed countries
5. Request for support from private sector & overseas organizations
6. Sandwich course/ apprentiveships/ specialized technician institute with cooperation from overseas organization
7. New University Acts.

2. RD&E Policy & Management

Institution	Function
# MOSTE - NSTDA - NRCT	1. Policy and Planning 2. S&T indicators or statistics 3. Cooperation, PR 4. Planning Strategy RD&E 5. Monitor efficiency and potential of RD&E 6. Generate activities closely linkage with industry to define technology need corresponding to RD&E
# OFFICE OF THE PRIME MINISTER - NESDB - BOI	1. Coordinate plan 2. Setting a strong concrete & consistent S&T policy which apparently affect the country's development
# MOI - Office of Industrial Economics - DIP	1. Policy and planning 2. Push for the policy on tax incentive for RD&E or activities in technology improvement both in public and private sectors, i.e.: lower RD&E equipment tax, income tax exemption for a company with RD&E 3. Set up specific areas of research and technical centers
# MUA	
# MOFA	
# MOF	
# MOE - Teachers' College - Technology Institute	
# MOAC	
# MOPH	
# MOTC	
# MOD	
# MOC - Department of Export Promotion	
# NGOs - TDRI - FTI	

-: notes

1. The government has to set a guideline for all scientists to do RD&E which will be most beneficial to Thailand
2. Create center for materials technology which is not combined with machinery
3. Reform supporting mechanism to be more flexible
4. Fully implementation of NSTDA/TDRI mission
5. Private sector's incentive
6. Mission plan, financial plan => integrated action plan
7. Tax incentives

3. Finance RD&E

Institute	Function
# MOSTE	1. Revolving fund
- NSTDA	2. Research fund
- NRCT	
- STDB	
- Research fund (1,200 Million baht)	
# OFFICE OF THE PRIME MINISTER	1. Set a clear S&T policy
- NESDB	2. Support and emphasize S&T develop activities
- BB	
- DTEC	
# Bank of Thailand	
# MUA	
# NGOs	
- Industrialists	1. Contribution
- Industrial societies	2. Low interest rate loan
- Private banks	
- S&T research institutes	
- IFCT	

-: notes

1. Special tax incentive to promote R&D in small & medium sized firms
2. By carefully, select topics or fields of research teames, provide enough grant & fund may be provided to two or three teams to work in the same field (to promote competition)
3. Having a research center that tell researchers in University or institute what to research
4. Funding on equipment, research and development
5. More government funding
   - Government sector : up 0.5% of GDP
   - Private sector: up 0.25% of GDP
6. Flexible grant management/spending
7. Soft loan

4. Information

Institution	Function
# MOSTE	
- NSTDA	1. Library services
- TIAC	2. Information center
- TISTR	
- STDB	
# MOI	
- DIP	1. Technical, investment, industrial potential, processing, machinery & equipment. 2. Satisfy SME's need of technology sources
# OFFICE OF THE PRIME MINISTER	1. Investment information
- NSO	2. Foreign technology
- BOI	
- NESDB	
# MUA	1. University Library
# MOC	
# MOFA	
# MOE	
# MOAC	
# NGOs	
- Industrial Association	
- The chambers of commerce	
- Professional societies	
- FTI	

-: notes

1. Establish a computer base, data bank for materials
2. Having an information center to study
   - people, researcher, raw materials, marketing, forecasting
   - member includings academic/research/industrial institute
3. Set up information centers
4. Link on-line network
5. Patent office (Domestic/overseas) contribution
6. Accumulate S&T statistic indicators

5. Cooperation

Institution	Function
# MOSTE - NSTDA	1. Technology services, standards 2. Linking industry with S&T organization and university
# MOI	1. Stimulate SMEs to use S&T as tools for improving productivity
# MUA	
# OFFICE OF THE PRIME MINISTER - BOI - NESDB - DTEC	1. Policy and guideline to promote - professional societies
# MOF	
# MOC	
# MOFA	
# NGOs - Industrial societies - FTI - Research institutes - Industrialists - Professional societies - International organizations	1. Set research topics

