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UNIDO

November 1989

18252

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THE ESTABLISHMENT OF AN INTERNATIONAL MATERIALS ASSESSMENT AND APPLICATIONS CENTRE (IMAAC)

A document prepared by an expert group mission on the design and definition phase of the project

8 October - 17 November 1989

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I. INTRODUCTION

The Discussion Meeting on Advanced Materials for Developing Countries, held in Vienna, 7-10 December 1987, recommended taht "UNIDO promote the establishment of an International Materials Assessment and Applications Centre for an in-depth analysis and promotion of the rational use of materials".

Following the December 1987 Discussion Meeting, the concept of and need for the Centre have been further discussed with several materials specialists in industry and government. The Government of Brazil expressed an interest in the establishment and hosting of this new international materials centre, and has, therefore, requested the assistance of UNIDO in this respect. UNIDO, in close consultation with the Government of Brazil, has therefore initiated a project for establishing a multi-disciplinary techno-economic International Materials Assessment and Application Centre (IMAAC) to be located in Brazil.

One of the most important objectives of the UNIDO programme on technological advances is, in fact, to promote necessary action to mobilize international and regional co-operation, particularly between the scientific and industrial community. This includes promoting the establishment of international centres and regional networks of centres of excellence in the field of new materials. The IMAAC project, while falling within these objectives, is an entirely new concept for which there is no parallel.

As part of this project two experts visited several selected institutions in Brazil, the United States of America, Japan and Europe, as part of the definition phase in the establishment of IMAAC. A list of the relevant institutions and meetings is offered in the Annex. The expert mission already possessed considerable knowledge and information regarding the needs and circumstances of developing economies in the materials field. Given the kind of design characteristics sought, the mission concentrated its focus of enquiry onto the mechanisms and means through which a range of such functions were already being met through existing institutions in developed economies, where the main developments in the materials field are occurring at the moment. A parallel aim of the mission was to collect information and hold discussions with technical experts and officials in these institutions, such that would assist in the design of the structure and aims of IMAAC. At this stage of the project the mission was especially concerned to exchange ideas on the most useful structure and functions to be performed by the Centre, as well as investigate possible forms of future co-operation between the Centre and the institutions visited. The results of the mission are encapsulated in the present Document, which offers a broad outline and specific suggestions as to the design concept of the Centre, the functions to be performed and possible areas of international co-operation.

The mission met with a great deal of positive response both at the individual and institutional level. The urgent need for establishing the Centre was almost uniformly recognized and both the concept and broad aims and functions to be performed by the Centre received endorsement and, in many cases, strong expressions of support and desire for active involvement and co-operation at all stages of the project. The mission is very grateful to all institutions it visited for their generous assistance, interest, encouragement, provision of information and offers of future co-operation.

What this project seeks to establish and address is complementary to a number of other UNIDO activities and initiatives in this area. A centre to promote materials science and technology, in the areas of superconductivity is currently in the process of being established in Trieste, Italy. This is an experimental and scientific centre, whose output and expertise can form a useful complement to the analytical and networking activities of IMAAC.

Further, the Expert Group Meeting on Prospects for Industrialization Policies in Developing Countries Taking into Account the Impact of Developments in the field of New and High Technologies, Vienna, 4-7 April 1989, further reiterated the need for the establishment of a new international centre to assist developing economies in the rapidly changing scientific and technological circumstances in the materials field (Report, PPD.118(SPEC.), 24 May 1989). The Meeting was requested by the Group of 77, and the conclusions and recommendations made in the summary report were subsequently adopted by the Group 77 in Vienna. The report was also adopted by the Intergovernmental Committee for follow-up of the ECDC/TCDC which was held in Kuala Lumpur in 1989, which then recommended that the ministerial meeting of the G 77 in New York also adopt it.

Further, UNIDO is already in the preparatory phase of seeking to establish regional networks of materials research and technology centres in Latin America, Africa and South East Asia. This is in line with the aim of promoting necessary action to mobilize international and regional co-operation amongst the scientific and industrial community, including regional networks of centres of excellence in the field of new materials. Such regional co-operation and networking efforts place heavy emphasis on the efficient utilization and upgrading of locally available resources to meet urgent basic needs in transport, housing, food, irrigation and health care domestically.

The establishment of IMAAC in no way impedes, contradicts or prejudices other initiatives, including those mentioned above. Rather it forms a fundamental basis for the co-ordination and finition of such other related initiatives and projects. IMAAC is a larger concept which can form an umbrella mechanism for co-ordinating the regional networks of materials institutions and nodal points, so that in fact the latter can be seen as indispensible building blocks towards the construction of the necessary international centre, whose functions go far beyond mere networking of existing institutes and centres of excellence.

The experts selected for the mission were Mr. Lakis C. Kaounides, Visiting Fellow, Institute of Development Studies, at the University of Sussex, United Kingdom, and Mr. Lelio Fellows Filho, Co-ordinator of the Technological Development on New Materials Department of the Ministry of Science and Technology, Brazil. This Document has been prepared by Mr. Kaounides, in his capacity as a UNIDO consultant, in accordance with the terms of reference on the definition phase, and in close collaboration with Mr. Fellows Filho of the Government of Brazil. Its aim is to form a substantive foundation for the subsequent phases of the project which will involve the detailed design of the Centre and the mobilization of the international community to participate and assist in the establishment of this new international Centre of great significance to the vast majority of developing economies in the years to come.

II. THE REVOLUTION IN MATERIALS SCIENCE AND ENGINEERING AND THE NEED FOR IMAAC

The new materials era and developing economies

The materials sector is emerging as a critical, high-technology sector upon which technical change and growth in the vest of industry, including microelectronics and biotechnologies, are coming to depend. In the years ahead those economies that control materials will gain global technological and comparative advantage.

Although the radical developments in the materials field are well recognized in the scientific community, awareness of the seriousness and speed of change in this area has still not permeated the public domain. Governments in the developed countries have responded to pressure from scientific and professional societies as well as high-technology sectors and have, for several years now, initiated large programmes of financial and institutional support for domestic materials pure and applied research. On the other hand, apart from few notable exceptions, both government and industry in the developing world show distinct lack of awareness of the potential impact of the new developments for domestic resources, industry and trade prospects. And, where the new scientific and technological circumstances have been identified, there is often a lack of appropriate institutional capacity to respond, and/or a feeling that such changes are too remote and operating at the frontiers of science, and, hence of not much relevance to developing economies.

