INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL.3, NO. 10 OCTOBER 1994

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

ITER-RELEVANT STATEMENTS MADE ON THE OCCASION OF THE 15TH IAEA FUSION CONFERENCE IN SEVILLE, SPAIN

compiled by Dr. E. Canobbio, EC Contact Person

The 15th International Conference on Plasma Physics and Controlled Nuclear Fusion Research was held in Seville, Spain, from September 26 to October 1, 1994. Following are excerpts, relevant to ITER activities, from speeches and statements made by high ranking officials at the Conference.

WELCOMING ADDRESS BY DR. S. MACHI, DEPUTY DIRECTOR GENERAL, IAEA

Since our last Conference in Wuerzburg 1992, several significant developments have taken place in controlled fusion research. In July 1992, the ITER Engineering Design Activities (EDA) Agreement and its Protocol 1 were signed by the four Parties – EC, Japan, the Russian Federation, and USA – under the auspices of the IAEA. In March 1994, Protocol 2, allowing to complete the ITER EDA was signed. The ITER EDA are now being fully implemented at three Co-Centres: in Garching near Munich, in Naka, Ibaraki, and in San Diego, California.

The UN Population Conference in Cairo, two weeks ago, reported that the world population today is 5,7 billion and increasing by 94 million per year. Such a dramatic increase of population and the rising living standards are accompanied by a tremendous increase of energy consumption.

At present, fossil fuels, such as coal and oil, are major energy resources – and are also, unfortunately, major sources of pollution. It should be noted that a large amount of SO_2 is emitted every day: for example, 15 million tons of SO_2 in the USA per year and a similar amount in China.

Another concern about the increasing and continued use of fossil fuels is the problem of CO_2 emission and its potential impact on global climate change as discussed at the UN Conference on Environment and Development in Brazil 1992.

From the viewpoint of future assurance of energy supply and environmental conservation, nuclear fusion energy is the best potential resource and, therefore, the increasing effort to achieve the ultimate goal of producing clean commercial energy by nuclear fusion as early as possible is of great importance for mankind.

EXCERPTS FROM THE SPEECH HELD BY ACAD. E.P. VELIKHOV, ITER COUNCIL CHAIRMAN

In 1968, Acad. Artsimovich, together with Acad. Kadomtsev, calculated the possibility of using the tokamak concept to build a demonstration fusion reactor; he asked me to look into the implementation of this approach.

Today, after almost thirty years, we are much closer to the goal of building an experimental thermonuclear fusion reactor on the basis of the tokamak concepts. The realization of this concept by developing ITER is a vitally important goal for each of the national programmes of the Parties.

ITER is a step in long-term activities aimed at the development of new sources of energy. Therefore, we need support not only from the fusion community, which we hope to achieve through proper co-operation and building of consensus between fusion scientists, but also from the scientific community at large, as well as from the industry interested in the development of new sources of energy and, in particular, in participation in the ITER construction. And, of course, we need political support for ITER, which, in some way, is the result of the cold war having come to an end and is the first example for a large international project involving many nations.

After two rather difficult years, we have built up the Joint Central Team and we have built up the home support for the Joint Central Team, the home support for Research and Development and for design activities. The great achievement of the Joint Central Team, the Home Teams and the former Director, Dr. Rebut, was the outline design which we have the chance to present to you tomorrow for a critical, but, I hope, friendly, discussion.

We hope to be able to complete in June '95 the interim design report, cost review, safety analysis and the report on the site requirements. We hope to produce in December '96 the detailed design report, cost review and safety analysis; and finally, in '98, to present to the Parties the full design, which is the basis for possible decisions on construction by the governments.

I think that all these milestones are extremely important, not only from the point of view of long-term development of fusion, but also from a philosophical point of view. The next 50 years will mostly be 50 years of natural gas and other non-renewable resources. If we succeed in extracting all these resources from the earth, we also need to succeed in giving to the future generations the technology which will eventually solve their energy problems. This is our goal and our task.

