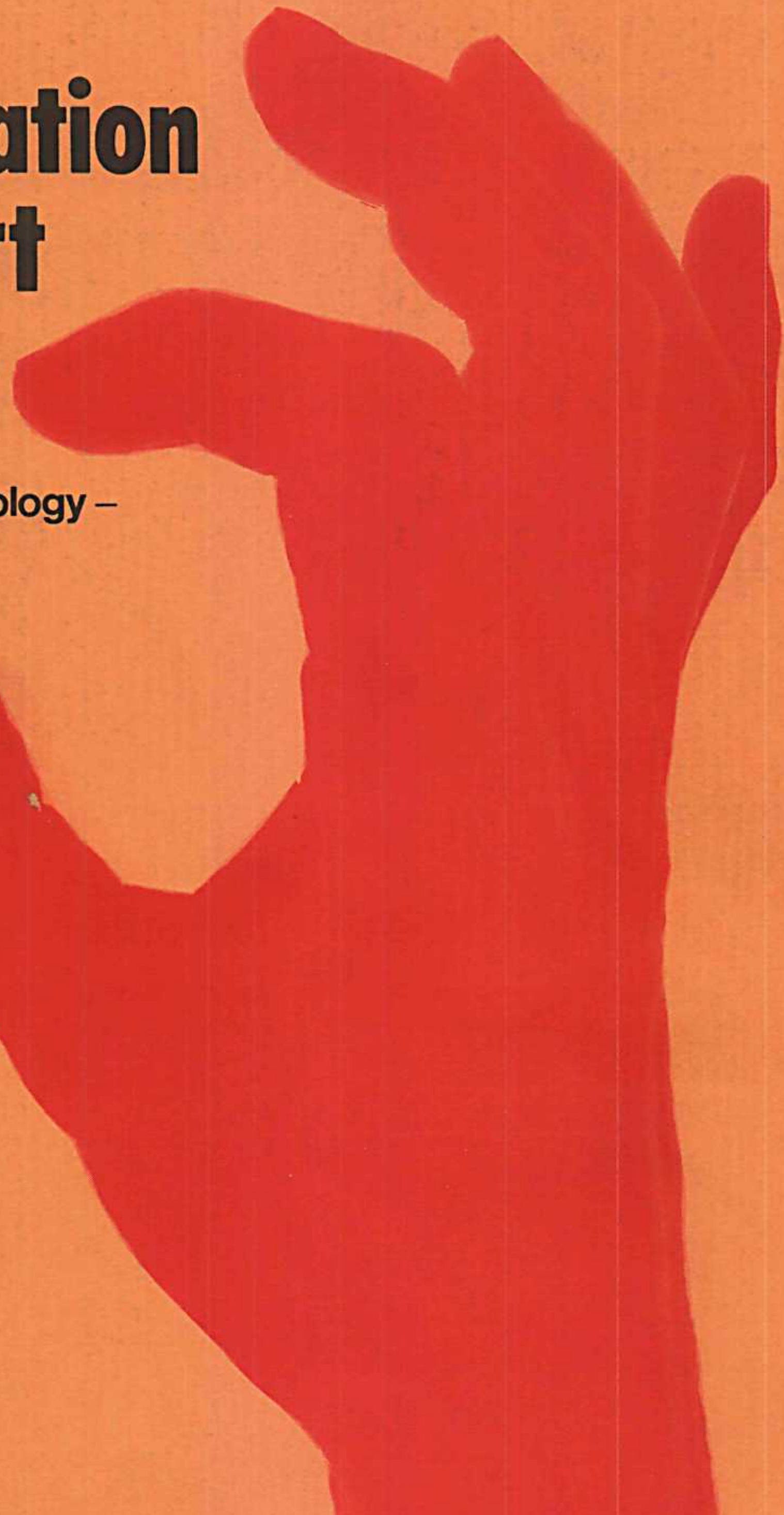
Evaluation Report 4.81

Industrial Tribology – India



NORAD
Direktoratet
for utviklingshjelp

EVALUATION REPORT OF PROJECT IND 014 AND THE INDUSTRIAL TRIBOLOGY, MACHINE DYNAMICS AND MAINTENANCE ENGINEERING CENTRE (ITMMEC) AT THE INDIAN INSTITUTE OF TECHNOLOGY IN DELHI

PREPARED FOR THE NORWEGIAN AGENCY FOR INTERNATIONAL DEVELOPMENT (NORAD)

AND THE INDIAN MINISTRY OG EDUCATION

AND SOCIAL WELFARE.

SEPTEMBER 7, 1981.

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The views and interpretations in the Report are those of the authors and should not be attributed to the Norwegian Agency for International Development (NORAD).

PREFACE

This report and evaluation of a project to assist in establishing an industrial tribology centre at the Indian Institute of Technology in Delhi has been prepared for NORAD and its counterpart in India. The findings and recommendations are based on fact finding missions in India in July, and in Norway in August 1981. A summary of the background, our major conclusions and recommendations appear in the Executive Summary. For anyone who is not familiar with the Centre, we recommend a reading of the report from an evaluation mission sent by NORAD in 1976, before the decision was taken to provide assistance. The contracts between the various parties involved in the project provide additional information. In the appendices we have provided detailed information on various critical resources and elements of relevance to the establishment of the Centre. The appendices also give information on the engineering education, and research and development in India, to provide the reader with some understanding of the environment which affects a technological centre located within an engineering institution of higher learning.

September 7, 1981
Gothenburg and Lund, Sweden
Delhi and Bangalore, India

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ABBREVIATIONS

BHEL	=	Bharat Heavy Electricals Ltd.
(the) Centre	=	ITMMEC
IIT	=	Indian Institute of Technology
IND 014	=	the Project
ITMMEC	=	Industrial Tribology, Machine Dynamics and Maintanance Engineering Centre
JINEC	=	Joint Indo-Norwegian Evaluation Committee
NOK	=	Norwegian Crowns (US $ 1 = NOK 5.99)
NORAD	=	Norwegian Agency for International Development
NTH	=	Norwegian Institute of Technology (Norges Tekniske Høgskole)
NTNF	=	Royal Norwegian Council for Scientific and Industrial Research
(the) Project	=	The project under which the NORAD aid to ITMMEC is administered (IND 014)
R&D	=	Research and development
Rs	=	Indian Rupees (US $ 1 = Rs 8.70)
S&T	=	Science and technology
SINTEF	=	The Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology

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EXECUTIVE SUMMARY

Objectives

A major objective for the Joint Indo-Norwegian Evaluation Committee (JINEC) was to assist NORAD in making the decision whether Norwegian assistance to the Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre, ITMMEC, at the Indian Institute of Technology in Delhi was to continue and make recommendations on requirements for possible further assistance to the development of the Centre. The Norwegian assistance is given under Project IND 014 which also regulates the relationship between the Centre and the Norwegian partner - The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF).

The Centre has been established to serve Indian industry in the area of industrial tribology which has a strong focus on problems related to bearings, lubrication and wear and more generally to maintenance and the reliable functioning of complex industries. We have sought to determine, whether there is a demand for the kind of services which the Centre can provide, considering the immediate need in Indian industry. We have also considered the demand for sponsored research of a more general nature, industrial training programmes and also more academic activities, although geared to industry.

Having established the demand for the services which the Centre can potentially provide we have analyzed initially the resources available to the Centre and studied its present mode of operation and need for changes. The Centre has come into existence through a close collaboration with an industrial research centre in Norway and during our work in India we realized the necessity to scrutinize the resources and activities of the Norwegian counterpart.

In addition to the more fundamental objective we were also, as specified in the terms of reference, asked to provide answers to more specific questions regarding the Centre and its relationship with SINTEF.

Activities

During a three week period of field visits in India we had discussions with a number of private and state owned companies, research institutes and government agencies. We had extensive discussions with the personnel at the Centre including its head, Professor J. P. Sharma, and also with leading personnel of the Indian Institute of Technology, New Delhi. Another ten days were spent in Norway and Sweden visiting industries in order to gain a better understanding of the needs that an industrial tribology centre can serve, the tribological activities in Scandinavia and the usefulness of links between industry and research institutions. An important part of this second period was spent at SINTEF, meeting the people who are responsible for the relations with the Centre in India. A significant portion of time was in both India and Norway spent on reviewing the achievements of the Centre as well as the effectiveness of cooperation between the two partners.

Summary of findings

ITTMEC will not serve the original objectives set up for the Centre unless action is taken to influence major activities of the Centre. The JINEC team has indentified a number of shortcomings in implementing the Project and it must be realized that both sides have contributed to the partial failures. The reasons are to be found in areas such as leadership, understanding of critical elements of the Project and occasional incompetence. These comments are made with the aim of bringing the Project to fruition, and must not overshadow the fact that the Project has been successful in building up considerable infrastructure facilities at the Centre which is not altogether an easy task. However, the Centre has now reached a stage where it is absolutely necessary to formulate a strategy which will guide the Centre and its partners towards meeting the objectives originally spelled out. The need for remedial action is not limited to the Centre itself, but is equally important for its Norwegian partner and our findings have consequences for NORAD as well.

We have come to the conclusion that there is a basic need for the services of an industrial tribology centre like ITMMEC. It is our belief that the Centre can meet a significant part of that need through industrial training, eventually in industrial consultance, in research and generally as a catalyst in creating an awareness and understanding of the problems in industrial tribology. This will, however, require major changes at the Centre. To achieve these we strongly recommend that a phase oriented strategy be formulated as outlined in chapter 7 on conclusions and major recommendations. This will, among other things, include a plan to build up competence area wise taking into account the available infrastructure, the immediate relevance to industry and the time factor. The strategy should also include a plan for equipment procurement to avoid duplication and bias towards research orientation. In addition we strongly suggest that changes are implemented for the Centre in the following four areas: management, organization, training and specialization towards industry, which are all discussed in some detail in chapter 6.

When viewing the establishment of the Centre as a joint project our findings have prompted us to conclude that the responsibilities for the shortcomings in the development of the first phase must be shared by the Norwegian partner. We suggest that the future involvement of the foreign partner - assumed to be SINTEF - is redirected towards not only providing technical assistance in the narrow sense, but - more important - giving guidelines and provisions for assisting the Centre in building up its competence in management, project leadership and analytical capability to identify the needs of Indian industry which can be met by the Centre. However, the final accountability for the management of the Project rests with NORAD, and should not be delegated to SINTEF, to avoid the present situation with SINTEF playing dual roles in the Project.

In a final chapter we have summarized, under separate headings, those observations which we consider to have general applicability to high technology projects involving technology transfer and foreign development assistance. We would in particular

like to stress the importance of the initiation and planning phases where, with the wisdom of hindsight, a number of obvious omissions can easily be identified.

Our findings reveal serious shortcomings both in the development of the Centre, yet to become a fully operational industry-oriented Centre, and in the administration of the Project. We have come to the conclusion that it is possible to redirect the Centre in its second phase of development along the recommendations outlined in the chapters 6, 7 and 8 which also discuss required changes in the Project. Given the real need in India for the services potentially available from the Centre, we recommend that additional resources are provided to the Centre and that NORAD assistance is continued, on the assumption that our recommendations will in the main be adhered to.

1. PREAMBLE

1.1 Appointment of the Joint Indo-Norwegian Evaluation Committee (JINEC)

In a meeting held with a Norwegian delegation and the Indian counterparts in October 1980, it was agreed that a review of the Project (i.e. the NORAD aid to ITMMEC) should be undertaken in 1981. The Ministry of Finance, Department of Economic Affairs, suggested that the review should be undertaken by a joint team of experts consisting of members appointed by authorities in Norway and India.

During May - June 1981, NORAD and the Government of India appointed the following participants in the evaluation team, JINEC:

- Assoc. Prof. Jon Sigurdsøn, Team Leader
  Research Policy Institute
  University of Lund, Lund, Sweden

- Assoc. Prof. Ove Granstrand
  Chalmers University of Technology
  Gothenburg, Sweden

- Prof. L.S. Srinath
  Department of Mechanical Engineering
  Indian Institute of Science
  Bangalore, India

- Shri Ajay Kumar Raman
  Divisional Manager R&D
  Scientific Research Centre
  Escorts Limited
  Faridabad, India

The evaluation task was carried out in July-August 1981. The evaluation team, JINEC, acted as an independent group.

1.2 Terms of Reference

The complete Terms of Reference is given in Appendix I. The following is a condensation of the tasks given to JINEC:

1.2.1 To outline the structure of objectives for the Project in light of higher order policies for Indian industry and foreign aid to R&D,

1.2.2 To assess the mutual fulfilment of contractual obligations,

1.2.3 To evaluate the establishment of ITMMEC with respect to:

- How independence and self-reliance can be secured,
- Recruitment,
- Assistance of Norwegian expertise,
- Training of Indian experts in Norway and elsewhere,
- Equipment,
- The setting of priorities,
- The outer organization of the Project (i.e. the triangle NORAD - SINTEF - ITMMEC),
- The inner organization of ITMMEC,
- The role of SINTEF.

1.2.4 To analyze the relations between ITMMEC and Indian industry regarding:

- The viability of developing parallel activities of interest for rural industries and semi-industrial sectors,
- The likelihood that ITMMEC, once fully established, will be successful in serving Indian industry,
- The past and future involvement of industry in defining the activities of ITMMEC,
- Shortcomings and proposals for establishing cooperation with industry,
- The value of industrial workshops initiated by ITMMEC,

- The viability and consequences of involving Indian industry more directly in the financing of ITMMEC.

1.2.5 To give recommendations regarding the continuation of the Project.

1.3 Concepts

The following concepts and definitions are central in this report:

Tribology: Stands for the science and technology of interacting surfaces in relative motion.

Industrial Tribology: Stands for a wider definition of the technology which has to do with design of mechanical products and equipment and their operation and maintenance with the aim of conserving material resources through a reduction of wear, conserving energy through a reduction in friction, and an increase of the economical operating life of equipment as well as increased standards of product reliability and personnel safety. Thus this wider connotation of industrial tribology, which is adopted in India, covers much of maintenance engineering, which is sometimes called terotechnology. In this report 'industrial tribology' or tribology for short, will be used in this wider meaning.

Research: Research in this report is taken to include development work as well.

Self-reliance: This is not to be interpreted as self-sufficiency in procuring technological knowledge or services but rather the capability of not having to rely on external (foreign) assistance (financial and managerial) in such a procurement.

Independence: This is taken to mean the capability of sufficiently supplying technological knowledge and services from each of several foreign sources or from an indigenous source.

Rural (village) industries: Industries in rural (village) areas. To be distinguished from small scale industries.

Network concept: Stands for the inter-organizational set-up of collaborative relations between various R&D units in a particular field. In this network, coordinative or communicative responsibilities may be assigned to certain R&D units.

1.4 Method

The method adopted has involved:

- Document studies (see List of Documents,)
- Interviews with representatives from industry, academic institutions and government bodies (see JINEC Program,)
- Hearings with research groups of ITMMEC and SINTEF, course attendants and senior managers,
- Evaluations of ITMMEC and SINTEF (as far as industrial tribology is concerned) made by outside researchers and industrialists.

Questionnaires in general were ruled out since ITMMEC had so far not established itself in India. However, in retrospect, it seems that questionnaires to industry could have been a complement to interviews in assessing priorities for equipment and problem areas based on industrial needs. (Such a survey was made in 1972, but did not result in establishment of explicit priorities.)

The selection of companies for visits and interviews were made on the basis that all industrial sectors to which tribology is most relevant should be covered. The sample of companies was chosen in a semi-structured way. Also the interviews were conducted in a semi-structured way.

In using a joint team for evaluation, the composition of the team is crucial. The experiences in this respect are presented on p. 76.

1.5 Assumptions and limitations of the report

The following assumptions have been made:

1.5.1 Foreign assistance is needed and welcomed by India in new, emerging technologies or in filling technological gaps.

1.5.2 Part of NORAD's aid to India should be used for projects involving advanced technology.

The following limitations pertain to this report and the results presented herein:

1.5.3 No in-depth survey of industrial needs in the field of tribology has been undertaken.

1.5.4 No comparative analysis, including other centres in India, was done in order to find out the necessary requirements, and limitations, in establishing a high technology centre using development assistance from abroad.

2. HISTORY AND CONTEXT OF THE PROJECT

2.1 Background and chronology of the Project

The chronology of the Project is shown in Figure 1. The build-up of resources of ITMMEC is shown in Appendix. (See also p. 27.) Section 5.2 gives the history of SINTEF involvement in the Project.

A short, and necessarily sweeping, review of the context of the Project is perhaps in order. India has a large domestic and international market for her industrial output. At the same time, she is rich in natural resources, skilled man-power and low-wage labour. India today has the world's third largest stock of scientific and technical manpower, after USA and USSR. The technology procurement strategy has to a considerable extent been geared to joint ventures with foreign partners, which may be contrasted to a pure license acquisition strategy as adopted by Japan. Since the 1970's an increasing emphasis has been laid on the build up of indigenous R&D, often concomitant with phasing out foreign partners. Various industrial sectors and technological fields are gaining priorities in this transitory stage. One field, which has gained recognition, is industrial tribology and maintenance. This area is often neglected both in developed and developing industries thus presenting large pay-offs for problem solving. The recognition of the importance of tribology and maintenance is now (1981) wide-spread in Indian industry, although the term tribology is not always used. The build up of various indigenous capabilities in industrial tribology and maintenance takes place at different locations in the economic system. Such capabilities regard identification and diagnosis, trouble-shooting, design, research and development. Locations for build up include industrial production, design and R&D departments as well as collective R&D institutes, university centres and departments and national research laboratories. A partial list of Indian resources in industrial tribology is given in Table 1. Thus, a situation has been created in which the network concept apply. However, it is important to realize that no single unit in this network can serve the whole industry or even a whole sector or state in the area of industrial tribology and

TABLE 1

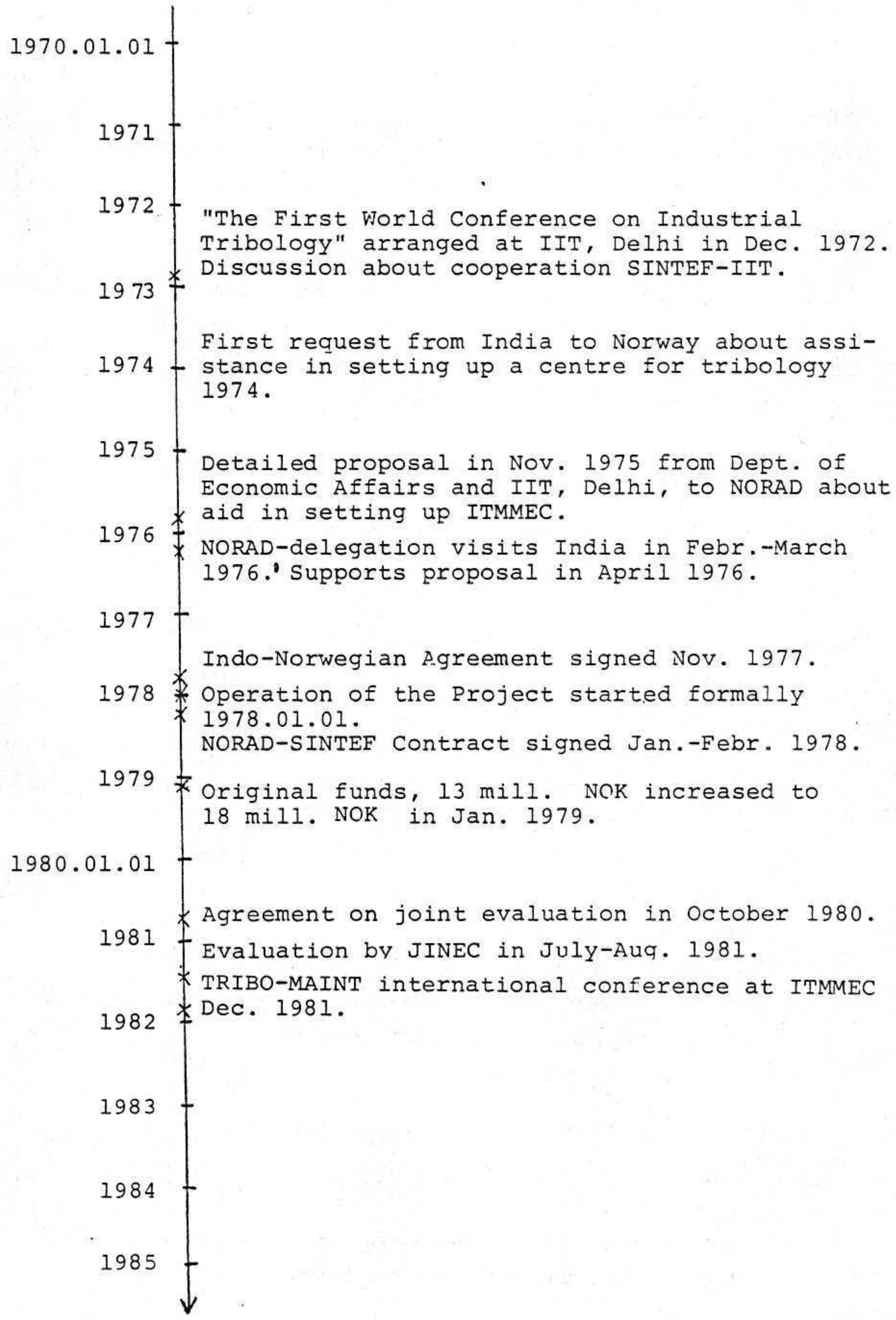
TRIBOLOGICAL ACTIVITIES IN INDIA (PARTIAL LIST)

Name of Institutions where Industrial Tribology & Maintenance Engineering Research (R)/Development (D)/Consultancy (C)/Teaching (T)/Industrial Services (IS) are carried out and Short-term courses for Industries (SI) as long term goal	Industrial Tribology & its associated subject	Maintenance
1. ITMMEC, IIT Delhi	R&D, C, T & IS	SI
2. IIT Madras	C & T & R	T & R
3. IIT Bombay	T & C	Nil
4. IIT Kharagpur	T & R	Nil
5. IIT Kanpur	T & R	Nil
6. IISc. Bangalore	T & R	-
7. MN Regional Engineering College, Allahabad	T	-
8. M A College of Technology,Bhopal	T	-
9. Regional Engineering College, Warangal	T	-
10. Centre of Plant Engineering Services, Hyderabad	C, IS, SI	SI & IS
11. Central Mechanical Engineering Research Institute Durgapur	R&D, SI	-
12. National Productivity Council	SI	SI & IC & IS
13. University of Roorkee	T&R	Nil
14. Regional Research Laboratories, Trivandrum	R&D	-
15. TISCO Jamshedpur	R&D	IS
16. Research & Development, Steel Authority of India, Ranchi	R&D	-
17. Bharat Heavy Electricals Ltd. Hyderabad	R&D	-
18. Engineers (India) Ltd.	-	IS
19. Ahmedabad Textile Industries Research Association	-	SI
20. Indian Institute of Petroleum, Behradun	R&D	-
21. Research, Design and Development Organisation of the Ministry of Railways, Lucknow	R&D	

maintenance. Also it is likely that not only the average level of competence in an industrial sector is increasing, but also the inter- and intra-sectorial differences in levels of competence are increasing.

In this context, ITMMEC has come into existence as one out of several locations for build-up of an indigeneous capability. It has come into existence through a particular mode of technology transfer, the set-up of a joint venture with a foreign partner, SINTEF, co-financed by NORAD and IIT - Delhi (through the respective governments). The agreement was initially for cooperation during 1978-1981 with NORAD/SINTEF providing equipment and training and IIT/ITMMEC providing personnel, management and infrastructure.
The joint venture has been labelled Project IND 014. The chronology of the Project is given in Figure 1. It should also be noted that ITMMEC was not created in a vacuum. To a large extent the Centre was inbred in the Department of Mechanical Engineering at IIT, Delhi. Dates for core staff recruitment is given in Appendix X. The fact that 3 persons has acted as Head of the Centre within a short time is noticeable.

FIGURE 1
CHRONOLOGY OF PROJECT IND 014



2.2 History of equipment procurement and reasons for time and cost overruns

A main unplanned change during the course of the Project so far has been the time and cost overruns regarding the build-up of equipment at ITMMEC. The Indo-Norwegian Agreement of 2nd November, 1977, for the establishment of ITMMEC envisaged supply of equipment worth NOK 7.3 million out of total Norwegian assistance of NOK 13 million for the Project. Due to late starting of the project, escalation in the cost of equipment, change in design of equipment as per Indian conditions etc. Norwegian authorities agreed to an upward revision of the equipment component from NOK 7.3 million to NOK 12.3 million thus increasing the total Norwegian assistance to NOK 18.0 mill. The assistance was phased over the 4-year period 1978-1981.

The chronology has been as follows:

1977 The agreement was signed in November 1977.
First comprehensive list of equipment prepared.

1978 The operation of the project began in 1978. By July/August letters were sent to collect specifications of equipment available at that time in the market. By the end of the year, evaluation of specifications of the equipment started at SINTEF.

1979 It was then estimated that if all equipment were delivered by 1980, the total cost of equipment would be NOK 13 million.
A request was then made in 1979, and an additional amount of NOK. 5 million was approved. The phasing of the capital for procurement of equipment was tentatively made as:

Year 1979	Year 1980	Year 1981
NOK 4.38 mill.	NOK 3.554 mill.	NOK 3.550 mill.

The actual tenders were then called for by SINTEF-Norway, for procurement of these equipment in late

1979, as per the above phased budget, and some equipment were then delivered.

1980 The prices then started escalating and this upset the equipment budget.

The equipment cost estimate was then reviewed again in July 1980, and it was observed that all approved equipment would cost around NOK 18-20 million. The manufacturers agreed to deliver the equipment by 1982, provided orders for all the equipment in principle were placed by 1981. But no guarantee was given if the orders were placed beyond the year 1981. This would then demand further upward revision of the cost of the equipment.

1981 All year-wise procurement lists revised once 1981-82 requirements were made firm. Additional requirements of NOK 11 million, conceived at ITMMEC.

The reasons for the hike in equipment cost have been attributed to:

1) Delays in the operations of the Project have made initial price estimates obsolete, due to inflation and the introduction of new models of equipment.

2) Elaborations of equipment lists during the course of the Project revealed that an upgrading of the quality of equipment and more spares were necessary. This was recommended by SINTEF.

These two reasons roughly account for equal parts of the cost hike.

The delays in equipment procurement and installation have been attributed to several reasons, such as:

. The amount of international communication involved
. Slow response by suppliers
. Non-availability of technical and supplier information
. Price fluctuations during negotiation stages
. Damages during transit

. Problems with insurance, customs clearance etc.
. Routing of equipment over SINTEF
. Lack of service and installation capacity.

As an illustration a specific case is given below.

The case of procuring the GC/MS equipment.

In summary the procurement of the Gas Chromatograph/Mass Spectrometer, GC/MS, had the following features:

1) A GC equipment was conceived of as an item on the 1979 list of equipment to be procured at ITMMEC. This list was made by ITMMEC and was received at SINTEF in 1978. The cost was initially estimated to 150.000 NOK to be paid by NORAD. In June 1979 Prof. Sharma suggested to SINTEF that this item on the list to be changed to a GC/MS. The decision as to type of equipment was taken by the Indian side, mainly Prof. Sharma.

2) GC/MS is an expensive instrument with applications to a large extent falling outside the field of tribology. There are GC/MS equipments available at other places in India, probably also at IIT, Delhi.

3) The competence in using GC/MS as well as a GC/MS was outside the Machine Design part of SINTEF but in the chemistry part of SINTEF/NTH.

4) Decision to procure taken in early Autumn 1979. The procurement procedure from call for tenders by SINTEF in Oct. 1979 up to decision on supplier and order took 8 months, in 1979-1980, which when going into detail was not abnormal considering the complexity of the equipment and the amount of international communication involved.

5) In the process of visiting suppliers, Prof. Sharma was personally active while the main work, of call for tenders and additional visits to suppliers and their demonstrations (e.g. JEOL in Japan) was carried out by Mr. Gåsvik and Mr. Fremstad of SINTEF. Dr. Jagga at ITMMEC,

during his stay at SINTEF, carried out the bulk of scrutinizing and evaluating different suppliers. About 60% of Dr. Jagga's training time at SINTEF was consumed by work with equipment procurement.

6) The availability of service on GC/MS in India was a main parameter in the choice of supplier and piece of equipment. The main evaluation of this parameter was made by Prof. Sharma, who in January 1980 recommended SINTEF to choose JEOL on this ground. The majority of tenders were received at SINTEF in February-March 1980.

Mr. Fremstad and Mr. Gåsvik found some support during Spring 1980 for the high service availability of JEOL in India, since JEOL had installed four GC/MS's in India.

7) In the final choice of JEOL, made by SINTEF and agreed upon by Prof. Sharma in June 1980, main attention was paid to the service availability. The "Rolls Royce" of GC/MS, Micromass, was not chosen.

8) The cost for the JEOL piece was 1,4 mill. NOK This was over 9 times the initial budget for the item on the list. NORAD was informed about this as late as in June 1980 and reacted immediately. SINTEF persuaded NORAD to order, which was done in late June 1980.

9) JEOL delivered rapidly to ITMMEC in September 1980 but in July 1981 ITMMEC was still waiting for JEOL personnel to install and start up the machine, despite the claimed service availability of JEOL. Helium gas was also missing, requiring at least 6 months for delivery.

