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INSIDE

THE EUROPEAN FUSION PROGRAMME, INCLUDING PARTICIPATION IN ITER CONCEPTUAL DESIGN ACTIVITIES

by Charles Maisonnier, Director of the European Fusion Programme

Foreword — Fusion research and development throughout the European Community plus Sweden and Switzerland is planned and implemented as a single, integrated programme. This includes effective participation in ITER Conceptual Design Activities, to which all components of the European Fusion Programme are contributing.

As stated in the Terms of Reference, in the ITER co-operation from 1988 through 1990, "the European Atomic Energy Community (EURATOM), including countries associated with the European Fusion Programme," is one of "four parties having equal status and making equal contributions." Since July 1988 the Euratom contribution to ITER has included Canadian efforts in design and supporting R&D at a level about one-tenth of the European efforts. The Canadian contributions were described in the October 1988 issue of the Newsletter; the following article focusses on the work in Europe.

Fusion work in Europe constitutes an integrated programme

Organizational Structure of the Programme — In view of fusion's potential benefits and the size and duration of the R&D required, the European Community (EC) member countries decided long ago to integrate their individual national efforts into a single European programme. Indeed, in conformity with reiterated decisions of the European Council of Ministers, "the Community Fusion Programme is a long-term co-operative project embracing all the work carried out in the Member States in the field of controlled thermonuclear fusion. It is designed to lead in due course to the joint construction of prototype reactors with a view to their industrial production and marketing."

At the Community level, the Commission of the European Communities has the overall responsibility for the implementation of the Programme. There is a single director of the Programme, with office in Brussels. The consultative structure consists of the Consultative Committee of the Fusion Programme (CCFP), assisted by two sub-committees: the Programme Committee (PC) for questions related to physics and plasma engineering and the Fusion Technology Steering Committee (FTSC) for NET and Technology. Membership of these committees is distributed throughout the Community.

For the JET Joint Undertaking, the responsibilities are vested in the JET Council and in the Director of the Project. The JET Council is assisted by the JET Executive Committee and may seek the advice of the JET Scientific Council.

Work is done at numerous sites

The European Fusion Programme is implemented by means of contracts of Association between EURATOM and the national organizations active in fusion, by the JET Joint Undertaking, by the Joint Research Centre and through a multilateral agreement concerning NET. As shown in Fig. 1, there are 12 Associations distributed in 8 of the 12 Member States of the Community and in two extra-Community countries, Sweden and Switzerland, which are fully associated with the European

Euratom - FOM Association
Stichting voor Fundamenteel Onderzoek der Materie (FOM)
– FOM - Nieuwegein
– FOM - Amsterdam
– ECN - Petten
The Netherlands

Euratom - UKAEA Association
United Kingdom Atomic Energy Authority (UKAEA)
– Culham Laboratory - Abingdon
– AERE - Harwell
United Kingdom

JET Joint Undertaking
– Abingdon
United Kingdom

Euratom - EB Association
Etat Belge (EB)
– Ecole Royale Militaire - Koninklijke Militair School Bruxelles/Brussel
– Université Libre de Bruxelles
– SCK/CEN - Mol
Belgium

Euratom - CEA Association
Commissariat à l'Energie Atomique (CEA)
– Cadarache
– Saclay
France

Euratom - CIEMAT Association
Centro de Investigaciones Energeticas Medioambientales y Tecnológicas (CIEMAT)
– Madrid
Spain

Euratom - ENEA Association
Comitato Nazionale per la Ricerca e lo Sviluppo dell'Energia Nucleare e delle Energie Alternative (ENEA)
– CRE - Frascati
– CRE - Casaccia
– IFP/CNR - Milano
– IGI/CNR - Padova
Italy

Euratom - NFR Association
Naturvetenskapliga Forskningsrådet - NFR
– Stockholm
– Göteborg
– Studsvik
Sweden

Euratom - Risø Association
Forsøgsanlaeg Risø
– Roskilde
Denmark

Euratom - KFA Association
Kernforschungsanlage Jülich GmbH (KFA)
– Jülich
Federal Republic of Germany

Euratom - KfK Association
Kernforschungszentrum Karlsruhe GmbH (KfK)
– Karlsruhe
Federal Republic of Germany

Euratom - IPP Association
Max-Planck Institut für Plasmaphysik (IPP)*
– Garching bei München
Federal Republic of Germany

The NET Team
– Garching bei München
Federal Republic of Germany

Joint Research Centre (JRC)
– Geel - Belgium
– Ispra (Varese) Italy
– Petten - The Netherlands

Euratom - Switzerland Association
Confédération Suisse
– Centre de Recherche en Physique des Plasmas (CRPP) Ecole Polytechnique Fédérale de Lausanne
– PSI - Villigen and Würenlingen
Switzerland

CEC DG XII/January 1989

*: also hosting the **Technical Site for ITER Joint Work**

Figure 1. Fusion Laboratories in Europe

Fusion Programme. Cost-sharing contracts are also signed with organizations of Member States which have no Fusion Associations. Industry is involved through development contracts as well as through the manufacture of equipment.