EXCERPTS FROM THE WELCOME SPEECH GIVEN BY MR. D.J.A. AZUARA, DIRECTOR GENERAL OF CIEMAT, AT THE RECEPTION OFFERED BY SPAIN IN THE ALCAZAR

This is the first time in the thirty years of history of this Conference, that it is held in Spain.

A great effort has been realized in the field of fusion by the Ministry of Industry, channelled mainly through the "Centro de Investigaciones Energeticas, Medioambientales y Tecnológicas" (CIEMAT) that I have the honour to direct, since the beginning of the co-operation between CIEMAT and the European Atomic Energy Community, until now. To give an example, the personnel in the Fusion Unit was 17 people in 1986 and is 96 right now.

Controlled thermonuclear fusion has a long-term potential for initiating a new path in energy generation, and this potential justifies a continuous and effective development in an international framework of co-operation because the magnitude of the human and economic resources needed indicates that it will be almost impossible to develop fusion at a national level. Therefore, international collaborations, such as ITER, are a good example to be followed in the future.

I do not want to leave without mentioning the need for an effort to bring together research centres and industries in every country, in a context in which the active character of the industrial policies is emphasized, to help the companies in their effort to improve their own potential.

EXCERPTS FROM THE RESPONSE BY DR. CH. MAISONNIER, DIRECTOR OF THE EUROPEAN COMMUNITY FUSION PROGRAMME, TO MR. AZUARA

It is a real pleasure to be in a country whose authorities are so supportive of fusion. Years ago, at the time of the cold war, large high-technology projects were funded relatively lavishly from domestic sources, as success in technological competitions was essential. Today international collaboration in big science is a necessity, in particular in domains such as energy where environmental and geopolitical consequences might be of a planetary scale.

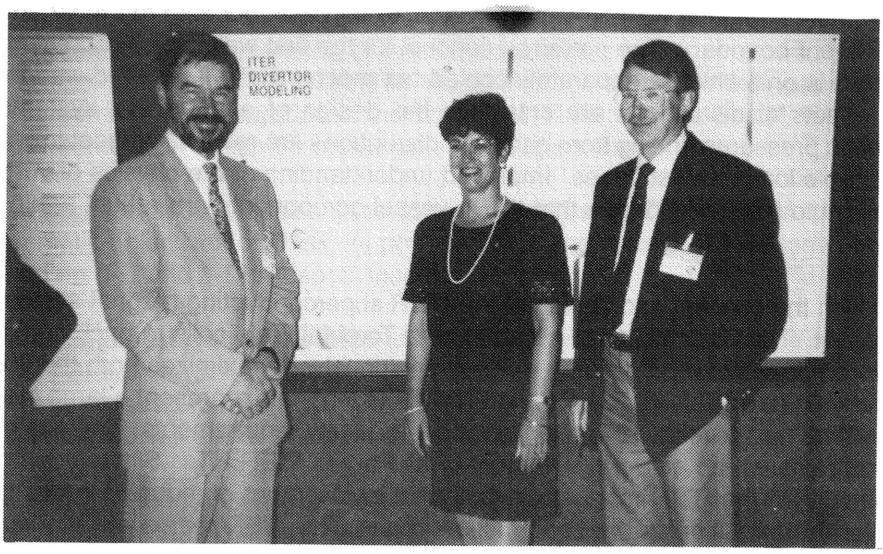
Fusion research is really big science: in Europe, each year we spend over half a billion dollars for fusion. But competition for money is now fiercer than ever; ITER, that we owe to the bold initiative taken a decade ago by Acad. Velikhov, is both our spear and our shield in this battle. So, now that collaboration takes over competition let me, in conclusion, quote Seneca, the Roman philosopher born 2000 years ago here in Andalusia, who said: "Consensus, in a sense, is a proof of truth." If we all agree that ITER could be built, and if we work hard for it, it might well be built. This is the best wish we can formulate for the future of our fusion community.

