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BLANKET REMOTE HANDLING DEVELOPMENT *

by K. Shibanuma (ITER Joint Central Team), E. Tada (Japan Home Team) and R. Haange (ITER Joint Central Team) for the Project Staff

The ITER shield blanket is segmented into around 730 modules which are mounted onto a back plate structure located in the vacuum vessel. The overall configuration is compatible with the requirement for the remote replacement of modules for maintenance, repair or removal. All shield modules are scheduled to be replaced with breeding blanket modules after the Basic Performance Phase in preparation for the Enhanced Performance Phase. The time to replace all modules is two years. The environmental conditions for maintenance include intense gamma radiation of ~10^4 Gy/h.

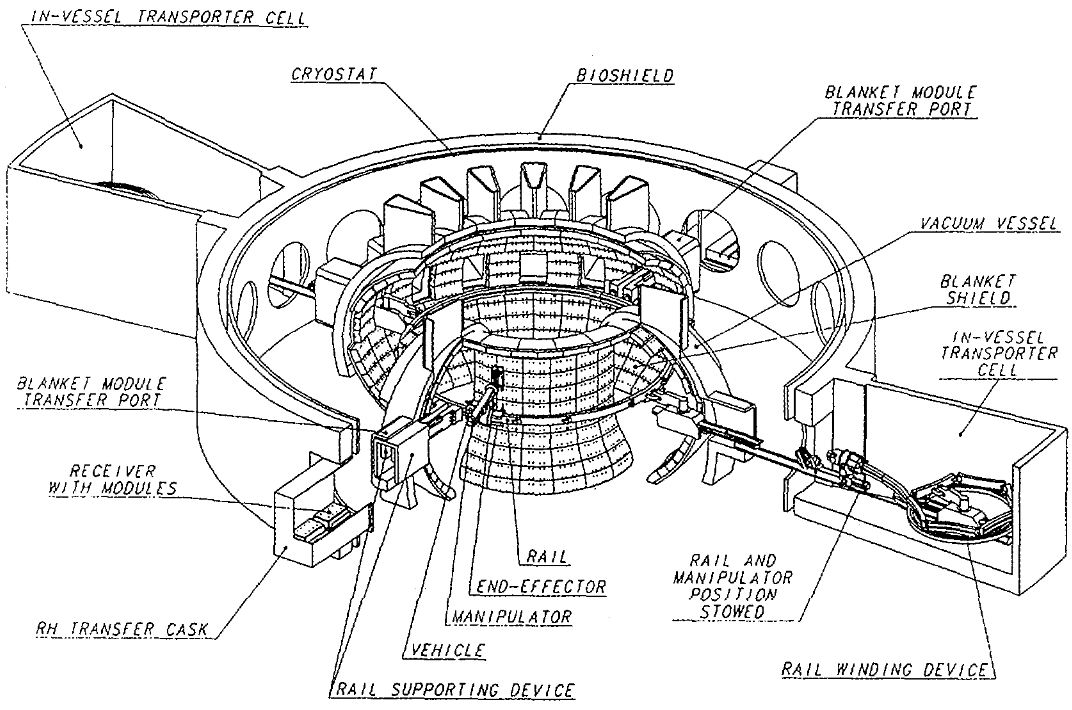

Fig. 1. Overview of the rail-mounted vehicle system for blanket module maintenance

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Drs. K. Shibanuma and E. Tada are the Project Managers for the Blanket Remote Handling (L-6) Project.

This article completes the series describing the Seven Large ITER R&D Projects. For the previous articles in the series see Newsletter Vol. 5, nos. 8 and 9, and Vol. 6, nos. 2,3, 4 and 5.

A rail-mounted vehicle equipped with a handling arm and an end-effector has been developed as the major remote handling equipment for shield blanket module replacement. During plasma operation, the rail/vehicle systems are stored in two maintenance cells spaced 180 degrees apart toroidally at the equatorial level. The system comprises two articulated rails (forming two semi-circles when deployed in the vacuum vessel), four vehicles (traveling along the rail and carrying out the replacement), two rail deploying devices with two-step slide arms and a rail winding arm (Fig.1). The rail/vehicle systems are inserted through the two ports connected to the maintenance cells and supported at two further equatorial ports (also used for module transfer through the ports) spaced at 90 degrees from the maintenance cells. The payload of the vehicle is 4.3 tonne for blanket module replacement. The module is held by the end-effector and the vehicle moves to a transfer point at the 90 degree port where the handling arm of the vehicle is lowered (or raised) onto the receiver. After being gripped by the receiver, it is released from the end-effector and moved by the receiver through the equatorial port into a sealed transfer cask via a double-seal door, and transferred to the hot cell for refurbishment or disposal.