This structure is thought to be well adapted also for the future, when Associations (whose research efforts provide the necessary breadth to the European programme) will gradually move from their current, mainly physics orientation to become more involved in technological tasks.

Three-step strategy for fusion power

Strategy and Content of the European Programme — The road to fusion reactors for energy generation can be schematically divided into three stages, namely demonstrations of: scientific feasibility, technological feasibility, and eventually economic feasibility. These stages are somewhat arbitrarily defined since they are not independent but overlap and interact in many respects. Presently fusion efforts world-wide are still primarily in the scientific stage. The Next European Torus (NET) was conceived as a device which should fully confirm the scientific feasibility of fusion in a first phase of operation and confront the problems of technological feasibility in a second phase.

Within the European strategy that culminates in a Demonstration reactor, the main objectives for the current Programme (1st January 1988 to 31 March 1992) are:

- to establish the physics and technology basis necessary for the detailed design of NET;
- to embark on the detailed design of NET before the end of the programme period if the necessary data base exists at that time;
- to explore the reactor potential of some alternative lines (mainly Stellarator and Reversed Field Pinch).

1200 professionals are now engaged

Status and Achievements — Expenditure on fusion research through the Community budget is currently running at a rate of about 200 MioECU a year. When funding by national administrations and other national bodies is added in, the total expenditure on fusion from all sources in Europe is estimated at about 450 MioECU a year. There are about 1200 professional scientists and engineers engaged in European fusion research.

The main scientific and technical achievements of the Programme are:

- JET, the flagship of the Community Fusion Programme and the world's largest tokamak, has successfully reached the halfway point in its scheduled experimental programme. It has full capability for an extended period of tritium operation at the end of its experimental programme.

- European medium-size tokamaks which are producing substantial contributions to the progress of fusion and the success of JET are ASDEX at Garching (D) and TEXTOR at Jülich (D). The large, superconducting tokamak TORE-SUPRA at Cadarache (F) and the high-field tokamak FTU at Frascati (I) have started operation. Other specialized tokamaks — ASDEX-UPGRADE at Garching, COMPASS at Culham (UK) and TCV at Lausanne (CH) — are in the construction phase.

- Within the alternative lines, the advanced Stellarator WENDELSTEIN-VII-AS at Garching (D) has just come into operation, the large Reversed Field Pinch RFX is under construction at Padua (I), and the Stellarator TJ-II at Madrid (S) is in the phase of engineering design. An original approach, the EXTRAP line of devices, is being investigated in Sweden.

Technology development aims at Next European Torus

- The NET activity was started in 1983 with the aim of producing a design and giving guidance to development in European laboratories of the technologies necessary for NET. NET is now in its pre-design phase, which is being carried out by the NET Team of about 65 professionals, who are working year-around at Garching. The Technology Programme, mainly NET-oriented, has a budget of about 45 MioECU per year.

Staff mobility is effective

- A staff mobility scheme is working effectively. Each year more than 250 professionals out of the total of 1200 are sent on assignment agreements to work outside their home laboratories for periods of up to a year or more. The JET and NET Teams are outstanding examples of effective application of mobility.

It is through these schemes for mobility that the smaller fusion laboratories, whether fully associated as in the case of Belgium and Denmark or participating more loosely as in the case of Greece, Ireland and Portugal, can play a part in the Community Programme. For example, through the mobility schemes, a small laboratory can take full responsibility for a task on JET or on one of the specialized machines in the larger Associations. The mobility schemes have been central to the establishment of good cohesion among all twelve countries of the European Community (plus Sweden and Switzerland) as regards fusion research.

Participation in ITER Activities — All components of the European Fusion Programme are contributing appropriately to the ITER Conceptual Design Activities. The responsibility for organizing and channeling these contributions has been assigned to the leader of the NET Team, Prof. Romano Toschi, who is also Managing Director of the Euratom efforts on ITER. The European Community members of the ITER Council are: Prof. P. Fasella, Director General for Science, Research and Development, Commission of the European Communities and Dr. Ch. Maisonnier, Director of the Fusion Programme; Prof. K. Pinkau, Director of IPP Garching, is a permanent expert to the ITER Council. The three European members of the ISTAC are: Dr. P.H. Rebut, Director of JET; Dr. D.R. Sweetman, UKAEA Programme Director for Fusion and Prof. F. Troyon, Chairman of the JET Scientific Council.