It is important to stress at the outset that the revolution in materials science and engineering has an impact right across the materials spectrum, from natural rubber, cotton, wool, wood, cement, to commodity metals such as primary aluminium and copper and the creation of new advanced alloys, engineering plastics, advanced ceramics and composites. New advanced materials are beginning to make inroads into the markets of traditional metals, but the latter are actually responding technologically and the outcome is by no means clear. In fact advanced materials in the next century could well include specialty steels, advanced aluminium alloys, and in some respects, cement and wood. The first point to note, therefore, is that the insights of materials science and engineering can be used, and must be used, to improve the properties and processing technology of existing traditional materials. Given the pressures of the world market and the user industries for higher quality, durability and reliability, no economy or industry can afford to ignore this in the years to come, at any stage of the materials cycle. Secondly, the tremendous needs of developing economies in housing, transportation, water, energy distribution, and health care can be met through more efficient use and upgrading of domestically available natural resources, using new and improved technologies. The materials revolution offers great scope for developing countries to make fuller use of domestic materials, while reducing environmental impact and energy requirements. Thirdly, many developing economies possess raw materials and/or technology skills that are directly relevant to the production and use of new advanced materials. Hence, the evolving materials era also afforts opportunities for developing countries, where appropriate, to gradually enter new materials production and trade at several stages of the transformation of the raw material into semi-processed and processed forms and components entering final end-use.

It is, therefore, imperative for developing economies to fully acquaint themselves with the ongoing scientific and engineering developments in materials and to begin to build the institutions and basic techno-economic and experimental capabilities which can be used to fully utilize and upgrade domestic materials availability. The specific forms that this will take will depend on the inventory of domestically available resources and already existing scientific and technical skills of countries at different stages of the path to economic development. Given the complexities of developments which span across the whole materials spectrum, the need for a central institution which can raise awareness and provide a competent and comprehensive mechanism for the study of these issues and their application to specific economies and industries emerges paramount. Given the large importance of materials in the world economy, industry and trade, the fuller and more efficient utilization of developing economies raw materials can only be viewed as a positive step by the world community.

Below we offer an outline, by no means comprehensive, of some of the characteristics, tendencies and implications of the materials revolution. We then point to the relation of these to the establishment of IMAAC the aim of which will be to assist developing economies to negotiate, survive and prosper in the new materials and information intensive era.

The revolution in MSE

Ever since the 1970s and, especially, the 1980s, it has become clear that the field of materials has been radically and irreversibly transformed. At the note of these dramatic changes lies the revolution in materials science and engineering (MSE). A number of factors acting in combination are responsible for this.

Although developments in quantum physics in the early part of this century offered a deep and continuously improving understanding of the structure and properties of matter, both crystalline and amorphous, such insights could only be taken full advantage of relatively recently. One factor involved the advent of very powerful new instruments, such as the scanning tunnelling electron microscope, which probe deep into the heat of matter, and the arrival of a battery of new experimental and characterization research equipment and techniques to study structure and properties. A second and related development, entails the use of new mathematical techniques and powerful methods of modelling and theoretical analysis. Thirdly, advances in computer science together with, crucially, the new number-crunching super computers which have facilitated the solution to the trillions of quantum mechanical calculations required even for the simplest atomic structures modelled or investigated. Finally, advances in materials synthesis and design have been supplemented by vastly improved existing or entirely new materials processing technologies and in-process non-destructive evaluation and measurements necessary for the engineering of the carefully controlled microstructures with the predicted and required properties and performance characteristics in use. All these developments have combined to usher in a remarkable revolution in materials science and engineering in the 1980s, confering upon it awesome powers and capabilities in terms of creating entirely new materials with properties unimaginable even a few years ago, as well as the potential to improve all existing materials and associated processing technologies.

The scientific and engineering basis of materials today is such that not only is it possible to improve the processing and properties of existing materials but entirely new materials with predictable properties can be designed at the atomic or molecular level and processed so as to acquire the performance characteristics required in a specific application. It is this, almost miraculous, ability of MSE to intervene at the microscopic level and construct novel materials with desirable properties, literally atom by atom, that lies at the care of the materials revolution which has spawned new families of materials such as advanced metals, advanced ceramics, engineering polymers, and ceramic, metal and polymer matrix composites which are currently finding application in high technology industries where performance is more important than cost.

"Materials" industries and economies

Such capabilities have reversed the hitherto existing sequence whereby materials availability and properties determined the development of end products. We can now start with the required properties and performance characteristics and design and process the material appropriate for the particular application. That is, materials scientists and engineers begin with end-use specifications and tailor the material to fit that application by choosing from a vast away of available materials or possibly an entirely new material. The erosion of traditional materials boundaries, the interpenetration of end-use markets and the tailorability of materials to meet performance requirements in use are major features of the new materials era. An already observed consequence of this is the tendency for individual firms and hitherto narrowly defined industries, such as steel, aluminium, chemicals, glass, ceramics, to begin to acquire multimaterial scientific and engineering competence. For example, metals industries are beginning to realize that they no longer produce 'metals' but rather materials with a group of properties required by the end use application. Metals industries are thereby on their way to becoming materials industries, while at the same time metal-based developed economies are restructuring their basic industries and are inexorably moving towards becoming materials producing and using economies.

Materials science and engineering is multicisciplinary

Materials science is now a multi-disciplinary science requiring inputs from solid state physics, chemistry, metallurgy, ceramics, composites, surface and interface sciences, mathematics, computer science, metrology and engineering. In fact, rigid separation of the different disciplines is becoming inappropriate and barriers or boundaries between them are beginning to erode. In any case, what is clear at this stage is that the nature and complexity of the problems in materials synthesis and processing is such that a joint simultaneous team effort across many disciplines, several professional staff and previously isolated research teams is now definitely required. Multi-disciplinary materials design, product development and processing capabilities are therefore becoming crucial at the level of the firm, the industry, the university, the research laboratory or the economy for that matter.

The central importance of processing

Materials research and development now require that materials scientists become closely involved in the processing and fabrication stages of production. The micro-structure of materials, that is the arrangement of atoms into crystalline arrays or disordered structures, determines properties and performance, but the mechanism that links all of them is processing. The controlled processing path a material follows will affect microstructure and thereby properties and performance in use. Hence materials science and engineering have now merged. A related aspect to this is that whereas in the past processing techniques were largely non-scientific and empirically based, now the science content of not only the material but, significantly, also of materials processing technology in both traditional and new advanced materials has increased by a quantum leap.

The integration of materials producers and users

Increasingly, the design and processing of a material must be integrated with the design and manufacturing path of the end-user. Materials design, and component and/or product design engineering and manufacture are merging and require close integration and iterative interaction. In some, and an increasing number of, cases the design of the material and of the end product and component is a simultaneous process involving large teams of specialists, such as in the case of composites materials design and manufacture of aircraft or automobile applications.

