COMMISSION DECISION

of 21 March 1994

concerning the conclusion of Protocol 2 to the Agreement among the European Atomic Energy Community, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America on cooperation in the engineering design activities for the International Thermonuclear Experimental Reactor (ITER), by the Commission for and on behalf of the Community

(94/267/Euratom)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Atomic Energy Community, and in particular the second paragraph of Article 101 thereof,

Whereas the Council, in its Decision of 21 March 1994 approved the conclusion of Protocol 2 to the Agreement among the European Atomic Energy Community, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America on cooperation in the engineering design activities for the International Thermonuclear Experimental Reactor (ITER),

HAS DECIDED AS FOLLOWS:

Article 1

Protocol 2 to the Agreement among the European Atomic Energy Community, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America on cooperation in the engineering design activities for the International Thermonuclear Experimental Reactor (ITER) is hereby concluded on behalf of the Community.

The text of Protocol 2, together with the negotiators' shared views, is appended to this Decision.

Article 2

The Member of the Commission responsible for science, research and development or his designated representative is authorized to sign Protocol 2 for the purpose of binding the European Atomic Energy Community.

Done at Brussels, 21 March 1994.

For the Commission

The President

Jacques DELORS

PROTOCOL 2

the Agreement among the European Atomic Energy Community, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America on cooperation in the engineering design activities for the International Thermonuclear Experimental Reactor

THE EUROPEAN ATOMIC ENERGY COMMUNITY (EURATOM), THE GOVERNMENT OF JAPAN, THE GOVERNMENT OF THE RUSSIAN FEDERATION, AND THE GOVERNMENT OF THE UNITED STATES OF AMERICA ('THE PARTIES'),

HAVING REGARD to the Agreement on cooperation in the engineering design activities (EDA) for an International Thermonuclear Experimental Reactor (ITER), concluded among the Parties on July 21, 1992 ('the Agreement'), and in particular to Article 3 thereof,

HAVING INITIATED the EDA under Protocol 1 to the Agreement, also concluded among the Parties on July 21, 1992, and having the intent to complete jointly the EDA under Protocol 2,

HAVE AGREED AS FOLLOWS:

Section 1

Scope

The Parties shall complete jointly the activities identified in Article 2 of the Agreement. These activities shall be conducted in accordance with technical objectives of ITER adopted pursuant to the provisions of the Agreement.

Section 2

Special working group

A special working group shall be established which, assisted by the Director, shall submit proposals to the Council on approaches to joint implementation for decisions by the Parties on future construction, operation, exploitation and decommissioning of ITER, as specified in Article 2 (e) of the Agreement.

Section 3

Implementation of the work programme

1. The Director shall implement the work programme and its updatings after approval of the Council in accordance with the schedules provided therein for the various tasks.

2. The technical description of a task, the task assignment, and the terms and conditions of its execution, developed in conformance with guidelines for implementation of task assignments established by the Council, shall form the subject of a task agreement. The task agreement shall be drawn up by the Director and signed by the Director and the Leader of the Home Team to whom the task has been assigned. Task agreements shall be concluded in accordance with the approved work programme and its updatings.

3. Each Home Team Leader shall ensure that access, for the purpose of interaction, monitoring of work in progress and evaluation of quality control, to the sites and premises where a task assigned to a Home Team is being carried out, as well as to the personnel performing and documents concerning the task, is not unreasonably denied either to the Director or to members of the Joint Central Team authorized by the Director. The Home Team Leader shall be notified in a timely fashion of such intended access. The detailed arrangements for this access shall be specified in the Task Agreement.

Section 4

Secondment agreements

1. For the purposes of this section,

— 'seconding party' means the party which makes a person available to the Joint Central Team in accordance with Article 8 (2) of the Agreement, irrespective of whether that party is the employer or not of that person;

— 'seconded person' or 'seconded personnel' means one or several persons made available by the seconding party to the Joint Central Team.

2. After the selection of a person in accordance with Article 8 (2) of the Agreement, the employer of that person shall second such person without any undue delay to the Joint Central Team. In respect of each seconded person a specific secondment agreement shall be drawn up by the Director and signed by the Director, the seconded person, that person's employer and the entity operating the joint work site to which that person shall be assigned. If the employer and the seconding party are

different entities, the seconding party shall endorse the secondment agreement(s) to indicate it has made the seconded personnel available to the Joint Central Team as described in Article 8 (2) of the Agreement. The secondment agreement for the Director shall be co-signed by the chair of the Council.

The secondment agreement shall state the work and the joint work site to which the secondment person shall be assigned, that person's reporting responsability, and that the seconded person and that person's employer will comply with the provisions of Articles 8 (2) and 15 of the Agreement and of this paragraph to the extent they concern the secondment, and that the seconded person will comply with the internal rules regarding safety and security to be observed on the premises of the joint work site. The duration of a secondment agreement may not exceed that of this Protocol.

