ITER-FEAT — Outline Design Report
report by the ITER Director

1.0 -Background and Introduction

Six years of joint work under the ITER EDA agreement yielded, by July 1998, a mature design for ITER as presented in the ITER Final Design Report, Cost Review and Safety Analysis (FDR)[1] (the 1998 ITER design), supported by a body of scientific and technological data which both validated that design and established an extensive knowledge base for designs for a next step, reactor-oriented tokamak experiment. The 1998 ITER design fulfilled the overall programmatic objective of ITER - to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes - and complied with the detailed technical objectives and technical approaches, and cost target adopted by the ITER Parties at the start of the EDA.

When they accepted the FDR report, the ITER Parties, recognising the possibility that they might be unable, for financial reasons, to proceed to the construction of the then foreseen device, established a Special Working Group (SWG)[2], and charged it with two tasks:

- to *propose technical guidelines for possible changes to the detailed technical objectives and overall technical margins, with a view to establishing option(s) of minimum cost still satisfying the overall programmatic objective of the ITER EDA Agreement*, and
- to *provide information on broader concepts as a basis for its rationale for proposed guidelines, and articulate likely impacts on the development path towards fusion energy.*

In reporting on the first task, the SWG[3] proposed revised guidelines for Performance and Testing Requirements, Design Requirements, and Operation Requirements, noting that "*preliminary studies ... suggest that the direct capital costs of ITER can be reduced significantly by targeting the less demanding performance objectives recommended..*" and expressing the view that "*these less demanding performance objectives will satisfy the overall programmatic objectives of the ITER Agreement even though these performance objectives are necessarily less than those that could be achieved with the present* [1998] *design.*" Consequently, the ITER Council adopted the recommended revised guidelines and asked the Director "*to continue efforts with high priority toward establishing, option(s) of minimum cost aimed at a target of approximately 50% of the direct capital cost of the present design with reduced detailed technical objectives, which would still satisfy the overall programmatic objective of ITER.*"[4].

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[1] ITER Final Design Report, Cost Review and Safety Analysis, IC-13 ROD Attachment 6

[2] IC-13 ROD Attachment 10

[3] ITER Special Working Group Report to the ITER Council on Task #1 Results, EIC-1 ROD Attachment 1

[4] EIC-1 ROD 3.1

In addressing the second task, the SWG reviewed and compared two possible strategies for meeting the programmatic objective of demonstrating the scientific and technological feasibility of fusion, based on:

- an ITER-like machine, capable of addressing both scientific and technological issues in an integrated fashion, and
- a number of complementary lower cost experiments each of which would specialise on scientific/technological issues.

With regard to the second strategy, the SWG[5] found that the complex non-linear interactions between α-particle heating, confinement barriers and pressure and current profile control, and their compatibility with a divertor can be addressed only in an integrated physics/technology step like an ITER-type experiment, capable of providing long burn in conditions in which α-particles are the dominant source of plasma heating. A satisfactory understanding of these physics/plasma/technology interactions is essential to any reactor-oriented fusion development programme. Moreover the SWG expressed the unanimous opinion that the world programme is *"scientifically and technically ready to take the important ITER step."*

Given the instruction to address revised technical guidelines from SWG Task 1 and against the programmatic background of the SWG Task 2 conclusions, the main features of ITER design activities since July 1998 has therefore been:

- the study of options for cost reductions against the new, reduced, technical objectives by reducing plasma performance and technical margins, using the advances in physics and technology understandings, and tools arising out of the ITER collaboration to date, and
- the studied convergence towards a specific single design, following newly adopted guidelines.

As a result, it is now possible to define the key elements of a device, referred to as ITER-FEAT. This Report provides the results to date of the joint work in the form of an Outline Design Report on the ITER FEAT design, which, subject to the views of ITER Council and of the Parties, will be the focus for further detailed design work and analysis in order to provide to the Parties a complete and fully integrated engineering design within the frame of the ITER EDA extension.

A companion paper[6] which documents the Technical Basis to this report was presented to the ITER Technical Advisory Committee for review at its meeting on 20-22 December 1999, in Naka.

[5] SWG report to the ITER Council on Task #2 Result, ITER Meeting 10-3-1999 ROM Attachment 5

[6] Technical Basis for the ITER FEAT Outline Design, Draft for TAC review, 12 December 1999

Plasma Performance

The device should:

- *achieve extended burn in inductively driven plasmas with the ratio of fusion power to auxiliary heating power of at least 10 for a range of operating scenarios and with a duration sufficient to achieve stationary conditions on the timescales characteristic of plasma processes.*
- *aim at demonstrating steady-state operation using non-inductive current drive with the ratio of fusion power to input power for current drive of at least 5.*

In addition, the possibility of controlled ignition should not be precluded.

Engineering Performance and Testing

The device should:

- *demonstrate the availability and integration of technologies essential for a fusion reactor (such as superconducting magnets and remote maintenance);*
- *test components for a future reactor (such as systems to exhaust power and particles from the plasma);*
- *Test tritium breeding module concepts that would lead in a future reactor to tritium self-sufficiency, the extraction of high grade heat, and electricity production.*

Design Requirements

- *Engineering choices and design solutions should be adopted which implement the above performance requirements and make maximum appropriate use of existing R&D database (technology and physics) developed for ITER.*
- *The choice of machine parameters should be consistent with margins that give confidence in achieving the required plasma and engineering performance in accordance with physics design rules documented and agreed upon by the ITER Physics Expert Groups.*
- *The design should be capable of supporting advanced modes of plasma operation under investigation in existing experiments, and should permit a wide operating parameter space to allow for optimising plasma performance.*
- *The design should be confirmed by the scientific and technologica database available at the end of the EDA.*
- *In order to satisfy the above plasma performance requirements an inductive flat topcapability during burn of 300 to 500s, under nominal operating conditions, should be provided.*
- *In order to limit the fatigue of components, operation should be limited to a few 10s of thousands of pulses*
- *In view of the goal of demonstrating steady-state operation using non-inductive current drive in reactor-relevant regimes, the machine design should be able to support equilibria with high bootstrap current fraction and plasma heating dominated by alpha particles.*
- *To carry out nuclear and high heat flux component testing relevant to a future fusion reactor, the engineering requirements are*

  Average neutron flux ≥ 0.5 *MW/m*^{2}

  Average fluence ≥ 0.3 *MWa/m*^{2}
- *The option for later installation of a tritium breeding blanket on the outboard of the device should not be precluded.*
- *The engineering design choices should be made with the objective of achieving the minimum cost device that meets all the stated requirements.*

Operation Requirements

The operation should address the issues of burning plasma, steady state operation and improved modes of confinement, and testing of blanket modules.

- *Burning plasma experiments will address confinement, stability, exhaust of helium ash, and impurity control in plasmas dominated by alpha particle heating.*
- *Steady state experiments will address issues of non-inductive current drive and other means for profile and burn control and for achieving improved modes of confinement and stability.*
- *Operating modes should be determined having sufficient reliability for nuclear testing. Provision should be made for low-fluence functional tests of blanket modules to be conducted early in the experimental programme. Higher fluence nuclear tests will be mainly dedicated to DEMO-relevant blanket modules in the above flux and fluence conditions.*
- *In order to execute this program, the device is anticipated to operate over an approximately 20 year period. Planning for operation must provide for an adequate tritium supply. It is assumed that there will be an adequate supply from external sources throughout the operational life.*

今回の会議にて配布した資料は多量な資料の為、入手を希望される方は下記３機関において閲覧・複写（有料）に応じております。

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