Appendix C

The Status and Plans of Four Parties

<JT-60>

The JT-60SA programme being promoted as one of joint programmes under Broader Approach (BA) agreement between Japan and EU and also as a Japanese domestic core programme of tokamak development is progressing steadily towards the first plasma planned in the end of FY2015. Procurements of JT-60SA components are shared by Japan and EU. Existing infra-structure and equipments for JT-60U, such as heating & current drive systems, cooling facilities, power supplies, diagnostics etc., will be utilized as many as possible.

Seven procurement arrangements for Japanese contributions have launched between the Implementing Agencies, JAEA and F4E, by November 2010. Fifteen of thirty-five EF(equilibrium field) superconducting conductors of ~450 m have been successfully provided in Naka Institute by November 2010. Trial winding with EF dummy conductors completed in November 2010. Trial upper half of the 20 degree sector of the vacuum vessel was successfully welded at the manufacture's factory in Japan. Based on the success, fabrication of two 40 degree sectors started and is going on as scheduled. As for the European contributions to the procurements, two procurement arrangements had been signed in 2009, and additional two procurement arrangements were signed for High Temperature SC Current Leads and TF Coils in 2010.

Disassembling and removing existing components in the JT-60 machine hall started in this April and will be completed in 2012. So far, it is also going as scheduled.

The development of gyrotron with a new improved mode converter was continued aiming at 1MW, 100s which is the long-pulse requirement of JT-60SA ECRF system. It was confirmed that the RF diffraction loss was remarkably decreased and the cooling water temperature for the DC break, which had limited the pulse length, was saturated at about half ($\Delta T \sim 30°C$) of that before the improvement. And the pulse length was extended up to 31 s (1 MW) in September 2010. Further conditioning is ongoing to extend the pulse length further. A mock-up antenna was fabricated featuring the linear motion (LM) concept which has an advantage of feeding cooling water reliably to the linearly driven mirrors, compared to the conventional antenna having rotatable mirrors. The mock-up antenna showed satisfactory beam steering range in both Toroidal (30°) and Poloidal (~80°) direction.

<KSTAR>

The KSTAR is progressing steadily towards the long pulse high beta plasma operation planned in the end of FY2014. The new start-up scenario was established for compensating the deformed magnetic field structure from ferromagnetic Incoloy 908 and the robust startup was possible against various discharge conditions such as wall condition, gas feeding, and toroidal field.

The diverted plasmas with high elongation (K>1.9) was achieved with in-vessel vertical control coils. The real time EFIT was validated and iso-flux control was tested for a shaping method. Finally ELMy H-mode was successfully produced with 1.1 MW NBI at the plasma current of 0.6 MA.

Few new diagnostics have been commissioned including the charge exchange recombination spectroscopy, the electron cyclotron emission imaging system, and the x-ray crystal spectrometer. Fifty-five experimental proposals with fourteen from international collaborators were scheduled for experiments and forty nine of them were performed.

The development of neutral beam was continued aiming at 2MW, 300s per an ion source which is the long-pulse requirement of KSTAR NB ion source and 1.7 MW with 100kV was finally commissioned and it contributed to make KSTAR's first H-mode. Plasma facing components including the passive stabilizer and graphite tiles was fully installed inside the vacuum vessel and sixteen segmented in-vessel control coils were installed to stabilize the vertical plasma movements. In addition, the divertor cryo-pump was also installed and ready for operation in 2012.

The next experimental campaign will begin April in 2011 with additional heating capability of 170 MHz, 1 MW of ECH system and with more diagnostics, concentrating on the H-mode characterization and the ELM control.

<U.S.>

The deliberations in the U.S. Fusion Energy Sciences (FES) program continue to evolve, with primary focus on developing pathways for establishing the credibility of fusion energy. The complexity of and challenges in fusion science and technology are great and requires break out from scientific and political isolation. The FES mission continues to be to expand the fundamental understanding of matter at very high temperatures and densities and to develop the scientific foundations needed to develop a fusion energy source.

In his recent presentations to a variety of different forums and stakeholder groups, Ed Synakowski has identified at least the following "three major scientific needs for establishing credibility for fusion energy:

(1) We must generate, study, optimize, and learn to predict the properties of the burning plasma state

(2) We must develop the scientific basis for robust control strategies for the burning plasma state

(3) We must develop the understanding of the material/plasma interface, and the fusion nuclear science needed to endure the fusion environment and to harness fusion power".

These needs inform the deliberations to evolve the structure and priorities of the US FES program. The U.S. participation in ITER is the highest priority which is aimed at successful demonstration of burning plasmas and understanding its underlying physics and technology integration for extrapolation to the next steps in the development of fusion energy.