Section 5

Termination of the work and final reporting

When approving the work programme and its annual updatings, the Council, assisted by the Director, shall provide for a timely and coordinated termination of the work to be carried out under the Agreement including the final reporting; if actions by the parties are needed or otherwise appropriate, then the Council, assisted by the Director, shall make suitable proposals.

Section 6

Resources

The resources required for the implementation of this Protocol shall be made available by the Parties in accordance with the applicable provisions of the agreement.

Section 7

Duration

This Protocol shall enter into force upon signature of the Parties and shall remain in force for the duration of the Agreement.

Done at Vienna, on 21 March 1994 in quadruplicate.

For the European Atomic Energy Community:
Corrado PIRZIO BIROLI

For the Government of Japan:
Kunisada KUME

For the Government of the Russian Federation:
Nikolai S. CHEVEREV

For the Government of the United States of America:
John B. RITCH III

Negotiators' shared views

At the conclusion of their work on the final draft of Protocol 2 on this date, the negotiators shared the following views:

1. *Detailed technical objectives*

   Detailed technical objectives of ITER referred to in Section 1 of Protocol 2 are adopted by the Parties acting through the Council. The Council adopted those detailed technical objectives on 15 and 16 December 1992. (Attachment 1)

2. *Guidelines for implementation of task assignments*

   The guidelines for implementation of task assignments referred to in Section 3 of Protocol 2 are adopted by the Council. The Council adopted such guidelines on 22 April 1993. (Attachment 2)

3. *Secondment agreements*

   The secondment agreements referred to in Section 4 of Protocol 2 should be as uniform as practicable and reflect the guidelines for secondment agreements, set forth in the attachment hereto. (Attachment 3)

   If the seconding party is not the employer of the seconded person, it will use its best efforts to ensure that the employer of the said seconded person complies with the provisions of Section 4 of Protocol 2 and the guidelines.

4. *Financing*

   With regard to Section 6 of Protocol 2:

   (1) each Party will bear its costs relating to:

   (a) the participation of its members and experts in the work and the meetings of the Council, the TAC, the MAC, and the SWGs, including the costs for travel and subsistence;

   (b) the secondment of its personnel to the joint work sites;

   (c) the execution of tasks assigned to its Home Team in accordance with Section 3 of Protocol 2; and

   (d) the organization of workshops taking place on its territory and the participation of its Home Team personnel in workshops, including travel expenses and subsistence;

   (2) in applying Article 14 of the Agreement, the Council will take account of the overall level of resources that each host party has offered as support for its joint work site;

   (3) other expenditures, considered by the Council to be necessary for the satisfactory completion of Protocol 2, will be financed through the Joint Fund.

5. *Monitoring of the ITER EDA*

   The coherence between the general constraints set out in Section 1 of Attachment 1 and progress of work shall be validated on a yearly basis, pursuant to Article 16 of the Agreement. In particular, the technical approaches and the accuracy of the assessment of the cost of construction of ITER shall be verified, as foreseen at point 1 (f) of Annex A to the Agreement, also on the basis of domestic data related to the main components of the facility. These evaluations may lead the ITER Council to readjust, if necessary, the constraints or the technical solutions.

6. *Outline design*

   The Council has endorsed the TAC-4 response that 'the outline design (Attachment 4) will provide a sound basis for continued engineering design work after (1) modest further optimization of the major machine parameters to provide a reserve against cost increases, (2) modification of the engineering approach in certain areas, and (3) a broadening of technical capabilities so as to achieve greater operational flexibility.'

ATTACHMENT 1

ITER DETAILED TECHNICAL OBJECTIVES

1. General constraints

The ITER detailed technical objectives approaches, including appropriate margins, should be compatible with the aim of maintaining the cost of the device within the limits comparable to those indicated in the final report of the ITER CDA as well as keeping its impact in long-range fusion research and development.

ITER should be designed to operate safely and to demonstrate the safety and environmental potential of fusion power.

2. Performance and testing

Plasma Performance

ITER should have a confinement capability to reach controlled ignition. The estimates of confinement capability of ITER should be based, as in the CDA procedure, on established favourable modes of operation.

ITER should :

— demonstrate controlled ignition and extended burn for a duration sufficient to achieve stationary conditions on all time scales characteristic of plasma process and plasma wall interactions, and sufficient for achieving stationary conditions for nuclear testing of blanket components. This can be fulfilled by pulses with flat-top duration in the range of 1 000s. For testing particular blanket designs, pulses of approximately 2 000s are desirable,

— aim at demonstrating steady state operation using non-inductive current drive in reactor-relevant plasmas.

Engineering performance and testing

ITER should :

— demonstrate the availability of technologies essential for a fusion reactor (such as superconducting magnets and remote maintenance),

— test components for a reactor (such as systems to exhaust power and particles from the plasma),

— test design concepts of tritium breeding blankets relevant to a reactor. The tests foreseen on modules include the demonstration of a breeding capability that would lead to tritium self-sufficiency in a reactor, the extraction of high-grade heat, and electricity generation.