MSE in the new manufacturing and market circumstances

In the 1970s and 80s there emerged strong pressures from the consumer and the manufacturer for higher quality, durability, reliability, and energy-efficiency, placing higher specification requirements right across the materials spectrum. The emergence at MSE as a coherent, multidisciplinary science, inseparable from engineering and closely attuned to an, indeed, purposely orientated towards the requirements of end-use designers and manufacturers is therefore complementary to the needs expressed in the market place for the commercial application of traditional and new advanced materials. Improved processing and higher quality of existing materials will be an important variable in the changing materials markets of the 1990s, and this is an area of obvious importance to developing economies at all stages of development. A central problem confronting industrialization and economic development strategies in the 90s will be the mechanisms and institutions whereby developing economies can absorb and utilize the new scientific and engineering insights and practices so as to upgrade their traditional and existing processing and materials capabilities to meet the higher specifications, quality and flexibility requirements in end-user markets nationally, regionally and globally. Inevitably, all materials producers, at all stages of processing, would need to address the changes ushered in by the employment of microelectronics based automation technologies and just-in-time organizational change across manufacturing industries, traditional and new, as well as pressures emanating from a fragmented and quality conscious market demand.

The critical importance of materials technologies in the 1990's

The ability to utilize advanced processing technologies for greatly improved traditional materials and the ability to both produce and use new advanced materials are beginning to be recognized as critical for maintaining competitiveness, growth and employment within national economies in the 1990s and beyond. Economies in possession of a critical mass of materials scientific and technological capabilities, associated infrastructure and networks of materials and component supplier firms, will be able to gain global competitive advantage not merely in specific materials branches in which they may specialize and excel, but also in an increasing array of high technology and traiditional industries.

It must be stressed that the mere possession of high scientific competence in materials research, design and synthesis is grossly insufficient without the complementary engineering and processing capabilities. In fact, the ability to translate and transmit basic science into materials processing technologies and commercial application may be <u>the</u> critical factor in global competitive advantage in the years to come. Thus emphasis must be placed on the acquisition of appropriate <u>materials processing and engineering technologies</u>, a point that is often neglected in recent discussions of material issues. The primacy of materials processing technologies and capabilities may in fact be of even greater relevance to developing economies in both traditional materials, and, in some cases, selected advanced materials. This is not to underplay the importance of acquiring enhanced scientific skills in the new conditions ushered in by MSE, but rather to point out that such skills must be developed in conjunction with a solid engineering basis. In fact, the domestic presence of advanced processing technologies and high quality engineers who have been trained in the best materials science and engineering departments, could provide the most direct and useful linkages between advances in science and commercial and industrial application, and could provide the first solid steps in a long-term coherent industrialization strategy appropriate to survival and prosperity in the materials conditions of the next century.

Not only are we living in an 'information age', but it is becoming increasingly clear that we are entering a 'materials science age', upon which information technologies, including telecommunications, and biotechnologies find themselves heavily dependent. In fact, further advances in systems for the storage, processing and transmission of information (e.g. optoelectronics) are at the mercy of solutions coming from the side of new materials. This illustrates the central importance that materials technologies are acquiring in the functioning and growth of industrialized and industrializing economies alike. Thus, the emergence of a science-steeped, knowledge intensive materials sector within national economies will possess formidable powers with which to arrest or accelerate technical change across both science-based high technology sectors and the rest of manufacturing industries. It is not widely recognized that it is the materials producing sector that conditions, constraints and facilitates innovation in high technology sectors, which themselves have large intersectoral linkages across the economy. As we enter the 1990s, the world economy will increasingly be driven and shaped by the development and application of three major technology families, namely new, improved and advanced materials, microelectronics and biotechnologies. Nevertheless, it is the materials sector, emerging as a new high technology sector in itself, upon which technological change across industry is increasingly coming to depend. Further, new and advanced materials and information technologies are becoming increasingly linked in the diffusion process across high-technology and traditional branches at industry.

It is in partial recognition of these far reaching developments that governments through out the industrialized world, including Japan, the United States of America, the E.E.C., amongst others, have already spent vast sums to: (a) support domestic materials R+D capabilities at Universities and research laboratories, (b) establish centralized basic and applied research and advanced instrumentation facilities and centres for the use of domestic industry in the areas of pure science, characterization, process and property measurement and data gathering and evaluation, development of standards and testing procedures, quality control and intelligent processing of materials, and (c) the promotion of consortia between government, university and private industry. In addition, concerted efforts are underway to revise awareness of the importance of new materials in the competitiveness of national industries, and tentative efforts, with various degrees of success, are being made to co-ordinate national materials research and development, the most far-sighted and coherently organized emanating from the Japanese MITI and Agency for Science and Technology.

In contrast, apart from a handful of cases, the vast majority of developing economies lack awareness of the importance of new materials developments, suffer from a lack of adequate institutions to deal with the attendant informational and policy issues, and have, as yet, made little headway in devising national materials, industry and trade strategies which take into account the new circumstances.

The need for establishing IMAAC

The ongoing importance of primary commodities

The discussion above highlighted some of the characteristics and tendencies ushered in by the transfomrations in MSE in the 70s and 80s, and the arrival of clusters of new advanced materials. The materials revolution is of fundamental importance to the world economy and of equal, if not greater, significance to the diffusion of information technologies across industrialized and industrializing economies. The quantum leap in the scientific and engineering technology capabilities of the materials sector, affords both opportunities and threats on a large and expanding array of mineral, metal, agricultural and tropical commodities of considerable importance to developing economies. It is sobering to note that agricultural and mining production is the single most important component of GDP for all developing economies, except the fast growing manufacturing exporters, and that for most the share in GDP is more than 30 per cent as compared to less than 10 per cent in developed market economies. Moreover, far more than 80 developing countries the share of primary commodities in total export earnings is above 50 per cent, in many cases also accompanied by a very high degree of export concentration on one or two primary products.

Examining export prospects not sufficient

In this respect, it is insufficient, although relevant, to examine the impact of advanced materials on the expert prospects of specific mineral and semi-processed commodities from developing economies. What is not recognized is that the revolution in materials and information technologies have radically transformed the world industrial landscape and the parameters within which successful materials and associated industrialization strategies can be devised and operated successfully. There is an urgent need, therefore, to carefully examine the scientific and technological developments in the area of materials, their impact on the global restructuring, relocation and transformation of basic industries, and the position, threates and opportunities implicit in this reordering of world scientific, technological and industrial capacity for developing economies at different stages of economic development. For, the new circumstances require that developing economies reassess not only long-term reliance on the exports of a specific or small group of primary and semi-processed commodities but also the appropriate institutions, scientific, educational and training policies, infrastructure, engineering and technological capabilities required in the 90s, in accordance with domestic availability of resources and skills, stage of development, basic needs to be met and the imperatives of the global market imposed upon large-scale commodity production, high-value added intermediates aimed for niche markets and final manufactures.

