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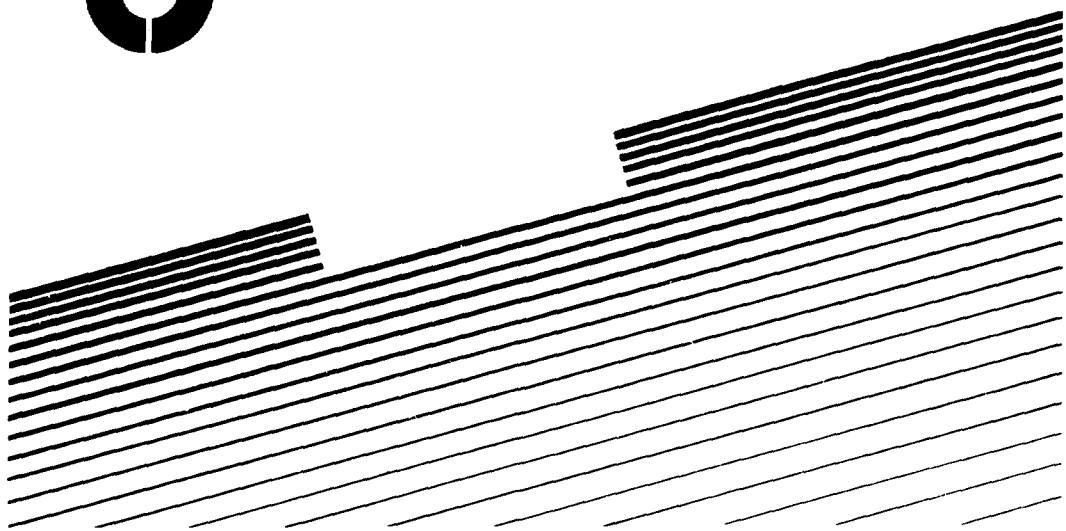

PRELIMINARY ITER COST AND SCHEDULE ESTIMATES

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1990

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PREPARED BY THE
ITER MANAGEMENT COMMITTEE
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FOREWORD

Development of nuclear fusion as a practical energy source could provide great benefits for all mankind. This fact has been widely recognized and fusion research has enjoyed a level of international co-operation unusual in other scientific areas. From its inception, the International Atomic Energy Agency has actively promoted the international exchange of fusion information.

In this context, the IAEA responded in 1986 to calls for expansion of international co-operation in fusion energy development expressed at summit meetings of governmental leaders. At the invitation of the Director General there was a series of meetings in Vienna during 1987, at which representatives of the world's four major fusion programmes developed a detailed proposal for a joint venture called International Thermonuclear Experimental Reactor Conceptual Design Activities. The Director General then invited each interested party to co-operate in ITER activities in accordance with the Terms of Reference that had been worked out. All four Parties accepted this invitation.

ITER Conceptual Design Activities, under the auspices of the IAEA, began in April 1988 and are scheduled to be completed in December 1990. The plan includes two phases, the Definition Phase and the Design Phase. In 1988 the first phase produced a concept with a consistent set of technical characteristics and preliminary plans for co-ordinated R&D in support of ITER. The Design Phase is producing a conceptual design, plans for R&D programmes, safety and environmental analyses, a cost estimate and a description of site requirements. All information produced within the Conceptual Design Activities is being made available for all ITER Parties to use either in their own national programmes or as part of a larger international collaboration.

As part of its support of ITER Activities, the IAEA is pleased to publish the documents that summarize the results of the Conceptual Design Activities.

CONTENTS

PREFACE

The Terms of Reference for the ITER Conceptual Design Activities (CDA) require, *inter alia,* cost, manpower and schedule estimates for the realization of the ITER.[1] Plans for completion of the CDA in 1990 include performing a cost analysis based upon completed conceptual design of the entire facility and conceptual plans for procurement, construction and operation. Estimates will be made of the costs that the Parties would incur if they agree to continue their co-operation through the stage of engineering design and then decide to procure, construct and operate the ITER.