3. PRESENT STATUS OF THE PROJECT AND ITS CONTEXT

3.1 Importance of industrial tribology in the national scene

The term "Industrial Tribology" as given in this report covers the technology that is concerned with the design of mechanical products and equipment, and their operation and maintenance with the objective

(i) to conserve material resources through reduction of wear,
(ii) to conserve energy through reduction of friction,
(iii) to increase the operating life of the equipment through maintenance engineering,
(iv) to increase standards on product reliability and personnel safety.

In a developing country like India, the importance of industrial tribology is self-evident. In order to achieve increased productivity, one should take care to see that machines are kept in good operating conditions with minimum down-time. A common source of functional disturbance in mechanical equipment and maintenance is the wear factor. Proper scientific and technological knowledge in this critical subject area is often lacking and sufficient work has not yet been done on this aspect. Even in developed countries, the annual maintenance cost of mechanical equipment amounts to 10-20% of the initial investment. A sample survey conducted by IIT-Delhi in 1972 during the First World Conference on Industrial Tribology indicated that introduction of even minor maintenance and tribological improvements in Indian industries will result in significant improvements in the performance and production abilities. The frequent break-down of hydro and thermal power stations in India have been attributed to inadequate maintenance practice of these plants. The serious consequences of these frequent break-downs on critical industrial sectors like steel, coal, cement etc. are felt year after year.

It is difficult to think of any industry, small or big, where tribology does not play a role. Lubrication, seals, bearings, wear, etc. are important aspects associated with the operation of any mechanical machinery. In the process of becoming technologically self-reliant, a country like India has to

acquire sufficient capability in the varied aspects of tribology, like development of a wide variety of lubricants; design of appropriate seals and sealings; design, development and production of ball, roller and other types of bearings not only to reduce friction but also to take thrust and other types of forces; monitoring of wear and other critical quantities to avoid or reduce breakdowns of operating machines; etc.etc.

The Government of India and the State Governments are fully cognizant of the importance of industrial tribology and associated aspects. The large number of research and development projects sponsored by their agencies, and the establishment of tribology cells in many R and D organizations, reflect the importance given to this vital subject. The National Productivity Council (NPC) and many professional societies (like the Institution of Engineers), have organized a fairly large number of courses and training programmes for the benefit of industries. Many universities and technical institutions offer regular courses in the area of tribology and have undertaken many research and development projects in the area. A very important component of tribology deals with the development of suitable wear-resistant materials to meet different environmental conditions. The Department of Science and Technology and the Ministry of Education have established Advanced Material Science Centres to undertake R&D activities on various aspects of material science, some of which deal with materials development from a wear resistance point of view.The awareness of industries towards the importance of tribology is not lacking. Several laboratories under the Council for Scientific and Industrial Research are actively engaged in many aspects of industrial tribology.

However, lack of sufficient information, trained personnel, lack of standard test procedures, etc. are serious constraints. The industries are aware that introduction of advanced and systematic methods and technologies of maintenance and repair will result in significant savings and increased productivity.

The subject of Industrial Tribology, Machine Dynamics and Maintenance Engineering which is multi-disciplinary in nature

is a very appropriate subject for effective collaboration between the university and the industrial sector. This has been the explicit goal of ITMMEC at IIT-Delhi. As stated in the original report from the 1976 mission (see Appendix IV):

> "... the purpose of ITMMEC is to further the industry-oriented research and development activities at IIT-Delhi in the field of Industrial Tribology, Machine Dynamics and Maintenance Engineering, and within this field to foster the cooperation between the institute and industry and commerce, as well as with other research organisations."

3.2 Technology gaps in tribology and related areas

The awareness of the importance of industrial tribology in the Indian industrial scene and the desire to become technologically self-reliant have brought into sharp focus a variety of shortcomings like lack of adequate information, insufficient R&D activities in the area of tribology, lack of trained personnel, lack of suitable testing and standardisation procedures, inadequate training programmes for persons in industries etc. While it is difficult to list all the technology gaps that exist in the area of industrial tribology in the context of India, still one can mention a few important examples to illustrate the point. In the case of power industry, a wide variety of ball, roller and thrust bearings are used. The design, development and production of these bearings call for a sophisticated technological know-how which does not exist to the fullest extent in India. In addition to this, the evaluation of the performance charactertics of bearings require standard test procedures and suitable testing equipment. The Indian know-how in this context is very much limited. In the area of anti-friction bearings, India is yet to make a beginning. In the area of failure analysis, sufficient competence does not exist. Maintenance management is yet another area where trained personnel are not available. The development of a sufficient level of technology base and the know-how in the field of tribology requires significant financial input, R&D infrastructure and a well planned organised approach. However, full implementation of these aspects are restricted due to several constraints.

3.3 Methods to overcome technology gaps in industrial tribology and available resource centres

A cross sectional survey of the Indian industries, R&D establishments, Universities/Academic institutions, Government plans etc. reveals a wide spectrum of activities and plans that have been undertaken to fill the gaps at a fast rate. Development plans in the field of industrial tribology is one of the components in the national S&T plan of the country. As mentioned earlier, a large number of universities and academic institutions have incorporated into their regular curricula courses in the area of tribology. Many research and development projects in this area are sponsored by several financing agencies like the Dept. of Science and Technology (DST), the Council for Scientific & Industrial Research (CSIR), etc. Many Public Sector Enterprises like Bharat Heavy Electricals, Indian Oil Corporation, Hindustan Petroleum etc. have fairly big tribology laboratories and have plans to expand them not only to find solutions to existing problems, but also to develop their own indigenous capability to tackle anticipated problems. Many bearing manufacturing companies have their own in-house set-ups in the area of tribology. The R and D division of the oil companies have been able to provide Indian substitutes for lubricants and greases which used to be imported. There appears to be a general degree of satisfaction so far as these lubricants substitutes are concerned. The Ministry of Education have made deliberate plans to promote advanced centres, in IITs and other academic institutions, in areas of relevance. The ITMMEC at IIT-Delhi is one such centre.

The National Productivity Council in collaboration with several professional societies have organised at regional and national levels courses and training programmes for persons from industries and R&D establishments. Under the Quality Improvement Programme of the Ministry of Education, intensive courses in the area of tribology have been organized to upgrade the level of knowledge of engineering college teachers in this area. ITMMEC has effectively participated in all these programmes. Wherever feasible and desirable, foreign assistance in the form of technical expertise, finance, training, etc. have been obtained.

In brief, the survey indicates that efforts are being made in several fronts in an organised manner to increase the indigenous technological know-how and to increase the level of self-reliance in the field of tribology. As a result of all these efforts, today, there exists in India a host of institutions and organisations where activities in the field of tribology are taking place.
Table 1 on p. 7 lists a few of the academic institutes, R and D organisations and other organisations, where activities in the area of tribology are being pursued.

3.4 Present status and plans for ITMMEC

The Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre at the Indian Institute of Technology, Delhi, came into operation in the year 1978 after the signing of an agreement between the Governments of India and Norway in November 1977. Under this agreement a sum of 13 mill. NOK (increased to 18 mill. in 1979 due to an upward revision) were made available by the Norwegian Government to cover the 4-year operational period 1978-1981. This amount was meant to cover:

(i) the expenses connected with the consultancy services provided for in the contract between the Norwegian Acency for International Development (NORAD) and the Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF);

(ii) The expenses connected with training of IIT-personnel in Norway;

(iii) the costs of purchase, insurance and transport of equipment and materials required for the implementation of the Project.

The purpose of ITMMEC as has already been stated is to further industry oriented research and development activities at IIT-Delhi in the field of industrial tribology, machine dynamics and maintenance engineering; and within this field to foster cooperation between the Institute and industry and commerce as well as with other research organisations. The activities of

the Centre are controlled by a Coordination Committee, an Advisory Committee, and a Management Committee. The advice and decisions of these Committees are implemented by the Head of the Centre. The constitution and the role of each of these Committees are given in Appendix IV.

At present, the Centre consists of 17 core-staff members and about 24 supporting staff members. According to the organisational structure of the Centre the research and development activities of the core-staff have been classified into the six groups below. The names of the core-staff members and their areas of activities appear in Appendix X.

I. Lubrication and Oil Analysis
II. Wear Resistance Technology and Analysis
III. Diagnostics and Condition Monitoring
IV. Equipment Performance
V. Failure, Design Audit and NDT (Non-Destructive Testing)
VI. Maintenance Management.

It is reported that since September 1978, nine persons from core-staff have gone to Norway to receive advanced training, in-depth exposure to the use of the equipment relating to their areas of specialization, and to work on "Joint Projects" with personnel of SINTEF-Norway. The periods of these visits have ranged from 3 months to 10 months. From SINTEF, about 8 persons have visited ITMMEC and the duration of these visits have ranged from one month to two months. A few of them have made repeated visits to ITMMEC. (See Appendix VI and VII.)

During the last 3 years, equipment to the tune of NOK 4 million per year have been procured by ITMMEC. Appendix VIII gives the list of equipment that have been delivered, equipment that have been ordered, equipment that are currently under procurement process and equipment that the Centre wishes to procure. Among the major equipment that have already arrived at ITMMEC, about 80 per cent have been installed and commissioned. The remaining are in various stages of unpacking, installing and commissioning.

ITMMEC receives considerably resources from IIT-Delhi and also directly from the Ministry of Education. On the basis of data compiled by the Centre we have attempted in Table 2 to show the major components of the resources allocated to the Centre since 1977.

The largest component is salaries and wages, allocated by IIT, for faculty and staff which is planned for Rs. 0.35 million in 1981. Out of a total of 22 faculty positions 15 have already been filled, another 4 are expected to be filled and 3 to remain open for the time being. It should be noted that salaries and wages are not channeled via the Centre.

The next largest component are budget allocations - recurring and non-recurring - given by the Ministry of Education to the Centre although routed via IIT. Non-recurring budget allocations are used for capital expenditure. Another large budget post is maintenance of buildings, infrastructure and costs for telephones, electricity and water for which only estimates are given.

The table shows an allocation of Rs. 0.6 million for buildings in 1978 which are the estimated costs for the 650 m^2 already provided. The costs for providing additional space would today cost considerably more than Rs. 1,000/m^2. In this context it should also be noted that most of the faculty are provided with housing and other infrastructure facilities within the campus of IIT-Delhi.

The various components added together indicate Centre has a budget from Indian sources of Rs. 0.9 million per year and Table 2 gives a total of Rs. 3.6 million for the period 1977-1981.

TABLE 2

ITMMEC FINANCIAL ALLOCATIONS FROM MINISTRY OF EDUCATION AND IIT-DELHI

(Million Rs.)

Category	1977-78 Actual	1978-79 Actual	1979-80 Actual	1980-81 Actual	1981-82 Plan
A. Ministry of Education - Recurring	0.058	0.160	0.168	0.313	0.297
- Non Recurring	0.150	0.200	0.085	0.209	0.219
B. Salaries and wages (faculty/engineering staff/supporting staff)	0.168	0.230	0.270	0.300	0.350
C. Building constructions		0.600			
D. Maintenance of buildings and infrastructure + charges for telephones, water and electricity		0.100	0.200	0.200	
E. Furniture		0.075	0.050	0.078	
F. Library (jointly with IIT)			0.010	0.010	
TOTAL	0.376	1.365	0.783	1.110	0.866

GRAND TOTAL 1977-81: 3.634

The Centre is the process of developing certain infra-structural facilities like: Tribo-Science Laboratory, Tribo-Engineering Laboratory, Tribo-Dynamics Laboratory, Anechoic Chamber, Vibration Isolation Table, Computer Room, and Fabrication Workshops. Simultaneously with these, the Centre has also been engaged on the design and fabrication of several jigs and fixtures for various research projects.

In an institute like IIT, the demand for covered space with all facilities like water connection, electricity, maintanance, etc. is at a very high premium. The administration of IIT-Delhi has to evaluate every project about its financial commitment, space allocation, infra-structural facilities etc. keeping in view its priorities, demands and the Institute's goals. As of March 1981, 650 m^2 of space has been made available to ITMMEC. An additional space of 350 m^2 has been promised, making up altogether 1000 m^2 of covered space. A visit to the laboratories indicate that the space provided now is not at all sufficient.

In the process of procuring equipment from Norway and other foreign countries, SINTEF is very closely involved. The mode of identification of the equipment and the procuring processes are given in the Progress Reports. Considerable delays in the procurement and commissioning of equipment exist. These delays have been attributed to a variety of reasons like non-availability of technical literature on the equipment, slow response to queries by the suppliers, price fluctuations during the negotiation stages, damages during transit, insurance problems, customs clearance, etc. It is stated that the identification of the equipment is done keeping in view the activities of the Centre. The price escalations (due to inflation) of equipment during the aid period have not been adequatly taken into consideration.

Currently, ITMMEC is involved in three major areas of activities:

(i) Organizing short and long-term courses for persons from industries and other organizations in selected areas of tribology. These courses are meant to bring an awareness

among the industrial participants and also expose them to the latest techniques and knowledge in these areas;

ii) Offering consultancy services to industries in areas where ITMMEC expertise lies. So far, this has been a very minor component;

(iii) Organizing long term programmes leading to M. Tech and Ph.D degrees to participants from industries and other organizations. The M. Tech programme is of 2-year full-time and 3-year part-time durations.

4. ASSESSMENT OF PRESENT GOAL FULFILMENT

4.1 External goals

Total value of the secondary sector in India amounts to Rs. 169.000 million which equals 20 billion US Dollars. This amounts to 23% of the country's gross national product. The value of the manufacturing sector is Rs. 73.000 million with an additional Rs. 43.000 in the unregistered sector. The most important manufacturing sectors are textiles, chemicals and metallurgy.

A large number of production lines and industrial enterprises have come into existance through the collaboration with foreign partners. The total number of such agreements since mid 1950's totals more than 6,000 although most of them have now been phased out. A short presentation of the situation in Indian R&D is given in Appendix XIII.

Obviously there is a strong need for facilities and competent personnel which can solve problems related to failures and maintenance in sectors such as power industry, steel industry, railways and road transportation. Similar problems including those of cutting fluids and lubrication oils exist throughout the engineering industry which is presently undergoing a rapid expansion. Many of the industrial needs were identified and documented in the original proposal to NORAD in 1975. In this context, it should be noted that this proposal and the Norwegian evaluation in 1976 and the subsequent agreement in 1977, all assume that modern large scale or medium scale industry are in the focus.

Thus, it was possible to identify the needs for a centre to serve industry in areas such as tribology and preventive maintenance. It must, however, be pointed out that tribology carries a much wider definition than is usually the case outside India. From the identification of the industrial problems and their possible solutions, one could derive the need for instruments and equipment - most of which could not be obtained in India.

In this context, IIT-Delhi decided to submit a proposal to NORAD. Most recently, an Indian Review Committee has studied the role of foreign technical assistance received by the Indian Institues of Technology of which there are altogether five. The Committee says that

> "... foreign technical assistance has had a significant impact on the IITs and in turn on the technical education system in the country. It has helped to develop expertise at international level and to build-up competent R&D infrastructure in a wide variety of scientific and technological fields."

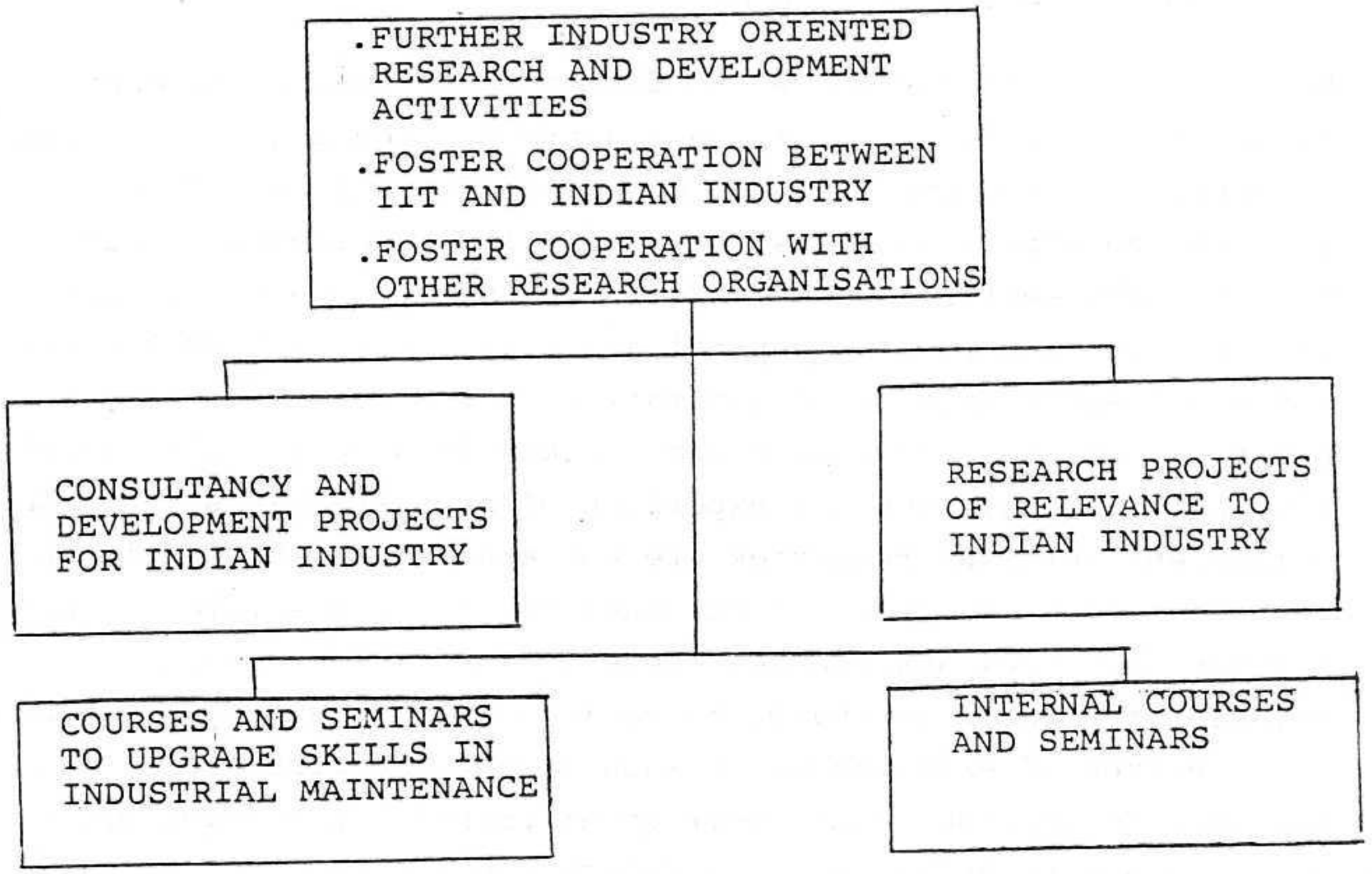
But the report stresses that no foreign technical assistance programme should perpetuate the country's dependence on foreign expertise and support. And the Committee further points out that the objective must also be to develop "indigenous capabilities and self-reliance". Notwithstanding these, the IITs may benefit from foreign capital aid - as distinct from foreign technical assistance on collaboration to replace old obsolete equipment and to consolidate and further develop areas in which they have already acquired expertise of high standards, in case sufficient internal resources are not available. The Committee had identified 15 areas - 3 for each IIT - for possible further foreign technical assistance. These areas which have been selected for their relevance to national needs may be developed into centres of excellence. In such areas, the IITs are expected to interact with their counterparts in foreign countries on a continuing basis to reduce the lag in developing these areas in India. 25 more areas have been identified which may be considered for foreign collaboration on equal partnership basis.

4.2 Obligations in agreements

The establishment and operation of the Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre in New Delhi, is spelt out in two legal documents. The first one, signed on the 2nd of November 1977, is between the Government of the Republic of India and the Government of the Kingdom of Norway. The second one is a contract between the Norwegian Agency for International Deve lopment (NORAD) and SINTEF. These two documents regulate the Centre and the Project respectively.

Before discussing in what ways and to what extent the obligations have been fulfilled, it may be useful to illustrate in a diagram the various objectives mentioned in the first agreement. See figure 2.

FIGURE 2
PLANNED PURPOSES AND OBJECTIVES OF ITMMEC (THE INDUSTRIAL TRIBOLOGY MACHINE DYNAMICS AND MAINTENANCE ENGINEERING CENTRE)



In the following we will only comment on objectives which have not been fulfilled assuming that all others not mentioned have in the main been fulfilled. Before doing so, it would be useful to repeat the background of the Project. The original proposal from IIT-Delhi envisaged a five year project with a total outlay of Rs. 36 million during the period. The NORAD sponsored evaluation mission in 1976 recommended a 4 year project with a total input to ITMMEC of NOK 13.9 million of which NOK 10.9 million would come from NORAD. NORAD agreed to provide NOK 13 million for the period 1977-1980 which was increased to NOK 18 million in an amendment.

The annexure says in article 2 that IIT shall at the invitation of the Centre make available 1000 m^2 of laboratory and building space for the activities of the Centre. An additional 500 m^2 shall be made available in due course. The real outcome was very different which is evident from Table 3.

TABLE 3
YEARWISE ALLOCATION OF SPACE TO ITMMEC

Year	Covered space provided	Total space available
1978, Dec.	150 m^2	150 m^2
1979, Dec.	100 "	250 "
1980, Sept.	150 "	400 "
1981, March.	250 "	650 "

The delay in providing the necessary space may, originally, not have posed any serious problem to the Centre because of similar delays in hiring staff and procuring equipment all of which are discussed further on in this report. However, more recently, the non-availability of space has become a serious hindrance.

In spelling out the collaboration between IIT and SINTEF the annexure says that this will mainly take the form of joint participation in:

1. Personnel education and training with the object of familiarizing personnel with advanced methods and techniques of relevance to the Indian industry.

2. Joint research projects of common interest within the field of industrial tribology and maintenance. These projects should be actively pursued both in India and Norway and should be organized for the optimum use of common research resources.

3. Joint participation in industrial research and development programmes. In Norway, this should be achieved by integrating visiting Indian personnel into appropriate programmes which the consultant - that is SINTEF - is carrying out in collaboration with Norwegian industry. In India, the consultant should take part in consultancy and development

projects which the Centre will be carrying out for Indian industry.

There have been serious short-comings in regard to all three aspects. Though, a fairly large number of persons have been recruited for the Centre, the picture regarding their experiences and background indicates a wide variation. The Centre does not appear to have made serious attempts to develop competence and expertise in a limited number of areas and recruit personnel accordingly. There are areas with just one or two persons. Formation of strong groups in a limited number of critical areas would have been desirable. Regarding points 2 and 3 above, very little has been achieved. The joint projects that are reported to have been undertaken, appear to be mere paper projects. In spite of the fact, that these two aspects are critical to the ITMMEC as well as to SINTEF, no organized approach appear to have been pursued. Equipment procurement, recruitment of personnel, training programmes at SINTEF, all have gone in a very haphazard way without any directional approach. One may concede that, given the likelihood of delays in recruitment of staff and procurement of equipment, a project period of four years may be insufficient to undertake joint projects of industrial nature, still, a strategy towards achieving this goal should have emerged. Unfortunately, no clear picture emerges from the present situation.

In this connection, the functioning of the Advisory Committee has not been very functional. This committee, consisting of about 15 members, including a significant number of representatives from industries, is supposed to

> "... endeavour to secure proper and necessary interaction with industry and particularly ensure that unnecessary duplication is avoided. It is important that the Committee seeks to keep the work of the Centre attuned to the needs of the industry at all times."

The manner in which the Committee is scheduled to meet and operate cannot possibly fulfill this obligation.

The second legal document is a contract between NORAD and SINTEF regulating the consultancy services which are required

for the establishment of the Centre. The document provides details of the scope of the services from SINTEF to the Centre, regarding equipment procurement procedure, personnel training, remuneration and payments, etc. The Terms of Reference require of SINTEF to advise and assist the Centre in all respects, so as to enable it to get established and to fulfill its objectives towards industrial tribology. In this respect, SINTEF has not altogether fulfilled its obligations of providing proper training to ITMMEC personnel, advising and assisting in research projects and participating in industrial research projects. It was required that SINTEF submit a quarterly report describing the progress of the project with respect to its obligations and plans. The reports submitted by SINTEF do not discuss the fundamental problems of the joint venture. However, SINTEF has fulfilled its obligation concerning assistance in equipment selection, procurement and necessary quality control.

4.3 Service of ITMMEC to Indian industry

The Centre can serve Indian industry in four major areas:

1. To carry out research projects on problems which are of critical importance to industry, sponsored by industry, research councils or other agencies.

2. To provide training in the form of seminars, workshops, training programmes, and other academic degree oriented courses.

3. To carry out consultancy projects sponsored by industrial enterprises on commercial basis.

4. To build up a documentation base and library in the area of tribology.

Research projects. The Centre has so far not carried out any sponsored research. This perhaps could not be expected in light of delayed procurement of equipment, non-availability until recently, of space for laboratories and the relatively inexperienced staff at the Centre.

The 1978 report mentions that joint projects would be actively pursued both at ITMMEC and SINTEF, and a list of 10 projects was given. The following five projects were given priority.

1. Rotor dynamics,
2. Diagnostic maintenance studies,
3. Wear studies and reliability,
4. Vibration analysis on turboblades,
5. Weight reduction.

The 1979 report lists the same ten joint projects and mentions that some of the projects were started during the year although most others were still only in the planning stage. Furthermore, the actual project work of the first 5 priority projects of 1978 might have undergone changes due to personnel reasons. This information is followed by a comment that the activity in 1979 had been far less than planned, due to the priority given to equipment procurement. The 1980 report repeats the same comments almost identically, stressing the priority given to equipment procurement. In Table 4 we summarize information on the status of joint projects as reported by SINTEF.

The information given above clearly indicates that the joint projects have played only a marginal role in the ITMMEC/SINTEF activities. It also shows that the original plan for joint projects became obsolete due to the preoccupation with the procurement of equipment and instruments and the late arrival of these. Furthermore, the viability of some joint research projects changed due to changes in personnel and activities of the Machine Design Division at SINTEF. In light of these, we consider that the group should have formulated a new and a more realistic plan for joint research projects which would have contributed to the competence build-up at ITMMEC during the phase of equipment procurement.

TABLE 4

STATUS OF SINTEF/ITMMEC JOINT PROJECTS

Project	Planned		Priority	Main Activity
	Year	Memo		
1. Rotor dynamics	1978	180472.70-1	Yes	Computer program modified, Design of journal bearing test rig completed.
2. Diagnostic maintenance	1978	180472.70-3 180473-1	Yes	Experiments on roller bearing test rig. Training in Ferrography and particle counting.
3. Wear analysis	1978	180473-1	Yes	Literature survey on manganese steels. Ion plating project scrapped because SINTEF no longer active in this area.
4. Blade vibrations	1978	180472.70-2 180472.30-3	Yes	TV-holography.
5. Low weight design	1978	180473-1	Yes	No activity.
6. On-site repair techniques	1978			No activity.
7. Noise reductions	1978	180473-1		Activity planned in 1981 (?)
8. Bearing performance/EHD	1978	180473-1		Some development on models and programming. Awaiting equipment and instruments to be installed by the end of 1981 or in 1982.
9. Seals	1978			No activity.
10. Planned maintenance	1978			No activity.
11. Boundary lubrication	1980			Required equipment expected to be available in 1981-82.

Industrial projects

The SINTEF annual report of 1978 mentions that this acitivity includes exchange visits of senior personnel to work on industrial projects in both countries and exchange of experience on research and consultancy. No projects were initiated in 1978, and none were carried out in 1980. However, an attempt to work in this area was done. In June 1979 a request for project assistance towards "Appraisal of Maintenance Management and Diagnostics in Faridabad Thermal Power Station" was made by ITMMEC and was approved by NORAD.[1] The project which was to be carried out over approximately 18 months and cost about Rs. 500.000 involving more than 10 people envisaged the following phases:

- Preliminary survey for budget and project proposal.
- Survey of faults and analysis.
- Implementation of recommendations.
- Monitoring and evaluation.

It was also decided that Mr. E. Engebretsen, Chief Engineer of the Ship Research Institute of Norway, should participate in the project for a period of 9 weeks, part of which would coincide with a workshop held at ITMMEC.

However, due to various reasons, the project was abandoned in the middle. A joint industrial project of this nature, which obviously involves considerable amount of earlier preparation, should not have been undertaken without assuring oneself a certain degree of possible success. Neither ITMMEC nor SINTEF was in a position to undertake such a joint venture.

Industrial consultancy

The Centre has over the past few years received a large number of enquiries and proposals for consultancy projects. Occasionally the Centre has entered into negotiations and even submitted proposals in areas where the Centre has not yet developed a

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1) The information is available in SINTEF project memo 180473.30-1 prepared by E. Engebretsen, January 31, 1980.

competence. As an indication of this attitude we provide in Appendix V a list of possible consultancy projects which was drawn up in 1980. The expected fees from these projects amounted to Rs 3.8 million.

The realized consultancy projects, however, are much more modest, which is evident from the table displayed in the same appendix. Almost all projects with the exception of a bicycle rickshaw project sponsored by the Ministry of Transportation have generated very little income and the total fees of all sponsored projects in Appendix V is in the region of Rs 0.15 million during 1978-80.

An analysis of the activities of the Centre in consultancy projects and training programmes reveal that the training programmes have been more significant in terms of finance than consultancy activities. This is evident from the information provided in Table 5.