-: notes

1. Establish advisory board with industry, university and govn't member to plan and implement overall strategy for materials
2. Having a board to cooperate academic/institute and private industry
3. Regular meeting between private/private & private/government sectors
4. Tripartite co-operation

<u>6. Technology Acquisition Assessment</u>

Institution	Function
# MOSTE	
- NSTDA	1. Generate technology transfer activities
- Technology transfer center	2. Policy for technology acquisition
# OFFICE OF THE PRIME MINISTER	
- BOI	1. Technology transfer plan 2. Generate domestic technology
# MOI	1. Acquire appropriate technology
# MOF	1. Tax incentive for technology transfer mechanism more efficiently
# MUA	1. Initiate and develop technology
# MOC	
- patent office	
# MOIT	
- Department of Labour	
# NGOs	
- FTI	
- Industrialists	
- R&D institutes	
- The Engineering Institute of Thailand	

-: notes

1. Send our students or researchers to become a "ninja" team and transfer technology from aboard
2. Technology assessment center set-up
3. Government policy improvement concerning free technology service
   => should not be free of charge / flexibility in buying technology and tax incentives
4. Pay back to government after make profit from the projects
5. Study tour before assessment and acquisition

Industrial Goals

1. Infrastructure

Institution	Function
# MOI	
- IEAT	1. More industrial estates for SMIs
- DMR	
# MOTC	
- PAT	1. Provide adequate and effective infrastructure
- TOT	
- DOH	
- CAT	
# MOIT	
- Department of Lands	1. Provide adequate and effective infrastructure
- MEA/PEA	
- MWA	
- ETA	
# OFFICE OF THE PRIME MINISTER	
- BOI	
- NESDB	1. Planning for infrastructure
# MOSTE	
- NSTDA	1. Industrial science park
- NEA	
# MOE	
# MOF	1. Tax incentive, Tax clearance
# MOAC	
# MUA	
# NGOs	
- Industrial societies	

-: note

1. Waste treatment and elimination activities promotion

2. Policy

Institution	Function
# OFFICE OF THE PRIME MINISTER	
- NESDB	1. Incentive policy
- BOI	
# MOI	1. Industrial policy 2. Develop scheme for small & medium sized industries
# MOSTE	
- NSTDA	1. Policy planning, set-up
# MOF	
# MOIT	
# MOAC	
# NGOs	
- FTI	1. Suggestion for policy & measures
- TDRI	

-: notes

1. Strict on pollution
2. Quality assurance
3. Awareness and contribution for S&T

3. Technology Acquisition Assessment

Institution	Function
# MOI - DIP	1. Arrange study tour abroad for medium and small sized factory and also visit and participate foreign trade shows
# MOSTE - NSTDA - TIAC	1. Provide transfer information 2. Consultancy service
# MUA	
# MOF	
# OFFICE OF THE PRIME MINISTER - BOI	1. Contract joint venture
# MOD	
# MOE	
# MOC	
# NGOs - Private banks - industrial societies - Domestic and foreign entrepreneurs - FTI	

4. Quality Products

Institution	Function
# MOI - DIP - MIDI - TISI	1. Service 2. Grading factories according to output quality 3. Support the production of high quality goods 4. Set standard and methodology
# MOSTE - NSTDA	1. Standardization system set-up
- STDB - TISTR	2. Technical consultancy services
# MOC	1. Support quality inspection equipment by lower import tax 2. Market requirement
# MOAC # MUA # NGOs - Societies - Entrepreneurs - TPA - FTI	1. Training and distribution of quality information