Opportunities for developing countries

It seems clear that the materials revolution affords substantial opportunities for developing economies to remain and enter, where appropriate, at different stages in the vertical process of transforming raw materials into processed and final goods. Such entry entails a deep and vigorous understanding of the technological and market trends for the industry and stage of processing and must be seen as an integral part of overall industrial strategy where each step is part of the dynamic process of building up indigenous scientific and technological capacity and human resources and skills. At the same time this cannot be dissociated from the need to identify the infrastructural, educational, maintenance and supporting industry, skill and legal framework requirements which would assist and encourage the flow of foreign capital, skills and technology such that domestic competence at different stages of materials processing can be cumulatively upgraded. For most economies the currently available options will mainly involve the upgrading of traditional materials and the use of more advanced processing techniques. For some, and an increasing number, the options include the establishment of high-value added fabrication activities and diversification into related and advanced materials fields such as ceramic or advanced alloys.

International co-operation

In general, the central concern of the international community in the years to come would be to understand such options as are available to developing economies in the age of materials and in information technologies and to encourage, indeed assist, the full participation of such economies in the world economy. For, it is in noone's interest, and especially those economies constituting four-fifths of the world population, in possession of large reserves of traditional and new materials, and full partners in world trade and payments in primary and manufactured commodities, that new technologies and scientific advances only work to the advantage of one group of countries, while increasing international inequality in industrial production and per capita incomes. Rather the aim must be that developing economies expand their scientific and technological capabilities, not least in the field of materials, in the framework of international co-operation, and expand their role in world industry and trade in the 1990s and beyond.

World economic activity and trade are interdependent. The more efficient and fuller use of resources and skills in developing economies and the expansion of their industrial and trade capacity can only lead to an enlargement of world output and economic welfare. The full participation of developing economies in the world division of labour and international exchange and the consequent efficient allocation of global resources can only be of benefit to both developed and developing economies. It is, therefore, in the interests of developed economies to promote the expansion of materials capabilities and technologies in developing economies, not only to meet basic needs in the latter, but also to meet their own import, trade and industrial requirements in the framework of a growing freely-trading world economy.

There are already some measures of international co-operation but they are confined to experimental work undertaken in developed market economies, including the EEC. Such co-operative measures must go beyond these important but specialized steps. That is, the North must take greater steps to promote materials development in the South, in the interests of both groups of countries. Further, some smaller developed economies cannot afford to enter the new materials field alone, and would therefore also benefit from measures aimed at greater international co-operation in traditional and new advanced materials scientific, technological and engineering development and application.

Materials issues: complex, multidisciplinary and transectoral

Materials issues are today multidisciplinary in nature and transmaterial and transectoral in impact. They must therefore be addressed as such. Examining the issues through the lens of a specialized materials institution, such as iron and steel or primary aluminium institutes, or individual commodity specialists is grossly inadequate in the current circumstances. Today's research output is monomaterial orientated and highly specialized. There is thus no central institution in which a multidisciplinary approach is adopted to study problems which span several materials. The central problems at hand are highly difficult, complex and elusive going across disciplines, specialized institutions and traditional approaches. The new circumstances and the new problematic thus call for a new approach. The concept and structure of IMAAC is thus both timely and necessary in order to meet the pressing need for a multidisciplinary, transectoral approach to materials issues facing developing economies. The centre would be able to grapple with the diffuse nature of the problems, cut across the complexities, and pull together the essentials of the issues facing specific industries and economies.

Materials management in transition

At the national level there is considerable lack of awareness and institutional capacity to monitor global trends and translate them to domestic industrial policy. At the same time materials strategies and materials management and planning are in a transition, calling forth much greater analytical and informational content than the traditional monomaterial preoccupations and central concerns with export prospects. While the economics side concentrates on export prospects and price and income elasticities, another are receiving attention in materials relates to the science base, laboratories, testing procedures and so on, with the two areas completely separated. Yet the latter is clearly an organic part of materials strategy and can be a central ingredient in a materials strategy. IMAAC can help to fill this analytical gap and assist developing economies to build institutions and skills to address materials issues in a comprehensive manner and develop appropriate materials strategies in the 90s. An important element of this must be the recognition of the differing needs of economies at different stages of their development and with materials displaying various degrees of importance in the national economy and exports.

Environmental issues

Another major area of increasing international concern, relates to environmental issues. Rather than the fragmentacy and incomplete approach now underway regarding the environmental problems involved at all stages of materials extraction, processing, manufacture, recycling and disposal, especially in plastics, IMAAC can provide a centralized framework whereby awareness is raised on these issues in developing economies and such that they are approached in a concerted, informed manner in the framework of international co-operation.

Networking

It is not sufficient to network existing institutions in order to deal with the issues identified above. IMAAC can provide an indispensible function by identifying and utilizing the strengths of existing institutions in developing countries and by providing a central umbrella and intermediation mechanism whereby university departments, scientific research centres and labs, professional societies, technical experts and information and data bases can be networked and put into contact with each other to enhance efficiency and international co-operation as well as the ability to centrally utilize these strengths in order to address materials problems faced by national economies and industries.

The pressing need for a new multidisciplinary, international centre

The remarks above hightlight the enormous tasks, analytical needs and informational requirements imposed by the revolution now embracing the whole materials field across both producers and users in industry. Such tasks are beyond the means of a single specialized research institute, professional society, firm, or ministry. There is now a pressing need for the establishment of a new international multidisciplinary centre which can centrally address:

(a) The in-depth investigation of trends in materials science and engineering and in the field of advanced materials, and relate these to the role of traditional and new materials in a restructuring world industry moving towards high-value added knowledge intensive production;

(b) the assessment of the resources available in specific developing economies, their future prospects in meeting domestic needs and/or global industrial market needs, and the role of the materials sector in a future industrialization programme;

(c) the need to build up institutions, and attendant materials education and training programmes in developing economies;

(d) the gathering, assessment, and dissemination of vast historical and continuously up-dated information and data on new improved traditional and advanced materials of relevance to developing economies;

(e) the need to intermediate across institutions, professional societies and expertise in materials related fields in developing economies to raise awareness of materials issues for national economies and to network existing national and regional data and standards institutes under a single umbrella.

This serious ongoing effort, therefore, to establish IMAAC is a very timely and much needed international venture designed to meet a perceived analytical and information gap to provide developing economies with a centralized institutional framework not available which can assist them to address materials issues of continuing importance to their economies in the years to come.

THE OBJECTIVES OF IMMAC

1. Assist developing economies to address materials issues. The rapid and far-reaching transformations under way in materials science and engineering which encompass both traditional materials and technologies in use in developing economies as well as the advent of new advanced materials, usher in new imperatives and requirements for the Third World. A central objective of

IMMAC would be to assist developing economies to build up the institutions, scientific and technological capacity, education and training programmes and information gathering and assessment capabilities to meet the challenges posed by the complexities and uncertainties surrounding the unprecedented changes and transitions in materials.