TABLE 5

INCOME GENERATED FROM CONSULTANCY AND TRAINING PROJECTS AT ITMMEC (thousand Rs)

Category	1978	1979	1980
A. Consultancy			
- Industry	20	16	23
- Government agencies	10	10	75
- Others	5		
Sub-total	35	26	98
B. Training	--	96.8	101
Total	35	122.8	199

Training

The strength of the Centre has so far been in its training programme which is a natural outcome as the Centre is an integral part of the Indian Institute of Technology, Delhi. In this context we would like to stress that ITMMEC is one of several centres at IIT-Delhi, all of which have the same status ad departments such as Mechanical Engineering, Chemistry etc.

A PhD research programme was initiated in the late seventies. The total number of PhD students now is 10 of which four are full-time students. Details of the programme are given in Table 6. In addition to the PhD programme, the Centre is also involved in a M. Tech. degree programme. This Masters degree programme lasts 2 years for full time students and 3 years for part-time students. All these students are people working in industry. However, only a very small number of them are actually sponsored by industry.

The training programme more directly geared to the needs of industry are the workshops or seminars of which eight have so far been arranged, in most cases under joint sponsorship with other agencies. Information on the workshops is given in Table 7. Special reports were prepared for four of these workshops and the contents of the reports appear in Appendix XI.

TABLE 6

Ph.D. PROGRAMME AT ITMMEC

	Project	Student	Time	Supervisor
Full-time	Some study in Boundary Lubrication in the field of lubricant film formation & failure	A.D. Telang	4.9.78 - early -82	Prof. J.P. Sharma Dr. C.R. Jagga
	Polymer Application in Tribology	V.K. Gosh	1.9.79 - approx.-82	Prof. J.P. Sharma Dr. C.R. Jagga
	Preparation & Evaluation of Lubricants	B.S.S.R.V.Rao	April -79 - approx.-83	Prof. J.P. Sharma Dr. C.R. Jagga
	Physio-Chemical Studies of Lubricants	S.C. Sharma	28.7.80 - 1983	Dr. U.S. Teswari Dr. Vasudevan
Part-time	Erosive Wear Studies in Pipe bends	V.K. Agarwal	May 1980 -	Prof. J.P. Sharma
	Signature Response for Rolling Contact Bearing	O.P. Gandhi	1975 -	Prof. J.P. Sharma
	Signature Response for Gears	A. Prakash	1975 -	Prof. J.P. Sharma
	Elastic Hydrodynamic Lubrication	S.C. Sharma	1979 -	Prof. J.P. Sharma
	Lubrication	B.G. Murlidhar	July 1980 -	Dr. S. Biswas
	Multilobe Bearings	B. Banerji	1977-81	Prof. J.P. Sharma Dr. Biswas

TABLE 7
WORKSHOP/SEMINARS ORGANIZED BY ITMMEC

Subject	Sponsor	Time Duration	No. of participants
1. Diagnostics of rotating machinery	ITMMEC	1978.01 2 weeks	99
2. Tribo Terotechnology for Engineering College Teachers	ITMMEC ISTE	1979.11/12 7 days	30
3. Diagnostics maintenance and health monitoring of power plants	ITMMEC ISTE	1979.12 6 days	35
4. Wear monitoring through oil analysis	ITMMEC ISIT	1980.3 3 days	30
5. Tribology aspects on machine tools	ITMMEC I Mech.E(I)	1980.4 6 days	15
6. Bearings and lubrication	ITMMEC ISIT I Mech.E(I)	1980.10 2 days	35
7. Diagnostics and condition monitoring	ITMMEC TDC	1980.12 4 days	27
8. Seals and sealing techniques	ITMMEC TDC	1981.4	35

ISTE - Indian Society for Technical Education
ISIT - Indian Society for Industrial Tribology
I Mech E(I) - Institution of Mechanical Engineers (India)
TDC - Tribology and Diagnostics Council

Recently there has developed an awareness at the Centre that there exists a need for training which falls between the traditional academic training and the very brief workshops/ seminars. Therefore the Centre has started to make preparations for a training programme for maintenance engineers working in various power plants in India. The discussions were initiated after the Power Engineer Training Society approached the Centre. The course which is expected to take place in late 1981 or early next year, will draw on faculty from ITMMEC and the departments of mechanical engineering and electrical engineering. It is expected that this course will be more industry-oriented than earlier courses, since work on case studies brought by the participants will constitute a major element of the proposed training programme.

5. ROLE OF SINTEF IN THE OPERATION OF THE PROJECT

5.1 Background on SINTEF

SINTEF is an organisation, established over 25 years ago, to be able to undertake R&D activities with the following objectives:

(a) Promote industrial research;
(b) Develop cooperation in this area between the industry and Norwegian Institute of Technology (NTH);
(c) Develop cooperation between SINTEF and other research organisations.

To be pragmatic in its approach, to be able to handle the industrial projects/problems, it was decided from the very inception of SINTEF that it work in close cooperation with NTH, so as to have a useful interaction between faculties of SINTEF and NTH. While there is an organizational separation between NTH and SINTEF there is a very close physical and personnel integration. This is evident from the Machine Design Division where 16 members belong to the Norwegian Institute of Technology, see Table 8. The group of seven people at SINTEF responsible for the collaboration with ITMMEC is found within this Division.

TABLE 8
STRENGTH OF PERSONNEL AT SINTEF MACHINE DESIGN DIVISION

Category	August 8, 1980	April 7, 1981
Researchers	26	30
Technicians	4	5
Workshop employees	2	2
Secretarial staff	4	4
Administration	2	2
SINTEF only	37	43
+ members of the Norwegian Institute of Technology	16	16
SINTEF only	53	59

In order to provide the reader with a reference of the industrial tribology projects undertaken at SINTEF during the period of collaboration between SINTEF and ITMMEC we have listed in Table 9 all major tribology projects. The table also provides information on sponsor, total contract fee and year of completion. These 20 odd projects have over this period generated between 1/3 and 1/2 of the income of the Department of Machine Design. From the information provided it is obvious that SINTEF has a capability to undertake sponsored research projects of various types within the field of industrial tribology. But it must not be overlooked that the capability at SINTEF - in terms of equipment and manpower - is dependent on what particular projects are being carried out at a given time.

The composition of SINTEF contracts and grants is as follows:

. Basic grants, primarily from RNCSIR[1)]	6,5%
. Project grants, mostly from RNCSIR	30 %
. Contracts with industry	30-40 %
. Contracts with public agencies	30-35 %

SINTEF's involvement in projects in developing countries, other than the Tribology Centre in Delhi, includes two minor projects in two divisions - Industrial Economics and Industrial Chemistry. In addition the Division of River and Harbour Laboratory has received two contracts in the range of NOK 1 million, one of which is a program for training students coming on NORAD scholarships.

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1) Royal Norwegian Council for Scientific and Industrial Research (NTNF).

TABLE 9
MAIN PROJECTS IN TRIBOLOGY, MAINTENANCE TEROTECHNOLOGY AT SINTEF 1976-81

No.	Name	Sponsor	Start	Finish	Economy[2]
236	Abrasive wear	NTNF[1] + Industry	73	77	900,000 + industry
237	Maintenance Norcem	NTNF + Industry (Norcem)	73	77	700,000 + industry
235	Plastics in Machine design and lubricating wear	NTNF + Industry	73	76	350,000 + industry
271	Polishing wear in manufacturing	NTNF + Industry	74	77	180,000 + industry
	Ball mill wear proj.	Industry	75	78	200,000
	Wear of abrasive resistant materials	Industry	76	78	200,000
400	Erosive wear under mass transport	NTNF - Industry	77	81	700,000
401	Info-Service Terotechnology	NTNF - Industry	77	-	700,000
366	Start Tero Information Centre	SINTEF Industry	76	-	
405	Transmission elements	NTNF - Industry	77	78	250,000
406	Terotechnology modules, operation	NTNF - Industry	77	78	200,000 + industry
407	Terotechnology, design aspects	NTNF - Industry	77	78	200,000 + industry
428	Condition monitoring, Lomotives	NSB (Norwegian National Railway)	78	81	150,000
509	Hydraulic systems, wear in operation	NTNF Industry	78	80	200,000 + industry
468	Tero engineering of production systems	NTNF	78	80	300,000 + industry
470	Industrial maintenance laboratory	NTNF Industry	78		300,000
471	Maintenance system data bank	NTNF Industry	78	81	700,000
546	Building of 3 wear test machine	Industry	77	79	220,000
493	Human and Organizational aspects of maintenance	Safety Offshore SPS	79	-	2,000,000
544	Terotechnology,management system	NTNF	80	81	450,000
548	Tero/Maintenance System Statoil	Industry	80	80	200,000
560	Condition monitoring wear in hydr. systems	Nordforsk	80	-	550,000

[1] NTNF = Royal Norwegian Council for Scientific and Industrial Research.
[2] NOK, all figures have been rounded.

(cont'd)

No.	Name	Sponsor	Start	Finish	Economy
572	Computer based condition monitoring system	PPCoN (Phillips Petroleum Co.)	80	80	150,000
OTTER	Maintenance simulator	PPCoN	81	-	100,000
588	Computer based condition monitoring system	NTNF Industry	81	-	275,000 + industry
592	Maintenance consideration in engine design	SPS (Security on the Shelf) + Industry	81	-	200,000 + industry
472/ 473	NORAD tribology projects - IND 014	NORAD	78	81	3,200,000
465/ 554	Safety valves operability, reliability, maintability	NPD (Norwegian Petroleum Directorate)	78	81	900,000

5.2 History of SINTEF involvement in the operation of the Project

At the 1972 conference on Industrial Tribology the idea of international cooperation within the field of tribology was initiated and discussed between Dr. Sharma, Department of Mechanical Engineering, IIT-Delhi, and Professor Christensen, SINTEF, In the following years informal discussions were held with the same persons. During the course of these discussions the possible financing of the venture through Norwegian foreign aid was considered, in which also Reidar Østvik and Kristian Tønder, both from SINTEF, participated. The initiatives by the two persons resulted in a proposal from India to Norway, applying for foreign aid for the cooperation conceived. The need for tribology in India had already been recognized for some years and in fact Dr. Sharma had been selected by IIT-Delhi for a PhD-education in tribology in United Kingdom in the 1960's. In the Indian search for forms (centres, schools of tribology etc.) and possible foreign partners for building up indigenous capabilities in tribology, the initiative to involve SINTEF and NORAD came conveniently and was assessed to be desirable by the Indian authorities. The alternative to involve some other body than SINTEF as the main partner together with Norwegian foreign aid does not appear to have been seriously considered, neither by the Indian nor the Norwegian side. Once Norway was given as a development assistance partner, SINTEF was considered to be natural partner for the Indian Centre.

The Indian proposal from 1974 was after request then reworked and a new, more detailed proposal was submitted to Norway in 1975. A Norwegian mission was then appointed by NORAD to evaluate this proposal. The background, terms of references, members and summary of findings of this mission is given in Appendix IV. The proposal assumed a close collaboration between IIT, Delhi and SINTEF, through the accomplishment of joint research projects. An explicit evaluation of the resources and competence of SINTEF in tribology was never made by the Indian

authorities. However, the activities of SINTEF were known through its publications and leading personalities at IIT-Delhi visited SINTEF in the mid 1970's and made their personal observations. At this time there were only two persons at SINTEF and NTH, Trondheim, which had tribology in a narrow sense as a speciality although in fields related to tribology there were additional persons. So, the total number of people active in industrial tribology was around ten. An expansion for SINTEF in the field of tribology was conceived of in 1974, but did not materialize and in 1981 there has rather been a shrinking of activities compared to the situation in 1974.

The 1976 mission supported the Indian proposal and laid the main foundation of ITMMEC in terms of objectives, management, organization, economy, range of activities, priorities etc., and thus was most decisive in the process of establishing the Centre. The Indian side had proposed a financial contribution from NORAD of 8,296,000 NOK over a 4 year period. The 1976 mission, supporting this proposal, in addition proposed an additional contribution of 2,593,000 NOK for covering the SINTEF manpower input, based on the cost level of early 1976. Thus about one fourth of the total foreign aid conceived was proposed to go domestically to SINTEF although this share was later on decreased when the allocation for equipment procurement was increased. The 1976 mission claimed that SINTEF had been active in the field of industrial tribology and maintenance for more than 15 years, which was obviously the case in areas such as wear analysis, and in addition had considerable competence in handling R&D problems for industry. The conceived collaboration between IIT-Delhi and SINTEF included:

a) Personnel education and training in using advanced techniques of relevance to Indian industry.

b) Joint research projects of common interest in industrial tribology and maintenance.

c) Joint participation in industrial R&D programs through integrating Indian visiting personnel in SINTEF's industrial R&D projects and SINTEF's visiting personnel in consultancy

and development projects carried out by the Centre in Indian industry.

A Project Manager from SINTEF was proposed with part time residence at the Centre. Also it was proposed that SINTEF was made responsible for the NORAD component of the project within a framework laid down in a separate agreement between NORAD and SINTEF, and that an ITT-SINTEF Coordination Committee was established with 2 + 2 members responsible for:

a) Assessing progress reports and make recommendations for annual budgeting of funds available from NORAD.

b) Handle details of cooperation.

Based on the 1976 mission, contracts between NORAD and ITMMEC and between NORAD and SINTEF were signed in November 1977 and Jan-Febr 1978. See Appendix II and III for the contracts. These contracts essentially followed the recommendations of the 1976 mission. SINTEF was given an advisory role to both IIT and NORAD. SINTEF was also to provide professional support for training Indian personnel in Norway, to draft annual budgets for the Project and to be responsible for keeping approved budgets. Also SINTEF was to be responsible for the procurement and arrangement of acceptance control of equipment financed by the Project. Finally SINTEF was to advise and assist in joint research projects and participate in integrated industrial R&D programmes in Norway and India as spelt out by the 1976 mission. In fulfilling its obligations SINTEF was free to sub-contract after formal approval by NORAD, which has also been done although only marginally.

Thus there was a large amount of continuity between the 1975 proposal from India, the 1976 mission report and the 1977-78 contracts. NORAD appears to have exercised minor influence in the general conception of the Project, a situation which was normal to many NORAD projects at the time. It also appears that NORAD informally became committed to the project at an early stage, maybe as early as in 1975.

The objectives of the Project were formulated too optimistically

and SINTEF personnel did not take on a responsibility corresponding to their informal influence in launching the Project. In fact, while formally confining the SINTEF role to an advisory one and leaving the management responsibility to, the Indian side with NOPAD as a financier both of SINTEF and ITMMEC within the Project, a situation had been created where the managerial capability of SINTEF was not fully utilized. Furthermore, we would like to stress that SINTEF had the dual roles of being the monitor of the Project on behalf of NORAD as well as being a technical collaborator to ITMMEC. This is not to be interpreted as a fundamental criticism of the effectiveness of SINTEF in carrying out its contractual obligations in the Project. Also it must be noted that there was a wish from the Indian side to take on the managerial responsibilities, and that both NORAD and SINTEF were inexperienced in this type of project involving the international transfer of high technology.

However, in evaluating the process of initiation and formulation of the agreement we have found shortcomings. Some parts were missing in the process of reaching agreement:

a) A close evaluation of the technological and managerial capability and proper role of SINTEF in the Project.

b) An effort geared towards the formulation of realistic objectives and an initial strategic plan for the Centre, with priorities based on non-superficial surveys of needs in Indian industry.

c) An attention paid to possibilities to involve and transfer foreign managerial capabilities in the Project.

Some parts of the agreement were obviously missing:

a) A clause regulating the sharing of inflationary effects and other components of budget overruns.

b) A requirement that in addition to annual plans and budgets, strategic plans had to be prepared and the procedure and responsibility for formulation and execution of these plans.

5.3 Contributions by SINTEF to ITMMEC

SINTEF has, both at the organizational level as well as at the individual level, been playing several roles during the last four years. Some of these roles form part of the obligations explicitly stated in the agreement and some are implicit. These activities of SINTEF have been categorized into the following three groups for convenience of discussion.

Equipment Procurement

Since the financial component pertaining to equipment forms a substantial part of the aid, one of the major roles of SINTEF is to assist ITMMEC in the process of appropriate equipment procurement. The Draft Report submitted by ITMMEC (1980) describes in broad terms the methods followed in equipment procurement. In practice, it appears, that the identification of a particular unit or an equipment and its specifications originate from ITMMEC. Since the latest and up-to-date information on many of the units may not be readily available in India, the participants who come to SINTEF from India for training, spend considerable amount of their time at SINTEF in drawing proper specifications, corresponding with the firms and suppliers for quotations, finalising equipment selection, etc. The time consumed for this purpose varies from 25% to 70% of a participant's stay at SINTEF.

Also, during the identification and selection process of the equipment, it has been the practice for SINTEF staff to participate in trips abroad and visit the firms or laboratories where these units are being used.

The receipt of the equipment from the suppliers and its assembly is to be done at SINTEF which is in accordance with the contract. This is being done to ensure that the units are in working order and that they function properly under various environmental conditions. The units tend to remain at SINTEF for periods ranging from 6 months to 18-20 months. This practice appears to have developed with the full knowledge and approval of ITMMEC. During such long periods, the SINTEF staff get an opportunity to work with the equipment getting them-

selves familiarised with the use of the equipment. The process offers definite benefits to SINTEF and also to its Indian counterparts who receive suitable training when they go to SINTEF.

In regard to certain very expensive equipment, judicious judgement does not appear to have been exercised either on the part of ITMMEC or on the part of SINTEF. Expensive research-oriented equipment have been procured without taking into serious consideration their immediate utility to the activities of ITMMEC. Furthermore, the procurement of equipment does not appear to follow any definite pattern, fitting into a strategy to build up area-wise competence and priorities do not appear to have been established.

Training and competence build-up

In the process of imparting training to participants coming from ITMMEC, the part played by SINTEF has rather been haphazard. The reports submitted by Indian participants indicate that the training programmes provided by SINTEF staff themselves, have been marginal. Not much attention has been given to this important aspect by the Project Management Group at SINTEF. In many areas of industrial tribology, at a given time, SINTEF has not been able to offer training and expertise. So, a number of participants have been sent to countries, other than Norway, to receive training in areas where adequate facilities do not exist at SINTEF. While this approach is good and desirable, the durations of visits have been too short to provide full benefits. A more carefully structured approach should be considered as soon as possible.

Efforts towards competence build-up has also been at a very low key, and this is a matter for serious concern. The training programme in many cases have been primarily towards the familiarization and acquaintance aspects of the equipment newly procured for ITMMEC. Participation of Indian visitors in the real industrial problem solving process has been very limited. This may be due to several reasons. Identification of the areas in which competence build-up is necessary, areas in

which SINTEF has immediate competence, areas outside SINTEF where training can be arranged, suitably structured approach in a time-bound frame, etc. should have been the strategy. Instead, a mere exposure to a wide spectrum of activities in the general field of mechanical engineering appears to have been the practice.

Joint projects

This is a most disappointing part of the entire project. There does not appear to be any head-way made in initiating seriously, joint research projects. In spite of the fact that undertaking joint projects is one of the aspects highly stressed in the collaborative programme, no serious attempt has been made to rectify the lapses involved although the awareness must no doubt have existed at SINTEF. The list of joint projects that keep appearing in the yearly reports and the reasons for not having done any worth-while work regarding them present a very dismal picture.

5.4 Benefits to SINTEF from collaboration with ITMMEC

In the process of assisting ITMMEC, many direct and indirect benefits have come to SINTEF. In any collaborative programme of the type that is being evaluated now, it is but natural that both parties benefit. But in this process, the senior or the more experienced partner willingly sacrifices a bit more. This sacrifice could be in the nature of sharing one's experience or know-how, providing facilities for competence transfer, etc. In the present SINTEF-ITMMEC collaboration, the gains for SINTEF have been considerable. For example, in the equipment procurement process, the SINTEF staff have received training on the new or the latest type of equipment, visited several laboratories and R&D establishments in Europe, have carried out investigations with the use of the equipment, and also progressed their own knowledge. Further, by participating actively in various National and International Conferences on Tribology organised by ITMMEC, definite benefits have been obtained by SINTEF.

In an invironment like that at SINTEF where an infra-structure already exists in the area of industrial tribology and machine dynamics, the benefits can be utilised more effectively and much faster. These remarks are made not with the intention of criticising SINTEF for utilising the opportunity for its own competence build-up, but with the main desire that in exchange, SINTEF should make a conscious and a more effective effort to build up competence at ITMMEC.

In Table 10 below we provide figures for the yearly SINTEF income arising from its contract with NORAD for the establishment of the Centre in India.

TABLE 10
SINTEF's FEES AND EXPENSES GENERATED FROM NORAD IND 014
(thousand NOK)

	Fees in		Expenses in		Total Fees & Expenses	
Year	Norway	India	Norway	India	Norway	India
1977	204	-	6	-	210	-
1978	436	200	47	80	483	280
1979	620	121	68	201	688	322
1980 (planned)	546	193	162	121	708	314
1981 (planned)	546	334	162	393	708	727
	2 352	848	445	795	2 797	1 643
Total	3 200		1 240		4 440	

The table shows that the total income, including the planned budget for 1981 amounts to NOK 4.4 million which, after deducting expenses of 1.2 million, is the same as the NOK 3.2 million set as an upper limit in the contract of November 2, 1977.

The total yearly income from fees for 1978-1981 from NORAD - Ind 014 should approximately cover the total salary costs for three full man years every year.

The importance of the contract is naturally increased by the fact that it has been running for a period of four years. The project group at SINTEF responsible for the NORAD project is

made up entirely of members of the Machine Design Division.

The expected income from NORAD's fees in 1981 is 1.7 million which falls in the range of 10-12% of the total budget for SINTEF section 18 - Machine Design Division after deducting outlay for new equipment. However, this NORAD project becomes only 0.3% in the total budget for SINTEF which is planned at NOK 230 million in 1981, for 960 full time workers.

6. THE SITUATION AT ITMMEC AND NEED FOR CHANGE

The JINEC team used a considerable part of the mission's time spent in India at the Centre interviewing people, both in groups and individually, studying the available documentation and investigating the status of equipment and the situation in laboratories. The knowledge thus gained in combination with our understanding of the overall situation in industrial tribology in India has prompted us to formulate recommendations on the following six aspects of the Centre: management, organization, training, competence build-up, specialization towards industry and equipment procurement.

6.1 Management of the Centre

The team has identified a number of management problems. In the existing staff structure, there does not appear to be an organized approach in forming teams with suitable organizational capability, nor is there a clear understanding of the need for leadership at various levels. This is a matter of serious concern for the future.

The phase-oriented approach discussed in the following chapter is in accordance with contemporary thinking in organizational theory. In this, some of the crucial aspects are top management, its style of leadership, succession, composition etc. In the process of establishing a new centre like ITMMEC, at the initial stages, in particular, there is a necessity for an individual who is able to deal with a variety of problems on a person-to-person basis. In this context, the present set-up at ITMMEC has been able to achieve substantial results. However, such abilities should be complemented when the next phase is entered. Then other abilities such as administrative skill, ability to deal with industrial problems and industries are needed. These different sets of abilities are not likely to be integrated in one single individual and thus it is necessary to let other individuals serve at the top management level in a complementary manner. Structurally, this may be envisaged as an executive body with shared responsibilities but the final outcome depends on the choice of individuals. Thus, utmost care must be taken in selecting these personnel.

It hardly needs to be pointed out that this procedure requires assistance from judicious people in the selection process. While subject competence may exist in the staff members, it is also desirable that they have also a certain degree of leadership abilities. In the recruitment of senior members of the core-staff whether the Project Manager should be involved or not is an open question on which consultations with the Director of IIT-Delhi and the Project Manager is required.

The solution to the question of the Centre's leadership cannot be expected to be conflict-free and the Board must be prepared to act in a conflict resolving manner. The solution then pertains to a second phase and the top management composition does not have to be perpetuated into the third phase. Rather, it may be advantageous if one can recruit individuals to temporary top positions in the second phase.

6.2 Organization

In discussions with industries and other organizations, we have been repeatedly reminded that ITMMEC must first establish its credentials with industries and other organizations regarding its capabilities. This means that ITMMEC cannot begin by acting as consultants to industries, until it has acquired sufficient in-house expertise in solving industry-oriented problems. This obviously takes a considerable amount of time. In this regard, an organised approach or a strategy is required. The approach appears to be a tie-up between ITMMEC and another organisation intent upon solving industry-oriented problems. There is likely to exist more than one such possibility to link up with an industry-oriented organization in India. Because of an urgent need to reorient the Centre towards industry, we have explored in some detail this possibility with the Corporate R&D sector of Bharat Heavy Electricals Ltd. (BHEL) at Hyderabad. This company has a group working on problems of tribology associated with its products. The products of BHEL cover a wide spectrum whose standards and qualities have to compete at an international level. Consequently, the problems faced by the tribology group of BHEL are not only live problems, but also call for continuous improvements and fundamental research investigations. Further-

more, the Corporate Director as well as the Manager of the Tribology Laboratory and their associates, in our discussions with them, were very favourable towards the idea of linking up with ITMMEC. We recommend strongly that this possibility be seriously explored because of its possible beneficial effects to ITMMEC. Obviously there are consequences for the Centre's relation with SINTEF.

The connection with SINTEF will essentially be with ITMMEC. The obligations will continue more or less on the same pattern as they exist now. The connection of BHEL will be essentially with ITMMEC. The problems posed by BHEL complexes will be shared between BHEL tribology group and ITMMEC. Problem dealing with routine testing, evaluation or standardisation can perhaps be mainly handled by BHEL Group, whereas those dealing with in-depth study, or research, or investigation or setting up new evaluative methods etc. can be shared between BHEL Group and ITMMEC Group. ITMMEC can provide to the BHEL Group the necessary academic exposure, the research training etc. The BHEL environment should provide to ITMMEC some of the necessary training in solving problems of industrial nature, identification of tribological problems in industries, etc. Periodic exchange of personnel between the two organizations should be practised. However, changes in company policy and new personnel at top level may drastically change the possibilities for the suggested collaborative links. Consequently it is necessary for ITMMEC to consider such a tie-up with more than one company.

6.3 Training

The close association of ITMMEC and its faculty members with the academic environment of IIT-Delhi can affect the priorities set by ITMMEC. It has to guard itself very carefully from becoming one more academic department in the Institute with programmes leading to B.Tech, M.Tech and Ph.D degrees. There are already signs indicating that ITMMEC may follow the traditional pattern set by other academic departments of the Institute and lose its identity. For example, the ITMMEC is having a 2-year fulltime M.Tech programme, 3-year part-time

M.Tech programme, and a Ph.D programme. While there may not be anything wrong with involvements in these programmes, one may question the priorities of these programmes with limitations on finances and time,limited faculty strength etc. One has to evaluate these academic programmes to see whether these programmes complement or counteract the basic objectives of the Centre.

Though it is claimed that these academic programmes do not consume much of the time of the staff members of ITMMEC, doubts exist about the necessity of these programmes. Instead of an M.Tech programme, perhaps, ITMMEC can consider running a one-year (i.e. two semesters) post-graduate diploma programme for persons from industries. In the first semester, the participants can be taught courses dealing directly with tribology and in the second semester, the participants can undertake projects dealing with problems of industrial nature. These projects can be carried out in the participants' own industries thus bringing a certain degree of R&D culture into those industries. Ph.D programmes can perhaps continue with the idea of keeping abreast in the modern areas of tribology on the assumption that problems for investigation are chosen in consultation with industries.

ITMMEC is also involved in organizing short-term courses to persons from industries and other organizations. While such activities are desirable, care must be taken to see that what is taught is not just bookish knowledge, but based on the expertise available at ITMMEC. Otherwise, credibility will be lost and it becomes difficult to re-establish it. With the reorientation of the Centre away from academic teaching programmes we want to stress the roll of visiting faculty. In the ITMMEC staffing structure, it is desireable to reserve 15-20% of faculty positions for visiting faculty. These visiting faculty should be drawn mainly from industries and other R&D establishments. These faculty members should work full-time at ITMMEC. The periods of the visiting faculty can range from a minimum of one semester to a maximum of three semesters. ITMMEC currently has on its rol a list of visiting faculty. But the association of these members is

restricted to part-time involvement and giving a few lectures. What is being suggested now is to have full-time visiting faculty. Suitable remuneration structure should be thought of to make persons from industries and R&D establishments to come to ITMMEC and serve. This concern is due to considerable differences in the pay levels that exist at ITMMEC and in industries.

Looking at the functional activities that are envisaged at ITMMEC a minimum core strength of 25 members plus 5 or 6 visiting faculty positions appear to be necessary.

6.4 Competence development

To make the collaboration between ITMMEC and SINTEF more effective a clearer pattern of operation is desirable. It is necessary to understand the strengths and weaknesses of SINTEF in the area of tribology. The initial development of expertise at ITMMEC should be in those areas where SINTEF has the necessary strength and can provide the necessary consultancy experts. We suggest that the role of SINTEF in the second phase is changed from giving training on instruments in Norway to an emphasis on guidance on problem solving for industry in India. The idea of having joint projects between ITMMEC and SINTEF is excellent. The problems chosen for these projects could belong to two categories:

a) Problems in those areas where considerable strength and expertise exist at SINTEF. The identification of these problems should be done in the context of the Indian industrial scene. These projects should be small enough to be completed in a given time period. The solutions to these problems should be available in the form of complete project reports accessible to industries.

b) Problems in those areas where joint investigations can be conducted at SINTEF and ITMMEC. Those problems should be of a fairly basic type contributing new knowledge in the field of tribology. Results of these investigations can form the basis for joint publications in international journals. These projects will help in creating a suitable R&D culture at ITMMEC.