Part of the EURATOM contribution is the technical site for joint work at Garching, provided by the Federal Republic of Germany on behalf of the EC. This includes offices and supporting services and arrangements for family housing at Garching. The Max-Planck-Institut für Plasmaphysik is the site host. (See November 1988 Newsletter.)

Joint work on ITER design is at Garching

In practice, because of the broad capabilities and the convenient location of the NET Team (adjacent to the technical site for ITER joint work), European contributions to ITER in the area of design come mainly from those members of the NET Team who are also assigned to the ITER activities. Research and development tasks, on the other hand, are widely distributed among laboratories (Associations, the Joint Research Centre, and JET).

The ITER Technology R&D Programme, comprising co-ordinated contributions from all four Parties, includes European tasks in every area: plasma-facing components, heating and current-drive, magnets, blanket, fuel cycle, and maintenance. Besides the work entirely within Euratom, the European Fusion Programme is a partner in both bilateral frameworks (with Canada, Japan and the United States) and multinational frameworks (Implementing Agreements under the auspices of the IEA and the ITER activities under IAEA auspices).

A broad effort on ITER R&D

In the area of plasma physics and engineering, the planning and execution of experimental programmes of European plasma machines take into account the needs of ITER. The experiments are producing information that is highly useful for ITER physics design and operational planning. Examples are discovery and elucidation by ASDEX of the favourable "H-mode" regime of tokamak confinement and TEXTOR's introduction and employment of wall carbonisation.

In summary, the design and R&D efforts of the European Fusion Programme are making a strong contribution to the accomplishment of the goals of the quadrapartite co-operation in ITER activities from 1988 through 1990.

PEOPLE WHO GUIDE AND MANAGE ITER ACTIVITES

The importance of ITER to each of the four Parties is reflected in their choices of people to guide and manage the Conceptual Design Activities. All are experienced in relevant fields and are strategically located in positions of authority and influence in their home countries or community.

Overall direction, execution, and expert advice

The ITER Council (IC), which has the top-level responsibility for the overall direction of the Conceptual Design Activities, is composed of two members from each Party.

Responsibility for execution of the Activities within the overall directions established by the IC is assigned to the ITER Management Committee (IMC). The IMC is composed of four Managing Directors, each of whom is responsible for the contributions of one of the ITER Parties. The ITER Scientific and Technical Advisory Committee (ISTAC) is composed of 12 eminent scientists and engineers, three nominated by each Party and accepted by all Parties. They are chosen so as to ensure that all areas of expertise required for execution of the Conceptual Design Activities are represented. The ISTAC's function is to advise the IC on scientific and technical matters. The members of these three groups, with their principal affiliations, are listed in Table I.

Table 1
MEMBERSHIP OF ITER COUNCIL, ADVISORY AND MANAGEMENT COMMITTEES 1988–1989

ITER COUNCIL

EURATOM	Prof. Paolo Fasella	CEC, Brussels
	Dr. Charles Maisonnier	CEC, Brussels
Japan	Dr. Katsuhisha Ida	STA, Tokyo
	Dr. Shigeru Mori	JAERI, Tokyo
U.S.A.	*Dr. John F. Clarke	DOE, Washington
	Dr. James F. Decker	DOE, Washington
USSR	Acad. Evgenii P. Velikhov	Kurchatov, Moscow
	Dr. Nikolai Cheverev	SCUAE, Moscow

ITER SCIENTIFIC AND TECHNICAL ADVISORY COMMITTEE

EURATOM	Dr. Paul-Henri Rebut	JET, Abingdon
	Dr. Donald R. Sweetman	UKAEA, Abingdon
	Prof. Francis Troyon	CRPP, Lausanne
Japan	Prof. Nobuyuki Inoue	Univ. Tokyo, Tokyo
	Prof. Tadashi Sekiguchi	Yokohama Natl.U., Yokohama
	Dr. Masatoshi Tanaka	JAERI, Naka
U.S.A.	Prof. Robert W. Conn	UCLA, Los Angeles
	Prof. T. Kenneth Fowler	UC, Berkeley
	Prof. Paul H. Rutherford	PPPL, Princeton
USSR	Dr. Valerii A. Chuyanov	Kurchatov, Moscow
	*Acad. Boris B. Kadomtsev	Kurchatov, Moscow
	Dr. Vyacheslav A. Krylov	Efremov, Leningrad

ITER MANAGEMENT COMMITTEE

EURATOM	Prof. Romano Toschi	NET, Garching
Japan	*Dr. Ken Tomabechi	JAERI, Naka
U.S.A.	Dr. John R. Gilleland	LLNL, Livermore
USSR	Dr. Yurii A. Sokolov	Kurchatov, Moscow

*Chairman

DEFINITION PHASE REPORT

The Definition Phase of the ITER Conceptual Design Activities in 1988 successfully defined a single set of technical characteristics in accordance with guidelines in the Terms of Reference, to which all Parties had subscribed. A concept of design and operation and a supporting research and development plan were generated under the direct supervision of the IMC and independently reviewed by the ISTAC. Based on the favorable outcome of this work, the ITER Council in November 1988 concluded that the ITER concept, according to present understanding, should suffice to demonstrate the scientific and technological feasibility of fusion power.