ITER AT THE 15TH IAEA CONFERENCE ON PLASMA PHYSICS AND CONTROLLED NUCLEAR FUSION RESEARCH

by S. Putvinski, D. Post, J. Van Fleet, Joint Central Team, San Diego Joint Work Site

The ITER Joint Central Team (JCT) and the Parties' Home Teams (HTs) collaborated in the preparation of a comprehensive technical presentation of the ITER EDA developments at the IAEA's 15th International Conference on Plasma Physics and Controlled Nuclear Fusion Research. This was the first full-scale technical presentation on the progress of the engineering design and R&D activities since the EDA began in 1992.

The last major ITER technical presentation was at the end of the Conceptual Design Activities phase at the 13th IAEA Conference in Washington, D.C. in 1990. This 15th IAEA Conference was held in Seville, Spain, from September 26 to October 1, 1994.



The authors of this article responsible for co-ordination and preparation of ITER presentations

At the invitation of the Director, the Parties' HTs were invited to collaborate with the JCT in presenting the ITER outline design and physics basis. ITER was allocated four and one-half hours in the conference program for its oral presentations and a dedicated poster session. The Paper Selection Committee accepted six oral presentations and 13 posters. A list of the manuscripts is provided at the end of this article. The 19 manuscripts were combined in a single reprint volume and were available at the Conference.

The central presentation at the ITER session – "ITER Outline Design" – was given by the former ITER Director, Dr. P.-H. Rebut. His presentation was devoted to the general design philosophy and design solutions chosen for major ITER systems and components. (The Outline Design served as a point of departure for proceeding into Protocol 2, the second and last step in the implementation of the ITER EDA Agreement.)

The next speaker was Dr. Y. Shimomura whose presentation was on ITER's operational capability and results of the "Sensitivity Study" carried out by the Director, the JCT and the HTs at the request of the ITER Council. The purpose of this study was "to determine the relative importance of different design parameters, within small ranges of variation, in determining the overall cost."

The operational capabilities extensively studied have shown that the present ITER design has sufficient but not excessive margins to achieve sustained burn, and sufficient capability of achieving ignition and sustaining long burn with additional heating power. The sensitivity analysis included study comparisons of several alternative ITER designs options. This analysis led to the conclusions that a significant cost reduction cannot be achieved without a significant reduction in performance and also that further development of the engineering design work is more important than the minor optimization of the basic parameters. The ITER Council took note of the TAC finding that the outline design has been successful in its attempt to maximize physics and engineering performance while minimizing cost and complexity.

The ITER design optimization as well as the Sensitivity Study were based on the physics specifications and models described by Dr. F. Perkins in the next presentation. The accent in his presentation was on the new physics and plasma technology which is introduced by the scale of ITER. He discussed a wide range of plasma processes vital for plasma performance including plasma energy confinement and validation of ITER-type discharges in the present experiments; He accumulation and removal; MHD stability and plasma disruptions; and alpha-particle physics. The main conclusion resulting from this presentation was that the knowledge base is adequate to determine ITER basic parameters that are appropriate to its mission. However, as pointed out in the presentation, much important physics remains to be evaluated for a plasma of ITER's scale. According to the presentation authors, ITER will teach us what we need to know for DEMO.

The ITER divertor concept was presented by Dr. K.J. Dietz. The reference design of the ITER divertor exploits the concept of the Dynamic Gas Target which is consistent with observations of detachment in existing tokamak divertor experiments. This has the promise of reducing the high heat flux conducted to the divertor plates to manageable values by depositing the power onto large surface areas adjacent to the divertor channel. It is expected that the detailed design of the divertor will evolve as progress in divertor physics is made. Many areas of the concept still require extensive analytical and experimental validation. During this evolutionary phase, the challenge for the design of the ITER divertor is to find a physics and engineering solution characterized by robustness and flexibility. It is believed that the presented design satisfies this requirement.