The partners in these two types of projects should be clearly identified. Provision should exist for these counterparts to meet and exchange ideas during their project periods. It is desirable that the periods of these projects do not exeed one year.

Another area where SINTEF and ITMMEC can work together is in producing text books, reference manuals and other types of documents useful to academic community as well as to practising engineers in industries. Sufficient indigenous resources/materials in the area of tribology do not exist in the Indian scene. Contribution of SINTEF in this important area can be very beneficial.

In sending persons from ITMMEC to SINTEF for training, it is desirable to explore the possibilities of giving the preliminary training in India by sending them to suitable R&D laboratories or academic institutions (like other IITs or IISCs etc.) where work in the desired area of interest may be going on. Visits to SINTEF after such preliminary training will be more beneficial to the participants.

Before the participant is sent to SINTEF or other training centres abroad, a clear idea about the field of training and how the trained participant will be utilised on his return at ITMMEC should be formulated. Similarly, an organised approach to utilize the resources of the visiting consultants from the SINTEF should be formulated.

The stay of the visiting consultants should not be too brief. Otherwise no impact of their visits will be felt. At the same time, as the period of stay of the foreign consultants will necessarily be short, enough homework should be done at ITMMEC before the visits of the experts take place.

It is evident that a Centre like ITMMEC has two goals to serve:

(i) to serve the needs of the Indian industries in regard to their specific problems, and

(ii) to keep itself abreast in the technological fore-fronts of tribology.

This calls for a strategy between ITMMEC and SINTEF. To become useful to industry means:

(a) appreciation of the tribological problems of a given industry, and

(b) capability to provide solutions to these problems.

If ITMMEC is to become an advanced National Centre in the area of Industrial Tribology, then a programme of development for ITMMEC with adequate financial, building and other inputs from the Ministry of Education, Ministry of Industries etc. is required.

6.5 Specialization towards industry

With the present level of mechanisation in industry, break-downs and failures which are mainly due to wear are very expensive. Reduced wear and subsequent saving in material is an important area needing serious considerations. ITMMEC is being developed with special emphasis on the areas of wear and lubricant studies and their related effects. Those areas are directly in line with the needs and therefore it is expected that in due course of time ITMMEC will be able to:

a) provide opportunities to industries to analyse designs and processes involving tribological studies,

b) provide to the industry personnel trained in the field of tribology.

We want to stress that ITMMEC cannot become involved completely with a wide variety of specific problems of the Indian industries. To be able to build up to the level of competence that industries would have confidence and depend upon ITMMEC, we strongly suggest that action in the following areas be planned:

a) Survey of critical industries where excessive wear is a problem like mining, steel and cement industries besides others;

b) Survey of various treatment techniques involved and selection of feasible techniques from a technological capability point of view.

The above mentioned surveys must be made in such a way that they realistically reflect the needs of industry and are instrumental in directing the efforts of the Centre. Consequently it is necessary to have the active participation of people trained in analyzing industrial problems and we suggest such participation both from India and Norway (SINTEF).

In the process of becoming involved in industry-oriented problems the ITMMEC should not get involved in providing solutions to isolated or particular problem contexts, but undertake tasks relating to industrial problems of larger contexts. This suggests that ITMMEC should start acquiring competence area-wise (or topic-wise like vibrations and noise reduction, or seals and sealing techniques, or low-weight design, or wear-analysis, or maintenance engineering etc.) and not industrial sector-wise (i.e. all aspects of tribological problems associated with power sector, or mass transportation sector, or steel-mill sector etc.).

The present status of proficiency in the field of industrial tribology at ITMMEC, is at a stage that, while it may not be able to provide ready answers to many tribological problems, it is capable of undertaking research work in those areas to generate technology and expertise in tribology. The collaboration and exchange of faculty with SINTEF and similar institutes in India, will further enhance the capabilities of ITMMEC.

6.6 Equipment Procurement

The major component of the Norwegian aid pertains to equipment supply to ITMMEC. According to the original agreement, the cost of equipment to be supplied was about NOK 7.3 million. However, by the time the project was actually initiated, the cost of much equipment had gone up due to inflation, and as a

result, the equipment aid part was increased to NOK 12.3 million which partly reflects the changes in specification of the equipment to be procured and the total Norwegian aid was escalated to NOK 18 million.

The equipment procurement is being done in close collaboration with SINTEF and the identification of the necessary equipment is done keeping in mind the requirements of the six functional areas (such as wear resistance technology and analysis, diagnostics and condition monitoring, lubrication and oil analysis, etc.) and the general requirements of all the research groups. Information on the status of equipment procurement is available in Appendix VIII. However, we have found no document and very little awareness of priorities or the order in which the equipment needs to be procured. This is necessary for the following two reasons:

a) to initiate some activity in each group after acquiring a minimum set of equipment,

b) to eliminate or cancel some of the orders in case of steep rise in the cost of some of the equipment or lack of funds.

It is desirable that ITMMEC does this in consultation with SINTEF.

It is desirable that ITMMEC should start acquiring expertise area wise and not industrial sector wise. Further it has been suggested that initially, ITMMEC acquire expertise in those areas where SINTEF has expertise. In view of these recommendations, it is suggested that ITMMEC reconsider its equipment list very carefully. This will require consultation with SINTEF.

Another point of concern in the process of commissioning of equipment is due to lack of coordination between the availability of space and the arrival of equipment from abroad. Availability of covered space at IIT-Delhi is at a high premium. However, it is necessary that the administration of IIT-Delhi should appreciate the seriousness of this aspect, as otherwise, costly and sophisticated equipment may remain uninstalled and unutilized for long periods.

7. CONCLUSIONS AND MAJOR RECOMMENDATIONS

7.1 Main conclusions

The JINEC team has identified a number of shortcomings in implementing the Project and it must be realized that both sides have contributed to the partial failures which have been identified. The reasons are to be found in areas such as leadership, understanding of critical elements of the project and occasional incompetence. These comments are made with the aim of bringing the Project to fruition, and must not overshadow the fact that the Project has been successful in building up considerable infrastructure facilities at the Centre which is not altogether an easy task. However, the Project has reached a stage where it is absolutely necessary to formulate a strategy which will guide the Centre and its partners towards meeting the objectives originally spelled out.

The JINEC team has arrived at the following main conclusions:

C.1. There definitely exists in India an immediate need for activities within the field of industrial tribology.

C.2. There is a wide-spread awareness of this need in industry, especially in large and technically advanced companies, as well as in government and academia. Sustained efforts to meet these needs are being made and in this context both NORAD aid and ITMMEC activities would further the cause.

C.3. In the resource establishment phase (1978-1981) at ITMMEC, time and cost overruns have been large but not exceptional in such high technology projects. The reasons for these overruns pose some critical questions about the functioning of NORAD, SINTEF and ITMMEC regarding the planning and efficient execution of the Project.

C.4. ITMMEC is presently aiming towards completion of build-up of a large potential regarding equipment and infrastructure in order to serve Indian industry and fulfill academic obligations. However, in order to achieve long-term success in this service, some fundamental changes regarding organizational structure and competence build-up of personnel and management are called for. Suggestions towards achieving these

changes are given.

C.5. The established cooperative relations between NORAD, SINTEF and ITMMEC/IIT and the managerial competence of SINTEF provide an opportunity for substantial improvements in the rate and direction of future acitivites of ITMMEC with the longterm objective of effectively serving Indian industry.

7.2 Major recommendations regarding strategy and structure of ITMMEC

Based on these main conclusions, the JINEC team has arrived at the following main recommendations, ? which have been formulated with a positive and constructive spirit:

R.1. NORAD ought to continue its aid to ITMMEC but in order to increase the benefit to Indian industry via ITMMEC, the aid should be redirected according to certain specific recommendations made subsequently.

R.2. In the strategic planning of ITMMEC a phase oriented approach should be adopted and elaborated. Tables 11 and 12 give a summary of the specific recommendations of JINEC in such a framework. However, the phase transitions should not be distinct in time (other than from a formal point of view), but gradual.

TABLE 11
SPECIFIC STRATEGIC RECOMMENDATIONS IN A PHASE-ORIENTED FRAMEWORK

STRATEGIC VARIABLE	PHASE 1[x]	2	3
Major phase characteristics and objectives	Resource establishment	Consolidation and build-up of industrial orientation, competence and credibility. Transitory stage	Steady-state operations serving industrial needs in a self-reliant manner
Calender time	1978-1981	1982-1985	1986-
Profitability	Non-profit	Non-profit	Non-profit
Financial sources	NORAD-Govt. of India	As before but phasing in industrial sources (possibly also other foreign aid)	Co-financed by Indian industry and Govt. (matching grants etc)
Resource build-up	Imbalances in procurement of equipment, personnel and space	Resource balancing and consolidation	Resource renewal in steady-state mode
Growth	About 20 R&D staff	About 20-35 R&D staff, Organic growth	Stabilizing R&D size. Additional growth through consultancy
Diversification	Spread of activities through capability push and ad hoc pull	Specialization to ca 3 core areas for R&D. Role differentiation in total network. Priority setting by sectors and companies. Teaching, dissemination and consultancy activities in subsidiary areas	Diversification to other core areas, possibly through moving to other areas. Establishment as Centre of Excellence possible
Main activities	Procurement, training & education. Building of infrastructure	Joint venture based R&D (+Testing, Education, Consultancy)	Collective R&D, Sponsored R&D Education, Consultancy
Marketing to industry	Unrealistic ambitions	Controlled and selective test marketing	Full scale marketing

[x] As concluded in Aug. 1981.
Phase 1 refers to a characterization what has happened. The recommendations pertain to phase 2 and 3.

TABLE 12

SPECIFIC STRUCTURAL RECOMMENDATIONS IN A PHASE-ORIENTED FRAMEWORK

STRUCTURAL VARIABLE	PHASE 1[x]	2	3
Outer organization	SINTEF-ITMMEC	SINTEF-ITMMEC ↔ Company 1 (BHEL), Company 2, Company 3; SINTEF-ITMMEC - Academ. institutions	ITMMEC-INDUSTRY; ITMMEC - NETWORK (Collective R&D, Sponsor R&D, Consultancy etc.)
Inner organization	Fluid	Decentralization into cost-benefit centres (Groups)	Matrix organization possible
Management at Board level	Advisory Council Co-ordination Committee (Norway-India) Board	Bodies as before but composed with more industrialists, especially in the Board	Advisory Council with international members as well. Board
Centre top management	Semi-planned succession of academic leaders. Power concentration. Entrepreneurial and personalized style of leadership	Executive body with at least one part-time industrialist	Executive body
Middle management	No management development	Development and training of Group Heads, assisted by SINTEF and industry	Continued management education, recruitment and promotion

[x]As concluded in Aug. 1981.
Phase 1 refers to a characterization what has happened. The recommendations pertain to phase 2 and 3.

What is written in the table about phases 2 and 3 concerns the anticipated realizations. However, in phase 1 there are differences in the anticipated and actual realizations, which have been discussed earlier.
The financial involvement of industry can take several forms - consultancy projects and R&D projects undertaken with and financed by individual companies as well as collective R&D programs for groups of industries. The latter, especially, could be stimulated through matching grants from Government sources. The contributions from industry should be of a core-funding nature, as well as making available its personnel and equipment to ITMMEC. The basis for this involvement should be a strategic plan for ITMMEC, approved by industrial representatives in management bodies. Largely, this set-up corresponds to the way some collective research institutes are set-up in some Western countries as well as in India.

The build-up of this involvement by industry should be careful, selective and on a small scale in phase 2. Some direct financial involvement of companies in R&D programs should be aimed at. This is not only for financial reasons but also to stimulate the involvement of companies in the definition of activities and control of results from ITMMEC. ITMMEC should be prepared to undertake industrial projects at less than full costs at the initial stages. As the activities of ITMMEC grow foreign aid from sources other than NORAD should also be considered.

The imbalances in the resource build-up in phase 1 had the character of rapid growth in staff positions and a slower growth regarding equipment procurement. Space, especially laboratory space, has been a serious constraint most of the time. The build-up of competence of the staff in utilizing the equipment has also been largely lagging behind the availability of equipment, rather than the other way around.

The organic growth of R&D staff in phase 2 should be in such a way that newcomers could be assimilated in existing R&D groups at ITMMEC. The steady-state phase is not to be interpreted as a state without growth and development.

The spread of activities through capability push and ad hoc pull in phase 1 refers to the fact that many areas and activities have been undertaken at ITMMEC because they have been related to specialities and interests of the key actors and/or have been initiated through spontaneous demands from outside. This is in contrast to an elaborate plan, based on a need and preference survey in industry. Industry has to a small extent been involved systematically in the definition of activities at ITMMEC. The 1975 proposal was in this respect insufficient and the interaction with industry representatives at this time was superficial. Relevance to industry then was a selling point in India, but this kind of salesman work was not penetrating enough for subsequent definition and planning of activities at ITMMEC.

The unrealistic ambitions regarding marketing to industry refers to the present eagerness at ITMMEC to look for and undertake all kinds of consultancy work with industry, sometimes in a very non-professional way. This may severely discredit the Centre in the long run. Also, the amount of industrial consultancy conceived of is unrealistically high, both with respect to demand and supply factors. However, the ambition to let the existence of ITMMEC be known in Indian industries through courses, workshops etc. is acceptable.

The inner organization of ITMMEC has been unstructured and unstable. Fluid conditions in this respect are natural and desirable to some extent in launching a new organization but in phase 2, a more structured organization is needed. In fact this was also initially spelt out in the contract. Especially, a decentralization is needed and in this process the establishment of R&D groups with some kind of cost-benefit if not profit-center responsibility given to them is instrumental. This also contributes to the development of middle managers and project leaders, which has been lacking so far.

7.3 Major recommendations regarding Project leadership and the responsibility of NORAD and its Indian counterpart

After the signing in 1977 and 1978 of the contract between the two governments and between NORAD and SINTEF respectively the

project has, in the main, only been discussed at the yearly economic cooperation consultations between India and Norway. The last such meeting was held in Delhi in October 1980. At this occasion it was agreed that a joint evaluation of the Project could be undertaken including a review of any assistance requirements. At the same time it was agreed, according to the minutes, to allocate NOK 4 million for 1982 and NOK 2 - 3 million for 1983. The two delegations also agreed that the following measures would contribute towards a successful implementation of the Project.

1. Speeding up of recruitment and filling up of vacant positions at the Centre.
2. Speeding up of procurement and safe shipment of equipment still pending.
3. Strengthening of the links with potential users.
4. Selective screening of new activities, priority to be given to practically orientic research and development projects with potential of bringing rapid improvements and tangible benefits to the users.

We agree on the last two points but disagree with the first two, for reasons discussed in some detail earlier in this report. We consider that the sponsors of the Project have a responsibility to guide the Project in functional operation and not only in the disbursement of funds. This would require an excercise of influence of leadership both at the Centre and its Coordination Committee and Management Committee, and the formulation of more relevant measures to screen the Centre's progress. We assume that this evaluation report would provide a basis for taking actions in these areas.

The earlier analysis and the recommendations above on the need to formulate a strategy clearly indicates the need to provide the Centre with the new leadership to guide the Centre through the next phase which is to have a strong industry-orientation. The Advisory Council of the Centre which now has six members from industry has in the past not

been able to properly guide the Centre. In combination with an improvement in leadership at the Centre, discussed above, we strongly suggest that action is taken to form a new Project Management Committee. Here we would like to stress that this Committee should be given such a composition and such powers that the strategy discussed above stands a good chance of being implemented. For that reason we suggest that the Project is managed by a committee with the following composition.

1.	Project Coordinator	to have the overall responsibility to guide the Project according to the strategy to be formulated
2.	Norwegian consultant	to advise the Project Co-ordinator regarding the facilities
3.	NORAD representative or consultant	to monitor the progress of the Centre from the Indian and Norwegian sides
4.	Director of IIT-Delhi	to provide the infrastructure facilities and have the overall responsibility for ITMMEC
5.	Head of ITMMEC	to execute the objectives and the strategic

We envisage a new Project Coordinator to be named considering that this person must have capabilities to build up the Centre's competence areawise, select industry-related activities and strike a balance between academic and industrial pursuits. The Project Coordinator is not expected to be permanently at the Centre but should be able to spend extended periods at ITMMEC involved in the planning work. We assume that Professor Christensen would continue as advisor considering his contributions to the Project and his good understanding of the Indian scene and the various constraints which have to be considered.

Also the composition and functioning of the Management Committee of the Centre, as distinguished from the Project, need to be reconsidered. In its capacity to act as a Board for ITMMEC it is a managerial body of high importance. The close interdependency between the Project and the Centre

calls for considerable member overlaps between their respective management bodies on board level. Thus the Project Coordinator and a NORAD representative should take on full membership in the Management Committee of the Centre. In addition the active involvement of two industrialists as members of this committee should be sought. To prevent from power concentration and information filtering upwards and downwards at the level of Head of the Centre, the participation in the meetings of the Management Committee by another member in the executive body of the Centre is recommended. It then appears as if the management of ITMMEC and the Project is top heavy but with suitable member overlaps this would not be the case. It must finally be noted that the implementation of a strategic plan is likely to fail if it is given a top-down approach without sincere support from the executive management of the Centre.

The changes which the JINEC team recommends obviously requires new contracts to regulate the obligations between the various parties. In this task we strongly urge NORAD and its Indian counterpart to include provisions in the contract so that screening of progress at ITMMEC and its Norwegian counterpart (assumed to be SINTEF) becomes an ongoing process. We assume that such provisions in the past would have made it possible to have taken corrective measures at an earlier stage of the first phase. We suggest that the strategic plan suggested above is formulated to facilitate corrective measures during phase 2 if need arises, and provided with check lists in order to facilitate the auditing of progress.

On the assumption that the Project will continue for another period of 3-4 years we suggest that simultaneously with the decision to extend the Project a decision is also taken to have a mid-term evaluation.

8. OTHER RELEVANT RECOMMENDATIONS

Below additional and more detailed recommendations will be given.

1. As already mentioned ITMMEC should aim at achieving competence area-wise and not industry-wise. The priorities for these areas should be spelled out carefully, taking into account:

   a) the infra-structural facilities available at IIT-Delhi
   b) the immediate relevance to the needs of the Indian industries
   c) ease with which the credibility of ITMMEC can be established vis-á-vis industries
   d) the time factor involved in building up the competence in the particular area.

2. The equipment procurement should be programmed in such a manner so as to agree with the desired competence build-up. SINTEF in consultation with the Head of ITMMEC should plan how the competence in the identified area can be built up. If SINTEF can arrange a suitable programme in its own organization in a time-bound frame-work, then it should be done so. If SINTEF cannot do this for one reason or another, then it should identify other places (including third countries) where effective training can be provided in the area of interest.

   It is desirable to set up an Equipment Committee to scrutinize and approve the procurement of equipment when the cost of individual items exceed a certain amount. The composition of this Committee should be such as to give suitable advice to ITMMEC regarding the desirability, priority, duplication, and other aspects of the equipment proposed to be acquired.

3. SINTEF and ITMMEC should make sure that during the participant's stay outside India, the participant gets an opportunity to associate himself with a project that is going on at the place of training. It is desirable, that the Indian participant, before leaving India for training abroad, visits other places in India, where work in the particular area may be going on. This will provide a certain degree of background to

the participant thus enabling him to utilize his period of stay abroad much more effectively.

4. In those areas where ITMMEC has built up competence, short term courses to persons from industry should be organised. This will provide a certain degree of confidence to the group concerned in facing industrial participants and also enable ITMMEC to sell itself and establish its credibility. ITMMEC should not involve itself in offering courses where its competence does not exist, as otherwise, its credibility will be jeopardized.

5. ITMMEC should strive hard to submit proposals to sponsoring agencies such as CSIR, DST, Ministry of Industry, ISRO[1], etc. The proposals should deal with problems having industrial relevance. Since Tribological Systems is one of the thrust areas identified as important for financial support and promotion, ITMMEC should definitely take advantage of this aspect. In the execution of these sponsored projects, SINTEF can also participate as an equal partner since the involvement will also benefit SINTEF. SINTEF should also consider raising funds for this purpose from Norwegian sources. The experiences and results gained from both sides can be shared. Also the possibilities to create joint ventures between Indian and Norwegian industry should be explored.

6. If a staff member wishes to work for his PhD, the problem should as far as possible have relevance to industry. In this process, SINTEF faculty can also act as co-guides.

   For the two-semester post-graduate diploma programme that has already been suggested, the dissertation projects identified, should be in the areas of competence already developed, and possibilites of having the project works carried out in the candidates' own industrial invironment should be stressed. In this process, SINTEF staff can also take part as co-guides. Heavy involvement in very academic programmes at initial stages should not be undertaken.

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[1] CSIR = Council of Scientific and Industrial Research,
DST = Department of Science and Technology,
ISRO = Indian Space Research Organization.

7. It is desirable that ITMMEC become successful in getting industry sponsored projects. As this kind of culture on the part of Indian industries may not exist to the desirable extent, perhaps, ITMMEC along with SINTEF should make in-roads to some forward looking industries. With financial assistance from the Ministry of Industries and other sponsoring agencies (like UNIDO, UNDP, etc.), ITMMEC along with SINTEF, should take up study projects pertaining to certain critical aspects like failure analysis and prevention, wear reduction, noise-control, etc.

8. There are many forward looking industries in India who are prepared to sponsor projects. These should be identified in areas like noise reduction, vibration control, failure prevention through suitable maintenance, etc. ITMMEC should definitely take advantage of this. These projects can also be at individual consultancy levels.

9. ITMMEC should explore the possibilities of making its facilities available to persons who can take up industry oriented projects and earn their own salaries through such industry sponsored projects. The salary structure for these persons can be higher than those followed for regular faculty members. However, certain precautions may have to be exercised regarding the suitability of these industry-sponsored projects.
In the difficult process of bridging the academic culture and the industrial culture this could be instrumental in instilling some of the industrial culture at ITMMEC.

10. In marketing the Centre the large number of users and the low level of technological competence of many users are straining the resources of the Centre. Thus, initially at least, marketing should preferably be directed towards large and competent users. Small scale industries could be served at a later stage through the use of intermediate organizations.

9. GENERAL EXPERIENCE FROM THE EVALUATION

The general experience from the evaluation will be summarized with a view to present their applicability to high technology projects involving foreign aid and technology transfer. References will be made to corresponding sections of this report for further details.

9.1 Initiation

The role of NORAD in the initiation of the project IND 014 was responsive rather than active. The dual roles to act as a technical and managerial advisor both to NORAD and ITMMEC were assigned to SINTEF first informally and then formally. The process of reaching contractual agreements as well as the product in forms of contracts had several flaws as dealt with in Section 5.2. There is in general a large amount of risk taking involved in the pre-planning and launching stages of a high technology project in the sense that sins of omissions and commissions are easily made regarding choice of partners and contractors, manning, location and initial strategies and activities.

9.2 Planning

The objective of ITMMEC was early conceived of as serving Indian industry. Such an objective was also a selling point in India at the time when the idea of the Centre was launched. There was a risk of over-selling the proposals without establishing priorities or procedures for doing so. A survey of industrial needs as perceived by industrial representatives was made in 1972 and again in 1975. This was a natural starting point for planning but no priorities were established and the knowledge gained was too superficial in nature. Efforts to arrive at a strategic plan for ITMMEC and the Project were insufficient and the understanding of real needs in Indian industry was inadequate as an input to such a plan. The lack of explicit strategic planning in the Project as distinguished from annual planning and budgeting has been pointed out in several sections of the report, for example in 5.2 and 7.

9.3 Organization and management

Recent management theory as well as actual experience point at the need to consider technology-intensive organizations in a dynamic, or life cycle, perspective, taking environmental changes into account. Thus a phase oriented framework ought to be elaborated upon for high technology projects and organizations. This has been dealt with in Sections 6.1, 6.2 and 7. A proper time perspective is then naturally important. As a point of reference, experience from developed countries point at the necessity to allow a decade or so for an R&D unit to fully establish itself, given that it is not an offshoot from a mother organization.

9.4 Cooperation with the recipient country

In a high technology project as IND 014 with a large part of technology transfer involved, it is important from an efficiency point of view that the technological and cultural gap between actors on the donor and recipient side is not too large. This problem may be accentuated if managerial responsibility is left with the recipient. The international nature of the S&T culture may decrease the importance of cultural and social differences.

There has in IND 014, as in many technology transfer projects, been a pre-occupation with the transfer of hardware and operating skills. These are necessary but not sufficient and may become overemphasized. Even if a primary responsibility rests with the recipient to acquire application skills as well, the donor ought to take on a secondary responsibility to cater for this and also attempt to overcome barriers in this respect on the recipient side. A similar point may be made regarding managerial skills.

Concerning cooperation in fulfilling contractual obligations, this is dealt with in section 4.2.

9.5 Development effect

It is yet too early to assess development effects among the users of ITMMEC in Indian industry. A recognition of and

awareness in Indian industry about tribology and maintenance problems is developing and in this process ITMMEC has already contributed. A certain educational effect has also resulted. Substantial assistance in industrial problem-solving through R&D and consultancy is yet to come. This has been dealt with in sections 4.3, 5.3 and 6.5.

9.6 Plan versus reality

The time and cost overruns in IND 014 are substantial and conspicuous. Yet they are not exceptional in high technology projects. For example a doubling of costs and occasionally time is not unusual for an industrial R&D project. Such overruns are attributable to several factors, including uncertainty, lack of planning in embryonic stages and a propensity of advocates to be overly ambitious and to underestimate costs and necessary time. In technology transfer projects there are additional complications since there are more actors involved. Maybe competence building has to take place at the donor side as well.

Time and cost overruns in IND 014 and some of their reasons are dealt with in sections 2.2, 5.1 and 5.3. A close follow-up of status reports, plans and budgets and the provision of an early warning system for corrective action has been lacking. A proper cost accounting and cost consciousness is yet to be developed at ITMMEC. There is also a learning process at the donor side, that is at SINTEF and NORAD, which so far has had limited experience from high technology projects in developing countries. The situation with dual roles of SINTEF to monitor the Project more or less on behalf or NORAD, at the same time being a technical collaborator to ITMMEC, has not been fortunate. NORAD ought to take on a more active role in managing a high technology transfer project. An in-house competence to perform regular audits ought to be built up at NORAD. Also NORAD ought to take on larger direct managerial responsibilites in the Project Coordination Committee and the Management Committee at ITMMEC, among other things in regard to contracting and subcontracting. However, it must finally be kept in mind that bureaucracy and rigid planning may easily

choke the creativity and entrepreneurial initiatives, which are needed in high technology projects.

9.7 Choice of technological field

There is no reason to doubt that industrial tribology qualifies as a field for NORAD aid, given that a certain amount of NORAD aid is allocated to high technology projects and given the importance of industrial tribology in Indian industry. This has been dealt with in section 3.1.

9.8 Method of evaluation

The methodological experience has been positive from this particular case of evaluation, using a team composed of 2+2 independent members appointed by the donor and recipient countries with a team leader from the donor side. However, such a choice of an evaluation method may be a risky one for several reasons:

(1) The group may not be able to settle itself in a short time;

(2) A 4 member group easily divides into two blocks, especially if two countries, two professions or two generations are involved;

(3) The donor - recipient relation may induce asymmetry and bias in the evaluation;

(4) Conflicts in the team may arise and consensus-seeking may become arduous.

This points at the need to be careful to select the team members and make preparations for the evaluation, especially if evaluation time is short and team members do not know each other. Naturally this type of team evaluation has advantages of being able to cover a pre-set range of perspectives and draw on a pool of experience and also to stimulate creation of ideas and checking of observations, but the socio-psychological aspects of small group dynamics must to the extent possible be given judicious consideration.

Concerning the object of evaluation, it has been felt necessary to go beyond a pure evaluation of fulfilment of contractual obligations and pre-set objectives. The history and process behind the inception of the Project and especially the prospects for the future were important to look into. In doing so, it has been our aim to provide inputs for a strategic plan and identify instruments for implementing recommendations. A strategic perspective in an evaluation must not preclude diving into details of operation in some selected areas.

Concerning criteria for evaluation, these must be adapted to the actual phase of the Project in which the evaluation is done. It is yet too early in IND 014 to apply a set of indicators to the various activities of an established R&D unit in order to assess their contributions to objectives. In doing so, flexibility must also be allowed for, due to uncertainty, the intangible nature of R&D results, the long time spans involved and the sensitivity needed to assess capabilities of R&D personnel.

Finally it must be recognized that an evaluation creates a certain dynamism in and around the object of evaluation. While this may complicate the evaluation procedure, it generally has a positive and hopefully non-transient effect on the performance of the object of evaluation.

APPENDIX I

July 1, 1981

TERMS OF REFERENCE
for the evaluation of the Project IND 014 - Tribology Centre.

1. Background

The Indo-Norwegian Agreement for the establishment and operation of the Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre (ITMMEC) at the Indian Institute of Technology (IIT), New Delhi, was signed in November 1977. The operation of the project bagan in 1978.

The funds available under the Agreement, 13 million Norwegian kroner, (increased to 18 million Norwegian kroner due to an upward revision in 1979) shall over the 4-year period 1978-1981 be used to cover:

i) the expenses connected with the consultancy services provided for in the Contract between the Norwegian Agency for International Development (NORAD) and the Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF).

ii) the expenses connected with training of IIT personnel in Norway.

iii) the costs of purchase, insurance and transport of equipment and materials required for the implementation of the Project.

In the annual consultations between the two governments in October 1980, it was agreed that a joint evaluation of the project would be undertaken during the first half of 1981 including a review of any assistance requirements.