Reports document results of 1988 work

The results of this first phase have been documented. The Definition Phase Report is a 14-page summary of the work and the major parameters of the chosen concept. This report is being published by the IAEA for distribution to all interested parties. A copy will be sent to each recipient of the ITER Newsletter.

For the benefit of those with needs for more detailed scientific and technical information, two additional volumes will be available. One is an extended technical summary and the other an in-depth presentation. Requests for copies of these volumes should be directed to one of the four members of the ITER Management Committee at the following address:

ITER Joint Work Site
Max-Planck Institut für Plasmaphysik
Boltzmannstrasse 2
D-8046 Garching
Federal Republic of Germany

WORK AROUND THE WORLD, AROUND THE CLOCK

Another session of technical joint work at Garching began on 20 February, this one for 4 weeks. As was the case during the 5-month session in 1988, there are about 10 persons from each Party at the joint work site. Concurrently work is continuing at home bases, involving over 50 people of each Party. An intriguing aspect of this situation is the effects of the differences in time of day between Garching and other locations. These are shown in Fig. 2.

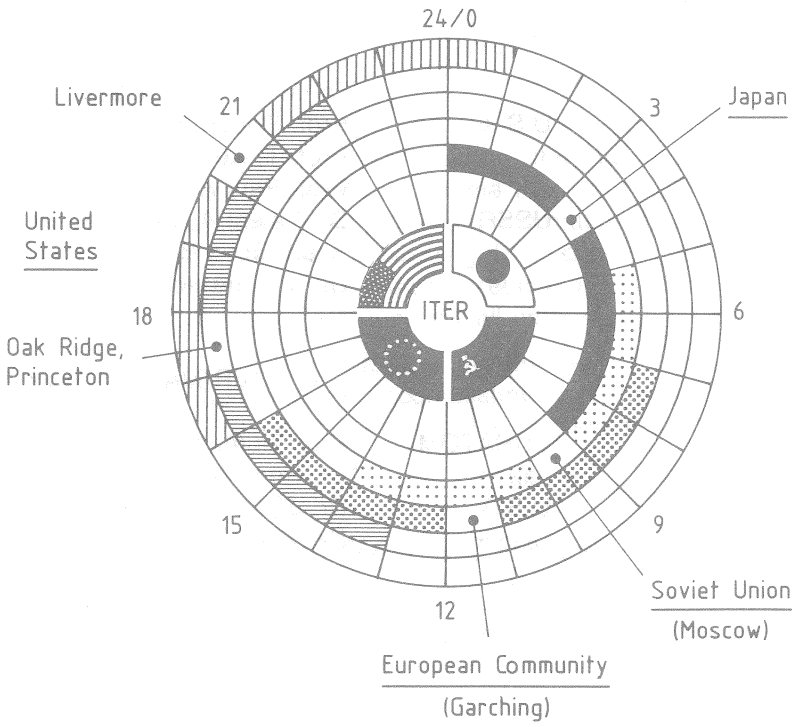

Figure 2. Working Hours of ITER Parties (Greenwich Mean Time)

Collaboration of home-based ITER workers

Some of the ITER analysis and design tasks entail daily interaction and exchange of information among sites located far around the globe. Separation of co-workers is a hindrance to discussions but, given the capabilities for rapid transmission of masses of data electronically, the differences in time zones have been of benefit in that computations on some jobs have proceeded for much more than the normal 8 hours a day. For example, when the workday is ending at Garching, the day is just beginning at Livermore, so people at one place can carry on while those at the other place are resting. In fact during the work week, one can say that there is no time at which ITER work is not going on somewhere on earth.

ITER EVENTS CALENDAR — 1989

Joint Design Review	Garching	20 Feb - 17 Mar
Joint Work Session	Garching	2 June–20 Oct
ISTAC Meeting	Garching	26–28 June
ITER Council Meeting	Vienna	12–13 July
Symposium on Fusion Engineering	Knoxville	2–6 Oct
ISTAC Meeting	Vienna	15–17 Nov.
ITER Council Meeting	Vienna	30Nov–1 Dec

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