The next presentation was on the ITER vacuum vessel and blanket/shield concept given by Prof. R. Parker. The vacuum vessel is perhaps the most straightforward in-vessel system in concept, but also the most critical since it forms a primary containment boundary. The preferred concept for the first wall, which represents a departure from the Outline Design, is one which is separately cooled but mechanically integrated with the shielding blanket modules. The effects of disruptions are critical to the design of all in-vessel systems. Induced currents and electromagnetic pressures arising from centered disruptions are relatively model-insensitive and lead to high, but manageable loads and stresses. Improved understanding of the physics of vertical displacement events is necessary to have confidence that the in-vessel components are robust against them.

The ITER session was concluded with the concept and design of the ITER superconducting magnet system, which was presented by Dr. M. Huguet. The basic concept is to allow the Toroidal Field coils to buck on the central solenoid. This results in a compact and mechanically efficient design which maximizes both the flux available from the solenoid and the space available for the plasma. The ITER magnets represent a large step from existing technology in terms of the field level at 13 T, the size and the quality requirements. The design of the full scale coils and structures requires the active involvement of all Parties' ITER HTs. Since industry will be responsible for the manufacture of the ITER magnets, substantial involvement of industry in design activities is essential to prepare for the transition to the construction phase. The ITER teams are working toward this goal.

The poster session which followed the oral presentations in 13 posters provided more in-depth presentations of ITER design, physics issues and results of modeling work.

The ITER presentations attracted the intense interest of the conference participants – the conference hall was full during ITER sessions and favourable comments were made on the overall quality of the ITER presentations.

ITER PRESENTATIONS

IAEA-CN-60/E-1-I-1	The ITER Outline Design
IAEA-CN-60/E-1-I-2	ITER Operational Capability
IAEA-CN-60/E-1-I-3	ITER Physics Basis
IAEA-CN-60/E-1-I-4	The ITER Divertor Concept
IAEA-CN-60/E-1-I-5	The ITER Magnet System
IAEA-CN-60/E-1-I-6	ITER Vacuum Vessel, Blanket and Shield

ITER POSTERS

IAEA-CN-60/E-P-1	Performance, Sensitivity and Optimization Studies and the ITER Outline Design
IAEA-CN-60/E-P-2	ITER Plasma Modeling and MHD Stability Limits
IAEA-CN-60/E-P-3	Projection of ITER Performance Using the Multi-Machine L- and H-mode Databases
IAEA-CN-60/E-P-4	Alpha-Particle Physics for ITER
IAEA-CN-60/E-P-5	ITER Steady-State Operation an Advanced Scenarios
IAEA-CN-60/E-P-6	The Physics Basis and Design of the ITER Divertor and of the Pumping, Fuelling System

IAEA-CN-60/E-P-7	ITER Divertor Modeling: Predictions and Experimental Validation
IAEA-CN-60/E-P-8	Ion Cyclotron Heating and Current Drive System in ITER
IAEA-CN-60/E-P-9	Neutral Beam and Electron Cyclotron Heating and Current Drive Systems for ITER
IAEA-CN-60/E-P-10	Plasma Equilibrium and Control in ITER
IAEA-CN-60/E-P-11	Superconducting Magnets: Major Design and R&D Issues for ITER
IAEA-CN-60/E-P-12	ITER Nuclear Engineering First Wall, Blanket, Shield Design, and R&D Program
IAEA-CN-60/E-P-13	Alternative Design of ITER First Wall, Blanket and Shield

FIRST WORKSHOP OF THE ITER EXPERT GROUP ON CONFINEMENT AND TRANSPORT

by Dr. V.S. Mukhovatov, Physics Integration Unit, ITER San Diego Joint Work Site

The first Workshop of the ITER Expert Group on Confinement and Transport was held on 22–25 August 1994 at the ITER San Diego Joint Work Site (JWS).