II. Participants, mode of work

For the evaluation task, NORAD and the Government of India have appointed the following participants:

Associate Prof. Jon Sigurdson,	Research Policy Institute University of Lund, Lund (teamleader)
Associate Prof. Ove Granstrand	Department of Industrial Management Chalmers University of Technology Gothenburg
Professor L.S. Srinath	Department of Mechanical Engineering Indian Institute of Sciences Bangalore
Shri A.K. Raman	Divisional Manager R&D Scientific Research Centre Escorts Ltd., Faridabad

The evaluation will take place in June/July 1981. The joint work of the Norwegian and Indian team members in India will be limited to approximately four weeks, including the drafting of the Report. The evaluation team will act as an independent group. The assistance it requires will be made available by the Project management IIT, Indian authorities and NORAD's Resident Representative in New Delhi.

The work will include the review of relevant documents, talks and interviews with Project and ITMMEC personnel, relevant Indian authorities, experts, and with representatives of various sectors of Indian industry. Visits to other relevant research institutes and to industrial companies may also be included in the work programme.

If the time permits, it may also be useful for the evaluation team to carry out a limited number of case discussions as to how the resources of the Centre may be made available to Indian industry.

III. Tasks of the evaluation team:

I. Objectives and obligations

1.1 The reference point for the assessment of the Project will be the objectives - explicit or implicit - of the Project. The evaluation shall outline the structure of objectives for the Project, defined by the overriding development problems of the sector in question, and by national policies for foreign assistance to technological research and development.

1.2 The evaluation Team is requested to assess whether or to what extent the obligations of each party as spelt out in the Project Agreement have been fulfilled.

2. Establishment of ITMMEC

The evaluation team shall:

2.1 Take a close look at the integrated character of the Project (with elements of expertise, equipment as well as training), the close relationship that has been established between SINTEF and ITMMEC, and see how independence and self-reliance on the Indian side can under these circumstances be secured.

2.2 Evaluate the situation regarding the recruitment of qualified scientific and other personnel for the ITMMEC, and what the prospects are in this respect. Identify the main reasons for recruitment problems and point to possible solutions.

2.3 Assess the role and character of Norwegian expertise.

2.4 Consider the training of Indian experts in Norway and elsewhere abroad, and see whether

- it has been restricted to areas where sufficient domestic training is unavailable, and whether the balance between training abroad and expatriate-assisted training in India has been rational,
- it has been relevant to the needs of the Centre,
- international training facilities have been offered to the best personnel and if those trained through the Project have stayed at the Centre afterwards,
- and to what extent the Project should finance participation in international conferences and meetings.

2.5 Assess the equipment of the Project as to whether

- the selection of items and makes has been satisfactory,
- the general status of the Project warrants further screening of the equipment lists,
- there are ways of speeding up the delivery of equipment, and if more of the equipment training and tests could be carried out at ITMMEC rather than at SINTEF,
- the Centre has been adequately prepared to utilize and maintain the equipment.

2.6 In general, take a fresh look at the scope and list of activities of the Project, with a view to establishing clear priorities. See to what extent the activities are in accordance with the major requirements, as understood in the light of national policies and Project objectives.

2.7 Examine the functioning of the organizational set-up of the Project, i.e. the triangle NORAD-SINTEF-ITMMEC, and the internal administrative structure of ITMMEC.

2.8 Assess the role of SINTEF in the operation of the Project.

3. <u>The relevance and usefulness of the Centre - relations with Indian industry</u>.

It has been an important concern of this Project that the ITMMEC should be an institution serving Indian industry. It will be a priority concern of the evaluation team to examine the likelihood of success in achieving this, when the centre is fully established.

3.1 A Centre like ITMMEC will quite logically be predominantly geared towards the more advanced technological

sectors of Indian industry. Given the great technological variety of the Indian production structure, however, and the essential significance of "traditional" or intermediate technology for the majority village population of the country, the latter sector should not be excluded from research and development in tribology. The evaluation team is therefore invited to take a look at the viability of developing parallel activities of interest for the typical village industrial or semi-industrial sectors, within the priority programme of the Centre.

It may still be too early for an intimate relationship with Indian industry to have materialized. However, a serious attempt should be made to assess the prospects for such a relationship, hased on the present set-up and programme of the Centre. With this in mind, the evaluation team shall

3.2.1 Find out to what extent industry has been involved in the definition of activities for the Centre, and suggest how such participation may be strengthened,

3.2.2 Look thoroughly into the problem of establishing cooperation with industry for the work of the Centre, identify reasons for possible shortcomings and come up with proposals for improvements of the extension service.

3.2.3 Assess the value of industrial workshops initiated by ITMMEC.

3.2.4 Study the viability and consequences of involving Indian industry more directly in the financing of the Centre.

IV. The Continuation of the Norwegian Assistance to the Centre and the Project

On the basis of the conclusions drawn from the questions raised in part III, the team is requested to give its recommendations as to the Continuation of the Norwegian assistance to the Centre, and to the requirements for possible further assistance to its development, i.e. continuation of the Project.

V. Reporting

A preliminary Report, containing the main conclusions, shall be prepared before the end of the Team's joint work in India. The final report is to be submitted to NORAD within one month thereafter.

Nils Vogt
Assistant Director General

APPENDIX II

A G R E E M E N T

between

THE GOVERNMENT OF THE REPUBLIC OF INDIA

and

THE GOVERNMENT OF THE KINGDOM OF NORWAY

regarding

The establishment and operation of the Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre in New Delhi, India.

- - - - -

The Government of the Republic of India (hereinafter referred to as "India") and the Government of the Kingdom of Norway (hereinafter referred to as "Norway"),

in pursuance of the Agreement between the Government the Republic of India and the Government of the Kingdom of Norway regarding Co-operation for the Economic and Social Development of India, dated 8 February 1974,

have agreed as follows:

Article I
Scope

Norway and India will during the years 1977-1980 co-operate in the establishment and operation of the Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre (hereinafter referred to as "the Project") outlined in an Annex to this Agreement.

Article II
Representation

In matters relating to the implementation of the the Norwegian Agency for International Development (N shall represent Norway, and the Department of Educati the Ministry of Education and Social Welfare, represe the Indian Institute of Technology, New Delhi (IIT), represent India.

Article III
Contributions and obligations of Norway

1. Norway shall, subject to Parliamentary appropri provide financial assistance on grant terms not excee Norwegian kroner 13 000 000 (Nkr thirteen million) fc partial financing of the Project.

2. The funds to be made available under this Agreen be utilized to cover:

(i) the expenses connected with the consultancy serv referred to in Article V, 2, and in the Annex, Section 3;

(ii) the expenses connected with training of IIT pers in Norway. Norway will cover:

- travel expenses between India and Norway,
- internal travel expenses in Norway in conne with the training of the personnel,
- living expenses, social insurance fees and allowances in accordance with the regulatic force from time to time for the Norwegian ship programme.

(iii) the cost of purchase, insurance and transport o: equipment and materials required for the implem of the Project;

3. Norway shall present to India semi-annual reports on the expenditures incurred by Norway under the present Agreement.

Article IV
Contributions and obligations of India

India shall:

1. Be responsible for the administration of the Project, and provide the necessary funds, academic and professional manpower and all additional resources, facilities and services which may be required for the successful implementation of the Project;

2. by 1 September each year, present to Norway for approval:

(i) lists of equipment to be procured under this Agreement,

(ii) annual budgets for the funds needed for such purchases;

3. by 1 March and 1 September each year submit semi-annual reports to NORAD on the progress of the Project;

4. promptly inform Norway or its representatives of any condition which interferes with or threatens to interfere with the successful accomplishment of the purpose of this Agreement.

Article V
Co-operation and Administration

1. Norway and India shall co-operate fully to ensure that the Project is implemented in an efficient manner. To that end, each Party shall furnish to the other all such information as it may reasonably require, and shall be free to send its representatives to visit the sites of the activities undertaken under the Project.

2. Procurement and shipment of equipment to be provided by Norway under the present Agreement shall be carried out according to the procedure set forth below:

(i) A consultant firm (hereinafter referred to as "the Consultant"), contractually responsible to NORAD for the conduct, execution and quality of its services, will prepare tender documents, call for tenders, evaluate the tenders received and present to NORAD its recommendation as to which supplier shall be given the individual assignments,

(ii) NORAD will thereafter enter into contracts with the suppliers in question.

(iii) NORAD shall be responsible for shipment of the equipmen and shall in that connection notify India of the estima date of arrival of all consignment of equipment immediately upon dispatch of carriers from a port of loading and shall also forward shipping documents, invoices and other related information.

(iv) India shall:

(a) notify NORAD of the import clearance agents to be used by India and of the documentation required for customs clearance,

(b) promptly issue import licences, after receipt of all required documentation and particulars in compliance with formalities,

(c) take all appropriate steps to ensure swift berthir and clearance of vessels and quick and safe recept of cargo,

(d) take appropriate measures for storage and early onward transportation,

(e) defray all costs and fees, such as customs duties and harbour fees pertaining to the entry of equipment into an Indian port, storage, and onward transportation in India,

(f) take on its own account as consignee, with respect to any consignment of equipment, such demurrage and dispatch as may accrue at an Indian port.

(v) India shall also establish procedures whereby the customs duties, taxes or any other fees normally imposed in India shall not be charged to Norway in relation to the supply of the said equipment.

(vi) If any consignment of equipment is partly or entirely lost or damaged during shipment to the port of destination India shall take all appropriate measures and institute any proceedings that may be required in connection therewith, such as lodging of sea protest against shipowner, obtainment of damage reports, etc., and shall notify NORAD as soon as possible thereafter.

(vii) In the event of establishment of a loss or damage of any consignment of equipment, NORAD will pursue the matter vis a vis the insurance company if in NORAD's opinion such action is justified. NORAD shall at its earliest convenience, within the limit of any amount that may be paid to NORAD under the policy of insurance taken out, grant additional equipment of a value equal to equipment lost or damaged. NORAD is under no further obligations than those stated in the previous paragraph.

Article VI

Disputes - Entry into force - Termination

1. If any dispute arises relating to the implementation or interpretation of the present Agreement, there shall be mutual consultations between the Parties with a view to secure a successful realization of the purpose of the Agreement.

2. The present Agreement shall enter into force on the date of its signature.

3. The Agreement shall terminate on the date upon which both Parties have fulfilled all obligations arising from it.

4. Notwithstanding the preceding paragraph, either Party may terminate the present Agreement by giving six months' written notice to the other Party.

IN WITNESS WHEREOF, the undersigned, being duly authorized thereto by their respective Governments, have signed the present Agreement in two originals in the English language.

Done in NEW DELHI.. this ..2nd..... day of NOVEMBER1977.

(PER GULOWSEN)
Ambassador of Norway
For the Government of
the Kingdom of Norway

(A.S. GILL)
Additional Secretary
For the Government of
the Republic of India

A N N E X

The Project is based upon the official request dated 25 November 1975 from the Government of India and the report of 6 April 1976 from the NORAD appointed mission to study and assess the Project proposal, prepared by the Indian Institute of Technology, New Delhi.

1. The Project shall comprise the establishment and operation of an "Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre". The Centre will be located in New Delhi.

The purpose of the Centre is to further industry oriented research and development activities at the IIT in the field of Industrial Tribology, Machine Dynamics and Maintenance Engineering, and within this field to foster co-operation between the Institute and industry and commerce, as well as with other research organizations.

Activities of the Centre are envisaged to fall within the following categories:

a) Consultancy and development projects for Indian industry with the aim of giving advice and assistance to Indian industry within the field of industrial tribology and maintenance.

b) Research projects of direct relevance to Indian industry with the view to developing and improving maintenance methods and techniques and adapt available methods to local conditions.

c) Courses and seminars with the aim of upgrading skills of industrial maintenance personnel at all levels.

d) Internal courses and training seminars within the Centre to acquaint personnel with available methods and techniques and to train personnel for active participation in industrial consultancy and development projects.

2. At the intitiation of the Centre IIT shall make available about 1000 m^2 of laboratory and building space for the activities of the Centre. An additional 500 m^2 shall be made available in due course.

Salary expenses for IIT personnel is to be met by IIT.

3. The Consultant shall, in addition to the services referred to in Article V.2 of the Agreement, assist in the implementation of the Project. Collaboration between IIT and the Consultant will mainly take the form of joint participation within the areas:

a) Personnel education and training with the object of familiarising personnel with advanced methods and techniques of relevance to the Indian industry.

b) Joint research projects of common interest within the field of industrial tribology and maintenance. These projects should be actively pursued both in India and Norway and should be organized for the optimum use of common research resources.

c) Joint participation in industrial research and development programmes. In Norway this should be achieved by integrating visiting Indian personnel into appropriate programmes which the Consultant is carrying out in collaboration with Norwegian industry. In India, the Consultant should take part in consultancy and development projects which the Centre will be carrying out for Indian industry.

4. The Centre shall be an integral part of the IIT, New Delhi, which will also be legally responsible for its operation.

The organizational structure of the Centre shall be given the following form:

Advisory Committee

The Centre shall be advised by an Advisory Committee consisting of from 15 to 20 members. Half of the members of the committee shall be representatives of the Indian industry whereas the others shall come from Government ministries and IIT, New Delhi. The Director of IIT, or a member nominated by him, shall be chairman of the Committee. The Committee, which shall be given authority from and report to the Director of IIT, New Delhi, shall meet at least twice a year.

The Committee shall endeavour to secure proper and necessary interaction with the industry and particularly ensure that unnecessary duplication of work is avoided. It is important that the Committee seeks to keep the work of the Centre attuned to the needs of industry at all times.

Management Committee

The Management Committee for the Centre will consist of six members, namely:

- Director, IIT, New Delhi,
- Head of the Centre,
- Dean of the Industrial Consultancy & Liaison,
- a member from the industry,
- two other members to be nominated by the Director, who are actively associated with the working of the Centre.

Director, IIT, New Delhi, or his nominee will be Chairman of this Committee.

The Project Manager, whenever he is in India, will be coopted as a member of the Committee.

This Committee will meet frequently for a proper implementation of the work of the Centre, to receive progress reports from the Centre and ensure speedy implementation of the projects and promote interaction between the industry and the Centre. The Head of the Centre will be responsible for day-to-day operation within the mandate given by the Management Committee.

Head of the Centre

The Head of the Centre shall be appointed by the Director of IIT and shall be responsible for the day-to-day operation of the Centre. The Head operates within a mandate given him by the Management Committee, to which he reports.

Project coordination

A Coordination Committee shall be established with the responsibility at annual project review meetings to

a) assess progress reports and make recommendations as to the annual budgeting of funds available from Norway.

b) handle details of co-operation between the parties.

The Coordination Committee shall consist of two IIT representatives, namely the Director of IIT and the Head of the Centre, and two representatives of the Consultant, one being the Project Manager and the other a representative of the Central Administration of the Consultant.

DIREKTORATET FOR UTVIKLINGSHJELP

APPENDIX III

C O N T R A C T

between

THE NORWEGIAN AGENCY FOR INTERNATIONAL DEVELOPMENT

and

S I N T E F

regarding

Consulting services in connection with the establishment and operation of the "Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre" (ITMMEC) in New Dehli

in

the Republic of India

This Contract is entered into between the Norwegian Agency for International Development (hereinafter referred to as "NORAD") having its headquarters located at Sørkedalsveien 10 B Oslo-Dep., Oslo 3, Norway, and Selskapet for industriell og teknisk forskning ved Norges tekniske høgskole (hereinafter referred to as "SINTEF") having its principal office located at N-7034 Trondheim-NTH, Norway.

WITNESSETH

WHEREAS, an Agreement regarding co-operation in the establishment and operation of the ITMMEC, New Dehli, between the Government of the Kingdom of Norway and the Government of the Republic of India (hereinafter referred to as "the Project Agreement") was signed 2. November 1977.

WHEREAS, NORAD in accordance with the terms of the Project Agreement desires to engage SINTEF to perform the consulting services outlined in Annex 1 to the said Project Agreement;

WHEREAS, SINTEF represents that it is ready, willing and able to perform such services;

NOW THEREFORE, the Parties hereto mutually agree as follows:

1. Scope of services

SINTEF undertakes on the terms and conditions set forth herein, to perform consulting services (hereinafter referred to as " the Services") according to specifications
./. contained in the Terms of Reference attached hereto, and shall thereunder exercise all reasonable skill, care and diligence.

1.1. SINTEF will provide necessary professional and supporting staff to meet the obligations laid down in this Contract. The composition of the staff is subject to the approval of NORAD.

1.2. SINTEF shall provide the necessary professional support for the Indian personnel under training in Norway. This includes provision of office facilities.

1.3. SINTEF shall assist in providing adequate housing for Indian personnel under training in Norway.

1.4. SINTEF may, if desirable, call in the assistance of other firms/institutions without charging any overhead costs. The sub-contracts containing i.a. curriculum vitae (C.V.) of personnel etc. will be presented to NORAD for approval. SINTEF is as liable for the work of the sub-consultants as for its own work.

1.5 SINTEF agrees that the performance of the Services pursuant to the requirements of this Contract, shall conform to high professional standards.

2. Remuneration and payments

2.1. NORAD shall pay to SINTEF compensation for the Services performed at rates set forth below on the basis of a detailed description of the activities actually performed and the period of time actually spent by the personnel in performing the Services.

(i) For services carried out in Norway, SINTEF will be paid on an hourly basis. The hourly rates are to be calculated on the basis of 1,2 0/00 of SINTEF's yearly salary expenses for each employee, including expenses connected with security and pensions. The calculation shall be based on salaries not higher than what is customary for personnel with the qualifications needed for the satisfactory performance of the Services.

The rates are subject to adjustments according to adjustments made in salaries and social expenses.

The rates shall, however, in no event exceed the maximum hourly rate of Statens bygge- og eiendomsdirektorat.

A detailed calculation of the hourly rates for each member of SINTEF's staff working on the Project and their C.V.s shall be forwarded to NORAD.

(ii) For services carried out in India, SINTEF will be paid on a weekly basis (necessary travel days included - max. two days per international journey).

The applicable rates shall be based upon the hourly rates referred to in (i) above and are based on 40 working hours and six working days per week. It is understood that no overtime is to be paid under this Contract. NORAD may, however, on the basis of detailed justification received from SINTEF make exceptions from this rule in individual cases.

2.2. Travel expenses and expenses for food and accomodation during the travel will be covered in accordance with the relevant Norwegian Government Regulations. Air flight expenses shall not exceed the applicable economy class rate.

A fixed amount of N.kr. 250,- to cover necessary travel expenses over and above air fares will be paid for each return flight. This amount shall cover expenses for vaccination and similar preparations, cost of transportation to and from airports, airport taxes and other expenses incurred during the journey. See paragraph 3 in Norwegian Government Regulations for Travelling Abroad, which is superseded by this clause.

The international travels are to be approved in advance by NORAD.

2.3. Payments referred to in paragraphs 2.1 - 2.2 above, are understood to cover all costs in connection with the execution of the Services under this Contract, with the exception of:

2.3.1 All certified expenses relating directly to the training of Indian personnel in Norway (no overheads to be charged), such as seminar fees, use of computers and special laboratory of instrumental facilities, literature, telex and telephone expenses.

2.3.2. Travel expenses of Indian personnel and expenses for food and accomodation in connection with annual review meetings held in Norway, in accordance with the relevant Norwegian Government Regulations. Air flight expenses shall not exceed the applicable economy class rate.

2.4. SINTEF will receive remuneration from NORAD on monthly basis. For services carried out in Norway, payment will be made against invoices certified by SINTEF's auditor. Each invoice is understood to contain a detailed description of the activities performed during the preceding month.

All payments by NORAD under this Contract shall be made to accounts designated by SINTEF.

2.5. Remunerations to be paid by NORAD under this Contract shall in no event exceed Norwegian kroner 3.200.000,- SINTEF undertakes, however, to perform the services defined or referred to in the Terms of Reference attached hereto in a fully satisfactory manner, even if this should involve costs exceeding the aforesaid amount.

3. Annual budget and procurement procedure

3.1. SINTEF is responsible for drafting the annual budgets of the Project, which are understood to specify the components (including the equipment to be purchased) to be financed by NORAD and the components to be financed by IIT. The draft budget will be presented to the IIT SINTEF Coordination Committee for comments before it is forwarded by the Indian authorities to NORAD for approval, c.p. the time limit set forth in Article IV. 2 of the Project Agreement.

When the budget is approved, it is SINTEF's responsibility that the SINTEF activities and expenses are kept within the frame given by the budget.

3.2. SINTEF will be responsible for the procurement and the arrangement of acceptance control of all laboratory equipment to be purchased according to the procurement procedure set forth in Article V,2 of the Project Agreement. It is left to SINTEF to decide - in consultation with IIT - whether purchased equipment items should be shipped directly to ITT, New Dehli, or to SINTEF for acceptance control and testing before being transferred to IIT.

All shipments to be undertaken according to this Contract shall be effected by Oslo Havnelager A/S. SINTEF undertakes to notify NORAD and IIT on each shipment (date of shipment, name of vessel, invoice- and freight value).

4. Notice and reports.

4.1. Any notice or request required shall be in writing. Correspondence shall be conducted in English, but may be in Norwegian on matters which are deemed to be of no interest to IIT and the Project.

4.2. SINTEF shall submit to NORAD quarterly progress reports, written in English, describing the progress or delay, difficulties encountered, movement of personnel, meetings etc. The progress reports shall be submitted no more than one month after the period to which they refer. SINTEF may also submit to NORAD other reports describing project activities.

4.3. At the end of each year, SINTEF shall submit to NORAD a summary report on the activities in the past 12 months in five copies with English text. The report is to be submitted not later than July the following year.

4.4. SINTEF and IIT retain the copyright to all documents/ inventions resulting from the Project. NORAD may,

use these documents for purposes considered useful, without being liable to pay any royalties.

5. Responsibility.

SINTEF shall act as a bona fide advisor to IIT and to NORAD and shall perform the Services in accordance with high professional standards.

SINTEF shall be held liable for any loss or damage to the Project caused by lack of professional competence or negligence arising during the execution of the Services up to the limit of 2 - two - million N.kr.

6. Entry into force - Cancellation and termination of the Contract

6.1. The Contract shall enter into force upon its signature, provided, however, that services perfonned and costs incurred from .1.September 19 .76..... for planning and organizing the services shall be deemed to be covered by the Contract. The Contract shall terminate when all obligations arising from it have been fullfilled.

6.2. NORAD shall be entitled to terminate the Contract at any time.

SINTEF shall be entitled to terminate the Contract in case of force majeure.;

In both cases, NORAD shall pay for the services carried out as well as compensation for proved necessary costs incurred.

6.3. If NORAD has terminated this Contract due to

(i) breach of contract by SINTEF, or
(ii) SINTEF being bankrupt or insolvent,

SINTEF shall receive remuneration for the part of the [illegible] carried out in accordance with the

Contract. NORAD is, however, entitled to compensation for any loss or increased costs caused by any event having led to termination of the Contract according to this paragraph.

7. Settlement of disputes

Any dispute in connection with this Contract, which cannot be solved amicably, shall be referred to the competent Norwegian court, and settled in accordance with Norwegian law.

However, if the Parties so agree, the dispute may be solved by arbitration according to the Norwegian Civil Proceedings Act of 18th August 1915, Chapter 32. To be valid, such Agreement has to be concluded in writing.

Oslo, 30th January, 1978

For the Norwegian Agency for International Development

Lasse Aasland
Director
Administrative Department

Trondheim, 2 February 1978

For SINTEF,

Selskapet for industriell of teknisk forskning ved Norges tekniske høgskole

TERMS OF REFERENCE

for

SINTEF

1. In pursuance of the Project Agreement between the Government of Norway and the Government of India, dated 2 November 1977, Norway shall, subject to Parliamentary appropriations, provide a grant of up to kroner 13.000.000,- for the establishment and operation of the Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre in New Dehli, India.

2. SINTEF's services will, in addition to those mentioned in the Project Agreement, include the following:

2.1. Advise and assist in personnel education and training with the object of familiarising Indian personnel with advanced methods and techniques of relevance to Indian industry.

2.2. Advise and assist in research projects of interest within the field of industrial tribology.

2.2. Participate in industrial research and development programs to be achieved in Norway by integrating Indian visiting personnel into appropriate programs which SINTEF is carrying out in collaboration with Norwegian industry, and in India by participation of experts from SINTEF in consultancy and development projects which the Centre will be carrying out in Indian industry.

2.4. Advise and assist in the purchase of equipment to be provided by Norway under the Project Agreement.

2.5. Arrange for the necessary quality control of all equipment referred to in Article V.2 in the Project Agreement.

3. SINTEF shall work in close contact with the Indian Institute of Technology and other relevant institutions and agencies in the field of industrial tribology.

APPENDIX IV

EVALUATION OF A PROJECT PROPOSAL FOR THE ESTABLISHMENT OF A TRIBOLOGY CENTRE IN NEW DEHLI

A REPORT PREPARED BY A NORWEGIAN MISSION

APPOINTED BY N O R A D

TRONDHEIM, APRIL 6TH, 1976

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1.0 Summary

The Indian government has, with reference to a project proposal prepared by the Indian Institute of Technology (IIT), New Dehli, requested financial assistance from Norway to create a centre of "Tribology, Dynamics and Maintenance Engineering". The project proposal requires a financial contribution of N.kr. 8.296.000,- from NORAD over a four year period starting in 1976, and assumes close professional collaboration with the Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology in Trondheim (SINTEF).

Extensive discussions with representatives of the IIT, Indian government officials and representatives from Indian industry confirm that the proposed centre, properly organized and managed, will represent a significant contribution to the technological development of the Indian society. The delegation would also stress that the location of such a centre at the IIT in Dehli will be an important step towards a closer University-Industry interaction of great benefit for both parties.

The delegation supports the idea of establishing a close professional collaboration in the field of Tribology and related areas between the IIT and SINTEF. SINTEF is prepared to assume such a responsibility and to commit its resources for this purpose.

The delegation finds the project proposal well prepared and the suggested resource requirements are considered adequate, seen apart from the equipment budget which need to be raised to include necessary spare parts and accessories. The project proposal includes a financial contribution from NORAD, of N.kr. 8.296.000,- over a 4 year period. This does not, however, include the cost of the SINTEF manpower input. To cover this component as well, the NORAD financial contribution must be increased to N.kr. 10.889.000,-. All estimates are based on the cost level of early 1976.

2.0 Introduction

A delegation was formed on February 12th, 1976 by NORAD to study and assess a project proposal, made by the Indian Institute of Technology (IIT), New Dehli, to establish a centre of "Tribology, Dynamics and Maintenance Engineering" at IIT. The following individuals were nominated as members of the delegation:

- Mr. E. Sødahl appointed Head of mission	Deputy Director General, The Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF)
- Dr. H. Christensen	Professor, Head of Research, SINTEF
- Mr. H. Høydahl	Director, Systematic Maintenance Consultants (SYMAC), Senior Consultant, NORCEM
- Mr. E. Rørstad	Senior Planning Officer, Planning Department, NORAD
- Mr. O.A. Lunder	Resident Representative, NORAD, New Dehli

The terms of reference required the delegation to investigate and assess the Indian project proposal of November 25th 1975, and to make recommendations for possible changes in the project proposal and to assess the extent of possible Norwegian assistance, both financial and technical. The complete "Terms of reference" for the delegation are attached, appendix 1.

./.

The work of the delegation has fallen into two parts:

1. A visit to India in the period February 18th - March 2nd, 1976. The programme for this visit was worked out in close cooperation with the IIT authorities and included extensive discussions with representatives of the IIT, Indian government officials and representatives from industry. The programme also included visits to a selected number of industrial enterprises. The full programme for the visit to India is attached, appendix 2.

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2. On return to Norway the mission made a final analysis of the findings and prepared this formal report.

Before proceeding with the report the delegation would like to express its thanks to Dr. N.M. Swani, the director of the IIT and all at the IIT who contributed to the success and pleasure of the visit. Dr. Swani and the IIT team attached to the delegation during the stay in India, could not have been more thoughtful in seeing to the needs and wishes of the delegation. Dr. J.P. Sharma and professors R.C. Malhotra, B.C. Nakra and J.S. Rao as well as the members of other faculties the delegation met at the IIT were all very considerate in giving their time and were exeedingly helpful in providing the delegation with the necessary information and sharing their ideas. The delegation express its sincere gratitude to all.

3.0 The significance of Industrial Tribology

The strict scientific definition of the term "Tribology" is the science and technology of interacting surfaces in relative motion and of related practices. It covers problems in connection with wear and lubrication. It is a multi-disciplinary subject spanning the chemical, mechanical and metallurgical sciences.

The term industrial tribology is in this report given the much wider definition of the technology which has to do with design of mechanical products and equipment, and their operation and maintenance with the aim of conserving material resources through a reduction of wear, conserving energy through a reduction in friction, and an increase of the economical operating life of equipment as well as increased standards in product reliability and personnel safety.

Wear is a common source of functional disturbances in mechanical equipment and maintenance is often the critical factor in the control of wear. Proper technological knowledge of this subject is often lacking. The fact that the annual maintenance costs for production equipment within industry in the developed countries, amount to 10-20% of the initial investment, clearly demonstrates the economic importance of the field. Increasing attention is given to the fostering of economic and industrial growth in developing countries through a high investment ratio and through transfer of capital and technical know-how from industrialized countries.