3. Design requirements

The choice of parameters of the basic device should be consistent with margins that give confidence in achieving the required plasma and engineering performance. The design should be sufficiently flexible to provide access for the introduction of advanced features and new capabilities, and to allow for optimizing plasma performance during operation. The design should be confirmed by the scientific and technological database available at the end of the EDA.

An inductive pulse flat-top capability, under ignited conditions, of approximately 1 000s should be provided. In view of the ultimate goal of steady state operation. ITER should be designed to be compatible with non-inductive current drive, and the hearing system required for ignition in the first phase of operation should have current drive capability.

To carry out nuclear and high heat flux component testing at conditions relevant to a fusion power reactor :

— the average neutron wall loading should be about 1 MW/m^2,

— the machine should be designed to be capable of at least 1MW a/m^2 to carry out longer-time integral and materials tests.

It is desirable to operate at higher flux and fluence levels. Within the engineering margins, the ITER designers should examine the implications and possibilities of exploiting a wider range of operational regimes. The design of the permanent components of the machine should not preclude achieving fluence levels up to 3 MWa/m^2. For the second phase of operation, the design should include the capability of replacing the shield with a breeding blanket.

4. **Operation requirements**

The ITER operation should be divided into two phases :

— the first phase, the basic performance phase, is expected to last a decade including a few thousand hours of full DT operation. This phase should address the issues of controlled ignition, extended burn, steady state operation, and the testing of blanket modules. It is assumed that for this phase there will be an adequate supply of tritium from external sources.

  — Controlled ignition experiments in ITER will address confinement, stability and impurity control in alpha particle heated plasmas. Extended burn experiments will address, in addition, the control of fusion power production and plasma profiles and the exhaust of helium ash.

  — The aim of current drive experiments in this phase should be the demonstration of steady state operation in plasmas having alpha particle heating power at least comparable to the externally applied power. Using the heating systems in their current drive mode, non-inductive current drive should be implemented for profile and burn control, for achieving modes of improved confinement, and for assessing the conditions and power requirements for the above type of steady state operation. Depending on the outcome of these experiments, additional current drive power may have to be installed.

  — Functional tests of blanket modules in this phase should consist of a few thousand hours of integral burn time, in parallel with the physics programme, including continuous test compaigns of three to six days at a neutron wall loading of about 1MW/m^2,

— the second phase, enhanced performance phase, is also expected to last a decade, with emphasis placed on improving overall performance and carrying out a higher fluence component and materials testing programme. This phase should address high availability operation and advanced modes of plasma operation, and may address reactor-relevant blanket segment demonstration. Operation during this phase should include continuous testing compaigns lasting one to two weeks, and should accumulate a fluence of at least 1 MWa/m^2.

  A decision on incorporating breeding for this phase should be decided on the basis of the availability of tritium from external sources, the results of breeder blanket testing, and experience with plasma and machine performance.

The implementation of the enhanced performance phase should be made following a review of the results from the basic performance phase and an assessment of the relative value of the proposed elements of the programme.

ATTACHMENT 2

GUIDELINES FOR IMPLEMENTATION OF TASK ASSIGNMENTS

A. Approval and revision of task agreements

1. Each task agreement exceeding 300 IUA in value shall be concluded only after the task with its technical description and assignment to a Party has been approved by the ITER Council.

2. Task Agreements equal to or below 300 IUA in value may be concluded directly between the Director and the Home Team Leader concerned. The Director shall promptly inform the other three Home Team Leaders of such task agreements.

3. The total value of task agreements equal to or below 300 IUA assigned by the mechanism established in paragraph 2 above should not exceed 3 000 IUA in any period between meetings of MAC.

4. Revisions to task agreements to incorporate minor technical changes within the scope of work already approved by the Council may be implemented upon agreement of the Director and the affected Home Team Leader. Task scope changes up to a limit of approximately 300 IUA or 20 %, whichever is smaller, per task may also be implemented upon agreement of the Director and the Home Team Leader. Tasks concerning work whose results are no longer required may be terminated by mutual consent of the Director and the Home Team Leader affected ; the ITER credit for such tasks must be revised appropriately. All revisions other than 1. minor technical changes, 2. scope changes less than or equal to 300 IUA and 3. termination as defined above must be approved by the Council through procedures defined in the agreement for new task assignments ; in these cases, the Director shall adjust the ITER credit as appropriate.

5. All revisions or task agreements not requiring Council approval must be reported to the Council.

B. Task identification, definition and valuation

In identifying and defining tasks, the following guidelines shall apply :

1. While acting in close interaction with the Home Team Leaders to identify tasks, the Director shall also establish the ITER credits that the Parties undertaking the tasks would receive. This interaction should, as far as possible, lead to a common understanding on feasible, effective approaches to identification and definition and the valuation of the tasks.

2. Before the list of these tasks is sent to the Home Team Leaders for formal response, the Director should inform the Home Team Leaders of the list of tasks together with the credits the Party undertaking each of the tasks would obtain ; any Party with an interest in performing a task should rapidly inform the Director so that if more than one Party expresses such an interest, the Director shall, in close interaction with Home Team Leaders, identify how these interests could best be taken into account, either through splitting into smaller tasks, parallel efforts or joint efforts.