Emphasis has to increase in validation of physics basis and computational models with close interaction between theory, modeling and experiments in the ongoing programs. Extrapolation of current results to ITER and beyond, and successful operation of 'steady-state' long pulse plasmas in the future require enhanced international collaborations and closer interaction with other disciplines such as the Advanced Scientific Community (ASC). The initiation of the long-range Fusion Simulation Project (FSP) in the US FES program is aimed developing the tools for such validated computer simulations.

Finally, 'materials' issue in fusion energy is now defined in a broader context to include resolution of both the radiation damage of structural materials, as well as the ability to handle high heat flux in plasma facing components. As follow-on to the ReNeW activities in 2008-2009, subgroups in the U.S. are examining issues in 'Fusion Nuclear Science Program (FNSP)' that would address such materials and tritium breeding issues.

The current organization of the U.S. FES program is contributing to these reformulated broad topical areas. The three major facilities (DIII-D at General Atomics, C-MOD at MIT, and NSTX at PPPL) provide the major new experimental results in the U.S. with primary focus on supporting ITER physics needs and U.S. participation in the International Tokamak Physics Activity (ITPA) and a wide range of fusion collaborations. The US Burning Plasma Organization (USBPO, http://burningplasma.org/home.html) continues to play an extensive role in the U.S. in coordinating burning plasma research (primarily tokamaks). These experimental programs also contribute to advancement of the tokamak concept beyond the ITER needs, and support physics needs for FNSP.

The Innovative Confinement Concepts (ICC) program, which involve smaller experimental facilities mostly at universities have now been redirected to support diagnostics development and theory/modeling validation of mainline toroidal research. Basic Plasma Physics research is expanding with additional collaborations with the National Science Foundation programs, and the High Energy Density Physics (HEDP) programs with enhanced collaborations with the National Nuclear Security Agency (NNSA).

The status reports of the three major facilities, including their recent scientific accomplishments, hardware upgrade plans, and their operational plans are summarized in the brief presentations can be found in the power point presentations on the web-page. Their scientific accomplishments during this year were mostly in the following areas:

- DIII-D
    - TBM
    - ELM Control
    - Disruption Control
    - L-H Threshold
    - T- Retention (Carbon walls)
    - Startup/Rampdown
    - Pedestal

    - Fast Ions

- C-Mod
    - I-mode studies
    - Extensive SOL Heat-Flux Footprint Studies
    - Lower Hybrid Current Drive

- NSTX
    - Divertor Heat Flux studies
    - ‘Snowflake’ Divertor studies
    - Lithium experiments on
        - Wall conditioning
        - Kinetic High beta RWM Stability
        - ELM stability
    - Error field effects
    - TAE avalanches
    - Co-axial helicity injection

<EFDA-JET>

The last 6 months on JET have been a period of intense operations concentrated around the Shutdown, which started on 26 October 2009 for the installation of enhancements of high scientific value and strategic importance (ITER-like combination of first wall materials (ILW with tungsten divertor and beryllium wall), NB Power Upgrade (30MW long pulse rather than 20MW short pulse to facilitate scenario development at high current, high β and high density), upgraded and new diagnostics, and a series of machine refurbishments). In addition, significant Fusion Technology Tasks were carried out.

The forward plan for JET ("Reference Scenario") covers the exploitation of the ILW up to 2014, followed by DT experiments up to the end of 2015. Two Task Forces have been established for the Experimental Campaigns of 2011 and, following the start of the process of experiment elaboration at the General Planning Meeting (GPM) of 1-5 March 2010, a Second GPM took place on 15-19 November 2010. Since then, main, back-up and parasitic experiments have been defined, together with a draft time-schedule for the period mid-2011 to mid-2012 From first plasma in late July 2011, the experimental programme will focus on the characterisation of the ILW, together with the exploration of ITER operating scenarios with the ILW and physics issues essential to the efficient exploitation of the ILW and ITER. Critical issues will be the minimisation of T-retention, material erosion and migration, mixed material effects, impurity control and the development of ITER scenarios fully compatible with a Be/W material mix. A major challenge will be to accommodate ~40MW of heating power with the ITER-like combination of first wall and divertor materials.

For the longer-term JET programme ("Alternate Scenario"), feasibility studies for an ECRH system (~10MW) for heating and current profile control (collaboration with Russian Federation) and a system of Resonant Magnetic Perturbation (RMP) coils for ELM control (collaboration with US), launched in 2009, have been concluded. These systems would allow the full exploitation of the ITER-like Wall and provide JET with a significantly increased capability for preparing ITER operations. However, this Alternative Scenario requires a significant increase in the level of contributions by international partners who would then become involved more actively in the decision-making process, including the joint revision of the JET Plan of Exploitation.

Since 2000, 152 JET FT tasks have been launched (allocated resources ~23M€

(~2.6M€ in 2009)), concentrating on tritium in tokamaks, tritium process and waste management, plasma facing components, engineering, and neutronics and safety.