The most critical issues for the blanket replacement are the positioning, attachment to the back plate, and transport of the four tonnes blanket modules with high reliability and accuracy within the confined space of the vacuum vessel and the maintenance ports. It is, therefore, essential to demonstrate the feasibility of the blanket replacement using a full scale mock-up prior to the ITER construction.

For this reason, blanket remote handling development is being conducted during the Engineering Design Activity (EDA) as one of the Seven Large ITER R&D Projects. The Blanket Test Platform (BTP) simulates the full scale structure of a 180 degree ITER in-vessel region, including the associated maintenance ports for the blanket replacement test. Full scale remote handling equipment is integrated into the BTP to demonstrate the feasibility of blanket module replacement (Fig. 2). The objectives of the project are summarized as follows:

- Study the static/dynamic behavior of the rail and vehicle/manipulator under design loading conditions
- Define the positioning and handling interface between modules and the back plate
- Demonstrate the remote deployment/storage of the rail transporter
- Demonstrate the removal/installation of the blanket module
- Demonstrate the cooling pipe welding, cutting and inspection
- Demonstrate the shield plug handling in the maintenance port
- Assess the maintenance time

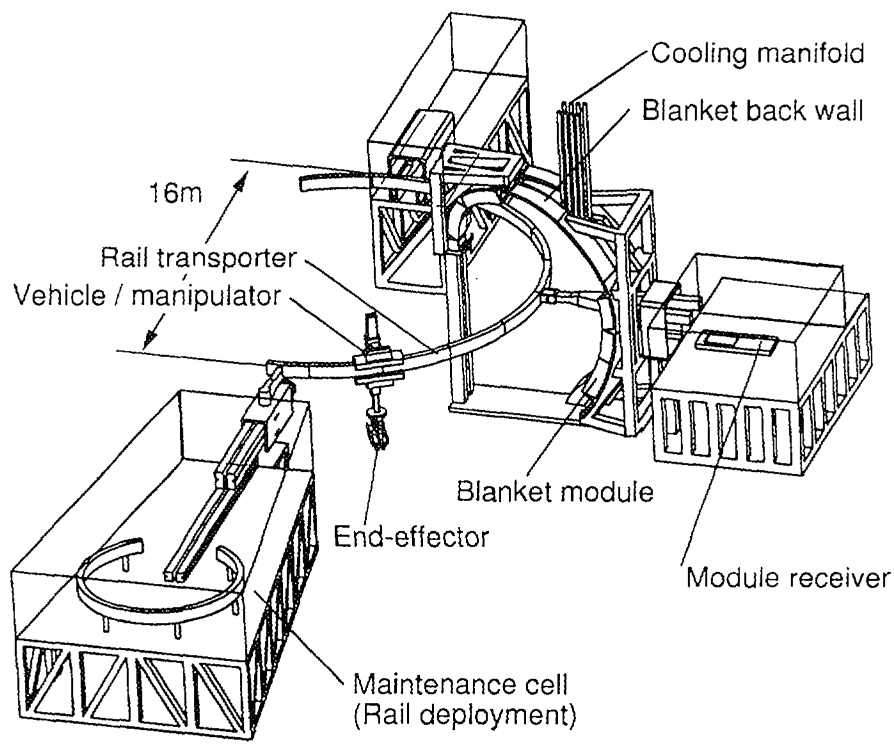

Fig. 2. Layout of the Blanket Test Platform

Blanket remote handling development is implemented by the Japan and EU Home Teams (HTs) in close collaboration with the ITER JCT. The BTP and full-scale remote handing equipment/tools, which are developed by the Japan HT, will be set up at the Japan Atomic Energy Research Institute (JAERI). Demonstration of the integrated tests for the blanket module replacement in the BTP is planned to start at the beginning of 1998. The port handling equipment, developed by the EU HT, will be delivered for the integration tests into the BTP after domestic tests at the ENEA Research Center at Brasimone (Italy). The Japan HT has lead responsibility for the project.