2. Promote greater participation of developing countries in the world economy. Given the implications of the diffusion of new information and materials technologies for the restructuring of world industry, location of extractive, processing and manufacturing capacity and for export trade patterns, the centre would perform the function of monitoring, analysing and promoting the conditions and mechanisms whereby a developing economies can participate more rather than less fully in world industry, trade and growth, with particular reference to materials. Hence, a central aim would be to strengthen the domestic capacity to absorb new scientific and technological advanced to upgrade and add-value to local resources and processing technologies, while creating the appropriate infrastructure, skills, incentives and legal framework which would encourage the inflow of financial resources, the successful transfer of technology and joint ventures in the fields of materials production and use. In this way, developing economies would be able to play an increasing rather than decreasing role in world industrial production, trade and growth in the 1990s.

3. Promote international co-operation

It is in the interests of the international economy and community that maximum use be made of material and human resources available in developing countries. The centre would aim at international co-operation in research, development and applications of improved traditional and new materials. Materials are central to industrialization and economic development efforts, and will continue to be so in the future, whether for domestic use or aimed at the world market. Hence greater utilization and downstream processing and fabrication of materials falls within the efforts to accelerate and promote rapid industrialization of developing economies within the framework of international co-operation. This acquires added significance given the need to integrate materials issues with those emerging in the areas of environmental pollution and energy conservation, requiring mutually agreed, urgent co-ordinated action for the benefit of global economies activity and fair distribution of its result.

The framework of international co-operation also encompasses the networking at a regional and international level of research institutes, professional societies, centres of excellence, and industrial concerns to address a common problematic, resolve outstanding issues, identify common interests and achieve mutually beneficial results. Thus the aims of co-operation and networking are to be in-built in the philosophy and manner of operation of the centre.

4. Serve the needs of world industry

The centre would aim at the strong participation of industry from developing and developed countries, and at creating the appropriate framework of meeting the needs of materials producing and using industries in both groups of countries. In addition, to identify the strengths and weakness and information needs of industry and times in developing countries, the centre will also be concerned with the needs of industry in the developed world. The expansion of productive capacity and technological capabilities in the developing world implies that greater information on material availability, properties, standards and companies be collected and disseminated to firms in the developed world concerned with imports, and sourcing foreign direct investment and technology transfer, joint ventures and licencing agreements in traditional and advanced materials.

IV. THE MAIN FUNCTIONS OF THE CENTRE

1. Gathering, assessing and disseminating materials information

Library Services

The centre would possess resources for only a small number of in-house subscriptions to journals. Rather the library services would rely on the abstracting and technical literature searching aids and services already existing, such as the ones on offer by Materials Information. Such searching services can be retrospective and customized to need. Other services to be utilized internationally involve Directories of Consultants and Translators, Source Journals in Metals and Materials, Translation Services, etc. The ultimative aim would be for the centre to build up its non Directory of Consultants and Expert on Materials in developing countries.

Materials properties data-bases: In-house capabilites and access to external sources

With regard to materials data bases already existing or being developed in the industrialized world, the centre would aim at accessing such information where possible: It can either enter commercial agreement with such services as ORBIT, which would give it access to ASM materials data base plus another 200 data bases. Or, it can lease magnetic tapes of information and load them onto an IMAAC mainframe computer. Nevertheless, current developments enable access to such data bases, search procedure and retrieval of specific information through the use of a personal computer: Information on thousands of materials can be obtained on-line through packet switched networks or over the telephone line. The centre would aim at establishing a data base an available data bases and close monitoring of international efforts to harmonize data systems. For example, the EEC is promoting the harmonization of 11 leading on-line data bases, through a common vocabulary, a computerized user guidance system (UGS) and a directory of materials data information services (DOMIS).

The most important function of the centre would be to build-up a specialized service on materials availability, properties, specifications and characterization, companies producing and using them in developing economies.

1. Standards

A central area relating to building and accessing materials data bases related to standards and testing procedures used. Very often there is a lack of compatibility in the properties and designation of engineering materials and the testing procedures under which they were obtained, as well as at the level of software, user interface, data presentation, terminology and data bank commands. Thus, the centre would be aiming to keep in close contact with efforts to harmonize standards and test procedures across countries and raise awareness in industry, government and standards institutes in developing countries as to the crucial importance of standards harmonization in the new materials age.

2. Studies on scientific, technological and industrial trends

The centre would be commissioning studies at the highest scientific and professional level, including from known consultancy agencies, on the nature, direction and speed of scientific, technological and market movements. Here, the networking and utilization of international scientific and technical expertise will be of the utmost importance. Where studies of high quality already exist, the aim would be not to duplicate but to draw on the relevant essentials.

3. Specially commissioned and specialized studies of a techno-economic nature

The centre would initiate as a response to requests from industry and governments, specially commissioned studies on specific traditional and advanced materials, policy planning and management, long-term strategy to utilize domestic resources, market trends, etc., to facilitate informed policy making on materials, industry and trade.

4. Workshops

Two to four workshops per annum covering areas of interest to the scientific and industrial communities and drawing upon world-wide expertise and institutions would be organized, as for example, on materials information and data management, metrology and standards harmonization, new metals processing technologies, etc.

5. Education and Training

Education and training programmes would concentrate, in the first instance, on the building of appropriate institutions and expertise in developing economies to manage materials information and policy issues. At the same time, and in close conjunction with the highly developed programmes offered by such institutions as ASM International, training programmes and packages will be assembled to meet the specific needs of industry and engineers in developing countries. Such materials education programmes could include intensive seminars by top industry experts, homestudy courses, video courses, and in-plant courses to meet specific materials need, by a company. In this way the centre would assist in developing technical skills, update engineering know-how, management capabilities and keep industry abreast of new developments.

6. Advisory Services

The centre would function as a readily available source of consultation and advisory services for industry government officials, scientists and professionals in the materials field. It will draw on the existing technical advisory services offered by UNIDO, other institutions and a network of experts in specific fields.

7. Intermediation and promotion of international co-operation

The centre would be interinstitutional. Thus, it would encourage the participation of many institutions and organizations from around the world. Industry would play a vital role and its participation would be encouraged from the earliest stage of the preparation and operational phase of the centre. Industry would be a working partner of the centre, both contributing and drawing upon its resources, information and world-wide expertise. Other institutions would include universities, professional societies, international organizations, research institutes, etc.

The networking and efforts at international co-operation aspects of the centre would not be accidental but an essential part of its functioning. A central function of the centre would be to draw upon and utilize resources world-wide in order to make more efficient and relevant contribution to materials-related problems.

The centre would thus draw upon the resource of professional societies in metals, polymers, ceramics and composites for its own programmes, as well as with the aim of bringing together people with the same research and technological interests from around the world.

V. STRUCTURE AND ORGANIZATION

Staff requirements

It is recommended that the centre employs between 6-10 permanent high-level staff supported by relevant clerical and technical assistance. The small, permanent multidisciplinary staff would be supplemented by a continuous inflow of short-term consultants and visiting experts, as well as nationally recruited technical personnel seconded by participating countries.