-: note

1. Adopt the ISO product standards and ISO 9000 for obtaining improved product quality

5. Information

Institution	Function
# MOI	
- DIP	
- DMR	
- Metallurgy division	1. Metallurgy information center on domestic production, import and export, and international metallurgy data 2. Feasibility study on metallurgical projects
# MOSTE	
- NSTDA	1. Information centers, computerized data bases on materials technology
- TIAC	
# OFFICE OF THE PRIME MINISTER	
- NESDB	
- BOI	
- NSO	
# MUA	
# MOF	1. Information on distribution, domestic consumption and export
- The Customs Department	2. Import/export information 3. Tax information
# MOFA	
# MOAC	
# Bank of Thailand	1. General information on production, distribution, import and export
# NGOs	
- Professional societies	1. Information supply, coordination, distribution
- Industrial Societies	
- Entrepreneurs	
- Abroad Universities/Institutes	
- FTI	
- TPA	
- IFCT	

-: notes

1. Establish a computer base, data base combined with technology

Appendix 5.2 Major Measures, Responsible Units, Time-Frame, Budget and Resources

(Summarized Questionnaire Results from Stakeholders)

APPENDIX 5.2
Major Measures, Responsible Units, Time–Frame, Budget and Resources

MEASURE 1: TAX

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
1. Reduce import tax - lab. equipment - fine measuring equip.	MOF: - Customs Dept. - Revenue Dept. MOSTE/MOC/BOI	Now 1993			
2. Tax incentives for R&D	MOC/MOF/NSTDA	Now 1993			
3. Revenue tax exemption for relocated industry/factory	MOF	Now			
4. Reformation of import regulations	MOF				
5. BOI policy	BOI	1992			
6. VAT decrease	MOF	1993			
7. Tax restructuring to promote industry	MOF	Now			
8. Tax incentives for regional operation headquarters	BOI	1993			
9. Gathering of private sectors' R&D tax informations	MOI/NSO	1993			
10. Study to identify effective tax structure to promote competitiveness in industry	MOF/MOI/MOSTE FTI	1992	10 MB.	5 M-Yrs.	1 Yr.
11. Study the affect of AFTA on competitiveness of local industries	MOF/MOI/MOSTE FTI/TDRI	1993	15 MB.	5 M-Yrs.	1 Yr.

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
12. Feasibility study for overseas equipment company to set-up in Thailand	MOI/FTI	1992	5 MB.	3 M-Yrs.	1 Yr.
13. Study and modify tax structure to promote S&T application in SMI's	MOF/MOI/FTI/ NESDB	1992	50 MB.	25 M-Yrs.	5 Yrs.
14. Project which apply the results of 11-13	MOF/MOI/MOSTE FTI/TDRI	1993	5 MB.	2 M-Yrs.	1 Yr.
15. Study of all the corresponding laws to identify the problems	MOF Prof. Society				
16. Coordination with concerning organization, officials, politicians to reform the law or enactment of promotion laws	Prof./Indus. Society				
17. Review and define medium term 2-3 years tax policy	MOF/NESDB				
18. Review and adjust period-ically	MOF				

Additional comments:

1. It is most important that MOF understands the issue surrounding the tax issues. The new tax policy should show a win-win situation for MOF and that the resulting revenue will increase, expected timing and the measure is crutial to national policy & direction, otherwise it will fail.
   (In fact this requirement holds true for all measure and complete picture must be presented.)
2. Fund raising for setting up professional societies to promote various activities in each field/industry by collecting special import surcharge (for example: collect 0.5% of import for 3 years etc.)
3. BOI and other offices under MOF should cooperate to promote tax reduction for the companies which apply R&D. The reduction should be year-by-year basis to prevent tax incentive abused.
4. The National Statistical Office should have a responsibility and authority to gather tax data from the BOI and other offices under MOF. It should cooperate with MOI to up-date data from industry. These will help the government to acquire accurate R&D and technology data from private sectors and can facilitate in S&T policy formulation.