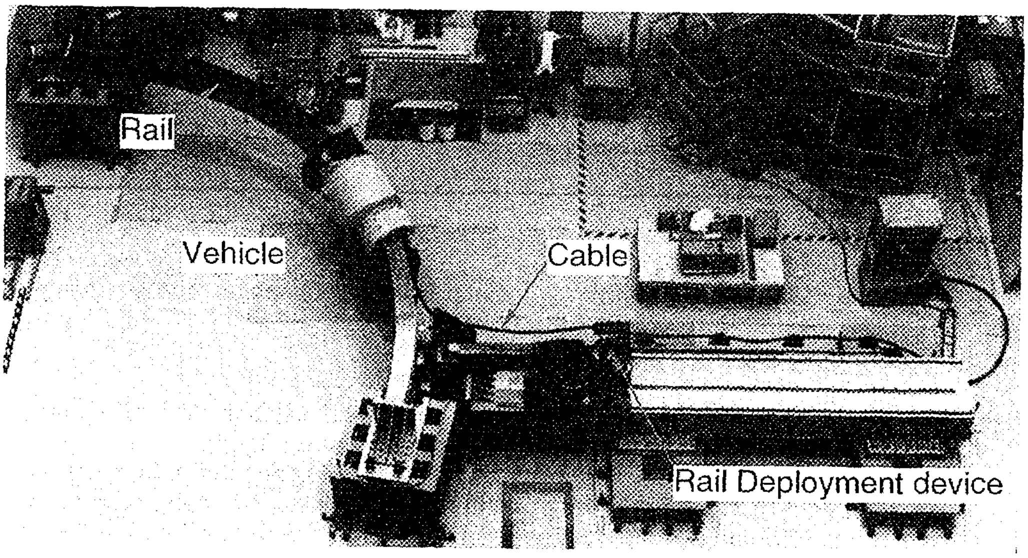

Fig.3. Partial model of the rail deployment system

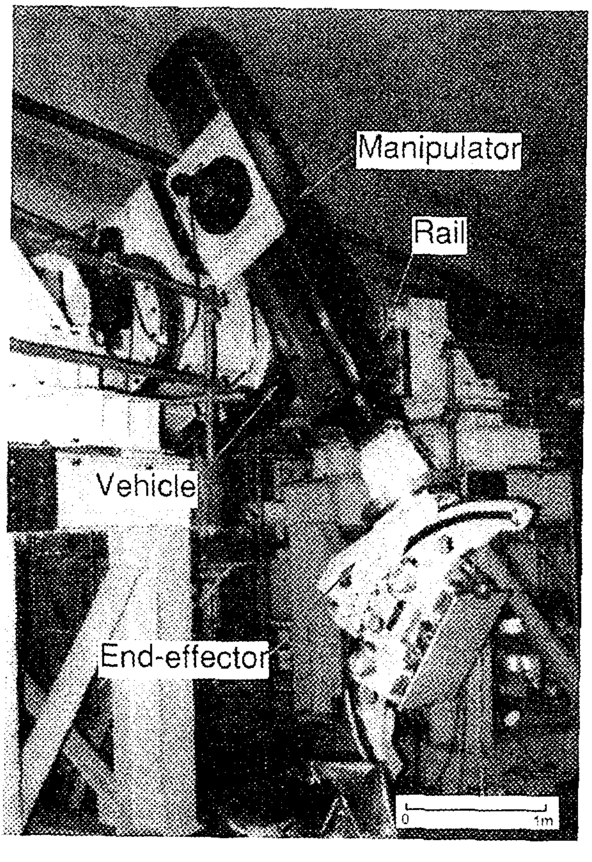

Fig. 4. Full-scale vehicle/manipulator of 4.3 tonne payload capacity

Reduced-scale or partial remote handling equipment has been fabricated and tested to fill the gap between the present and the required technology and to reduce the risk/cost for the development of the full-scale equipment. This includes the following:

- A partial model of the rail deployment system has been fabricated and tested to assess the basic controllability of the rail deployment in the vacuum vessel, the management of the long power cables during deployment, etc. (Fig. 3)
- A vehicle/manipulator of 1.2 tonne capacity (cf. 4.3 tonne full-scale) has been fabricated and tested to assess the positioning accuracy, repeatability, module replaceability, sensor-based control, etc.

Based on these test results, a database for the fabrication design of the major full-scale remote handling equipment has been established. The fabrication of the full-scale equipment/tools, such as the rail-mounted vehicle/manipulator system, and cooling pipe welding/cutting/inspection tools is almost completed and a preassembly test at the factory is being conducted. Integrated tests in the BTP will start on schedule at the beginning of 1998. Tests that have already been conducted included the following, as specified on the next page.