For the initial stages of the project it is recommended that the staff comprise of a director and seven other permanent staff whose areas of competence, consistent with the functions to be performed by the centre, are described below and shown diagrammatically in the next page.

1. Director

The Director must have proven leadership and organizational capabilities, as well as the ability to interface and co-ordinate policy across a diverse network of participating institutions and technical expertise.

2. Techno-Economic Studies Unit

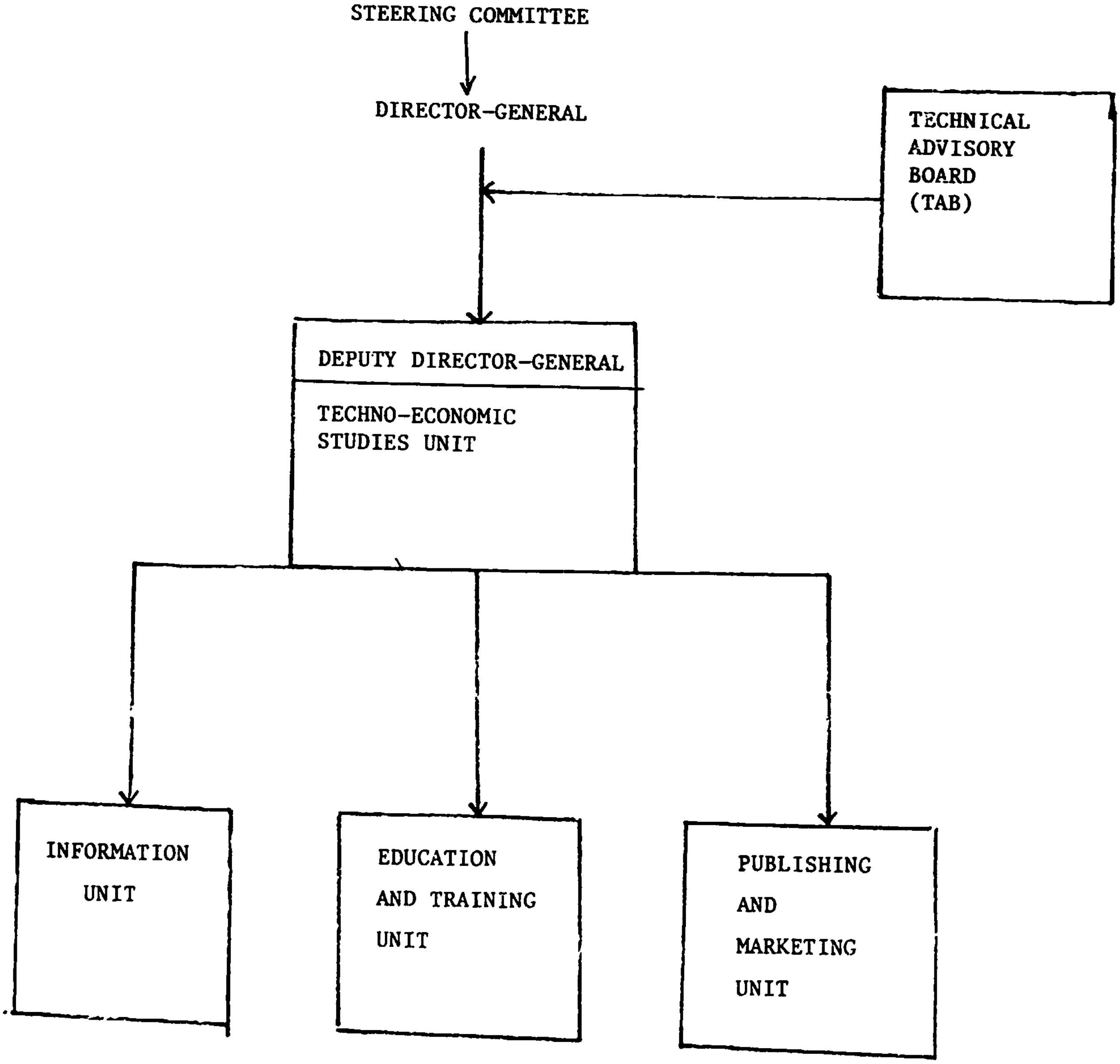
Four members of staff with an engineering, business and economics background, responsible for the commissioning of general and specific studies from a network of technical experts, the organization of workshops and the setting of the guidelines for the informational requirements, educational and training programmes and publishing and marketing efforts of the centre. One of the four shall perform the duties of Deputy Director-General.

3. Information Unit

One information science specialist in charge of setting up:

(a) library facilities and bibliographic data base, with the assistance of locally recruited library staff.

STRUCTURE OF IMAAC



(b) Access to external materials data bases and information.

(c) Appropriate hardware and software capabilities for in-house specialized materials properties, standards and producing companies data bases covering a range of materials and industries in developing economies.

The information specialist would be supported, at this stage, by the relevant library and secretarial staff and technician/system analysts, and would need to commission studies from experts on the most appropriate mechanisms and software capabilities required for accessing and networking with external data base systems together with specialized in-house materials information requirements. The enlargement of the staff in this area of information gathering, assessment and dissemination would be a matter for discussion at a subsequent stage in the light of experience, needs and technical expert recommendations.

4. Education and Training Unit

One experienced professional educationalist to design ongoing educational and training programmes for professionals, engineers, technicians and government officials from developing countries. This permanent member of staff will be liaising with the education and training systems already developed by other institutions in the area of materials, such as those on offer by ASM International and the Institute of Metals in London, redesigning them to meet the identified needs of developing countries.

5. Publications and Marketing Unit

One permanent member of staff with a publishing and/or marketing background in charge of the various publications of the centre, the global marketing of the products and services available and public relations.

Organizational Aspects

It is recommended that the functioning and activities of the centre, in broad terms, shall be guided and evaluated by a Steering Committee. Given that the centre is being currently established as a UNIDO Project of an international character the Steering Committee would, in the first instance, accord with UNIDO procedures and be comprised of representatives from UNIDO and the host country, and subsequently enlarged by invited members from other developing and developed countries.

Further, a Technical Advisory Board should be set up composed of a small number of eminent persons in the fields of science, technology, industry and economics, who shall offer advice on developments in the fields of materials science, technology and industry and, therefore, the direction and work programme to be followed by the centre in its efforts to meet the specific requirements and aspirations of developing economies. The Technical Advisory Board should meet at least twice a year and offer its advice to the Director-General of IMAAC. It is suggested that the Director-General and Deputy Director-General be members of both TAB and the Steering Committee, while the Chairman of TAB be a member of the Steering Committee.