MEASURE 2: INFORMATION CENTERS

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
1. Main Information Center - integration in existing sources through computer network - linkage with other information centers - complete data bases on market, raw materials, domestic demands, technology, machine & Equipment, export oriented industry, training, patent, demand & supply - update data every 2 years	MOSTE/NSTDA/TIAC Technolgy Transfer Center MOI	Now 1993	50 MB/Y 200 MB	50 M-Yrs.	5 Yrs. 5-10 Yrs.
2. Information sub-center	Government Orgn. Technological Institute	Now	50,000 B /y/unit	1-2 M-Yrs.	5 Yrs.
3. Provide funding support to acquire text book and journals from various sources	MOSTE	Now	100,000 B /y/unit	1 M-Y.	5 Yrs.
4. Semianars	MOSTE	Now	1-2 MB/y	2-5 M-Yrs.	5 Yrs.
5. Improvement of industrial data source to be able to effectively device to industry	Office of Industrial Economics DIP/NSTDA				
6. Promotion of technical journal publication	MOSTE/MOF/FTI	1992			
7. Establishment of information center for each materials (metals, ceramics & polymers)	MOI/DIP/MIDI NSTDA Office of Industrial Economics MTEC		6 MB	10 M-Yrs.	1 Yr.

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
8. Identify all existing info.	NSTDA		0.25 MB		
9. Put together a plan for information center (IC)	NSTDA		0.25 MB		
10. Set up controlling body to run IC. (hopefully private sector)	NSTDA		0.10 MB		

Additional comments:

1. Sufficient information, journals, texts is a must.
2. Meeting and seminars facilitate information transfer.
3. Setting up a responsible body is only partial success, maintenance is a must.

MEASURE 3: TRAINING INSTITUTIONS

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
1. National manpower policy	MUA/MOSTE/MOE MOI	Now	200-300 MB /Y	800-1500 M-Yrs/Y	5 Yrs.
2. Relationships or linkage between govern.-academic and industry	MOSTE/MOI	Now	50-100 MB /Y		5 Yrs.
3. Specify specialization and center of excellence in the universities and government institutions	MOSTE/MOI/Industry	Soon	50-100 MB /Y		5 Yrs.
4. Strengthen vocational school	MOE/NSTDA	Now			
5. Provision of scholarship to university, vocational school for students at all levels	NSTDA/Industry	Now			
6. Providing and supporting facilities and human resource	MOSTE/NSTDA/TISTR MOI/MUA	1993	200 MB/Y		
7. Identify training needs	MOE/MUA/NSTDA				
8. Training of trainers	MOE/MUA/NSTDA				
9. Design training courses - various needed technology - technology transfer - export promotion - testing / RD&E - basic technology / new technology	MOE/MUA MOSTE/NSTDA DIP				
10. Looking for expert	MOE/MUA/NSTDA				
11. In-house training accord-ign to each company needs	MUA/NSTDA/Industry	1994 Now	1,000 MB		3-5 Yrs.

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
12. Professional education in university level	MUA				
13. Skill development fund set-up for technicians from industry	MOF/FTI	1993	collecting from factory or salary basis		10 Yrs.
14. Set-up of training centers for specific subjects	MIDI/DIP/NSTDA/TISTR DMR/Matallurgy and Materials Science Research Institute	Now			
15. Training in Ind. technology	BOI and TPA MIDI/NIST	Now		Output 20,000 Man-day in the first year and ~100,000 Man-day in the 5 years	Con.
16. Determine the missing capability	NSTDA				
17. Thai German Technical Institute		3 Yrs.	500 MB		Con.
18. Customer training center for multinational - companies	BOI	Now			
19. Come up with plan to build up, consistent with established goals	NSTDA				
20. Set up "Teaching factory" type institutes simular to German-Singapore Technical Institute	NESDB/NSTDA/FTI	Now	100 MB	10 M-Yrs.	3 Yrs.
21. New University Acts to allow more flexibility, dynamism and new system of management should respond better to country need	MUA/Parliament	Sep 1992			

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
22. Gradually convert gov't technical institutes to be come "teaching factory"	MOE/MOIT	Now			5 Yrs.