3. Within two months after receipt from the Director of the list and technical description of tasks, each Party shall for those tasks in which it has an interest, make a formal response providing the following information :

   (a) a description of its capability to meet the specifications and schedules as well as the availability of necessary resources, facilities and know-how ;

   (b) an identification of where the work would be performed ; however, where it is not possible to provide such information due to the iterative nature of a Party's contracting procedures, the Party shall give the Director an indication of the type of performing institutions likely to be involved with final notification immediately upon selection of the performing institutions ;

   (c) an evaluation of the technical risk and, in case of high technical risk, possible suggestions for parallel efforts.

4. On the basis of the above information and of the guiding principles set out in Annex B, 1 (C) to the Agreement and these guidelines, the Director shall propose in the work programme to be submitted periodically by the Director to the Council pursuant to Article 11 of the Agreement, the assignment of tasks to each of the Home Teams.

5. In concluding particular task agreements, consideration will be given by the Director to including in the ITER credit the relevant work that pertains to those tasks and was initiated by the Party after the signature of the ITER EDA Agreement and Protocol 1.

6. Within each task system area, there should be a reasonable balance of tasks shared among the Parties. In assessing this balance, the qualitative characteristics of the tasks to be assigned, e.g. the nature of test facilities and the level of technology, should be taken into account.

7. Where no Party expresses an interest in performing a particular task, the Director shall, through close interaction with the Home Team Leaders, attempt to interest at least one of the Parties. If the Director fails to interest one of the Parties, he may appeal to the ITER Council, in accordance with Article 21 (1).

8. For some individual tasks, parallel efforts by more than one Party may be justified because of high perceived technical risk or uncertainty, which could involve staged assignments.

9. The ITER Director shall, in close interaction with the Home Team Leaders, ensure that the disaggregation of work into tasks covered by task agreements does not exceed what is necessary to ensure an efficient execution of the work, bearing in mind the need to ensure a reasonable sharing of the work between the parties. Each task agreement shall describe a reasonable, coherent, self-contained scope of work with well defined interfaces.

10. The distribution of design work between the JCT and the Home Teams should, in general, respect the principle that the JCT should perform only that work which can be more appropriately performed by a central team. The total ITER credit for design tasks assigned to the Home Teams is understood to be the equivalent of about 500 professional-person years.

C. **Selection criteria**

1. Expressions of interest to perform a task should be considered for selection only if they document the capability to meet the specifications and schedules as well as the availibility of necessary facilities and know-how.

   Before rejecting any expression of interest on the grounds that the technical requirements are not satisfied, the ITER Director shall inform the relevant Home Team Leader, who for a short period will be given the opportunity to revise the Party's proposal.

2. The selection from among those expressions of interest that meet these technical requirements shall be based primarily on :

   (a) technical experience and capability of the proposed implementing institutions ;

   (b) technical risk of the proposed approach ; and

   (c) demonstrated understanding of the technical and managerial requirements.

   Other factors, such as the need to maintain a reasonable balance of tasks in a task system area, the priorities assigned by the Parties to the work, or the quality of the proposed approach, should be taken into account as appropriate.

D. **Role of MAC**

MAC shall meet as frequently as necessary to ensure that the Director's proposals are acted upon quickly between Council meetings. Electronic and other communications should be used to ensure rapid approval by the Council of MAC's unanimous recommendations ; other cases require Council approval according to the normal Council of Procedure.

E. **Inadequate performance by a Party on design and R&D tasks**

1. Inadequate performance by a Party on a task assigned to it is defined as the Home Team's inability to make adequate progress toward completing the task as specified in the task agreement or the Home Team's inability to achieve an adequate standard of design or workmanship in performing the task.

   Each task agreement should contain a standard article describing the broad principles concerning inadequate performance contained herein.

2. When a Home Team Leader becomes aware of the possibility of inadequate performance on a task assigned to his Party, he shall immediately notify the Director.

3. If the Director considers there to be a likelihood of inadequate performance on a task, the Director shall issue a formal 'notice of inadequate performance' to the Home Team leader concerned specifying :

   — why the Director considers the might be inadequate performance on the task ;

   and

   — a reasonable period within which the Home Team concerned should demonstrate, to the Director's satisfaction, that adequate performance can be achieved.

   For tasks assigned to the Parties whose credit is equal to or below 300 IUA, the Director may then proceed directly to reassign the task to another Party.

4. For tasks whose credit exceeds 300 IUA, a copy of the formal notice of inadequate performace shall be sent to the Council for information.

   If, at the end of the period specified in the notice, adequate performance cannot be demonstrated, the Director shall make a proposal concerning the future of the task to the Council.

5. When the Director, having followed the procedure in point 4, proposes to reassign part or all of a task to another Party, his proposal to the Council shall identify the following :

   — the work to be reassigned, and its relationship to the original task,

   — the Party to whom the work will be reassigned,

   — the number of ITER credits to be reassigned,

   — the information and hardware and equipment to be provided by the inadequate performing Party relative to the work completed ; business confidential information that had already been provided to the JCT with an obligation concerning its confidentiality shall be provided to the Party taking over the task ; business confidential information that had not been provided to the JCT need not be transferred to the Party taking over the task.