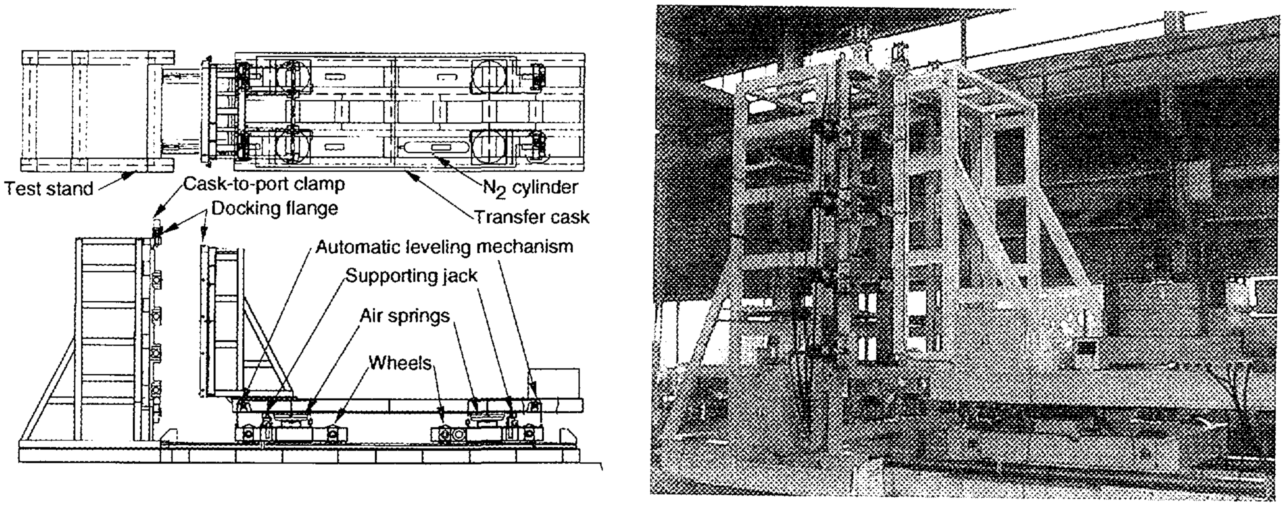

Fig. 5. Full scale transfer cask with automatic leveling mechanism and air spring

- For the vehicle/manipulator with 4.3 tonne payload capacity, the fabrication and functional tests in the factory have been completed (Fig. 4).
- A transfer cask, mounted onto railway bogies via air springs to accommodate misalignment between cask and port interface, has been fabricated and tests, such as position adjustment and seal tightness check at the cask/port docking interface, have been successfully completed (Fig. 5).
- For the branch pipe connection between modules and cooling manifold, a remote laser-based welding and cutting tool as well as non-destructive weld inspection including leak test equipment has been developed (Fig. 6).

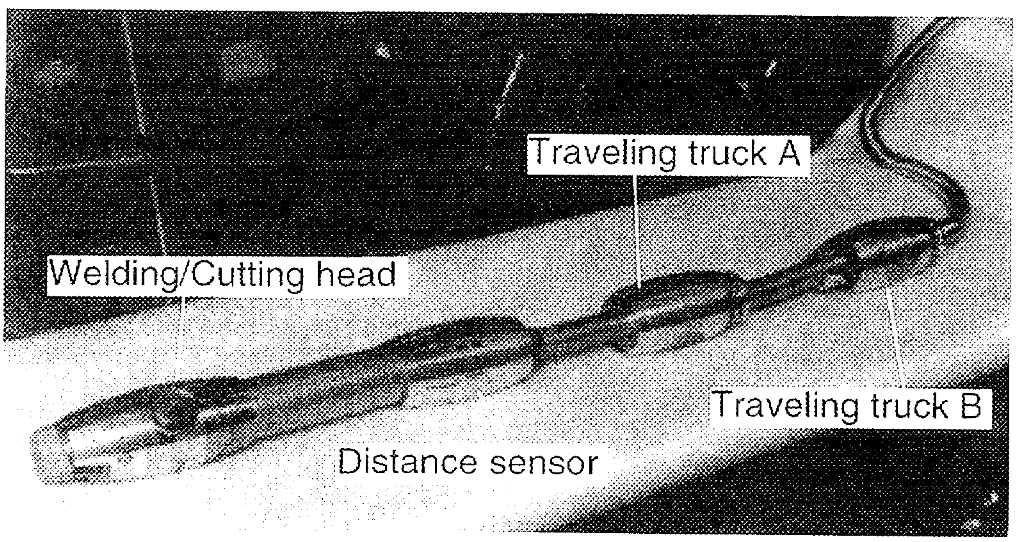

Fig. 6. Laser based pipe welding/cutting bore tool

It is expected that, as a result of the tests, at the end of the EDA, the feasibility of a major remote maintenance activity will have been demonstrated, both from a procedural and from an equipment point of view. This would then allow completion of the detailed design of components and the remote handling equipment, although further detailed tests, particularly with respect to the verification of rescue scenarios, and development of improved procedures, will be required.