Surveys carried out in the developing countries show that much of the equipment installed in these countries is in poor mechanical condition due to lack of adequate repair and maintenance. This results generally in loss or efficiency or the equipment, lower product quality giving economic losses through higher production costs and lower outputs. Another result is the direct deterioration of the equipment, and the shortning of its useful life. This is a serious waste of capital, already a comodity in short supply in the developing countries. Industrial development and the transfer of technology becomes more difficult and costs more. The developing countries "balance of payments" problem tends to aggravate this situation as the import of replacement parts and materials grows.

An improvement in the standards of repair and maintenance in the developing countries could be a most effective and important way of stimulating industrial growth. Relatively small resources could yield considerable gains both in the short and, above all, in the long term.

The talks with representatives of the Indian government, university authorities and Indian industry has convinced the mission that the situation described above is, to a large extent also true for India. The Indian authorities are themselves aware of this as is demonstrated by the weight and priority given to industrial tribology and maintenance by the government planning authorities. If more advanced and systematic methods and technologies of maintenance and repair could be introduced into industry, a very significant saving would result. In addition to the reduction in foreign exchange spending, increased standards of maintenance would also lead to the increased life of components and machinery, and therefore also result in higher productivity.

Although India has a number of scientific and industrial research and development centres or institutes, there is, at present, no centre with the responsibility of advising and assisting industry with their maintenance and repair problems. On the other hand, the mission found a great willingness within established bodies and institutions with responsibility for other aspects of technology (i.e. National Productivity Centre) to cooperate with a centre of Industrial Tribology and Maintenance if such a centre were to be established. Likewise, representatives of Indian industry expressed considerable interest in making use of the facilities and expertise available at such a centre.

4.0 The ITT, New Dehli

The IIT Dehli is the youngest of the five IIT's created in India as centres for higher training, research and development in science, engineering and technology. In the academic year 1974/75 the Institute accomodated 1150 undergraduate students, about 400 students on post graduate courses and about 440 were registered for Ph.D.

In spite of the present surplus of university trained manpower in India, the IIT graduates are in high demand within Indian industry. This fact demonstrates the quality of the teaching programmes of the Institute. The mission was impressed by the high professional standard of the IIT faculty, and a number of the faculty members demonstrated a keen interest in working on industry-oriented problems and giving service to industry. Through the resent establishment of an Industrial Consultancy Liason Board (ICLB) the Institute has taken an important formal step towards an increased interaction with industry.

With adequate financial support and proper advisory assistance the delegation finds that the Institute forms a promising basis for a viable centre for industrial tribology, machine dynamics and maintenance.

5.0 Recommendations

5.1. Principal assessment of the project proposal

The basic idea of the Indian project proposal is to establish a centre of "Tribology, Dynamics and Maintenance Engineering" which will be of benefit to both the academic programmes of the IIT and the industrial performance in India. The centre is supposed primarily to undertake industry-oriented research and development (R&D) work and will establish a close liason with the Indian industry through undertaking contract research projects, offering training courses, seminars and related activities. The proposal assumes a close collaboration between the IIT, Dehli and The Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), through the accomplishment of joint research projects.

The financial assistance which is requested from NORAD is:

approx.	4.5 M.N.kr.	for laboratory equipment
"	3.9 "	for recurring expenditure

over the 4 year period 1976-79.

The mission supports the view that a properly organized and guided industry-oriented research centre such as is proposed should represent a significant contribution to the industrial development of the Indian society. It should in addition become an important tool for promoting a fruitful interaction between the IIT as an university and industry. The mission therefore recommends that NORAD gives the project its full support.

SINTEF has confirmed to the mission that it is prepared to take on the responsibility as a collaborating party as described in the proposal, and to commit its resources for that purpose. The nature and volume of this function is outlined below.

5.2 The objectives of the centre

The centre's name should be altered to "Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre" (ITMEC) to stress its industry-oriented nature. The mission further recommends that the purpose of the centre should be expressed explicity in the project documents and would suggest the following formulation:

> The purpose of the ITMEC is to further industry-oriented research and development activities at the ITT, Dehli, in the field of Industrial Tribology, Machine Dynamics and Maintenance Engineering, and within this field to foster the cooperation between the institute and industry and commerce, as well as with other research organisations.

It is strongly recommended that when the centre has become established after the initial years, and has proved its viability, the possibility of enlarging its operation for the benefit of the Indian industry and the IIT shall be concidered.

5.3 Activities and priorities

In line with the proposal the activities of the centre is envisaged to fall within the following categories as specified in the proposal:

a) Consultancy and development projects within Indian Industry with the aim of giving advice and assistance to Indian industry within the field of industrial tribology and maintenance.

b) Research projects in contact with and in collaboration with Indian industry with the view to developing and improving maintenance methods and techniques and adapt available methods to local conditions.

c) To conduct courses and seminars with the aim of upgrading skills of industrial maintenance personell at all levels.

d) To arrange internal courses and training seminars within the center to acquaint personell with available methods and techniques and to train personell for active participation in industrial consultancy and development projects.

5.4 Collaboration ITT - SINTEF

SINTEF's active engagement within the field of industrial tribology and maintenance extends to more than a decade and a half. Through this engagement SINTEF has gained considerable knowledge and experience in handling practical research and development problems for industry. Collaboration between ITT and SINTEF will mainly take the form of interaction and joint participation within the three areas:

a) Personell education and training with the object of familiarizing personell with advanced methods and techniques of relevance to the Indian industry

b) Joint research projects of common interest within the field of industrial tribology and maintenance. These projects should be actively persued both in India and at SINTEF and would be organized for the optimum use of common research resources.

c) Joint participation in industrial research and development programs. In Norway this would be achieved by integrating Indian visiting personell into appropriate programs which SINTEF is carrying out in collaboration with Norwegian industry. In India, experts from SINTEF would take part in consultancy and development projects which the centre will be carrying out in Indian industry.

5.5 Resource requirements

a) Personell

The mission considers the proposed increase of staff at IIT as set out in the proposal as realistic. After a consideration of available personal resources at SINTEF the mission suggests that on the average a commitment of two man years per year will be allocated to the project. This includes a SINTEF Project Manager. He will organize and supervise training of personell in Norway and also be responsible for the Norwegian component of joint research projects. He will spend part of his time in India and part at SINTEF. Through their talks with representatives of Indian industry the mission was convinced that the range of problems to be solved was very wide indeed. This makes it inefficient to rely on one resident SINTEF expert at the centre. SINTEF must be prepared to supply a range of experts for shorter periods with qualifications matching the problems to be solved. Although this will mean increased travel costs it is considered essential for the efficient working of the project.

b) Equipment

Although the existing IIT laboratories are reasonable well equipped for teaching purposes their available equipment is neither complete nor well suited for carrying out the industrial research work required to be done in the country. The mission agrees therefore with the Indian proposal that equipment procurement is of prime importance and should be started as soon as possible. The mission recommends that the estimate requirement to be raised to a figure of N.kr. 6 Million, to include necessary spare parts and accessories.

c) Space

At the present time IIT is prepared to make about 1000 m^2 of laboratory and building space available for the activities of the centre. An additional 500 m^2 can be made available in due course. The mission considers that the ultimate space available to the centre will be adequate.

5.6 Financial support

The project proposal states that financial support for meeting the objectives of the centre are required from NORAD and from the IIT, Dehli itself. The proposal also indicates an income of about 500.000 N.kr from contract work over the 4 year period. The mission finds this estimate adequate for the initial period but recommends that a more ambitious goal should be set for the contract research activities of the centre within the next 2-4 years. It agrees,however,that for the initial 4 year period, NORAD should meet a larger share of the planned investment in capital equipment and instruments, as well as the recurring expences for exchange visits for professionals, meetings, seminars, maintenance expences and for creation of a NORAD chair at the Institute.

Some budget adjustments are necessary as a result of the alteration in the staff exchange programme (see chapter 5.5), the increase in equipment budget and to meet the actual cost of the SINTEF manpower input. A revised budget is shown in appendix 3 and 4.

The total financial input is summarized in table I.

Table I. Total input in the ITMEC over a 4 year period (1000 N.kr)

	NORAD	IIT	Total
1. Non-recurring expenditure, equipment including spares and accessories	6.000	400	6.400
2. Non-recurring expenditure, space for laboratories and residence		200	200
3. Recurring expenditure	4.889	500	5.389
4. Inputs by way of use of existing IIT facilities		1.900	1.900
Grand total	10.889	3.000	13.889

The mission appreciate the difficulty of specifying the IIT financial support in an interdisiplinary area of this kind, and the figures in table I referring to this component are taken from Table 4 in the Indian proposal.

The mission agrees that the project runs for four years with the possibility of further extention. The rate of capital expenditure is likely to be below average the first year, and reaches a peak during the second and third years.

If the project is started within the next 3-6 month the mission will recommend that the following activities are financed by NORAD in the current year 1976:

Visit to Norway by three IIT representatives to familiarize themselves with SINTEF and NTH and to discuss details on equipment priorities and procurement. Approximately 3 weeks stay	45.000
Procurement of priority equipment	900.000
Meeting of Coordination Committee in India for detailed planning of activities 1977	45.000
Estimated total cost ~ N.kr.	1.000.000

5.7 Organizational structure of the Centre

The mission feels that, ideally, though operating on the premises and utilizing the resources of the IIT, Delhi, such centres should be established as administratively and financially autonomous organizations, primarely to secure the necessary freedom of operation, especially when dealing with contract research involving various kinds of commitments, and to have the possibility of accumulating financial reserves. It is, however, understood that the present constitution of the IIT does not permit such a solution. The centre will therefore have to be an integral part of the IIT Delhi which also will be legally responsible for its operation. This situation has to be reflected in the organizational structure which is recommended given the following form:

Advisory Committee

The Centre should be governed by an Advisory Committee consisting of 15-20 representatives from Indian Industry, Ministries, Institutions of IIT Delhi. The Advisory Committee, which has to be given authority from and should report to the Director of IIT Delhi, should meet minimum twice a year, and should mainly deal with matters of policy making nature and to ensure constant interaction with the industry.

Management Committee

The Management Committee will be constituted by the IIT and should, for the sake of efficiency, have maximum 6 members. At least one of the members should be from industry.

The management Committee will have the same function as a board and should meet frequently, presumably once a month.

Head of Centre

The Head of the centre who naturally will be appointed by the Director of IIT, will be responsible for the day-to-day operation of the centre. The Head operates within a mandate given him by the Management Committee, to which he reports.

Research Divisions

The research activities should in the beginning be organized into a limited number of subdivisions by major research areas.

6.0 Project coordination

The mission recommends that SINTEF is made responsible for the NORAD component of the project within a framework laid down in a separate agreement between NORAD and SINTEF, and that SINTEF appoints a Project Manager.

It is further recommended that an IIT-SINTEF Coordination Committee be established with a responsibility at annual project review meetings to

a) assess progress reports and make recommendations as to the annual budgeting of funds available from NORAD

b) handle details of cooperation between the parties

This committee should consist of two IIT representatives and two SINTEF representatives.

Trondheim, April 6th 1976

E. Sødahl, Head of Mission

H. Christensen

H. Høydahl

E. Rørstad

ES/RAn

Norwegian Agency for International Development
NORAD

Director-General

Oslo,

TERMS OF REFERENCE

for

NORAD's delegation to the Republic of India, to study the setting up of a tribology centre in New Delhi, February 1976.

1. Background

In 1974 India requested assistance from Norway to establish a centre of "Tribology, Dynamics and Maintenance Engineering". At the annual review meeting in New Delhi in October, 1975, it was agreed to recommend that Norway should consider assistance in this field. Financial assistance for this purpose would be covered under the allocations recommended for science and technology under the Norway/India country programme 1976 - 1979, with 2 mill. kr. in 1976, 3 mill. kr. in 1977 and 2 mill. kr. in 1978, whereas technical assistance would be covered under the provisions made for technical assistance: 0,5 mill. kr. in 1976, 1 mill. kr. in 1977, 1 mill. kr. in 1978 and 1 mill. kr. in 1979. The type and composition of the assistance would be determined on the basis of a new and more detailed request from India and after consultations between India and Norway.

A more detailed request was presented by the Indian authorities in a letter of November 25th 1975 from the Ministry of Finance, Department of Economic Affairs, with a project proposal from the Indian Institute of Technology (IIT), New Delhi.

As part of the consultations between Norway and India it was agreed during the annual review meeting that Norway should send a mission to New Delhi, in order to have a more detailed

discussion of the Indian proposal for setting up a tribology centre and of the extent and nature of possible Norwegian assistance.

2. Appointments

- Mr. E. Sødahl is appointed Head of mission	Deputy Director General, The Foundation of Scientific and Industrial Research at the University of Trondheim (SINTEF)
- Dr. H. Christensen	Professor, Head of Research, SINTEF
- Mr. H. Høydahl	Director, Systematic Maintenance Consultants (SYMAC), Senior Consultant, NORCEM
- Mr. E. Rørstad	Senior Planning Officer, Planning Department, NORAD
- Mr. O.A. Lunder	Resident Representative, NORAD, New Delhi,

are appointed members of the mission.

3. Assignments

3.1 On the basis of a thorough review of the project proposal of November 25th 1975 the Mission shall study and assess the following:

3.1.1 the aim of the project,

3.1.2 the extent to which the project is application oriented and industry oriented,

3.1.3 the need for technical assistance and to which extent this must be met by Norway,

3.1.4 the need for manpower; for permanent staff as well as for research, design, development, consultancy and education in the field of industrial tribology,

3.1.5 the need for investments (buildings, machinery, equipment etc.) and to which extent this should be met by Norway,

3.1.6 the financial cost of the project, over a certain period and distribution per year,

3.1.7 the need for services of the centre to relevant industrial enterprises,

3.1.8 the administrative set-up of the centre, co-operation with private industry, advisory committees, etc.

3.2 Recommendations

On the basis of the investigations and assessments described above the Mission shall evaluate the request, and make recommendations of possible changes in the project proposal and the extent of possible Norwegian assistance, both financial and technical.

4. Implementation of the study

4.1 The study in India should be undertaken between February 18th and March 1st 1976.

The Mission should visit relevant industrial enterprises.

4.2 The study should be made in close co-operation with the proper Indian authorities (Indian Institute of Technology (IIT), Indian Society for Industrial Tribology, Department of Science and Technology etc.) and other institutions, organizations, individuals etc., as may be deemed necessary.

5. Report

A report of the Mission's findings, with conclusions and recommendations, should be submitted in English to NORAD within 6 - six - weeks after the completion of the mission.

Oslo, 9th February 1976

APPENDIX V

LISTS OF EXPECTED AND REALIZED CONSULTANCY PROJECTS AT ITMMEC*

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* Based on information provided by the Centre

TABLE A

PROJECTS/CONSULTANCY/R&D WORK AWAITED TO BE HANDLED BY THE CENTRE ON SPECIAL EQUIPMENT (1980)

S.No.	Organization	Nature of work	Equipment required	Estimated project value (Rs)
1.	Delhi Transport Corporation New Delhi (C.T.C.)	Oil analysis, wear analysis maintenance schedule	Ferrograph, Hiac X-ray surface Constituent analyser, image analyser	100 000
2.	Central Board of Power & Irrigation	Boiler tube failures, Erosive , wear resistance coating	X-ray surface constituent analyser, large Ionplating & CVD Coating	1 600 000
3.	Badarpur Thermal Power Station, New Delhi	Signature analysis of bearings abrasive wear studies and oil analysis	Simulation for bearing analyser on Real Time analyser, Tape recorder Transducers, Ion implantation, X-ray surface constituent analyser	300 000
4.	M/s. Eicher Tractors Ltd., Faridabad	Wear analysis	Same as Sr.No. 1 & 2	50 000
5.	Punjab Tractors Ltd., Chandigarh	Wear analysis	- do -	50 000
6.	Swadeshi Polytex, Ghaziabad	Wear resistance coating, Ion plating & Implantation	Ion plating, Ion plantation CVD	100 000
7.	Department of Science & Technology:-			
	a) Regional Research Laboratory	Wear of bearings performance of bearings & Pistons, Cylinder liners of the special graphite aluminium material, wear resistance plating & Implantation	Same as in Sr. 1, 2 & 3	300 000
	b) Central Mech. Engg. Research Institute (CMERI), Durgapur	Wear resistance coating, solid lubricant coating, Ion implantation		300 000
8.	M/s. Engineering Technical Service, Allahabad	Waste heat recovery & failure diagnostics	Thermography, X-ray surface Constituent analyser Image analyser	50 000

Table A (continued)

9.	J&K Industries, Udaipur	Signature analysis, wear resistance coating and treatment	Same as in S.No. 2&3	50 000
10.	M/s. Vulcan Laval, Poona	Dynamic balancing, signature analysis	Same as in S.No. 3	100 000
11.	M/s. Sandvik, Poona	Wear resistance coating, lubricant coating, implantation & performance	Same as in S.No. 1, 2&3	200 000
12.	Bharat Gears	Coating Special treatment of gears implantation failure & signature	Same as in S.No. 1, 2&3	300 000
13.	Topaz Blade Industry	Coating of solid lubricant & implantation	Same as in S.No. 2	100 000
14.	Indian Railways	Oil & Wear analysis, Diagnostics & wear resistance and coating	Same as in S.No. 1	100 000
15.	Defence	Oil & Wear and Signature analysis	Same as in S.No. 1, 2&3	100 000

The above projects totalling Rs. 3.8 million can only be taken if special equipment as mentioned and agreed are received, installed and operated in ITMMEC. As such it is difficult to generate the project as mentioned above.

TABLE B

ITMMEC CONSULTANCY PROJECTS 1978 - JUNE 1981

Year	Sponsor	Project	Pesponsible faculty	Fee Rs.
1978	M/s. Eicher Tractors Ltd., Faridabad (Scholarship & facilities at site)	Design of Three wheeler tractors		5,000
	Calico Mills, Ahmedabad	Lubricant Planning	)	5,000
	Calico Mills, Ahmedabad	Design Audit of bolster spindle	)	
	Hindustan Electro Graphite Pvt. Ltd. Bhopal	Electrographite characterization		5,000
	Swadeshi Polytex, Ghaziabad (UP)	Prevention of knife edge wear used for stapple cutting	)	5,000
	Swadeshi Polytex, Ghaziabad (UP)	Cooling of knife chamber for friction reduction	)	
	Council for Scientific & Industrial Research (CSIR), New Delhi	E.H.D. by Interferometer		10,000
1979	Vulcan Laval, Poona (field trial and travel)	Vibration response & balancing		5,000
	Badarpur Thermal Power Station	Identification of problem areas in Badarpur Thermal Power Station	)	
	Badarpur Thermal Power Station	Diagnostics by vibration response in antifriction bearings	)	5,000
	Badarpur Thermal Power Station	Wear resistance coating & prevention	)	
	M/s Escorts Pvt. Ltd., Fariadabad	Design Audit & Computerization Eight speed gear box		4,000
	Swadeshi Polytex, Ghaziabad	Failure detection in staple cutting machine		2,000

1980	Jamuna Auto Works, Jamuna, Nagar	Maintenance Design audit of tempering & Annealing furnance	5,000
	Kirloskar, Poona	Failure of Bearings - Study	n.a.
	M/s. Khosla Compressors, Faridabad	Maintenance evaluation of compressor Air filler	14,000
	Plastic Peels, Bombay	Solid lubricant characterization & evaluation	2,000
	Ministry of Shipping & Transport, Delhi	Design Audit & Redesigning of Cycle Rikshaw	70,000
1981	U&K, Udampur & New Delhi	Heat balance & evaluation of Boiler efficiency	
	Cement Corporation of India	Kiln Gear Failure Analysis	
	Delton Dables, Faridabad	Maintenance of Furnance & efficiency	

APPENDIX VI

INFORMATION[x] ON SINTEF PEOPLE SENT TO ITMMFC

(NOT INCLUDING CHRISTENSEN AND HUSEBY)

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[x] List prepared by SINTEF (August 1981)

Name, background	Visit to India	Main activity	Report
Engebretsen, E. NSFI, Oslo	Oct. 28- Dec. 9, 1979	Project acquisition and Planning. Workshop 79 Papers: - Trends in modern control - and instrumentation techniques. - Essentials of the Predict 10-Steam Condition Monitoring System.	180473.30-1
Langset, Jan G.,researcher borne 100246 NTH 1970 Machine Dept. A/S Årdal & Sunndal verk March 72 - May 73 NSFI April 79 - Now working for AKER Trøndelag, Trondheim. Langset participated in the project as project coordinator/leader until the end of March 1979	March 11-31,1978 Nov.21-Dec.16, 78 Dec. -79	Project coordinator Project coordination and Workshop -78 Papers: - Maintenance Strategies - Oil Analysis Workshop -79 Paper: - Planned maintenance for greater plant availability. - Systems for maintenance planning and control.	
Bakken, G. Maintenance Manager Refinor Mongstad	Dec. 1978	Workshop 78 Papers: - Diagnostic machinery maintenance Mongstad Refinery. - Centrifugal compressor C401 at Mongstad Refinery. Case of high vibration, April 1978.	

Name, background	Visit to India	Main activity	Reports
Onsøyen, Eldar, researcher born 230852 NTH 1976 Machine Devision SINTEF Jan 77 -	Nov/Dec 1980	Workshop -80 Contribution to preparing and running the workshop. Papers: - Vibration analysis techniques.	
Lippe, Jon, researcher Born 261248 NTH 1974 Physics NTH, Inst. for ship-machinery SINTEF Jan 77 -	Nov/Dec 1978	Workshop -78 Papers: - Introduction to condition monitoring - Measurement of vibration, instruments and applications.	
	Nov/Dec 1980	Workshop -80 Papers: - Maintenance strategies - Introduction to condition monitoring. Also important contributions to preparing and running the workshop.	
Wahl, Magnar Instrument technician	March/April -81	Instrument and equipment maintenance	To be prepared

APPENDIX VII

LIST OF ITMMEC PEOPLE

RECEIVED AT SINTEF SEPTEMBER 1978 - AUGUST 1981[x]

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[x] prepared by SINTEF (August 1981)

NAME	LENGTH OF STAY	PEASONS FOP COMINC MAIN ACTIVITIES	AVAILABLE REPOPTERS
Dr. K.N. Gupta	Sept-78 Feb.-79 5 months	Joints projects : Turbine Blade Vibration Rotor Dynamics Instrument procurement	180472.40/4 180472.30/6
Mr. K.L.Awasthy	Sept-78 March-79 6 months	Joint projects: - Wear of Manganese steel - Wear of lifting fork and piston in hydraulic system -Ionplating and Wear Studies - Application of Holography in Wear Studies Equipment procurement	180472.40/2
Mr. R.P. Mana[illegible]	Sept-78 March-79 6 months	Instrument maintenance Instrument procurement Instrument familirezation	180472.40/3
Mr. O.P. Gandhi	April-79 Oct.-79 6 months	Diagnostic maintenance Condition monitoring and Wear Studies Oil Analysis Design of Rotor Dynamic Test Rig Equipment procurement	180472.40/5
Mr. A. Prakash	Oct.-79 July-80 9 months	Diagnostic maintenance Condition Monitoring and Wear Studies Rolling Mill Test Rig Design Follow up activity on bearing test rig Equipment procurement Dev.ment of computer progr. for instant gear tooth fuction	180472.40/9/15 180472.30/18/19
Dr. C.R. Jagga	Oct.-79 July-80 9 months	Surface Films & Solid/Lubricants Surface structure techniques and surface composition determination. Ion plating Testing/Analysis of Lubricants and additives Oil Analysis, Wear Studies,Equipment procurement	180472.40/8/ /13/14/17/18 180472.30/10
Mr. O. Prakash	Jan.-80 July-81 6 months	Non Destructive Testing Techniques Wear and surface studies - design of rig Holograph Equipment procurement	180472.40/21/22/ 24/25/26/27/28
Mr. N. Tandon	Jan.-81		180472.40/21/ 22/28/29
Mr. S.C. Sharma	Aug. 17, -81	Joint project: EHD Interferrometry Instrumentation of rig. Experiments	

APPENDIX VIII

STATUS OF EQUIPMENT PROCUREMENT
(Excerpt from SINTEF Memo No. 27, IND 014, 1980-11-07)

In setting up the equipment list in "Draft Budget and Plans of Operation for 1981" the cost of each item was distributed into appropriate columns according to whether it was (D) delivered, (O) ordered or (C) under consideration. The cost of items which by ITMMEC had previously been given second priority (1) was placed in a separate column with heading (W) "wishes from ITMMEC". We then reached a total equipment cost without insurance and freight of Nkr. 16.7 mill. Since the budget limit for Equipment procurement is 12.3 mill., we had to reduce this total sum with 4.4 mill. plus insurance from the C-column to the W-column. To have a guideline for which type of equipment should be transferred, the instruments were grouped according to their field of applications with sub-groups. They are:

I WEAR AND FRICTION

- I.1 Material testing
- I.2 Wear test via lubricant testing
- I.3 Machine element test
- I.4 Auxillary equipment

II LUBRICATION

- II.1 Lubrication properties
- II.2 EHD
- II.3 Hydrodynamic lubrication

III MATERIALS/SURFACES

- III.1 Instruments for chemical analysis of gases, solids and liquids, especially oil analysis
- III.2 Material studies
- III.3 Material treatment
- III.4 Surface analysis
- III.5 Surface treatment

IV MACHINE DYNAMICS

IV.1 Vibrations

IV.2 Noise and sound measuring equipment

V NON DESTRUCTIVE TESTING

VI GENERAL LABORATORY EQUIPMENT

VI.1 Condition monitoring

VI.2 General electronic equipment

VI.3 Temperature measuring devices

VI.4 Mechanical measurement

VI.5 Motors

VI.6 Photographic equipment

VI.7 Data equipment

VI.8 Education/office

Below, we have given the equipment list according to this grouping. Each item that has been transferred from the C-column to the W-column by SINTEF is given an accompanying explanation. This transfer has not been easy, since many of the instruments concerned would have been very useful for ITMMEC. The transfer should be regarded as a proposal and will be discussed with the ITMMEC representatives. A new item 10/80 has been added, because SINTEF considers it very important that ITMMEC should be well equipped with instruments for general maintenance.

Note that the insurance and freight costs are presently not known. The estimated total sum of Nkr 697.000 probably is too low and therefore the sum of equipments under consideration might have to be further reduced.

I WEAR AND FRICTION

Group	Serial No.	Name of equipment	Status M10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
MATERIAL TESTING	21-79	Four Disc.Mach.	D	150	273	273				
	22-78	Four Ball Mach.	D	110	122	122				
	33-78	Pin and Disc. Machine	D	100	104	104				
	1-79	Wear and Friction	D	75	95	95				
	4-79	Pitting Disc Machine	W	140					140	
	9-79	Polymer Wear Studies	W	100					100	
	10-79	Twinheaded Five-ball Machine	W	75					75	
	12-79	Friction Stud. high temp.	W	100					100	
	14-79	Pendulum impact-friction	W	80					80	
	18-79	Falex Amster Test	W	60					60	Put in W-column becau wear and friction mac seem to be rather well represented already.