6. Where a task has been reassigned or cancelled in whole or in part following inadequate performance, the Director shall make every effort to assign remaining ITER task in a manner that maintains the principle of approximately equal sharing of tasks as defined in Annex B. In doing so, no work will be withdrawn from a Party performing that work satisfactorily.

F. Reuse of facilities and other assets resulting from a completed task agreement

In his call to the Parties for expressions of interest in a task, the Director shall include, when appropriate, an element dealing with any reuse for the facilities and other assets resulting from completion of such a task agreement within the EDA period. Any specific Article within the task agreement shall be negotiated by the Director and the Home Team Leader(s) concerned.

Terminology

The following definitions are used in the development of the guidelines for the implementation of task assignments.

Task : that work which is performed by the Joint Central Team (JCT) or a Home Team. A task which is assigned to a Home Team is the subject of a task agreement, of which there may be hundreds. A task assigned to one Home Team may involve other Home Teams.

Task system area : a group of tasks that comprise a natural ITER system, of which there may be ten(s).

Task assignment : the process by which tasks are assigned to each of the Home Teams and the JCT.

Task agreement : the agreement document that contains the technical description of the task, the results of the task assignment process, and the terms and conditions of its execution.

Staged assignment : an approach to assigning those tasks whose technical complexity or risk warrants a step-by-step assignment process in which conceptualizing, designing, developing, and testing (or other steps) may be successively assigned either to the same party or multiple parties or to a narrowing set of parties in which case the initial tasks involve multiple parties but subsequent tasks are refined to involve fewer parties.

Design tasks: those tasks needed to carry out the design (both engineering and physics design) activities to be assigned to both the JCT and Home Teams, and whose cost estimate was included within the estimated US $ 250 million in January 1989 for design work in the final report of the ITER conceptual design activities (CDA).

Technology R&D tasks: those tasks supporting the design which include the Basic Technology R&D and the Specific Engineering R&D as defined in the abovementioned Final Report and whose total cost was estimated to be about US $ 750 million in January 1989 (US $ 400 and 350 million respectively) in that Report.

Work programme: introduced in Article 11, the work programme is understood to be an evolving document receiving regular refinement throughout the EDA.

ITER credits: the value in ITER units of account (IUA) (equivalent to US $ 1 000 at January 1989 values) attributed to a particular design or technology R&D task by the ITER Director at the time the task is sent to the Home Team Leaders with a request for expressions of interest. The only corrections to this value will be those related to changes in the scope of the task. The sum of all such credits should be comparable with the estimates in the final report of the CDA.

ATTACHMENT 3

GUIDELINES FOR SECONDMENT AGREEMENTS

(a) The seconded personnel shall remain employees of their existing employers and the contract of employment between the seconded personnel and its employer shall subsist during the secondment. The employer shall continue to pay its seconded personnel their salaries and other related expenditure such as social charges, allowances, fees and cost reimbursement according to the legislation and rules applicable to the employer;

(b) the employer shall ensure that accident insurance and other insurance in favor of the seconded person which exist by virtue of the conditions of employment remain valid during the secondment to the Joint Central Team. The employer will immediately inform its responsible departments and its insurers of the secondment. If an existing insurance protection of the seconded person is affected, the employer will be responsible for re-establishing an equivalent insurance protection;

(c) during the secondment, the leave regulations of the employer will be valid and shall be communicated to the Director. The timing and duration of leave during the secondment shall be arranged with the Director who shall notify the employer. In accordance with paragraph (b), the regulations of the existing employer in regard to sick leave shall remain valid during the period of the secondment; and

(d) the employer of the seconded personnel shall, with regard to the careers of its seconded personnel, give due consideration to the performance of these seconded personnel during their secondment to the Joint Central Team.

ATTACHMENT 4

OUTLINE DESIGN

The Council took note of the TAC report on the outline design and, by endorsing a recommendation made by TAC, considered that the outline design report constitutes an acceptable basis for consideration by the Parties to proceed toward the conclusion of Protocol 2, although it is recognized that the detailed technical design will have to envolve in order to address the concerns that have been identified by TAC.

Consequently, the Council asks the Director to address each of the recommendations on the outline design in the TAC report.

In particular, as recommended by the TAC, the Council requests the Director and JCT to conduct a sensitivity analysis to determine the optimum way to achieve a reduction in cost while minimizing the impact on the performance margin.

ITER outline design

I. *Introduction*

This report describes the outline design for ITER developed during the first 18 months of the ITER EDA. A coherent design has been developed which satisfies with appropriate safety margins the agreed programmatic and detailed technical objectives of ITER. The estimated cost of constructing ITER for the basic technical objectives of ITER. The estimated cost of constructing ITER for the basic performance phase is within limits comparable to those indicated in the final report of the ITER CDA.