The Director-General of IMAAC ought to have sufficient powers to decide on major, as well as minor, policy issues and translate the advice received into specific projects and work programmes, execute policies, and set the centre moving fast and efficiently along the predetermined path. The Director-General shall be appointed by the Steering Committee, for a period of three years, with the possibility of further reselection for a second term of three years, up to a maximum of 6 years in total. The Director-General shall submit an annual report to the Steering Committee at its annual general meeting.

VI. INTERNATIONAL CO-OPERATION AND EXTERNAL LINKS

A central objective of the centre would be to form close links with a network of participating institutions, organizations, societies, and technical experts from both developing and developed economies. The aim would be to promote a framework of greater international co-operation in the field of materials, and to utilize resources and expertise worldwide.

As part of this the networking of regional centres of materials information, standards and research institutes would play a central part. IMAAC would, in fact, assist their functioning under its umbrella, and they in turn would facilitate the role of IMAAC.

The mission has uncovered a large measure of interest and support for the concept, orientation, functions and proposed work programme of the centre from the various institutions visited, as well as in many instances, a strong desire to co-operate and assist the centre in many areas of its activities. These measures of support and spirit of co-operation ranged from committments to assist, from an early stage in the design of the information system and data banks of the centre such that they complement and fit into existing ones while avoiding duplication and waste of resources, to the provision of off-the-shelf educational packages on materials training and keen offers of participation in seminars, workshops and commissioned studies.

More specifically, ASM International in Cleveland, and the Institute of Metals in London have offered to assist the centre in terms of access to library service, search services, publication, education and training programmes for developing countries and accessing their materials data bases. UNCTAD and IPC have offered to work closely in the preparatory phase to develop comprehensive and mutually complementary materials information data bases and techno-economic analytical capabilities. Strong offers of support and desire to participate in a number of ways were also received from individuals in such institutions as MIT, U.S. Bureau of Mines, Science Policy Research Unit in Sussex and others.

VII WORK PROGRAMME

Right from the start the work programme of the centre will be structured around a set of realistic and feasible objectives. During the first 2-3 years and, as the centre builds up its technical and operational capabilities, a focused and selective approach will inform its activities.

1. One of the first priorities of the centre would be to commission a comprehensive multidisciplinary study from a committee of high-level technical experts, which would deal with trend in materials science, engineering and industry and the dynamic implications for and imperatives ushered in for economic development strategies and policies. It is important that the centre produces for wide dissemination, at the end of its first two years of existence, a substantive study of the new circumstances prevailing in traditional and new advanced materials which is utilized to raise awareness and provides an informed and relevant basis for the derivation of appropriate materials policies for countries at different stages of economic development. Most studies currently available in this area are, understandably, undertaken from the point of view of the needs of industrialized economies and are thereby divorced from the realities and conditions appertaining to materials in developing economies. There is therefore a clear need to bridge this gap and to provide an overall analytical and empirical framework of global trends which forms the basis for assessing the position and future options open to materials producing and using developing economies.

2. In essence the centre would be concentrating its analytical and informational focus on understanding the major trends and issues in materials and addressing them to the specific needs of developing economies right across the materials spectrum. Within this overall aim, therefore, and in parallel to it, the centre would be arranging a number of workshops in conjunction with specially commissioned studies which address specific issues relevant to the resources, materials and local conditions in developing economies. For example, one such workshop could investigate the trends in materials for the building and construction industry and assess the implications for the use of locally available materials for meeting domestic and regional needs in urban and rural residential construction programmes in the 90s. The ensuing

commissioned study would then be made available for wide dissemination and can form the basis for country requests for studies related to their specific domestic material availability and needs. Other workshops and specially commissioned studies could include, (a) the impact of optical fibres on the copper industry and the transmission of electricity in developing economies in the 1990s, and, (b) the implications of the advent of new advanced steel processing technologies for the iron and steel industries of developing economies.

3. At the same time the centre will be making a concerted effort to build up its materials information and data base, such that over a period of several years it can become an indispensible international reference centre for materials in and of interest to developing economies, as well as to institutions and industry in developed economies. For this, it will be necessary to construct a network of on-line connections with a number of professional societies, research institutes, standards associations and specially created nodal points in developing economies. One outcome of this, would be a range of specialized directories available on-line or in published form, providing information to users and subscribers on R+D centres and institutes, materials availability, producing and using companies, export-import data, and technical experts in each economy.

During the preliminary setting-up stage of the centre (Section X below) and the first 2-3 years of its operation, the design of the hardware and software programmes and information gathering activities, will be undertaken in conjunction with and in close collaboration with experts and institutions that have expressed an interest in assisting and in co-ordinating the centres and their materials information systems in a workable, complementary and harmonious framework. It is also worth mentioning that the Brazilian government has already made available substantial funds for the acquisition of computer hardware and peripherals, and that there is already a comprehensive study group in Brazil examining the whole issue of computer requirements, compatibility, gateways, software systems, etc., appropriate to the needs of the centre.

4. Finally, in consonance with the techno-economic study programme for the first 2-3 years of the centre's existence, to be decided upon on the advice of the Technical Advisory Board, a primary aim must be the setting of priority objectives in the areas of education and training, drawing upon the experience of institutions with long and fruitful experience in materials education. In addition to short-term training courses on materials management for officials and industry personnel, long-term specific training programmes for engineers from developing countries, as for example, on advances in metals processing and high-value added fabrication technologies would also be in order. The publications programme would need to reflect the ongoing techno-economic studies and informational and educational priorities to meet the perceived user needs.

VIII. FINANCIAL CONSIDERATIONS

Land and Buildings

In the first few years of its operation it is expected that the centre will be physically located within the premises of CETEM, which itself is located within the confines of the University City of Rio de Janeiro. Our mission has confirmed that the CETEM building offers modern and readily available office facilities to house the permanent staff, secretarial support, computer facilities and library (which will be linked to the existing one on the premises). At the same time, the location offers a large auditorium which, together with similar university facilities, can be utilized for workshops and meetings.

There is the possibility that over time a need may emerge for the construction of a separate building to house an enlarged IMAAC. This would be a matter of a future study to be undertaken if and when the need arises and in conjunction with possible resources to be made available for such an undertaking. What should be mentioned here is that there already exists over 1,000 sq.m. of land space available next to CETEM which has been earmarked for future use as a possible site of a new building to house IMAAC.

Telecommunications and Miscellaneous Equipments

The centre will mainly require computer hardware and software facilities and telecommunications equipment such as facsimile machines and telex terminals. A study is underway in Brazil on various aspects of the computing requirements of the centre, given the tasks to be performed, such as on software design, compatibility, gateways, etc. It should be mentioned, in this connection, that the Government of Brazil has already allocated substantial funds towards the setting-up of the centre and meeting the costs of communications and office equipment. Six powerful P.C.s (each with 80 megabyte winchester), six Modem, six fax machines, and six no-Brakes, 12 transmission phone lines, amongst other hardware, have already been bought costing around US$500,000 for use by the centre. There is therefore a process underway by which IMAAC will be networked with other national, regional and international materials research centres and professional societies. The final form of software capabilities and international networking will be arrived at, in the month ahead, following advice and interaction with other professional societies and international organizations interested in harmonizing the information and data gathering activities of the centre with their own.