I WEAR FRICTION CONTINUE

IP	Serial No.	Name of equipment	Status 1/10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
Wear test rig & lubrication testing	20-78	Gear lubr.test rig.	D	100	237	237				
	31.78	Test Mach. for lubr. ev.	W	80	Comb. with 20/78					
	16-78	Chip detector Syst.	D	180	185	185				
	18-78	Ferrograph	D/C	205	132	122		10		
	1-80	Radioactive tracer unit	W	300					300	
Machine element test	3-79	Journal Bearing Test	C	180	320			320		
	41-79	Small motr. pumps	C	20	20			20		
	42-79	Clutch test rig	W							
Aux. Equipn.	30-78	Climatic chambers	W	100					200	Separate climatic chamber may be put low on the priority list, since several test machines have their own climatic chamber.
		Sum total Wear friction		2155	1488	1138	0	350	1055	

II LUBRICATION

Group	Serial No.	Name of equipment	Status W10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
Lub. properties	19-78	Viscometer for Rheolog. Stud.	W	110					500	We propose a low prio for this item because feel that the cost is high for a simple vis meter, and maybe too for equipment require advanced rheological ies.
	7-79	Microcalorimeter	O	65	105		105			
EHD	37-78	EHD optical Interf.	C	60	80			80		
Hydrodynamic lubrication	2-79	Air Bearing App	O	25	34		34			
	37-79	Seal Testing Unit	C/W	150	900			900	450	Cost proposed reduced because of financial situation. The origi cost includes freight which has now been su tracted. Futher, the hydraulic power pack is as desc in BHRA offer of 24th June-80 since rolling mill, item 6/79, is p on W-list. Finally, we propose t the logger controller left out for the time beeing.
	8-80	Bearing Test Rig	C		80			80		
		Sum total lubrication		410	1199	0	139	1060	950	

III MATERIALS/SURFACES

up	Serial No.	Name of equipment	Status 1/10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
	13-79	Spectrophotometer	W	100	Comb. with 33-79					
	17-79	Dielectric of fluid tester	O	40	96		96			
gases, soli) and liquids, especially oil analysis	27-79	Differential Thermal Analyzer	O	55	532		532			((: Cost estimate :
	30-79	Infraked spectrometer	D	180	677	677				
	33-79	Gaschromatograph Mass. spec.	D	150	1400	1400				
	5-80	UV spectrophotometer	D	180	179	179				
	9-80	Atomic absorption	W	150					150	
		Sum		855	2884	2256	628		150	
Mater)l studies	8-78	Hydraulic shaker	W	750					750	
	23-79	Precision Control temp. furnace	D	40	57	57				
	3-80	Fatigue and Creep testing mach.	W	200					200	
		Sum		990	57	57			950	
Material treatment	6-79	Rolling mill	W	200					400	Given low priority becaus it is felt that important research contributions in this field may demand eve more expensive equipment than expressed by the buc
	26-79	Autoclaves	O	80	104		104			
	7-80	Experimental extrusion rig	W	180					180	
		Sum		460	104		104		580	

roup	Serial No.	Name of equipment	Status V10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
Surface analysis	23-78	Interferometer	D	295	347	347				
	24-78	Surface const. analyzer	W	400					1600	This item comprises an spectrometer and an ima analyzer. The approxir prices are XRF-spectror Nkr 700 Image analyzer " 900 Under the present budget situati the image analyzer is low priority for reaso given in SINTEF memo o 1979-10-29[2]. We sup that IIT is equipped w a scanning electron mi scope. IF ITMMEC has to such a microscope w X-ray analysis facilit we recommend low prior also for the XRF-spect meter. If not, the pr of this item has to be concidered.
	25-78	Microhardness tester	D	60	18	18				
		Sum		755	365	365			1600	
Surface treatment	11-79	Ionplating a) and b)	W	240					1450	ELAB, SINTEF, has laid their activity on ion ing. Since SINTEF the can not contribute to field (e.g. to joint p ects) we recommend low rity for this item.
	15-79	Ion implantation	W	800					3000	
		Sum		1040					4150	
	Sum Materials/ surfaces			4100	3410	2678	732	0	7730	

IV MACHINE DYNAMICS

VIBRATION

P	Serial No.	Name of equipment	Status M10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
	1-78	Vibration Moni-toring syst.	D/C/W	160	85	10		75	105	The original proposal of two complete monitors is reduced to one single, although capable of 12 channels.
	2-78	Vibration Measu-ring Equipment	D/C	365	440	215		225		The original proposal is reduced to about half the amount of accelerometers. By including a new subite: Hottinger SM60 Vibration Meter as proposed in memo 180427.30 No.18, 1980-07-: the total sum of Nkr 50.0! is maintained unaltered.
	3-78	Real Time Ana-lyzer	C		430			430		It is strongly recommende: that this item is procure: It will serve a variety o: purposes on vibration and sound analysis in the laboratory. The 2-channe: version is required for study of frequency respons
	4-78	Shock Pulse Meter	D/C		21	11		10		The Center has noted the need for a Shcok Pulse Meter type 43A, which is a more industrial type com-pared to the 21A model which is already delivere SINTEF also recommends this item, as it has prov to represent a reasonable "first step" for many industrial companies who are considering the utili-zation of condition moni-toring equipment.
	5-78	Frequency Respo-nse Measuring Syst.	D	110	120	120				
	7-78	Servo-Control-led Dynamic Excitation syst.	C/W	330	180			180	270	This item is reduced by Nkr 270.000 which is obta: ed by skipping all but on exciter head. The equipme may easily serve the pur-pose of item 25/79 Torsio-nal Exciter, by connectin the shaker to the torsio-nal system via a cantilev beam.

roup	Serial No.	Name of equipment	Status 1/10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
	10-78	Laser with holographic dit	D/W	250	225	225			225	The Image Detector (apr cost Nkr 250,000) is gi low priority since it i necessary only for meas ments of rotating objec
	29-78	Isolator table	D	50	55	55				
	32-78	Balancing Machine	D	150	260	260				
	19-79	Audio-Frequency Spectr.	W	150	Comb. with 5/78					
	22-79	Proximity picups	C	170	170			170		This instrument is giv priority because it is central for condition toring of turbines, co pressors, large pumps which are actual types machinery in the power plant project.
	25-79	Torsional Vibration Exciter		80	Comb. with 7-78					
	38-79	Linear Displacement Monitor	D	14	30	30				
	44-79	Argon laser	D	100	110	110				
		Sum		1929	2126	1036	0	1090	625	
	6-78	Noise and Sound Meas. Equip.	D/C/W	175	220	48		172	5	
	28-79	Complex Modulus Apparatus	C/W	20	3			3	22	Reduced according to m 180472.30-26. "Noise a Sound Measuring Equipm Systematization after Meeting at Bruel & Kjæ
	29-79	Broad Band Accoustic Test Syst.	C	100	110			110		
	6-80	Standing Wave Apparatus	C/W	40	19			19	21	Reduced according to m 180472.30-26: "Noise a Sound Measuring Equipm Systematization after Meeting at Bruel & Kjæ
		Sum		335	352	48	0	304	48	
		Sum total								

V NON DESTRUCTIVE TESTING

Serial No.	Name of equipment	Status 1/10-80	Original Budget	Budget Revised	D	O	C	W	Comments
15-78	Thermography equipment	D	285	290	290				
20-79	Video-scan system with laser	C/W	200	100			100	100	The cost of this item is reduced with Nkr 100.000 mainly because a laser is procured under item 44-79
24-79	Ultrasonic detector	D	150	45	45				
40- 9	Eddy current crack detect.	C	54	70			70		
43-79	Accoustic emission	W	170					250	Given low priority because it is felt that this is a too specialized equipment for NDT purposes
2-80	X-ray unit with control	D	250	100			100		ITMMEC has given low priority to this item. However, an X-ray unit is a standard instrument for a NDT lab. and we therefore have set up Nkr 100.000 under this item. This should also include necessary facilities for magnetic particle and penetrant liquid test systems.
	Sum total Non destructive testing		1109	605	335		270	350	

Group	Serial No.	Name of equipment	Status V10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
Conditon monitor	9-78	Digital torque meter	D	55	51	51				
	11-78	Multichannel slipring	C	25	25			25		
	12-78	Instrum. tape rec.	C	200	220			220		
	13-78	Multichannel strain gage.	D	140	125	125				
	34-79	Peak pressure indicator	C	40	40			40		
		Sum		460	461	176	0	285		
General Electric Equipment	14-78	Multichannel Recorder	C	70	70			70		
	16-79	Capacitance bridge	C	30	30			30		
	21-79	Storage oscillo-scope	O	120	52		52			
	10-80	General electr. equipment	C		200			200		It is felt that ITMMEC should be well equippe with general electroni instruments for mainte purposes. Nkr 200.000 therefore set up under new item. It should i portable field oscillo voltmeters, pen record electronic filters, os scopes, amplifiers DC etc.
		Sum		220	352		52	300		
Temp. measuring devices	17-78	Cont.temp.rec. syst.	C	45	60			60		
	8-79	Digital ther-mometer	C	60	20			20		
	31-79	Distillation unit	O	20	43		43			
	35-79	Very high temp meas.	C	40	40			40		

P	Serial No.	Name of equipment	Status 10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
MEASUREMENT	34-78	Talyround	D	80	206	206				
	4-80	Universal profine measuring	W	100					100	Since ITMMEC are supposed to work mainly with tribology aspects, this item is given low priority.
	32-79	Machining Centre	W	150					150	
	35-78	Talysurf.	D	80	316	316				
		Sum		410	522	522			250	
MOTORS	36-78	Hydraulic motors	W	150					150	
	36-79	Central hydraulic power pack	W	200	Comb. with 37/79					
		Sum		350					150	
PHOTOG PHIC EQUIPMENT	5-79	Polaroid Camera	C	2	2			2		
	39-79	Development kit & high speed camera	C/W		10			10	90	A proper functioning of a high speed camera require one person almost completely devoted to its operation. Since this might b difficult for ITMMEC to fulfil, the high speed camera is given low priority.
		Sum		2	12			12	90	
EQUIPMENT	38-78	PDP-11		650	750			750		
		Sum		650	750			750		

Group	Serial No.	Name of equipment	Status M10-80	Original Budget	Budget Revic-ed	D	O	C	W	Comments
EDUCATION/OFFICE	(18-79)	Overhead project electrostensil	C	0	10			10		
	26-78	Slide projector	D	2	3	3				
	27-78	Duplicating machine	D	60	28	28				
	28-78	Matematical typewriter	D	6	16	16				
		Sum		68	57	47		10		
		Sum General lab. equipment		2325	2317	745	95	1477	490	

APPENDIX IX

COMPOSITION AND ROLES OF MANAGEMENT, COORDINATION AND ADVISORY COMMITTEES OF ITMMEC

The activities of ITMMEC are controlled by a coordination Committee, a Management Committee and an Advisory Committee. The decisions and advices of these committees are to be implemented by the executive Head of ITMMEC.

1. Current list of the members of Management Committee of ITMMEC for the year 1980-81.

1.	Prof. O.P. Jain	- Director, III Delhi Chairman
2.	Prof. J.P. Sharma	- Head, ITMMEC, Convener
3.	Dr. S.K. Suri	- BHEL, Industry representative
4.	Prof. M.C. Chaturvedi	- Dean ICL
5.	Prof. M.S. Sodha	- DY-Director, Representatives of other departments
6.	Prof. B.C. Nakra	- Professor, Mech. Engg. Dept. Representative of other departments
7.	Prof. H. Christensen	- Project Manager ITMMEC - Representative of SINTEF whenever in Delhi
8.	Mr. R. Huseby	- Project Leader - Representative of SINTEF whenever in Delhi

The Management Committee should act as a Board of ITMMEC.

2. Coordination Committee

The role of the coordination committee is said to include:

- Adopt agenda points proposed by ITMMEC, IIT Delhi, SINTEF and NORAD;
- Review activities of the ITMMEC;
- Development of infrastructure;
- Project planning and selection of Joint projects of SINTEF and ITMMEC;
- Budget formulation and adoption.

The coordination committee consists of:

- Director IIT Delhi	Prof. O.P. Jain
- Vice Managing Director SINTEF	M.Sc. E. Sødahl
- Project Manager - ITMMEC Project from SINTEF	Prof. H. Christensen

- Head, ITMMEC — Prof. J.P. Sharma
- Local NORAD representatives as observers.

The meetings of the co-ordination Committee were held as shown below:

1978	1979	1980
Feb. 7, 1978 at SINTEF, Trondheim	Nov. 21, 1979 IIT, New Delhi	Dec. 4, 1980 IIT, New Delhi
Nov. 28, 1978 at IIT, New Delhi		

3. Advisory committee

The role of the advisory committee is said to:

- Advise on the feasibility of implementation of projects
- Work out priorities for projects
- Secure proper and necessary interaction with industry and to see that unnecessary duplication of work is avoided
- Keep the activities of the centre tuned to the needs of industry at all times.

Composition and functioning of the Committee.

The Advisory Committee has been functioning since the inception of the centre in 1977 and has a composition with the aim to ensure that interests, particularly those of the industry are represented.

The composition of the current committee is given below.

The committee meets once a year under the Chairmanship of the Director IIT.

The meetings of the committee so far held as shown below:

1978	1979	1980	1981
Aug. 29, 1978	March 9, 1979 (New Delhi)	March 11, 1980 (New Delhi)	July 24,1981 (New Delhi)

ADVISORY COMMITTEE MEMBERS

1. Dr. H.L. Somani
   Director (Operation)
   J.K. Industries

2. Mr. D.H. Pai Panandikar
   Secy General
   Federation of Indian Chamber
   of Commerce & Industry

3. Dr. H.S. Rao
   General Manager
   National Research
   Development Cooperation

4. Sr. Ajaya K. Raman
   Sr. Research Manager
   Research & Development Centre
   Escorts Ltd.

5. Dr. J.P. Dalal
   Managing Director
   Lubrizol India Ltd.

6. Dr. I.G. Gulhati
   Director
   Indian Institute of Petroleum

7. Mr. P.N. Arumugham
   Chief of Quality Assurance
   Bharat Heavy Electricals Ltd.

8. Air Cdr. V.N. Aggarwal
   Director of Maintenance Inspection & Planning
   Air Headquarter, R.K. Puram

9. Mr. V.J. Thakar
   Project Manager
   Calico Mills

10. Dr. S. Ramchandran
    Advisor
    Steel Authority of India Ltd.

11. Dr. J.P. Sharma
    Professor & Head
    ITMMEC Convener

12. Lt.Gen. M.M.L. Chhabra (Retd.)
    C-20, Defence Colony

13. Mr. B. Sinha
    Director General
    Power Engineers Training Society

14. Dr. S.P. Sabharwal
    Professor, C.E.S.

15. Prof. B.C. Nakra
    Mech. Engg. Deptt.

16. Prof. M.S. Sodha
    Dy, Director

17. Prof. M.C. Chaturvedi
    Dean, ICL

18. Dr. Mahashwar Dayal
    Advisor
    Dept. of Sci. & Tech.

19. Prof. S.P. Luthra

APPENDIX X

CORE STAFF RECRUITMENT AT ITMMEC

CORE STAFF RECRUITMENT AT ITMMEC

S. No.	Name	Category	Date of joining	Date of leaving	Terms of service	Educational Qualification/experience
1	2	3	4	5	6	7
1.	Dr. J.S. Rao	Prof. & Head	Dec.1976	June,1978	Head of the Centre	D.Sc., 17 years
2.	Dr. J.P. Sharma	Chief Design Engr.	Dec.1976		Faculty and Research Staff	Ph.D., 17 years
1.	Mr. K.L. Awasthy	Sr. Design Engr.	1977		- do -	M.Tech.(Moscow) 12 years
2.	Dr.E.Raghvacharyulu	Design Engineer	1977	1978	- do -	M.Tech,,3 years
3.	Mr. K. Athre	Design Engineer	1777		- do -	M.Tech.,7 years
1.	Dr. B.C. Nakra	Prof. & Head	July 1978	Oct. 1978	Head of the Centre	Ph.D.,19 years
1.	Dr. J.P. Sharma	Prof. & Head	Oct. 1978		Head of the Centre	Ph.D.,18 years
2.	Mr. Arun Prakash	Lecturer	1978		Academic Staff	M.Tech.,16 years
3.	Mr. Om Prakash	Lecturer	1978		Academic Staff	M.Tech.,10 years
4.	Dr. C.R. Jagga	Design Engineer	1978		Research Staff	Ph.D., 5 years
1.	Dr. O.P. Chawla	Chief Design Engr.	1979		Research Staff	D.Sc., 17 years
2.	Dr. C.R. Jagga	Lecturer	1979		Academic Staff	Ph.D., 6 years
3.	Dr. S. Biswas	Asstt. Proffessor	1979		Academic Staff	Ph.D., 10 years
4.	Mr. N. Tandon	Design Engineer	1979		Research Staff	B.E., 3 years
5.	Dr. U.S. Tewari	Design Engineer	1979		Research Staff	Ph.D., 12 years
6.	Mr. S.C. Sharma	Design Engineer	1979		Research Staff	B.E., 3 years

Appendix (contd.)

1	2	3	4	5	6	7
1.	Dr. S. Chandra	Asstt. Professor	1980		Academic Staff	Ph.D.,14 years
2.	Mr. B.G. Muralidhar	S.S.O, I	1980		Research Staff	Ph.D.
3.	Mr. C.S. Pant	Design Engineer	1980		Research Staff	M.Tech., 6 years
4.	Mr. O.P. Gandhi	Asstt. Professor	1980		Academic Staff	M.Tech.,10 years
5.	Mr. K.L. Awasthy	Asstt. Professor	1980		Academic Staff	M.Tech.,14 years
6.	Dr. A. Jain	Asstt. Professor	1980		Academic Staff	Ph.D., 6 years
1.	Mr. V.K. Agarwal	Design Engineer	1981		Research Staff	M.Tech., 1 year

APPENDIX XI

LIST OF PUBLICATIONS BY STAFF MEMBERS AND ITMMEC REPORTS

1. K.L. Awasthy & J.P. Sharma "An Experimental Study of Wear of Ferrous Material", WEAR, 53 (1979), 211-228.

2. K.L. Awasthy & J.P.Sharma "Design of a Surface Hardening Device", Proceedings of First Cairo International Conference on Mech. Engg. Vol. II (1979), 519-526.

3. K.L. Awasthy & Rajmohan Singh, "Wear Measuring Device" Proceedings of Third ISME Conference on Mech. Engg. Vol. 1 (1980), 251-255.

4. K.L. Awasthy "The effect of Low Frequency Vibration on Sliding Friction", Proceedings of Third ISME Conference on Mech. Engg. Vol. 1 (1980), 283.

5. K.L. Awasthy & J.P. Sharma "Limiting Permissible Wear and Services Life of Machine Components", Proceedings of 24th ISTAM Conference, Rourkela, Regional Engineering College (1980), 31.

6. Ghosh U.K., U.S. Tewari & P. Vasudeva, "Polymer Applications in Tribology" Polym. Symp., Kurukshetra University, Kurukshetra (May 1980).

7. O.P. Chawla, "Maintenance of Heat Exchangers" Corrosion & Maintenance Journal, Vol. 3, No. 4, 1980.

8. O.P. Chawla, "Effect of Radiating Gases on the Performance of Thermal Regenerators" J. of Thermal Engineering, Vol. 1, No. 3, 1980.

9. S. Chandra & A.D. Telang "Friction Induced Vibrations", I.E. Seminar on Vibration and Noise Pollution, Jaipur Sept. 1980.

10. C.S. Pant & J.P. Sharma, "Design & Fabrication of a Wear Resistant Coating Rig" Proced. of Silver Jublee Congress of ISTAM & The International Conference on Non-Linear Continunam Mechanics at IIT Kharagpur Dec. 17-20, 1980.

11. J.P. Sharma, K.L. Awasthy & O.P. Sharma "An Experimental Studies on Wear of EN 391B Steel", Euro Trib 1981 (Warsaw).

12. U.K. Ghosh, C.R. Jagga, S. Maiti & P. Vasudevan "Tribological Applications of Polymers in Industry" New Industry Polymer Symposium at Madras Univ., Madras, March 1981.

13. J.P. Sharma & A.D. Telang, "Maintenance of Tribo-Elements - A Wholistic Approach", Accepted for publication in "Maintenance & Corrosion".

14. J.P. Sharma & A.D. Telang, "On the Lubricant-metal Compatibility in Boundary Lubrication". To be presented at "Tribology Technology, Advanced Studies Institute", a NATO Sponsored course at Marutea , Italy, Sept. 13-26, 1981.

15. J.P. Sharma & M.V. Khemchandani, "Theory on Boundary lubrication film failure" ASME/ASLE conference At. Louis, Missouri, U.S.A., May 1979.

16. J.P. Sharma, P.C. Nautyal & S. Singhal, "Wear mechanism in piston ring" Proc. International Conference on Wear of Materials, April 1979.

17. J.P. Sharma, P.C. Nautyal & S. Singhal, "Role of Boundary Lubrication in Piston Ring Wear" Proc. Third National Conference in Industrial Tribology, March 1980, New Delhi.

18. W. Leszek, M.M.L. Chhabra & J.P. Sharma, "Lubricants - evaluation and standardization" Proc. Recycling of Waste Oil 1979, Madras.

REPORTS*

1. DIAGNOSTICS AND HEALTH MONITORING OR POWER PLANTS EQUIPMENT AND UTILITIES (DECEMBER 4 - 9, 1979) [1)]

Lecture by NORAD Resident Representative
Introduction to Workshop
Planned Maintenance for greater plant availability
A system for maintenance planning and control
Diagnostic Maintenance and signature
Maintenance Strategy (part 1)
Maintenance Strategy (part 2)
Problems of Spare Parts
Trends in modern control and instrumentation techniques
Vibration Analysis Instruments and Applications

* The titles refer to lectures on papers presented at workshops.

Condition Monitoring & Preventive Maintenance by Modern Spectroscopic Methods of Oil Analysis

Oil Analysis

Performance Testing of Lubricating Oils

Bearing Design

Basic Vibration Theory

Self Excited Bearing Vibrations

Signature Analysis

Noise and Noise in Machinery

Noise Prevention

War on Wear

Wear Mechanisms

Terotechnology - A Systems Aspects

Terotechnology - Life cycle cost aspect

Productive Maintenance by Ferrography

Failure Analysis of Gears

II. WEAR MONITORING THROUGH OIL ANALYSIS (MARCH 27 - 29, 1980)

Particle Contaminants and its Sources in Industrial Equipments by Prof. J.P. Sharma

Ferrography - A new Technology for Monitoring Machine Wear by Mr. L.W. Waley

Ferrography - A Modern Tool for Engineers in Condition Monitoring by Mr. K.L. Awasthy

Physical & Chemical Properties of Lubricants by Miss S. Pandita

Analysis of Oils Degradation - Dr. W.J. Leszek

IR - Spectroscopy as an Analytical Tool - Dr. G.V. Jere

Spectrometric Oil Analysis Programme (SOAP) - Dr. U.S. Tewari

Particle Counting - Mr. O.P. Gandhi

Filtration of Lubricating Oils - Mr. A.D. Telang

Efficient Storage & Handling of Lubricants - Mr. S.P. Sachhar

Reclamation of Used Oils - Mr. S.P. Sachhar

III. TRIBO-ASPECTS OF MACHINE TOOLS (APRIL 24 - 26, 1980)

List of Participants

List of Contributors

Inaugural Address

Key-note Address

Tribo Effects in Machine Tools and Problems

Heat in Journal Bearings
Wear of Machine Tool Slide Ways
Designing for Sliding Wear
Maintenance Strategy in Machine Tools
Need for More Accurate Systems of Machine Tools
Acceptance Sampling
Cuttomg Fluids - Lubricants and Coolants in Machine Tools
Force Measuring Dynamometer
Measuring of Temperature by Infrared Thermography
Thin Film Laboratory
Friction and Wear Testing Machine
Particle Size Analyzer
Talyrond 200 with Talydata
Bowden Laben Machine

IV. LUBRICATIONS AND BEARINGS IN INDUSTRY (OCTOBER 24-25, 1980)

List of Contributors and Participating Faculty
Failure of Lubricated Bearings - A. Cameron
Mechanism of Lubrication (Systems Approach - A.D. Telang & J.P. Sharma
Special Purpose Lubricants - U.S. Tewari
Selection of Lubricants - K.L. Awasthy
Lubricant Handling and Storage - S.P. Sachar
Reclamation of Lubricants - S.P. Sachar
On Life Aspects of Antifriction Bearings - S. Biswas
Hydrodynamic Bearings - K. Athre
Hydrostatic Bearing - S.C. Sharma
Design Audit - S.Chandra and J.P. Sharma
Analysis of Oil Degradation - W.S. Leszek
Lube Oil Analysis - O.P.Gandhi
Heat Dissipation and Temperation rise in Bearings - O.P. Chawla & S. Biswas
Bearing Faults & Diagnostics - Arun Prakash

APPENDIX XII

COLLABORATION BETWEEN INDUSTRY AND INSTITUTIONS FOR ENGINEERING EDUCATION IN INDIA --- IN PARTICULAR INDIAN INSTITUTES OF TECHNOLOGY (IITs)[x]

In the following we have provided a fairly detailed summary on the relations between industry and the institutions of engineering education in India. We have thought it would be useful for the reader to have a exposure to the problems and possibilities of solving them as the ITMMEC Centre is located within an Indian Institute of Technology and given the explicit objective of serving Indian industry.

Background

India has extensive and widespread facilities for higher education but there is a need to coordinate them and maximise their utilization. The Sixth Plan (1981-85) notes that there is sufficient scope for and possibility of, greater use of the infrastructural physical facilities and resources which might need only minimum additional support to make them critically viable. But inter-sectoral linkages are yet to be brought about and coordination established between work places, schools and development activities for fostering appropriate manpower development programmes.

This has resulted, among other things, in an undesirable growth of facilities for general higher education,especially at the under-graduate stage in arts, commerce and humanities, and in the consequent increase in incidence of unemployment among the educated. It has also not been possible to evolve systems approach to educational planning and development aiming at flexibility and mobility among different types and levels of education and at maximisation of benefits from educational investment for rapid progress in the different sectors of

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[x] This section is in the following pages mainly based on information contained in the following two reports:
1. Report of the Review Committee on Post-Graduate Education & Research in Engineering & Technology, Ministry of Education & Culture, June 1980.
2. Workshop on Engineering industry/IITs collaboration Proceedings and Action Plan, Association of Indian Engineering Industry, Madras, June 1981.

national economy. This has in the words of the Planning Commission, undermined the role and capability of the higher ecucation system to promote and maintain excellence and high standards in academic programmes, encourage pure scholarship and extend the frontiers of knowledge as well as to participate in national S&T activities and develop national scientific and technical manpower. We will now consider some of the specific problems of linking industry with engineering education technological development. It is desirable that institutions and industry should establish cooperative relationships such as: industry sponsored research projects in the institutions; results of research carried out in the institutions to be made freely available to industry; technical and other data to be provided by the industry to help in the projects work of postgraduate students, appointment of the staff of institutions as consultants to industry; research and design office facilities in industry to be made available to postgraduate students; endowment of professorships and scholarships by industry etc. It is also desirable that industry and other organisations should sponsor their serving personnel to undergo postgraduate courses and improve their knowledge and competence in their respective fields of work.

Reviews of the situation

A review committee in 1971 (Chandrakant) emphasized that an ideal situation would be where the industry, the research laboratories and/or CSIR collaborated intimately in conducting postgraduate courses. A beginning must be made in instituting such programmes. At the same time it was mentioned that the curricula of postgraduate courses have a heavy padding of theory. In some cases only 20% or less of time is spent on experiments and project work. The curricula of these courses, therefore, need reorganisation. The postgraduate courses can be oriented into two directions; one design-oriented and the other research oriented. The design oriented courses should be evolved and developed in consultation with industry, so that the products are useful to them. The courses should also provide training in entreneurship. For this purpose, the industry should cooperate fully in reorienting these courses properly to make them really useful.

In early 1970s, committees were appointed to review the working of the IITs and Regional Engineering Colleges (RECs). The findings/recommendations of these committees in respect of post-graduate programme offered by these institutions are of interest in this context. The reports stressed close collaboration with industry in opening new courses at postgraduate level, taking more active part in solving problems of industry by greater collaboration with them, development of faculty for other engineering colleges and exchange of faculty with other institutions were also stressed. It was envisaged that during the Fifth Five Year Plan period beginning in 1974, the principal direction of growth in the IITs should be interdisciplinary research. New areas for such research work were identified in marine engineering, marine biology, rock mechanics, atmospheric studies, ocean bed engineering, food processing, aircraft structures, courses related to defence and development of energy, exploration and development of fuel and other fields of immediate development to meet the economic needs. These courses should be developed on sponsorship basis.

All earlier reports made many practical recommendations for change. There have, however, been shortcomings in implementing them. Many of the recommendations of the earlier reports are valid still, even after many years since their issue. Many improvements in the present socio economic situation might have been achieved if more effective action had been taken to implement the recommendations made after the earlier reviews.

Today industry's involvement in higher education is limited and the total technical manpower imployed is small. A sense of urgency has been felt by the Government of India to review the whole system of postgraduate education and research in engineering and technology. An important aspect is that for historical reasons - science and technology has so far developed in India under Western perspectives. Most of India's institutions, including the higher technological institutes, carry out research on borrowed ideas. The Committee emphasises that the main aim of research should not be to publish papers, or to act as cheap

scientific labour for just monitoring data for global projects of the affluent countries, but to produce something useful and relevant to this country.

A recent report on industrial R&D prepared by the Department of Science and Technology (DST) presents a picture of imbalances and the private industry's inability to respond to R&D despite Government incentives. In the public sector also R&D activity was concentrated in a few areas and the base of the growth of the R&D expenditure as compared to sales turned over was very low.

The recent Review Committee[x] notes that in many of the emerging areas, which are science-based but heavily technology oriented, there is need to train scientist-technologists who can handle the twin responsibilities of scientific research and innovative application. The traditional framework of engineering programmes is inappropriate for this purpose and a separate stream of postgraduate courses of 3 semesters duration ofter MSc in science has to be developed. These courses should be introduced in selected engineering/technological institutions/ university departments having adequate infrastructural facilities. Mobility and exchange of faculty between academic institutions, R&D organisations and industrial establishments should be encouraged to prevent inbreeding. Industrial experience should be prescribed as an essential qualification for teaching positions at a postgraduate level. Technical competence, scientific understanding, creative ability and humanistic wisdom should be the requirement for teachers particularly at postgraduate level.

Suggestions

We will now mention various forms of institution-industry collaboration. Experimental learning and practising can only be achieved if there is an environment of interdependency between professionals in the industry and professionals in the academic world. A very recent Review report[x] suggests that the Government

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[x] Report of the Review Committee on Post-Graduate Education & Research in Engineering & Technology, Ministry of Education & Culture, June 1980.

should consider imposing requirements on industry as well as on postgraduate institutions to collaborate with each other on the basis of the various suggestions made in this report. Legislative action should be taken, if necessary. Every effort should be made to further increase and expand the two-way exchange of staff between industry and teaching establishments including the introduction of systems of recognition and incentives.

Institutions should contribute towards continuing education of practising engineers by giving courses in the 'state-of-art' as well as on advanced topics. Specific modules of training programmes should be introduced for railways, defence services, posts and telegraphs etc. Seminars and symposia of 1 to 2 days duration are not of much use and should be discouraged. To be meaningful, the duration of the courses should not be less than 2 months. They should be designed for personnel at various levels. Here it may be pointed out that the MITs' Centre for Advanced Engineering Study accepts persons even at the level of Chief Engineers/Directors. The Participants are in residence for 2 semesters or so. Similarly, the General Electric Company runs a course of 9 months duration for senior executives of the electric utilities. Institutions should also design and provide self programmed courses to update the knowledge of practising engineers. The cost of running these courses should be met by industry on a 100% basis.