The outline design now provides a basis for the continued engineering design work, for focusing ITER research and development, and for other related activities within the scope of the ITER EDA Agreement.

II. *Programmatic and technical objectives*

The overall programmatic objective of ITER, as defined in the ITER EDA Agreement, is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. ITER would accomplish this by demonstrating controlled ignition and extended burn of deuterium-tritium plasmas, with steady state as an ultimate goal, by demonstrating technologies essential to a reactor in an integrated system, and by performing integrated testing of the high-heat-flux and nuclear components required to utilize fusion energy for practical purposes.

Detailed technical objectives along with the technical approaches to determine the best practicable way to achieve the programmatic objective of ITER have been adopted by the ITER Council, under the terms of Protocol 1 of the ITER EDA Agreement.

The main characteristics and parameters of the outline design for ITER follow from the agreed programmatic and detailed technical objectives. The statement of detailed technical objectives establishes two phases of operation as necessary to meet the programmatic objective, the basic performance phase and an enhanced performance phase. The outline design provides the design for basic performance and allows for a future incorporation of features which could be needed to achieve the objectives of the enhanced Performance Phase.

The size, configuration and performance of the plasma in the outline design are set to meet the objective of demonstrating controlled ignition providing and inductive pulse flak-top capacility, under ignited conditions, of approximately 1000s. The characteristics of the in-vessel components and the overall scale of the Tokamak follow from this objective and from the design objectives set for carrying out nuclear and high-heat-flux component tests at conditions relevant to a fusion power reactor.

The outline design incorporates safety and technical margins consistent with this major step in fusion development.

III. *Main elements of the outline design*

III.1. Principal parameters

The principal parameters of the outline design for ITER are listed in Table 1 :

Table 1:

Principal parameters of the ITER outline design

Fusion power (nominal)	1,5 GW
Burn time (nominal)	1 000 seconds
Plasma current	24 MA
Major radius (nominal) (*)	7,7 m
Plasma minor radius (maximum)	3,0 m
Elongation	1,6
Divertor configuration	Single null X
Toroidal field (at nominal major radius)	6 Tesla
Toroidal field ripple at plasma edge (maximum)	± 2 %

(*) The nominal major radius is the barycenter of the standard plasma configuration.

The main features of the outline design are shown in cross section and in 3-D in figures 1 and 2.

III.2. Physics basis

Physics studies of the core of the plasma, based on statistical analysis and scalings of experimental results from leading fusion devices, indicating that the outline design provides good assurance of sustained and controlled ignition under a range of conditions and operating scenarios. The ignition domain is resilient to the key areas of physics uncertainties — achievable plasma confinement, plasma impurity levels and thermal helium removal. The overall machine parameters are set at the minimum size necessary to provide reasonable safety margins and to avoid the risk of harm from instabilities or disruptions.

III.3. Superconducting coils and mechanical structure

The ITER objectives dictate the use in ITER of superconducting magnet technology. The design of the overall magnet system is integrated with that of the mechanical structure in order to minimize stress under the planned operating conditions. The system comprises 24 toroidal field coils, a central solenoid and six external poloidal field coils. The toroidal coils are bucked on the central solenoid in order to provide the maximum volt second capability and a balance of electromechanical forces. the toroidal field coils are layer wound allowing for structural stiffness to be provided by steel shear plates between each conductor layer. the central solenoid is also layer wound with a thick-walled conductor which provides the necessary structural strength. The poloidal coil system is flexible enough to accommodate a wide variety of plasma configuration which could be of interest in the enhanced performance phase.

III.4. Vacuum vessel

The vacuum vessel is a double wall structure fabricated from 24 toroidally continuous segments, welded between posts and filled with metal balls and coolant. It also acts as a shielding component and containment structure. Access ports are provided at three levels, upper (for shield-blanket installation and replacement) equatorial (for heating and current drive, blanket module testing, remote handling and diagnostics), and lower (for divertor operations, pumping).