FUSION RESEARCH SUPPORT BY THE IAEA

by Drs. T.J. Dolan and U. Schneider, Physics Section, IAEA

The IAEA provides many services to facilitate nuclear fusion research. The provision of nuclear data, atomic and molecular data, and plasma-material interaction data is very important to researchers around the world.

Since 1961 the Agency has organized Fusion Energy Conferences (formerly called International Conference on Plasma Physics and Controlled Nuclear Fusion Research). At the 16th IAEA Fusion Energy Conference (October 1996, Montreal, Canada) on ITER there was a review paper by the ITER Director, five oral papers, and 28 poster papers. The proceedings of these conferences are published and distributed to the participants and to the relevant authorities of the IAEA Member States. Preparations for the 17th IAEA Fusion Energy Conference (October 1998, Yokohama, Japan) are underway.

The IAEA's monthly journal "Nuclear Fusion" publishes papers relevant to thermonuclear fusion, including plasma theory, experiments, and fusion reactor concepts. The Agency published the "World Survey of Activities in Controlled Fusion Research" in1994, which lists fusion research institutions and staff in 48 countries, and the book "Energy from Inertial Fusion" (1995), which summarized the issues (driver beams, targets, chambers,etc.), current achievements and future prospects for inertial fusion power plants.

From 1982-88 the IAEA organized the International Tokamak Reactor (INTOR) workshop to define the next major tokamak. This group assembled information on plasma behavior, cross sections, and materials properties, produced a reference reactor design, defined the issues to be resolved, and produced a series of documents. Based in part on the successful international cooperation of the INTOR project, high-level governmental contacts led to the launching in 1988 of the ITER Conceptual Design Activities (CDA) by the four ITER Parties under IAEA auspices, followed by the Engineering Design Activities (EDA) in 1992. The IAEA provides for the ITER EDA assistance with meetings, publishes this monthly Newsletter, publishes ITER administrative and technical documents, and administers the ITER Joint Fund.

Other IAEA activities supporting fusion research include Coordinated Research Projects (CRPs),), Advisory Group Meetings (AGMs), Technical Committee Meetings (TCMs) and Technical Cooperation projects in developing countries.

The purposes of a CRP are to advance the research and to help developing countries improve their research capabilities. A CRP typically involves about 6-15 participants, many of whom are from developing countries, and lasts 2-5 years. A joint research topic is selected, and each participant works on a specified aspect of the problem. The Agency usually publishes the results of the CRPs as IAEA Technical Documents (TECDOCs). Here are some recent CRP topics:

- Software development for numerical simulation and data processing (1993-1995, TECDOC in progress)
- Plasma heating and diagnostics systems in developing countries (1994-1997)
- Applications of Plasma Physics and Fusion Technology.(1996-1999)
- Alternative Confinement (1998-2000)
- Lifetime prediction for a fusion reactor first wall
- Plasma-interaction induced erosion of fusion reactor materials (the results will be published in a two-volumes Handbook in the IAEA series "Atomic and Plasma-Material Interaction Data for Fusion").
- Radiative cooling rates of fusion plasma impurities (TECDOC in progress)
- Tritium retention and release from fusion reactor plasma facing components
- Atomic and plasma-wall interaction data for fusion reactor divertor modeling (termination expected in 2000).
- Reference data for thermo-mechanical properties of fusion reactor plasma facing materials. The results will be published as a topical volume of the IAEA series "Atomic and Plasma-Material Interaction Data for Fusion" in 1998/99.
- Plasma-material interaction data for mixed plasma facing materials in fusion reactors (initiated in 1997).

AGMs are called for the purpose of getting advice on the Agency's programmes. These meetings typically have 5-10 experts, who discuss a specific issue and write a report. Several AGMs have been held on Inertial Fusion Energy (1990-1997) and on Third World Plasma Research (1996).

TCMs are called to share information on a scientific topic. Such meetings typically last 2-4 days and are attended by 20- 70 participants, nominated by their governments. The proceedings are usually published in a technical journal or as an IAEA TECDOC. The table overleaf lists some recent TCMs on fusion research.