Additional comments:

1. Exchange of experts between each institution for technology transfer.

MEASURE 4: FUNDING

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
1. Technology transfer	MOSTE/BOI/MOI NSTDA	1993	100 MB/Y		Cont.
2. Study for strategy to raise fund	Prof./Ind. Societies				
3. Low interest loan for R&D	Bank of Thailand	Now	30% of total loan from each bank		
4. Funding support for the active society	MOF				
5. R&D fund	NSTDA/USAID	1993			
6. Overseas scholarship for education & training					
7. Fund for the development of specific industry	NGOs/MOI/MOF/ MOSTE	1993			
8. Take 0.1% of industrial tax to support RD&E and professional societies	MOF/MOI/MUA/ MOSTE/Industrial	Now			1-3 Yrs.
9. Set up industrial fund 50/50 from industry and government (this money will be use for the propaganda of Thai technology and products for export promotion	MOF/MOI/MOC MUA/MOSTE	Now	300 MB		1-5 Yrs.
10. Set-up of modernization scheme for SMI's appropriate field	MOF/MOI/FTI	1993	200 MB		5 Yrs.
11. Identify the need for funding (amount, area and timing) come up with short & long term plan to be self sufficient					

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
12. Extra income from training centers and data circulation					
13. Special budget from govn't for investment in initial stage of professional institute sponsoring R&D project conducted by external researching group as well as staff of prof. institute					
14. Increase R&D funding for private industry R&D to correspond to 7th plan (0.25% of GNP)	FTI	Now			

Additional comments:

1. Many of the identified areas may have to be subsidized at first, however funding should eventually be drawn from industry

MEASURE 5: PROFESSIONAL SOCIETIES

Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
1. Law to enforce the company to be professional society members and to pay for membership fees	MOI	Now			
2. Government should promote the set-up of professional society and provide funding and management supporting at the initial stage	MOI/MUA/MOE	Now			
3. Promotion of professional societies to be centers of - training - information services - consultancy services - study tour to access technology - coordination for the benefit of members	MOI/FTI	Now			
4. Linking professional societies or related groups (ie. government, industries, academic) for harmonic activities	NSTDA	Now			
5. Promotion of the accumulation of industrial organizations to promote professional societies	NGOs/MOI	1995			
6. Strengthening present professional societies		Now	100 MB		5-10 Yrs.
7. Determine the number of active societies					
8. Establish goals for these societies					