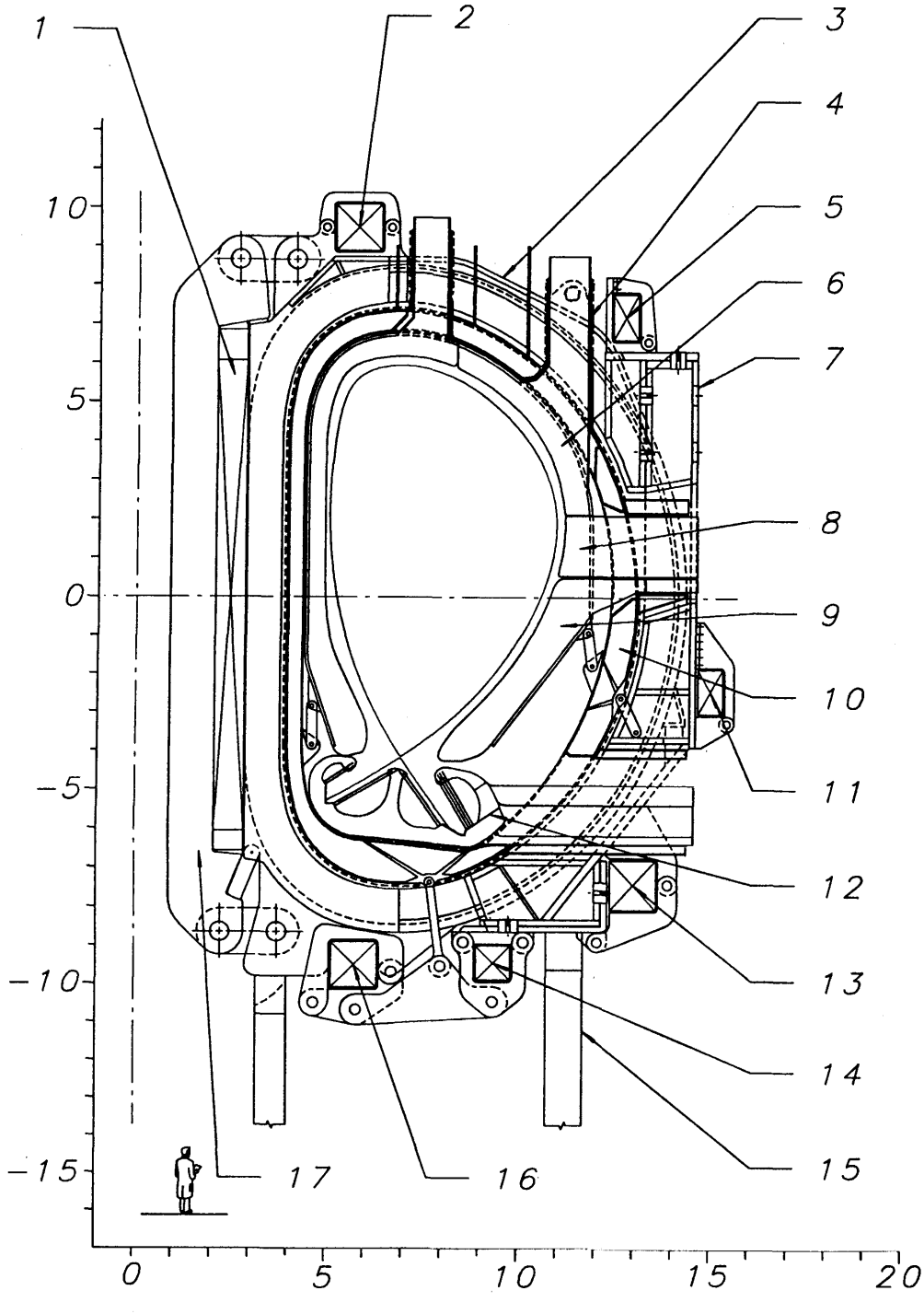
III.5. First wall and shield-blanket

The first wall forms a part of a low temperature (200 °C), water-cooled shield-blanket using conventional structural materials. The principal material is stainless steel; copper is used for the high-heat-flux surfaces so as to ensure good safety margins at the reference wall loading for the basic performance phase. The shield-blanket is divided into separate inboard and outboard components and subdivided toroidally to allow installation and replacement through the upper access ports. The first wall is coated with low-Z-material.

The test blanket modules are installed through the outer port. They are operated separately from the shield-blanket and could be removed independently.