IAEA Technical Committee Meetings on Fusion Research

Title	When	Where	Number Papers	Publication
Alpha Particle Physics	Apr. 1995	Princeton, USA	71	42 papers published in Nuclear Fusion 35, No. 12, Dec. 1995
Alpha Particles in Fusion Research	Sep.1997	Culham, UK	62	Selected papers will be published in Nuclear Fusion
H-mode Physics,	Sep.1995	Princeton, USA	61	Plasma Physics and Controlled Nuclear Fusion 38, number 8, August 1996
H-mode Physics	Sep.1997	Kloster Seeon, Germany	62	To be published in Plasma Physics and Controlled Nuclear Fusion
Research using Small Tokamaks	Dec.1995	Ahmedabad, India	26	Being published as IAEA TECDOC
Research using Small Tokamaks	Nov.1996	Prague, Czech Republic	40	Being edited for IAEA TECDOC
Research Using Small Fusion Devices	Nov.1997	Cairo, Egypt	40	To be published as IAEA TECDOC
Advances in Computer Modeling of Fusion Plasmas	Oct.1996	Los Angeles, USA	14	Unpublished; Individual papers reproduced for limited distribution
Data Acquisition and Management for Fusion Research	July 1997	Garching, Germany	29	Submitted to Fusion Engineering and Design
Fusion Safety	Oct.1996	Naka, Japan	27	Journal of Fusion Energy 16, Nos. 1&2 (1997)
Drivers and Ignition Facilities for Inertial Fusion	Mar.1997	Osaka, Japan	100	Proceedings being published by Osaka University

The IAEA is also coordinating its fusion research activities with those of the International Energy Agency (part of the Organization for Economic Cooperation and Development, Paris).

The International Fusion Research Council (IFRC), comprised of the twelve senior fusion researchers/administrators listed on the next page meets annually to advise the Agency on fusion matters.

Dr. Ernesto Canobbio, Adviser for International Relations, Fusion Programme, Directorate-General for Science, Research and Development, European Commission, Brussels, Belgium

Dr. Renato Dei Cas *., Deputy Director, Division of Fundamental Research, CEA, France

Dr. N. Anne Davies **, Associate Director for Fusion Energy Sciences, Office of Energy Research, U.S. Department of Energy

Dr. Francesco De Marco, Associate Director, ENEA Fusion Division, Italy

Dr. David P. Jackson, Director, National Fusion Program, Canada

Academician Boris B. Kadomtsev, Director, Nuclear Fusion Institute, RRC Kurchatov Institute, Russia

Prof. Dr. Michael Kaufmann, Director, Max-Planck-Institut für Plasmaphysik, Germany

Prof. Predhiman K. Kaw, Director, Institute for Plasma Research, India

Dr. Derek C. Robinson, Director, UKAEA Fusion, United Kingdom

Dr. Adolfo Rodrigo, Head, Grupo Recubrimientos y Tratamientos Superficiales, Comision Nacional de Energia Atomica, Argentina

Dr. Tadashi Sekiguchi, Vice Chairman, Fusion Council, Atomic Energy Commission of Japan

Prof. Naiyan Wang, Academician, China Academy of Sciences

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* Dr. J. Pamela has been nominated to replace Dr. Dei Cas

** Dr. A. Davies is usually represented by Dr. Michael Roberts, the US ITER Contact Person, in his capacity as Director, International and Technology Division, Office of Fusion Energy Sciences, DOE.

The IFRC report entitled "Guidance to the IAEA on Nuclear Fusion Research Activities" (March 1997) provided a strategy for the Agency 1999-2000 Programme Plan, and specific fusion research activities were recommended by the IFRC at its meeting in June 1997.

ITER Contact Persons Michael Roberts (US) and Ernesto Canobbio (EU) have been active in the IFRC in their domestic capacities and, as appropriate, providing information and insights from their ITER capacities.

In summary, the Agency is supporting fusion research with many activities, including the provision of nuclear, atomic, molecular, and plasma-material interaction data; the journal Nuclear Fusion; the biennial Fusion Energy Conference; publication of books; coordinated research projects; Technical Committee Meetings; Advisory Group Meetings; and provision of auspices for ITER. The funds spent by the IAEA on these activities are greatly enhanced by the voluntary contributions of Member States who do research, host meetings, provide experts and publish reports.

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 237762, or e-mail: basaldel@ripo1.iaea.or.at (phone +43 1 206026392).

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