- The main objectives of the Workshop were:
- Agreement on the mandate of the Expert Group;
- Refinement of the ITER research needs and agreement on their priorities;
- Agreement on preparation of the document "ITER Physics Basis";
- Agreement on a plan for meetings of the Expert Group.

At a short introductory session, the Joint Central Team (JCT) members presented reports concerning the programmatic objectives of ITER, its physics basis and results of assessments of plasma performance in ITER based on 0-D and 1-D transport models.

The second session was devoted to discussions regarding the scope of work and mode of operation of the Expert Group. It was agreed that the Expert Group will assist the JCT in the development and validation of the physics basis for predicting the ITER confinement capability and plasma performance. In particular, the Expert Group will assist in defining and prioritizing the ITER physics R&D needs and will help in identifying experimental programs and areas for new work in transport theory that are of primary importance to ITER. The Expert Group will provide also an input to and liaison with the ITER Confinement Database and Modeling Expert Group, translate information on ITER physics issues to fusion researchers in each Party, and report annually on activities and progress in the area of confinement and transport to the ITER Physics Committee. The Expert Group agreed to contribute to and co-author sections of the document "ITER Physics Basis" summarizing the physics basis in the areas of plasma confinement and transport. Minority views on the physics basis or design choice will be reported to the ITER Physics Committee by the Expert Group Chair. The design section, which advocate design choices, remain the responsibility of the JCT.

Major discussions at the Workshop were devoted to the ITER physics R&D needs and their prioritization. Three priority levels were adopted, i.e. (1) urgent research needs which may provide an impact on the ITER design, (2) high priority needs to support decisions on ITER construction, and (3) long-term needs to justify ITER operational scenarios.

Earlier this year, the JCT specified 16 research needs; additional research needs were identified by the experts before and during the Workshop. At the Workshop many research needs were reformulated and enhanced, while some needs were deleted. As a result, 13 research needs were selected as important, out of which two were specified as urgent and four as high-priority:

Urgent Research Needs (results by December 1995):
- H-mode power threshold;
- Tokamak demonstration discharges with ITER non-dimensional parameters.

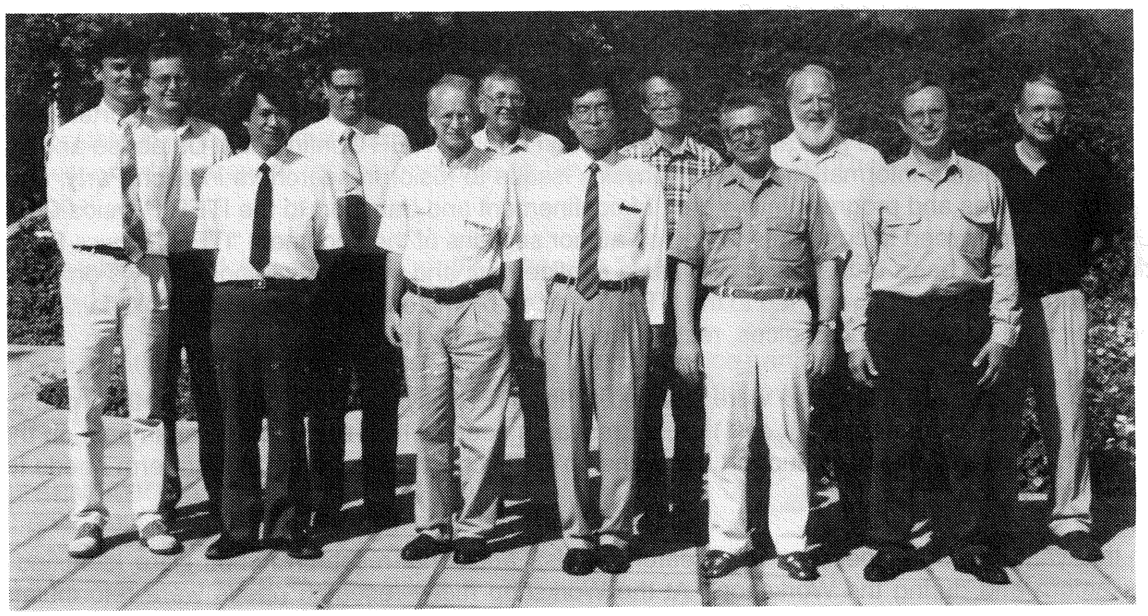
High-Priority Research Needs (results by December 1996):
- Differential transport properties of helium and hydrogen isotopes;
- How can we control ELMs?
- Confinement improvements in X-point L-mode discharges;
- Develop transport models.