In 1989 the ITER Council asked the ITER Management Committee (IMC) to make preliminary estimates of the capital cost of the ITER facility. This was done and the results have been reported.[2] In order to provide information to the Parties for use in discussions of possible Engineering Design Activities (EDA), the Council subsequently asked the IMC to make preliminary estimates of costs and schedules for all phases through construction and operation. By the end of the January-March 1990 session of joint work, the IMC had complied with this further request. Results are presented in this Report. The components of the estimated overall costs of ITER, from the start of the Engineering Design Activities (EDA) through to the end of operation are summarized, together with the corresponding project schedule.

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[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Establishment of ITER: Relevant Documents, ITER Documentation Series, No. 1, IAEA, Vienna (1988).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, ITER Conceptual Design: Interim Report, ITER Documentation Series, No. 7, IAEA, Vienna (1990).

1. INTRODUCTION

This report summarizes the components of the estimated overall cost of ITER from the start of the Engineering Design Activities (EDA) to the end of operation and presents the underlying project schedule.

These estimates are preliminary and approximate at this stage and sensitive to the assumptions. The Conceptual Design Activities (CDA) are still underway and many technical and organizational issues which can have an impact on cost and schedule remain to be resolved. Further study on the subject will take place during the summer 1990 joint work.

2. OUTLINE ASSUMPTIONS

The basic assumption underlying the estimate is that there will be a Central Team throughout the EDA (5 years), Construction Phase Activities (8 years) and Operation Phase Activities (18 years). This team will have overall responsibility for ITER design, construction and operation. Throughout these phases, there will be "Home Support" organizations run by each of the Parties to conduct specific design and R&D, assigned by the Central Team, in home research institutions and industry.

The Central Team will be sufficiently strong to carry out detailed design, draw up specifications, guide R&D, handle procurement, monitor manufacture, assemble the tokamak with industrial assistance, perform commissioning and operate the device. Wherever possible, bearing in mind the need to guarantee the multinational nature of the project, contracts will be awarded by this Team to the lowest-price, technically acceptable tenderer.

During the Operation Phase Activities, the Central Team will perform experiments and run the machine, but additional resources should be provided by the Parties to conduct other experiments and tests. The host Party will be expected to decommission the plant and therefore decommissioning costs cannot be estimated properly at this stage. Transport and permanent disposal of wastes arising during operation are also considered to be the host responsibility, after the project has paid for such waste to be suitably packaged.

All costs have been estimated in January 1989 US$.

3. PROJECT SCHEDULES

A possible project schedule for the EDA leading on to the start of construction is given in Fig. 1. After a decision to proceed with the EDA, five years will be needed to carry out the design and to complete the necessary