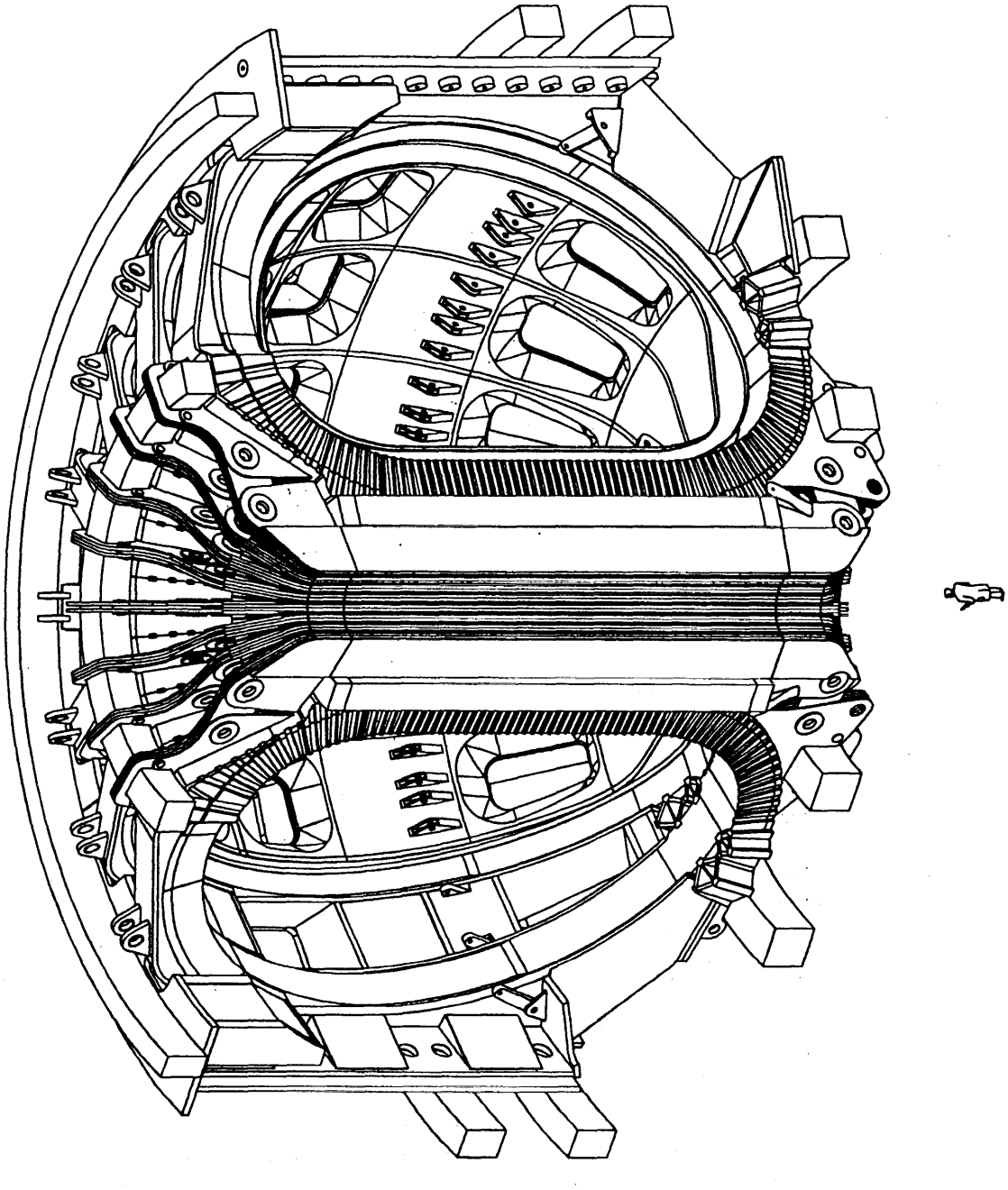
Provision is made in the outline design for a future incorporation of a breeding blanket which could be needed to meet the objectives of the enhanced performance phase. The shield and blanket are both self supporting, independent components.

Figure 1



1. Central solenoid CS
2. Poloidal field coil PF2
3. Toroidal field coil
4. Upper port closeout
5. Poloidal field coil PF3
6. Shield
7. Mechanical structure
8. Removable shield for R.H. access
9. Removable shield module
10. Vacuum vessel
11. Poloidal field coil PF4
12. Divertor
13. Poloidal field coil PF5
14. Poloidal field coil PF6
15. Machine support structure
16. Poloidal field coil PF7
17. Bucking cylinder

Figure 2



III.6. Divertor

The outline design incorporates an advanced divertor concept in which power is transferred from the plasma edge to the walls of the divertor chamber before it reaches the divertor plates. The divertor comprises a modular structure with each module containing a cooled array of baffles to intercept the power. The coolant used is compatible with that of shielding blanket.

III.7. Heating and current drive

About 50 MW of additional heating is provided in the outline design. The design is based on ion cyclotron frequency waves but is compatible with other forms of heating and current-drive such as electron cyclotron waves and neutral beam injection. ICRF design is such that the antenna is able to launch a travelling wave (fast wave) with current drive capability. The total power could be increased up to 100 MW or more without changing the antenna.

III.8. Cryostat

The cryostat is a filled, double-walled steel structure which acts also as a shielding component and containment structure.

III.9. *Safety and environment*

The ITER experimental device will be the first fusion facility integrating major elements of a thermonuclear reactor. ITER is designed to operate safety and to demonstrate the safety and environmental potential of fusion power. Specific features of the outline design include:

— fast fuel recycling to minimize tritium inventory,

— several barriers of confinement for radioactive materials including the shield-blanket, the vacuum vessel and the cryostat,

— incorporation of technical and physics margins.

Analysis to date shows that the the outline design is consistent with the anticipated regulatory limits for routine as well as accidental exposure to the public.

IV. *Estimated costs of construction*

On the basis of work done to date, the costs of constructing ITER according to the outline design are estimated at US $ 5,6 billion (January 1989 values). A preliminary cost breakdown in main components are listed in Table 2.

Table 2:

ITER outline design — estimated costs of construction

in million US $ (January 1989 values)

Superconducting magnet systems	1 733
Vacuum vessel, blanket, divertor	495
Cryostat, cryoplant, vacuum and heat transport	580
Heating, fuelling, power supply and other plant	799
Buildings and structures	590
Assembly equipment and assembly	470
Sub-total	4 667
Contingency (20 %)	933
Total	5 600

The cost estimate is based on the specific features of the design which meets the technical objectives of the basic performance phase and does not include the ITER team. The estimates are indicative at at this early stage of the project and will be updated as the work of the EDA proceeds. Firm cost data can only be determined when the detailed design, including industrial cost estimates, is complete.