Long-Term Research Needs (results by June 1998 and beyond):
- Investigation of advanced tokamak scenarios for ITER;
- Study of impurity density profiles (Be, C, high Z) in ITER-relevant conditions;
- Scaling of thermal and plasma diffusivity with β, κ, ν^* in addition to ρ^*
- Isotope scaling of confinement;
- Particle and heat pinch in ITER-relevant regimes; local versus non-local transport;
- Transport near the density limit;
- Influence of fast ions on transport.

The first urgent task, i.e. "H-mode threshold", was adopted unanimously by the experts as the most urgent confinement research need for ITER, since plans are for ITER to operate in the H-mode of confinement. However, an existing empirical scaling gives a threshold heating power of $\approx$100 MW to get the H-mode in ITER which is twice as high as the present design value of auxiliary heating power (50 MW). Clearly, more experimental data from machines of different sizes at different densities and magnetic fields are urgently needed to improve the accuracy of the scaling and to predict the required heating power for ITER with greater confidence.

The second research need that was specified as urgent was "Tokamak demonstration discharges with ITER non-dimensional parameters". It has to provide a more firm physics basis for prediction of ITER confinement capability by defining an extrapolation principle (Bohm or gyroBohm) from the present-day machines to ITER. To accomplish this task, a scaling of local electron and ion transport with respect to $\rho^* \propto (MT)^{1/2}/BR$ at other dimensionless parameters the same as ITER has to be obtained.

The high priority research has to provide additional information on transport of helium ions, ELM control, and prospects of ITER operation in L-mode with improved confinement, e.g., $H \approx 1.4$ will provide $Q \approx 15$, $R_{fus} \approx 1.5$ GW at $P_{aux} = 100$ MW. Further, significant improvement is needed in transport modeling, in particular, an accommodation of more realistic boundary conditions is urgently required.



Participants in the Meeting

wo expert subgroups were established at the workshop. The first subgroup includes representatives from major tokamak experiments and is responsible for co-ordination of experimental programs aimed at the ITER confinement research needs. The second subgroup consists of theoreticians and is responsible for transport model development.

It was agreed that close interaction between the Expert Group on Confinement and Transport and the Expert Group on Confinement Database and Modeling is important. Subsequently, a short joint meeting of both Confinement Expert Groups was held during the 15th International Conference on Plasma Physics and

Controlled Nuclear Fusion Research (September 30, 1994, Seville, Spain). The objective of the meeting was to develop a preliminary plan of experiments on JT-60U, JET, DIII-D, ASDEX-U, Alcator C-MOD, COMPASS-D, JFT-2M, PBX-M and TEXT-U to meet the urgent research needs.

Based on the discussion at the workshop it was recognized that there are two serious concerns:

- auxiliary heating power of 50 MW adopted in the present design is probably too low to get an H-mode;
- resources for plasma modeling and model development are inadequate in both the JCT and four Parties.

The second ITER Expert Group Workshop of Confinement and Transport will be held on September 4–7 (provisional), 1995 at one of the ITER JWSs (the specific site will be selected later). The objectives of this Workshop will be (i) to discuss the draft Confinement Chapter of "ITER Physics Basis", (ii) to discuss results from the urgent and high priority tasks, and (iii) to revise the ITER physics R&D plan for 1996.