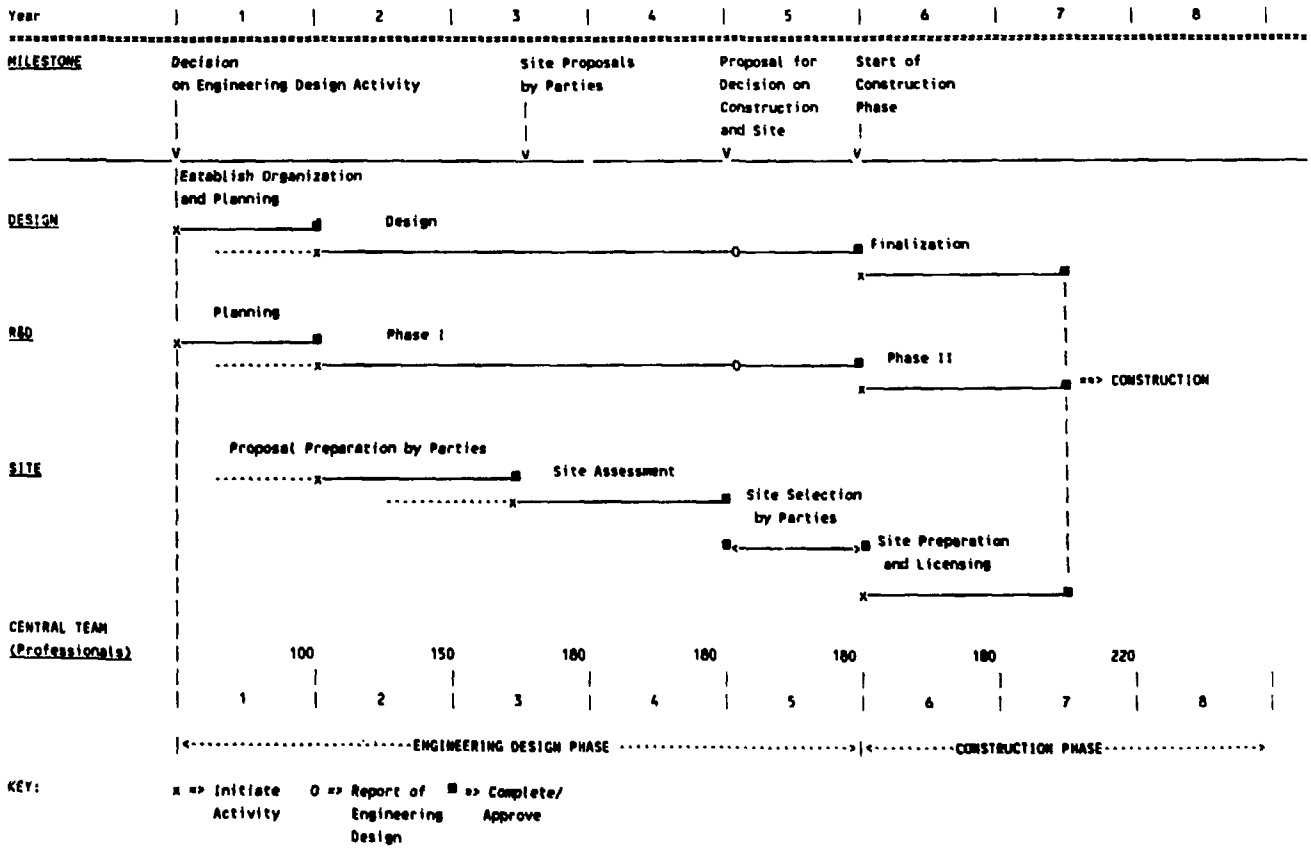

Fig. 1. Possible ITER Engineering Design Schedule

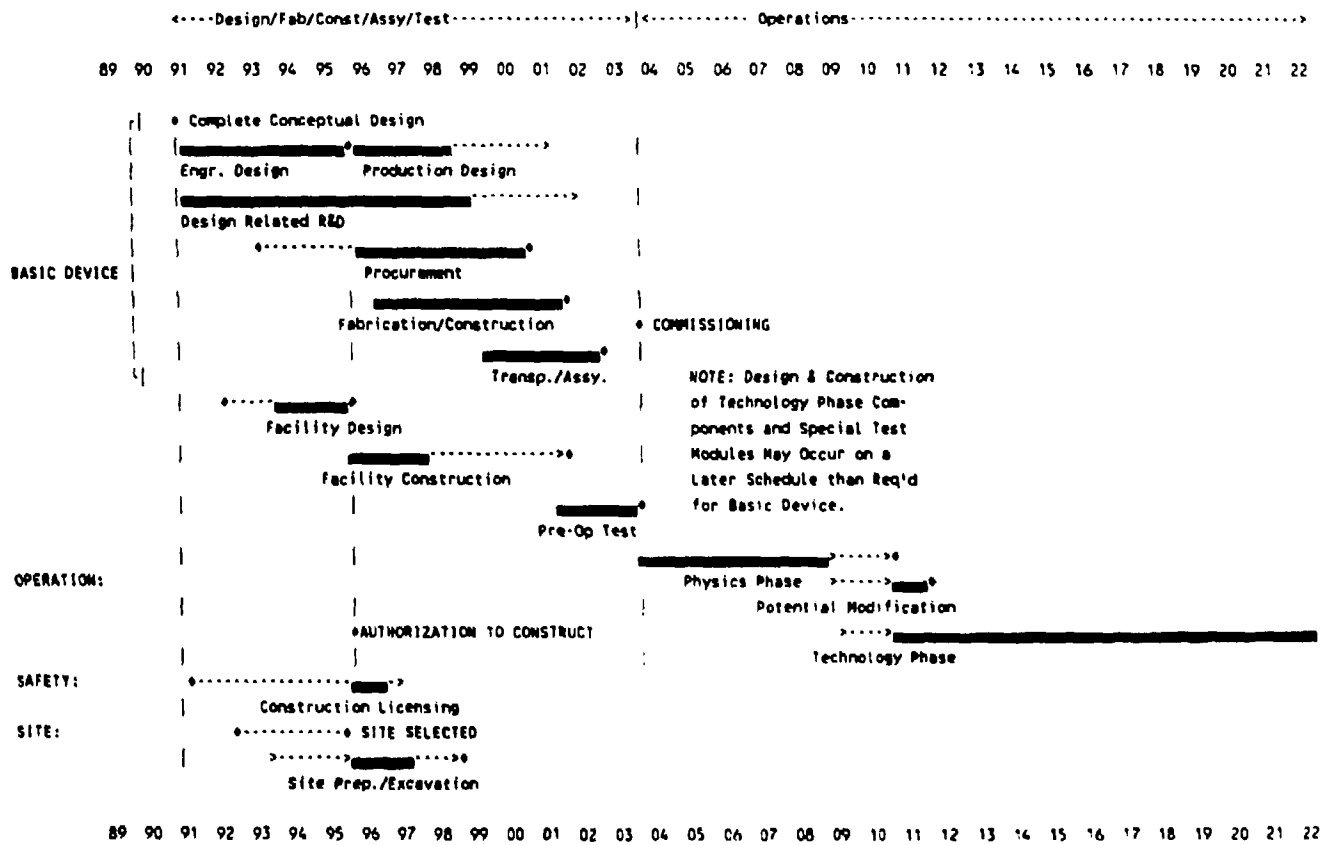

Fig. 2. Possible ITER Design, Construction, Operation Schedule

R&D to provide the Parties with well-documented and technically convincing information for making a decision on construction and siting. The Construction Phase can then begin, building up through design finalization to approval to construct 1-1/2 years later, assuming one year to expedite formal licensing. A further 6-1/2 years later the first tokamak shot should take place. This overall timescale is shown in Fig. 2.

The costs have been derived assuming that the EDA start at the beginning of 1991, and would have to be reassessed should there be a significant delay, for example of more than two years.

4. COSTS DURING ENGINEERING DESIGN ACTIVITIES

The aim of the EDA is to produce:

- a complete description of the device, specifying auxiliary systems and facilities, performance and objectives, detailed component design, assembly procedures, maintenance, decommissioning, and operating plans;
- the supporting physics, technology and engineering database;
- a safety analysis and environmental impact statement;
- an assessment of the implications of choosing particular sites;
- cost and manpower projections for the project;
- specifications for long-lead items; and
- procurement procedures and the work breakdown.

To do this requires a Central Team for design and R&D co-ordination and Home Support by each Party, both for design and R&D.

The professional manpower needed to carry out the design activities during the EDA phase amounts to about 1200 professional man-years (pmy). This work will be conducted at a central site by a team whose strength would rise up to about 180 professionals and by the Home Teams. The cost of this design work, including full overhead and support personnel, is estimated to be about $250 M. It should be emphasized that labour costs differ somewhat from country to country around the nominal average values employed here.