Operational costs

The following estimates of the annual operating costs for the centre are offered provisionally and only as rough guidelines.

	1989 dollars
Permanent staff	US$ 600,000
Secretarial Staff	US$ 250,000
Communications (Library, publications, fax, telex, mail, etc.)	US$ 200,000

Meetings, Workshops	US$ 200,00
Training Programmes	US$ 200,000
Consultants	US$ 400,000
Travel and other expenses including translation services	US$ 100,000
Total	US$ 1,950,000

The figure for the permanent staff was arrived at from the UN salary scales P5 to P2 and for the secretarial staff from local high-level current secretarial salaries (for a total of 15 full time library, technical and secretarial staff). It is recommended that these figures be viewed as maximum amounts not to be exceeded in the recruitment phase. There is also a healthy balance between expenditures on salaries and expenditures on information acquisition and dissemination and the commissioning of special studies and organization of workshops and education programmes. It should also be clear that such a prudent approach to expenditures within the first stages at operation falls within the constraints imposed by the available core funds. Higher expenditures can only be considered as additional funding becomes available.

Core Funding

It must be pointed out at the outset that the Government of Brazil has already allocated approximately US$ 500,000 in 1989 and US$ 2,000,000 for 1990 to meet the costs and preparatory work necessary in setting-up the centre and making it operational. Further, it is expected that the Brazilian government will make available to the centre US$ 2,000,000 per annum as a contribution to the annual expenditures incurred by the centre. It is important that the latter annual figure be seen as core funding or seed money, to be supplemented by contributions from other interested parties including governments, international organizations and private industry.

It is necessary that this US$ 2,000,000 of core annual funds be provided by the host country, since it is the critical minimum mass of funds for the centre to function. In addition, such funds would provide the centre and the funding process with the necessary momentum in the months and years ahead.

As the centre gains reputation and functional competence, it would be able to charge clients for studies commissioned by them and for requests for information, data and literature searches. Additional funds can be obtained by cash contributions and donations from governments, private and public industry and world organizations. In-kind contributions could include the secondment of staff by another country at a cost born by the latter, subject to a selection procedure by the centre.

Finally, it is recommended that serious consideration be given to the establishment, through a variety of mechanisms and sources, of an endowment of between US$ 20-30 millions which can then be used to provide the centre with an annual income of US$ 2-3 millions. This is the best means to ensure that the centre's financial position and core funds are not subjected to annual fluctuations or political interference. Several countries and international bodies may wish to contribute to such an endowment. UNIDO should pursue this line of action in the months ahead.

IX. CONSIDERATIONS ON THE LOCATION OF THE CENTRE

The centre would need to be located in an area which provides the necessary intellectual and scientific ambience, access to practical engineering and technological developments and be surrounded by an adequate supporting infrastructure and telecommunications facilities. This is so in order to be able to execute its functions and attract the necessary high-quality personnel, researchers, workshop and conference participants, seconded staff and so on.

The mission visited both Brazilia and Rio de Janeiro, and is satisfied that the location of the centre within the physical confines of Rio de Janeiro university and, initially, within the premises of CETEM (Centre for Mineral Technology), which, importantly, is in the process of transforming itself into a centre for materials technologies meet all the above objectives and is, therefore, recommended. At the same time it must be noted that IMAAC will not, in any way, be part of the University of Rio de Janeiro, nor of CETEM, which in any case does not belong to the university. Thus the independence of the centre must not be and must not be seen to be, compromised in any way.

The location of the centre at CETEM, in the area of Fundao Island, an objective supported by the Brazilian Government, offers manifold advantages. Not least is the fact that the centre will be surrounded by and closely benefiting from interaction with a number of research institutes and places of higher education:

1. Federal University of Rio de Janeiro (which included the Physics Institute, Chemistry Institute, the Institute of Macromolecules, Chemical Engineering Department and the Engineering School).

2 CEMPES: Research Centre of Petrobras (State oil company).

3. CEPEL: Research Centre of Electrobras (state energy company).

4. Nuclear Energy Research Centre.

5. BIORIO: Research and Development Centre on Biotechnology.

6. COPPE Post-graduate Programme on Engineering Co-ordination. This is the largest post-graduate engineering programme in the southern hemisphere, with over 1000 graduate students in civil, mechanical, chemical and other branches of engineering, belonging to the University of Rio.

Thus the location of IMAAC at CETEM would benefit from a wide range of inputs from both the scientific and engineering side. The association with research institutes supported by large industrial concerns with emphasis on technology issues would be an added advantage, given the preoccupations of the centre. The library of IMAAC could co-ordinate and utilize the already established library facilities of CETEM, and of the University which possesses an access to a global network of bibliographic sources and references.

Another potential location could be Sao Paolo, where there is also a very high level of scientific activity at several universities and research centres. At the university of Sao Carlos advanced research is being done in ceramics and metals, whereas Campinas University has a high reputation in solid-state physics and microelectronics research is underway at the University of Sao Paolo. While recognizing the very high level of scientific competence of these and other research centres in Brazil (such as the Brazilian Centre for Research in Physics, CBPF), it is a central aim of IMAAC to utilize the expertise and staff of such centres to enrich its information, study and education programmes, and, as such, this aim will not be impeded were the centre to be physically located in Rio de Janeiro.

X. SUBSEQUENT STAGES OF THE PROJECT

1. Ratification

Consideration and ratification of the present document by both UNIDO and the Brazilian Government.

2. Invitation to join

Distribution of the document to all countries and several international organizations. The beginning of a phase during which UNIDO will extend an invitation to other countries to co-operate and participate in the centre, through visits, meetings and other forms of contact.

3. Preparatory Work

Simultaneously with the efforts to enlist the participation of other countries, the preparatory work for the establishment of the centre will continue at an even more intensive pace in order to draw up the detailed specifications of the operational requirements and functional activities of the centre:

- Detailed study of the information and data base requirements and associated software capabilities. This design of computer hardware, software capabilities, data banks and global accessing and networking of existing materials data bases will be undertaken in close collaboration with institutions such as ASM International and UNCTAD, both at this setting-up stage and at the initial stage of operation of the centre. This is so in order to minimize wastage and duplication of effort, ensure the complementarity, comprehensiveness of coverage compatibility and standardization of data between the institutions from an early stage, and increase the efficiency and usefullness of the information services offered by IMAAC during its operation.

- Utilizing the experience and pre-existing services of other institutions in order to design appropriate educational and training programmes, publications and workshops, soon after the centre becomes operational.