MEMBERS OF THE EXPERT GROUP

EC:	JA:	RF:	US:	JCT
J.G. Cordey	M. Wakatani (Chairman)	Y. Esipchuk	B. Carreras	D. Boucher
J. Connor	M. Mori	S. Lebedev	K. Burrell	V. Mukhovatov (Co-Chair)
L. Lourent	K. Toi		S. Wolfe	F. Perkins
				M. Rosenbluth
				J. Wesley

Drs. J. Connor, L. Lourent, Y. Esipchuk and S. Lebedev were unable to attend the workshop. Dr. P. Yushmanov was invited by the Chairman and Co-Chair to represent the Russian Federation at the workshop.

ACHIEVEMENT REWARDS FOR COLLEGE SCIENTISTS (ARCS) FOUNDATION VISIT SAN DIEGO JOINT WORK SITE

by N. Carroll, Manager, Technical Support Services, SAIC

On 13 October the ITER San Diego JWS hosted a local philanthropic group, the ARCS Foundation, for a briefing on the ITER project and a tour of the facility. Afterwards, the ARCS Foundation hosted a reception for their members and guests, as well as the ITER staff.

The ARCS Foundation is a U.S. national volunteer women's organization dedicated to providing financial support to the best and brightest U.S. graduate students seeking advanced degrees in natural sciences, medicine and engineering.

Nancy Carroll, SAIC, demonstrating electronic access to the University of California Library System Databases

Foundation was formed in 1958. Since then, ARCS has grown to 14 chapters throughout the United States. Its volunteers have raised over $18 million to support more than 5,800 scholars at over 60 U.S. colleges and universities.

The San Diego ARCS Chapter is composed of women with varied talents and abilities who come from all areas of the country. They and their spouses are primarily professionals – scientists, engineers, doctors. lawyers, business people – and are influential in the community. An important facet of the ARCS Foundation is member education; ITER was selected for one of the educational field trips to which spouses and other guests are invited. Among the 65 or so distinguished visitors at the briefing and tour were:

Mr. and Mrs. Walter Shirra	Former U.S. Astronaut (3 missions)
Dr. and Mrs. J. Robert Beyster	Founder and CEO of SAIC
Mr. and Mrs. George Leisz	Founder and CEO (retired) and Aerojet General
Mr. and Mrs. Jasper Welch	General, USAF (retired)

The briefing was presented by Dr. V. Chuyanov, Dr. T. Dillon, Group Sr. Vice-President of SAIC, and Mr. M. Sabado, ITER Support Services General Manager. Dr. Chuyanov presented "Fusion and International Collaboration", and "What is ITER?" Dr. Dillon discussed "What is Fusion?" and "The ITER Reactor – the Tokamak". And Mr. Sabado covered "ITER Organization and Management", "The San Diego Connection", and "The Challenges".

Dr. Aymar also welcomed the group and said a few words about ITER. The group was then divided into six small groups for a tour and demonstrations. These included a CAD demonstration, the IPMS system demonstration, overview of the California contributions to the San Diego JWS, a discussion and demonstration of the ITER data communications network, a demonstration of electronic access to the University of California library, and a short tour of the facility, including the CAD area.

ARCS would like to repeat the tour and briefing of the San Diego JWS during its national convention which meets in San Diego in 1995.

FORTHCOMING EVENTS *)

- Magnet Technical Meeting, Naka, Japan, 8–11 Nov.
- MAC-7, Tokyo, Japan, 30 Nov.–2 Dec.
- TAC-7, Naka, Japan, 5–7 Dec.
- Technical Meeting on Irradiation Testing, Garching, Germany, 12–16 December
- IC-7, Naka, Japan, 14–15 Dec.

*) Attendance at all ITER Meetings by invitation only.

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 (phone 23606392).

Printed by the IAEA in Austria
January 1995

95-00170