The R&D in support of the design includes physics R&D, basic technology R&D and specific engineering R&D.

The R&D in physics will need to include:

- power and particle exhaust physics;
- disruption control and operational limits;

- confinement;
- heating and fuelling physics;
- long-pulse operation and optimization of discharge startup and rundown; and
- physics of burning plasmas.

Costs of the physics R&D are not included in this report since they are integral to the world fusion programme and cannot be separately estimated.

The basic technology R&D provides the database for the specific engineering and design by studying the properties and behaviour of basic component elements (e.g. superconducting cable), measuring basic processes (e.g. tritium release/retention), characterizing the manufacturing processes, and investigating properties of irradiated materials. The research areas covered are:

- magnet,
- containment structures,
- assembly and maintenance,
- current drive and heating,
- plasma facing components,
- blanket and structural materials,
- fuel cycle, and
- plasma diagnostics.

For the basic technology R&D the foreseen expenditure is about $400 M including R&D to provide alternatives or backup options to the primary choice. The cost of developing DEMO-relevant blanket modules to be tested on ITER is not included since this work is assumed to be part of the long-term home R&D programmes.

The specific engineering R&D include demonstrations of prototypes and their test facilities and are estimated at $350 M.

5. COSTS DURING CONSTRUCTION PHASE ACTIVITIES

Based on the current level of design, preliminary estimates of the various components and systems making up the ITER device and its supporting plant and services have been made. In most cases these estimates are based on scaling from similar systems, using the main cost driving parameters (e.g. mass, power, etc.). Wherever possible, industrial experience has been used to produce such estimates.

The costs include facilities for manufacture and testing on- or off-site; all manufacturers' costs (e.g. R&D, prototype/samples) from the finalization of

design specifications up to and including acceptance testing and installation (where appropriate) on site; and facilities potentially provided by the host, e.g. roads, cafeterias and offices. It does not include purchase and clearing of the site, test blankets and services, plasma diagnostics not needed for control, taxes and insurance. Within the cost estimates there is an implicit contingency to cover missing items and present unknowns. An explicit contingency is calculated to cover uncertainties in both unit costs and driving parameters in the current estimates.

The construction cost has been estimated to be about \$4900 M (i.e. Tokamak, \$1700 M; Tokamak Auxiliaries, \$1400 M; Buildings and Plant Auxiliaries, \$800 M; Costing contingency \$700 M; Assembly and Transport, \$300 M.

The professional manpower needed during the Construction Phase has been estimated to be about 2900 pmy, provided primarily at the construction site. The cost is estimated to be about \$800 M. The staffing level at the construction site will rise over the early years from the 180 professionals of the engineering design phase to the level of 300 professionals.

During the construction phase there will be the need of technology R&D (estimated to cost about \$300 M) and of physics R&D (cost cannot be separately estimated from the world fusion programme).

6. COSTS DURING OPERATION

Operation costs for ITER include personnel and their overheads, energy costs, spare parts, waste packaging and temporary storage (negligible), insurance, taxes and fees, and fuel. They do not include decommissioning (assumed to be the host responsibility), plasma diagnostics for experimentation, and blanket test modules and their services; these are all assumed to be provided by the home organizations free of charge to the project. Space is already included to accommodate these items.

A typical physics and technology testing programme would lead to an eventual first wall mean fluence of 1 MW-y/m^2 over a period of 18 years. During the early years, shot frequency and availability are likely be low, but in later years more continuous operation may be necessary. It is assumed that the machine would breed about two-thirds of the tritium it consumes. The resulting preliminary operating cost estimates amount to about \$4900 M (i.e. Personnel \$1600 M, Energy \$750 M, Spares \$2100 M. Fuel \$250 M, Other Items \$ 200 M), giving an average annual cost of approximately \$270 M/y.

7. CONCLUDING REMARK

All the above information is sensitive to the assumptions and will be updated as the technical and organizational issues are resolved further.

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