Industrial establishments should examine how to strengthen their access directly and indirectly to teaching/research institutions with a view to make better use of the consultancy and research services offered by the teaching/research institutions. Higher technological institutions and industrial establishments should prepare corporate plans for working together for social development and mutual benefit. The tendency on the part of industry to look at the West for technical know-how should be discouraged. It is recommended that a tax be levied on any know-how imported.

A 'research cess' should be levied on each industry for research in the areas of industry's interest. This fund should be kept

and operated separately with the active participation and involvement of industry. Regular long term postgraduate programmes suggested by industry jointly or otherwise should be financed by industry at least on a 50% basis. Short term courses suggested by industry should be financed by them on a 100% basis. A 133% tax deduction should be allowed on all payments/contributions/investments made by industry in postgraduate education and research. Polite persuasion and concealed compulsion are called for to legitimise industry's involvement in postgraduate education and research.

The institutions should be allowed to charge sponsored research projects. Consultancy should be encouraged and regulated on the basis of pre-determined norms. While the emphasis should be on institutional consultancy, individual consultancy should also be allowed especially when institutional facilities are not utilised. However, it should be ensured that individual consultancy facilities are not misused. The money earned from sponsored and consultancy projects should be utilised for developing the research capability of the institutions. Industrial consultancy should not be confused with routine testing and analysis, which should be discouraged.

The situation at the IITs

We will now consider the IITs. The Indian industry's primary concern in relation to IITs continues to be the quality of trained manpower. The need for up-dating technology on a continuing basis is now being recognised all the more as the Indian engineering industry was gearing up to play a decisive role in the international market. So, it is natural to find an increasing realisation that interaction with IITs could also be very effective in technology development. The Technical Education and Training (TET) Committee of the Association of Indian Engineering Industry (AIEI) has for sometime been working towards achieving effective interaction between the engineering industry and the Indian Institutes of Technology (IITs) in specific areas of technical education and industrial training.

To that end, the Committee organised a 2 day workshop with the

IITs on the 27th and 28th of March 1980 at New Delhi. The recommendations made during this workshop were widely publicised within the engineering industry and the IITs throughout the country. In 1981, the members of the TET Committee again called a meeting to review implementation of the programme of cooperation between the engineering industry and the IITs. During the meeting it was pointed out that, while interaction between the engineering industry and the technical institutions (not necessarily IITs) had started at the individual level, a thrust to this programme could only be given if the efforts were institutionalised. At the recent meeting a number of measures were discussed - those considered most important being listed below.

A. Increased interaction between the IIT faculties and industry is essential. This could be encouraged through exchange programmes wherein the faculty members would work in industries for a certain period and the industry specialists would go to IITs for giving courses and lectures on practical aspects to supplement academic instruction. Interaction in this area has already started between the IITs and the engineering industry. Senior managers from industry were serving the IITs as Adjunct Professors and Visiting Professors. The idea of residency needed to be promoted, so that senior managers of industry could go and stay in the IITs for short durations (3-6 months). This will install in them the IIT culture and also give them an opportunity for individual study and use of the extensive library facilities. The exchange in the opposite direction, ie. IIT faculty members going to industry for longer durations has not materialised in a big way. This was due to the lack of incentive to faculty members as well as problems of accommodation in the industrial centres. Member companies of the Association of Indian Engineering Industry (AIEI) had agreed on a plan which will enable 15 experts from either side to be exchanged in 1981-82. They would receive Rs. 2000 to Rs. 3000 per month as honorarium, which will take care of their problems of accommodation and out-of-pocket expenses.

B. Industry should assist the IITs in the creation of "Chairs" and "Centres for Technology Development" and industries should be allowed tax exemption for donations given to IITs by way of machines, equipment and materials. Joint studies may be undertaken by experts in the industry and IITs faculty relating to projects on emerging technology. Adjunct consultants may be appointed from faculty members in consulting firms. Educational materials like handbooks, monographs, etc., should be produced jointly by the IITs and industry. On this latter proposal the Departmental and Institute Committees will work out the proposal. IIT Kharagpur has already initiated publication of a series of books on technology in collaboration with Oxford Publishing Company. Adjunct Professors from the industry were invited to collaborate in writing these books.

C. Facilities should be developed in IITs for continuing education to enable engineers from industry to update their theoretical knowledge. These programmes should be designed in such a way as to entitle the participants to earn a M Tech degree. One of the common complaints against IITs was the lack of industrial background for teachers and students. It was suggested that the IIT students should be provided with 24 weeks in plant training. The Government and industry should each provide 50% of the stipend. However, the duration of undergraduate courses has been reduced from 5 to 4 years and it was felt that it would be difficult to implement 24 weeks in plant training programmes.

D. Each IIT should identify a consortium of industrial organisations in their respective regions and, in collaboration with them, chalk out a systematic practical training programme for students at the 3rd and 4th year (now 2nd and 3rd year) levels. The industries should select students at the 4th year level (now 3rd year) for possible prospective employment and give them training and suitable stipend for the completion of their final year studies. Some industrial organisations have already embarked on this scheme.

E. Some specific period of industrial training was considered necessary for anyone joining the teaching profession. Since it was difficult to get teachers having industrial experience, institutes will see that they get training in an industrial establishment for one year after selection within a period of 5 years. There was a need to reorient the curricula with the involvement of industry. The present curricula did not lay much emphasis on management.

F. To develop effective collaboration between the IITs and the engineering industry, it was suggested that a 3-tier organisational set up, comprising departmental, institute level and national collaborative committees be formed. Representatives of the engineering industry and IITs will be members of these committees. Consequently it was decided that the Departmental Committees be set up by 31st August 1981. The AIEI Regional TET sub committees would suggest 3 names from the industry for each major discipline of the IITs in their respective regions. The professor in charge of the concerned department will be the convener of the committee. The committee will meet at last 6 times á year. Each Departmental Committee will decide upon the area of responsibility and the work plan. Here we would like to stress that there is wide spread disappointment that not much had been done towards greater collaboration between the engineering industry and IITs since the earlier meeting in 1980. IITs could have done with a little extra effort on both sides. IITs have 4 main functions:

1. Imparting education - both formal and continuing.
2. Training at undergraduate level.
3. Postgraduate training and consultancy.
4. Research and development.

The first 3 functions could be carried out successfully with the help of the TET Committee. Many of the recommendations made during the 1980 Delhi workshop were not implemented. There was no feedback about the number of IIT professors and senior managers of industry who were prepared to participate in the exchange programme. A proposal for setting up an industrial film library had not taken shape. Assistance from

industry in creating "Chairs" and "Centres for technology development" had not been forthcoming. Educational materials were not being jointly produced by the IITs and industry. There were many such areas where industry and the IITs could collaborate. The Government can only act as a catalyst and major work in this direction would have to be done by the engineering industry and the IITs. On its part, the Government had already initiated action. Instructions were already issued to the technical institutions that the lecturers should have a minimum of one year industrial experience. If fresh graduates were appointed as lecturers, they would have to be trained in industry for one year by the Institute within a period of 5 years. The Government was also ready to finance the scheme of adjunct professorship and residency. The application of the Apprenticeship Act to the students taking vocational training was also under consideration. The representatives of industry and the IITs were urged to give momentum to this collaborative programme, so that the fruits of interaction could be discernible on a national level.

IIT - Delhi

Finally we will briefly comment on the situation at IIT - Delhi. The recommendations of the Engineering Industry/IITs Collaboration Works held in March 1980 were considered/ approved by the Senate at its meeting held on 31st December 1980 and have been sent to concerned heads for active and expeditious implementation. The mechanism of implementation of the various recommendations was being formulated by the concerned heads.

The Institute has already started the following programme towards collaboration with industry:

a) Establishment of Industrial Consultancy Centre to render expertise to the industries in solving their problems.

b) Undertaking research and development projects from private industry as well as from government agencies.

c) Running special courses to cater to the specific requirements of industry.

d) Organizing special sponsored M Tech programmes in specific areas of interest to industry.

e) Deputation of Faculty to industry for one year on mutually settled terms.

As a more general problem we would like to refer to the findings of a review committee explicitly mentioning one of the IIT-Delhi Centres.* Here it is mentioned when discussing the Centre of Energy Studies at IIT-Delhi that the centre is suffering from the following shortcomings.

1. Perhaps over-equipped
2. No technologies for commercial exploitation
3. Not so relevant theoretical projects
4. Faculty/staff heavily science based
5. Not being able to link with DEA, BARC, BHEL and CFRI (which are its main potential customers)
6. Admission does not stress engineering
7. Inter-IIT collaboration is on a low key.

With regard to the participation of Industry's experts in the formulation of curricula for undergraduate the postgraduate courses, the Institute would now implement the recommendations more rigorously, although in the past experts from industry have been associated with this work.

The recommendation for appointing Visiting Faculty from industry was under consideration by the Institute. The major constraint in implementing this recommendation was the lack of accommodation and also in identifying people from industry who could be given the assignment.

*Report of the Review Committee on the Centres of Advanced Studies in the Indian Institutes of Technology, Ministry of Education and Culture, June 1981.

APPENDIX XIII

RESEARCH AND DEVELOPMENT IN INDIA[x]

The Industrial Tribology, Machine Maintenance and Engineering Centre (ITMMEC) at the Indian Institute of Technology (IIT) in Delhi is obviously a high technology institute which can play an important role in developing the country's indigenous capability in tribology and maintenance. In order to put ITMMEC in the perspective of national development we will provide information on the R&D sector in India.

Scientific research in India is organized under four broad headings; (i) Research organized under various institutions in different Ministries of the Central Government, (ii) Research carried out by the State Governments, (iii) Research undertaken by Universities and Institutes of Technology, (iv) Industrial research programmes of the private sector. The ministries include the eight major scientific agencies and the other ministries/departments of the Central Government.

Altogether India has more than 1300 research institutions which are under the administrative control of either the major scientific agencies, ministries and departments of the central government or the state governments, or the private industries.

The total national expenditure on R&D was at current prices Rs. 5.2 billion for the year 1978-79. The corresponding projected figures for 1979-80 and 1980-81 are Rs. 6.0 and 6.9 billion respectively. In relation to GNP, India now spends 0.6 per cent on R&D and figure 1 shows the trend of R&D expenditure on the national scale over the period 1958-1977.

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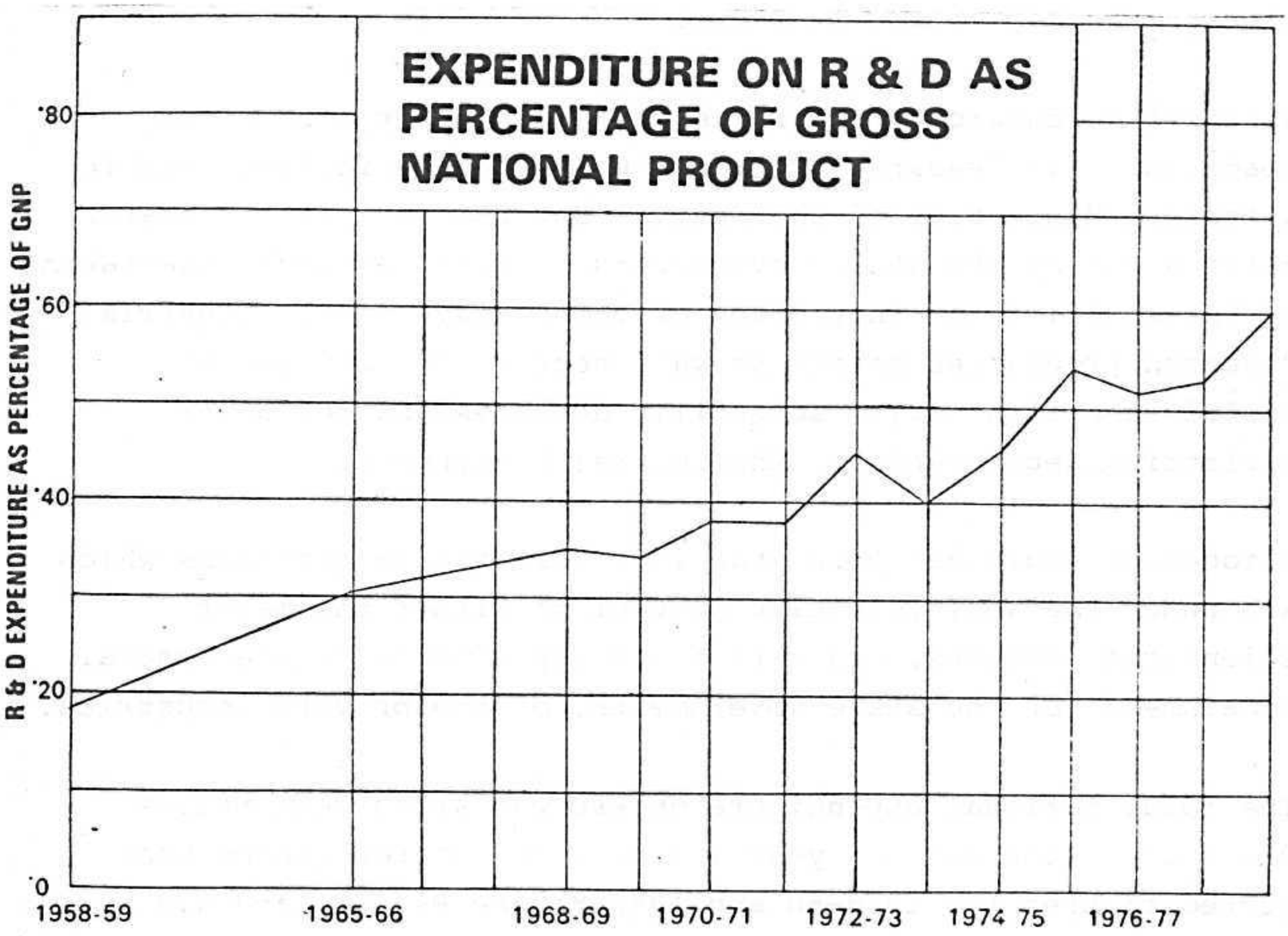
[x] This section is based on information which appears in the following three publications:

1. Sixth Five Year Plan 1980-85, Planning Commission, New Delhi 1981, chapter 19, Science and Technology pp. 318-342.
2. Research and Development Statistics 1978-79, Department of Science and Technology, New Delhi 1980.
3. Research and Development in Industry 1978-79, Department of Science and Technology, New Delhi 1981.

Most of the resources for science and technology activities come from the Central Government. In terms of share of R&D expenditure, the Central Government spent 79.4 per cent of the total, the State Governments share was 8.2 per cent, while the share of private sector spending was only 12.4 per cent, or Rs. 720 million.

Figure 1



Total stock of economically active S&T personnel in India at the end of 1978 was estimated to be 1.94 million. About 150,000 personnel were employed in R&D establishments in the country in 1978, out of which 56,500 personnel were directly engaged in R&D work.

A trust in science has been embodied in the Historic Scientific Policy Resolution of the Government of India adopted in 1958. In the last thirty years or so, 119 universities, affiliating about 1650 colleges, 5 institutes of technology, 150 engineering colleges and about 100 medical colleges and 350 polytechnics

have been established: about 150,000 qualified scientific and technical personnel are produced every year. A total stock of scientific and technically qualified manpower, estimated at 2.5 million, gives India the third largest resource of such manpower in the world after USA and USSR, occupying a unique position among developing countries.

About 130 specialized research laboratories and institutes have been established under the aegis of Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), the Indian Council of Medical Research (ICMR), the Departments of Atomic Energy, Science & Technology, Space, and the Defence Research & Development Organisation, etc. In recent years, public and private sector organizations and undertakings, assisted by fiscal incentives, have established over 600 in-house research and development laboratories largely to meet their internal technological requirements.

A relatively new but important development in the last fifteen years is the rapid growth of engineering consultancy organizations to provide design and consultancy services and act as the bridge between research institutions and industry. There are now over 150 such firms of varying size and capability employing over 20,000 technologists.

The total stock of scientific and technical manpower in India appears large at first sight but as a proportion of the total population it does not compare favourable with that in the advanced countries or even some other developing countries. The fact is that the science and technology content of Indian society as it is today as well as its involvement in P&D, is low in comparison to the size and population of the country. This is particularly true for the industrial sector.

A large part of the total stock of S&T manpower is not actually engaged in activities that can be construed as scientific or technical. Even more significantly, the quality of these personnel varies widely; there will be need for a considerable reorientation and upgrading of a large proportion of this stock of manpower through appropriate training programmes.

In large areas of economic activity, relatively obsolete cost ineffective technology continues to be applied, the pace of scientific and technological innovation remains unimpressive and the adoption of the available scientific and technological knowledge is tardy. There are many gaps in new important fields and in the ranks of leadership and in excellence.

In universities and several other institutions, the support provided has not kept pace with the increased need for better facilities. In a large number of areas, India's capabilities are almost twenty years behind those in the advanced countries according to the Planning Commission and also behind those established recently in some developing countries. There is also a lack of coordination behind manpower requirements, in terms of areas and levels of training and numbers, and the actual training of personnel which has led to serious shortages of qualified and trained manpower in many areas.

It is only in recent years that a number of enterprises and a few departments of the Government have set up in-house R&D organizations. Their efforts have been mostly confined to providing assistance in establishing process and product standards, substituting imported raw materials and intermediates and towards bringing about product improvements based on feedback from the market or users. A major initiative would be to induce the public and private enterprises to enlarge their R&D capabilities to grow rapidly with a view to engaging them in the task of promoting technological innovations. These would of course need to be facilitated through appropriate institutional mechanism to enable the managements of such enterprises to have R&D advice in the pursuit of technological innovations as a part of corporate planning. Financial institutions and development banks could obviously also play a useful role in evaluation of technology, preinvestment studies, choice of technology, risk taking in the use of indigenous technology, facilitating, horizontal transfer of technology etc.

The Planning Commission mentions some needs for large and medium industries. The principal objectives for heavy industries would

be the development of energy efficiency, increasing productivity, improving the process design and development of capabilities for the design and fabrication of equipment and plants for the manufacture of fertilizers, petrochemicals, cement, paper, steel, non-ferrous metals, etc.

As far as machine tools are concerned, development of the capacity of the industry to design and manufacture newer and more sophisticated tools and development of supporting technologies would be the principal goal. Specific areas where major effort would be required are automobiles, agricultural equipment and machinery, mechanical and electrical equipment and printing technology.

The R&D programmes will be carried out by the public sector units such as Bharat Heavy Electricals, Hindustan Machine Tools, Bharat Heavy Plate and Vessels, Bharat Pumps and Compressors, Heavy Engineering Corporation, Mining and Allied Machinery Corporation, and institutions such as Welding Research Institute, Central Machine Tool Institute and Automotive Research Association Institute.

The main objective of in-house R&D units will be to develop competence to provide engineering services, bring about improvement in product design and efficiency, import substitution and technology absorption as also for a steady flow of new products, processes and services. In the case of textiles, the R&D programmes will be looked after by industrial research associations for jute, cotton textiles, silk, man-made fibres and wool.

By the end of 1978 there were 450 establishments in the private sector registered with the Department of Science and Technology DST. In this context it should be noted that more than 50% of these have foreign shareholders which clearly indicates the tie up between Indian industry and foreign companies.

The R&D survey of 1978-79 called for data on import of equipments from different countries by private sector R&D units and 197 such units provided this information. The terms capital and non-capital equipments were not defined by DST and it was left

to the discretion of the responding units to classify the equipments as capital or non-capital and give the data accordingly. According to this information the import of equipments by private sector inhouse R&D units amounted to Rs. 101 million which is about 14% of total R&D expenditure by private sector. Out of this, capital equipments accounted for Rs. 52 million and non-capital equipments accounted for Rs. 49 million. About 51% of the total imports by private sector R&D units are from UK. This followed by USA and FRG with 19.2% and 13.3% respectively. This means that the majority of imports by private sector inhouse R&D units are from UK, USA and FRG.

Linkages and mechanisms for the effective application of science are deficient in most fields. This has also led to an insufficient use of science generated in universities and national laboratories, giving rise to the often expressed feeling that the fruits of science and technology have not reached the bulk of the population and have not contributed to planned economic and social growth.

Such deficiences are tending to reduce the impact of science and technology in dealing more effectively with the economic and social problems. While there are exceptions to this, it is clear that the major investments in India will require a much more deliberate and sustained application of science and technology than hitherto. This requires not only financial support for S&T activities, but more importantly, improved linkages between the various sectors - educational, R&D establishments, industry and government agencies - and policies conducive to the use of endogeneous efforts. Instuments for policy formulation and task implementation in this regard are, in the main, still lacking.

APPENDIX XIV

QUESTIONS POSED TO JAIN SONS (JULY 21, 1981)

Shri. B.G. Sashi Kanth Jain
Jain Siddhantha Jyotishalay
Fraser Town
Bangalore Cantt

Member of:
The All India Astrological & Astronomical Society
The Mysore Ayurvedic and Unani Practicioners' Board
The Theosophical Society

Q.1. Shall the evaluation of ITMMEC, commissioned by NORAD, continue in Norway.

Q.2. Is it necessary for NORAD to improve its (method of) evaluation?

Q.3. How shall it improve (its evaluation)?

Q.4. Should the Norwegian support to ITMMEC continue, and if not, will ITMMEC then successfully come into operation in servicing Indian industry?

A.1. This will not be completed in INDIA. 75% success is indicated.

A.2. The methods adopted by the senders have got a few problems. This will be corrected by themselves on their own.

A.3. There is no use trying to tell them.

A.4. They should give full support.

JOINT INDO-NORWEGIAN EVALUATION COMMITTEE (JINEC)

PROGRAMME IN INDIA JULY 9 - JULY 29, 1981

July 9		Arrival in Delhi (AF-198, 0300 hrs)
	Morning	Meeting with NORAD representative Ms. Vigdis Varn and Prof. J.P. Sharma, Director of ITMMEC
	Afternoon	D. Parshad, Head, Industrial Consultancy & Sponsored Projects Centre IIT-Delhi
July 10	10.00	Gedore Tools (I) Pvt. Ltd. Faridabad (Industrial visit with Granstrand, Sigurdson and Chawla) Dr. S.C. Jhalani
	Afternoon	O.P. Jain, Director, IIT
	Evening	Meeting with team member Rahman
July 11	11.00	Departure for Ahmedabad (IC-461 0645) Calico Mills (Industrial visit for Granstrand, Sigurdson and Sharma) 1. Mr. K.G. Shah - Chairman, R&D 2. Mr. V.K. Thakkar - Chief Processing Engineer 3. Mr. B.N. Joshi - Spinning Master 4. Mr. Chavan - Weaving Manager 5. Mr. Majumdar - Manager/Sewing Thread Processing 6. Mr. V.J. Thaker -Manager, Engineering Services 7. Mr. R.A. Gauni - Spinning Master
	Afternoon	Discussion with representative of Ahmedabad Textile Industries Research Association (ATIRA) K. Subramanian, Assistant Director
July 12	Morning	Departure for Bombay (IC-461 0830) JINEC members Granstrand, Rahman and Sigurdson interviewing ITMMEC Director J.P. Sharma
	Afternoon	Sight-seeing
July 13	Morning	Mahindra & Mahindra Ltd. (Industrial visit with Granstrand, Rahman and Sigurdson) Mr. R.S. Bhagat, General Manager - Projects
	Afternoon	Discussion with Vikram Dalal, Managing Partner, P. Dalal & Company

July 14	Morning	A. Sigurdson - Departure for Poona (IC-101 0640) Visit to Automotive Research Association of India (ARAI), K. Ramachandran, Director B. Granstrand - Visits to SKF companies Man.Dir. Krishan Chand, Skefko Techn. Dir Keshwani, Mr. V.K.D. Kapur, Mr. D.K. Sen Man.Dir. Ulf Jemsby, SKF
	Evening	A. Departure for Bombay (IC-158 1840) Sigurdson and Granstrand depart for Dehli (IC-183 2030)
July 15	Morning	Meeting with Nayudamma, Vice Chancellor Nehru University
	Afternoon	JINEC meeting
July 16	Morning	JINEC meeting
	Afternoon	Interview of ITMMEC groups
July 17	Morning	Interview of ITMMEC groups
	Afternoon	Meeting with Dr. K Gopalan, Deputy Educational Advisor, Ministry of Education & Culture
July 18		---
July 19	Afternoon	Departure for Bangalore (IC-403 1615)
July 20	Morning	Meeting with M.E. Visveswaran, Director Central Machine Tool Institute
	Afternoon	Kirloskar Electric Co. Ltd. (Industrial visit for Granstrand, Sigurdson and Srinath) M.R. Sridhar, Senior Manager Works Unit P.N. Hiriyannaiah, Chief Executive S.C. Ramachandra, Executive Vice President Small Industries Service Institute B.V. Gundu Rao, Deputy Director Discussions with Sanjay Kumar Biswas Assistant Professor, Dept. of Mechanical Engineering, Indian Institute of Sciences

July 21	Morning	HMT Limited (Industrial visit with Granstrand, Sigurdson and Srinath)
	Afternoon	Departure for Hyderabad and Delhi respectively
July 22	Morning	A. Srinath, Granstrand in Hyderabad BHEL, Corporate R&D Unit: Sri. D.S.M. Vishna - Specialist (M) T. Muralidharato - Lab. Manager/Tribology Dr. S.K.Bhave, Manager/Failure Analysis K. Ganapathy, Group Coordinator/Vibration
	Afternoon	Hyderabad Asbestos Cement Products Ltd., Sanatnagar, Hyderabad Mr. Mohan Sarma Mr. Pattabhi Mr. Radhaswamy B. Departure for Lucknow (IC-480 0730) Sigurdson Visit to Research Designs, Standards Organization, Ministry of Railways Mr. B.K. Palit, Director (Civil Standards) Mr. A. Chellum, Director (Research) Mr. H.P. Mittal,Director (Automotive) Mr. Jagjit Singh,Deputy Director General Dr. P. Moudgill, Joint Director Mr. A.L. Kalra, Deputy Director Departure for Delhi (1815)
July 23		JINEC meeting
July 24	Morning	JINEC meeting
	Afternoon	Interview with ITMMEC group
July 25		---
July 26		---
July 27		JINEC meetings
July 28	Morning	JINEC plenary meeting
	Afternoon	Presentation and discussions of JINEC recommendations at: A. NORAD Resident Repr. in India, Mr. Haakon B. Hjelde B. Dept. of Economic Affairs, Ministry of Finance, Mr. S. Gurumurthi, Deputy Secretary Mr. Jaishankar, Under Secretary

July 28 (continued)	C. Ministry of Education and Culture, Dr. Jha, Educational Advisor Dr. K. Gopalan, Deputy Educational Advisor Gilautra, Asst. Educational Advisor	
July 29	Morning	Presentation and discussion of JINEC recommendations with: Dr. O.P. Jain, Director, ITT Meeting with Dr. Dhar, Dept. of Science & Tech.
	Lunch	Meeting with representatives: Department of Mechanical Engineering Rural Development Centre
	Afternoon	JINEC work at ITMMEC

COMPLETION OF THE JINEC MISSION IN INDIA.

JOINT INDI-NORWEGIAN EVALUATION COMMITTEE (JINEC)
PROGRAMME IN SCANDINAVIA AUGUST 17 - AUGUST 30, 1981

August 17		Srinath, Raman, arrive in Oslo
	Afternoon	Visit to Det Norske Veritas
August 18	Morning	Visit to Elektrisk Bureau
	Afternoon	Departure for Trondheim
August 19	Morning	I. Johansen, Rector NTH E. Sødahl, Vice Adm. Director, SINTEF
	Afternoon	Reidun Gustafson, Heaf of Information NHL - laboratories VHL Einar Ottesen, Planning Manager SHL
August 20	Morning	R. Husebye, H. Christensen
	Afternoon	J. Lippe, SINTEF Machine Design Division K. Madsen, SINTEF, Production Engineering Lab. (avd. 17) O. Ørjasæter, SINTEF Machine Design Div. E. Halmøy, SINTEF, Div. of Materials and Processes (avd. 16) K. Gåsvik, SINTEF Machine Design Div.
August 21	Morning	K. Tønder, SINTEF Machine Design Division Dr. D. Fremstad, Applied Chemistry Division (avd. 21) M. Wahl, SINTEF (avd. 16) H. Christensen, SINTEF Machine Design Div. R. Husebye, -"- -"- -"-
	Evening	Departure for Oslo
August 22	Morning	JINEC Meeting
	Afternoon	JINEC Meeting. Report writing Meeting with Tandon, Hutchinson
August 23	Morning	---
	Afternoon	JINEC Meeting. Report writing

August 24	Morning	Visit to Kvaerner Brug A/S Hans J. Haug, Manager Manufacturing Engineering
	Afternoon	---
	Evening	JINEC Meeting
August 25		Reporting to NORAD
August 26	Morning	Departure for Sweden
	Afternoon	---
August 27	Morning	Srinath, Raman in Stockholm. Visit to Dept. of Machine Elements Royal Institute of Technology, Stockholm Mr. A. Folkeson
	Afternoon	---
August 28	Morning	Srinath, Raman departure for Gøteborg 0745 Srinath, Granstrand visit to Dept. of Machine Elements, Chalmers Univ. of Technology Mr. B. Andersson, Mr. P. Grunewald, Mr. O. Larsson
	Afternoon	Visit to R&D Department, SKF Gøteborg Mr. M. Kjellstrøm
August 29	Morning	Srinath, Raman departure for Lund by train
	Afternoon	Report writing
August 30	Morning	Report writing
	Afternoon	-"-
August 31		Departure

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