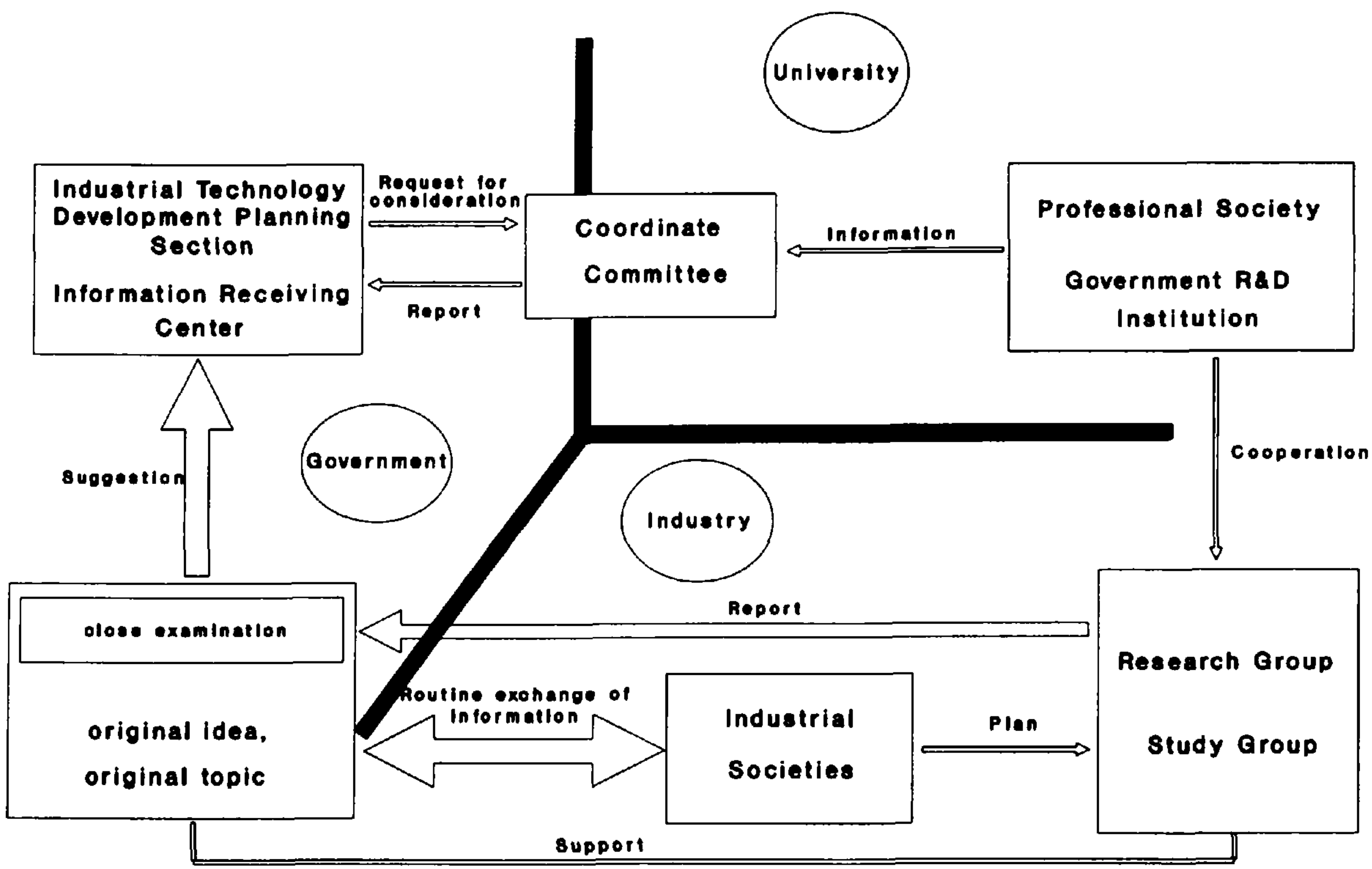
Activity	Responsible Unit	When to Start	Resources Needed		
			Budget	Man-year	Duration
9. Build up so that societies can serve their members					
10. Reduce number of societies by consolidating (merging) simular societies.	FTI/MIDI	Now			

Additional comments:

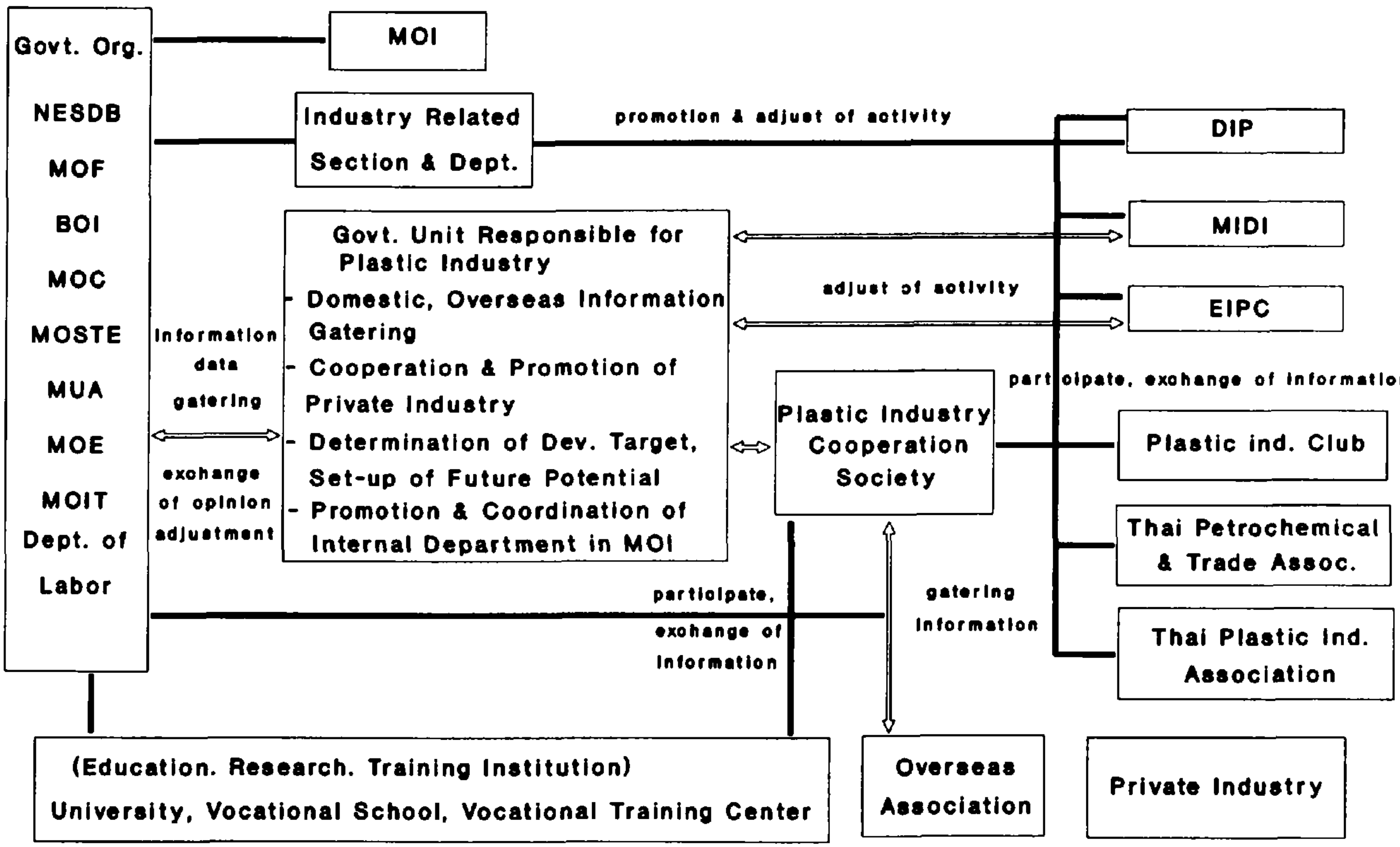
1. Funding support is the major problem. Funding may be acquired from the government and various activities (seminars, exhibition, information membership fee).
2. Recruitment of professional manager such as FTI manager.
3. As much as government sector needs to be committed, private sector through professional societies need to be committed to long-term goals and not just short-term, self-serving issues.

Appendix 5.3 Examples of Tri-party Cooperation in Japan and in Thailand

a) The Relationship between Government and Private Sectors in RD&E Topic Determination in Japan



b) The Relationship between Government and Private Sectors in RD&E in Thailand



Appendix 5.4 Evolution of Industrial Technology Policy in Japan

Appendix 5.4 Evolution of Industrial Technology Policy in Japan

1945 Revival of Economy Period

- Industrial standards Law (1949)

1950 Korean War

- Rationalization of industry
- Export promotion
- Technology import measures (control of foreign reserves)
- Mechanical Industry Promotion Law (1956)
- Electronic Industry Promotion Law (1957)

1960 High Growth Period

- Heavy Chemical Industry
- Giant Project Promotion (1966)
- Tax exemption for expansion of RD&E (1967)
- Funding support for important RD&E (1968)
- Increasing of University, Technical manpower, Vocational school & colleges

1970 Steady Growth Poriod

- 1st oil shock
  Start Sunshine Plan (1974)
- 2nd oil shock
  Start Moonlight Plan (1976)

1980 Focus for creative Intellectual

Start RD&E system for the development of technology for supporting industry of the "next generation"