As 2005 comes to an end, it is important to highlight what an important year this has been for fusion research. On 28 June, the ITER parties (Europe, US, Japan, China, South Korea, Russia) took the decision to construct ITER in Europe, in Cadarache, France. More recently India has joined ITER and the negotiations, which restarted at the end of summer, are now coming to a conclusion. With ITER construction close to starting, EFDA launched a new enhancement programme in April and July that will reinforce the JET capability to prepare for ITER operation. A key element will be the installation in three years time of a complete set of ITER-like wall and divertor materials. Looking at the shorter term, we hope that 2006 will see a number of successful JET experimental campaigns, capitalising on the recent enhancements of the facilities. With so many exciting events as a backdrop, I would like to wish all those involved in JET and their families a Merry Christmas and a happy 2006.

Seven of the large European research organisations (including EFDA JET) – collaborating under the banner EIROforum – recently organised the fourth “Science on Stage” Teachers Festival at CERN. Four hundred science teachers from over twenty European countries met up to swap ideas, experiments and experience. The focal point of the event is the teaching fair – where teachers demonstrated their own favourite classroom experiments – from weather balloons to mousetrap cars, DNA made out of coke cans to jewellery made from copper wire. The most innovative and enthusiastic presentations and experiments in the fair were considered for the European Science Teaching Awards. EFDA JET granted its special prize to Eilish McLoughlin et al. from Ireland, for their innovative teaching method “Teaching Science as a Process” – an Irish science class will enjoy a sponsored visit to the JET facilities.

By spreading their experience and new knowledge when they return to their classrooms (to thousands of students and other teachers), EIROforum hopes Science on Stage really increases the wonder of science and the value of experiments in the classroom. For more details please visit http://www.eiroforum.org, http://www.scienceonstage.net

The 65th meeting of the Section for Transport, Energy, Infrastructure and the Information Society (TEN) of the European Economic and Social Committee was held at JET in the Culham Science Centre on 23th and 24th November 2005.

The European Economic and Social Committee (EESC) is a non-partisan body that gives representatives of Europe’s organised civil society interest groups, and others, a formal platform to express their points of views on EU issues. The competences of the committee arise from the EC treaty. Its opinions are forwarded to the larger institutions - the Council, the Commission and the European Parliament. It thus plays a key role in the Union’s decision-making process.

49 members of the Section, including the President Alexander-Michael Graf von Schwerin, were welcomed to the JET site by Dr. Jérôme Paméla, EFDA Associate Leader for JET, and Professor Sir Chris Llewellyn Smith FRS – Director, UKAEA Culham Division. Following two presentations on fusion, a general discussion was held with the participation of leaders of JET scientific taskforces, Dr. Wojtek Fundamenski, Dr. Thierry Loarer, Dr. Jef Ongena, Dr. Xavier Litaudon and Dr. Paola Mantica. Dinner in the JET foyer was followed by a tour of the JET facilities, including a visit to the flywheel generators, Torus hall and Remote Handling facility.

The Section’s meeting was held the following day in the Hans-Otto Wüster room. It was the first time in almost 20 years that a meeting with simultaneous language translation was held at JET, reviving the translation booths for their original purpose.
Scientific objectives for the 2006 experimental campaigns

Task Force S1 - Standard Scenario
Richard Buttery, Joerg Hobirk and Thierry Loarer

For the experimental campaign C15 to C17, the S1 programme follows three lines:

• High current operations will exploit the new ‘MKII-HD’ divertor to document a more ITER like shape at up to 3.5 MA with high input power. Here we will focus on measuring the Edge Localised Modes (ELMs) and pedestal, testing the confinement, plus exploring and maintaining the stability. A strongly integrated programme with the physics task forces has been planned to jointly take forward and solve all the issues for this scenario.
• ELM amelioration is essential for developing the ITER Q=10 operation. Here passive techniques include development of regimes with benign ELMs (Grassy and type II) and good confinement. Active techniques such as impurity injection and vertical position oscillations will be assessed. But we must also work to extend the type III regime as a better fall back for ITER. The priority is to demonstrate the use of these techniques in main scenarios and extend application to others.
• A major increase in work on the Hybrid scenario is planned to qualify this as a high fusion gain long pulse regime for ITER. Work will focus first on documenting the limits (beta, density), confinement and transport, comparing with baseline scenarios and pushing to ITER relevant parameters (high shape, low edge safety factor q95). Further studies will integrate with Task Force S2 to explore the role of current profile and long pulse operation.

Complementary to this, collaborations on physics aspects such as transport, pedestal, stability, and burn control with the other task forces are planned particularly to validate the scenarios for the future W/Be JET wall project (see JET Bulletin, June edition).

Task Force S2 - Advanced Scenario
Xavier Litaudon, Clive Challis and Flavio Crisanti

Improvement of the tokamak concept in terms of high confinement and stability without the need for large plasma current is a crucial challenge that could finally lead to the operation of future devices in continuous mode. The long term scientific objective of the Task Force S2 activity is to develop ITER relevant regimes capable of purely non-inductive current drive operation with a large fraction of the plasma current self-generated by the neo-classical (pressure driven) ‘bootstrap’ effect. With this in mind, Task Force S2 has prepared a coherent scientific programme for 2006 in line with the priorities agreed by the Scientific and Technical Advisory Committee (STAC). To form and sustain reliable non-inductive scenarios as close as possible to ITER relevant non-dimensional parameters, Task Force S2 aims to develop and exploit advanced regimes on JET: (i) at ITER-relevant safety factor q and plasma shaping (high triangularity) taking advantage of the new divertor capabilities; (ii) at high values of pressure normalized to plasma current and magnetic field (beta) to investigate MHD stability limits and optimize the bootstrap current; (iii) where temperature and q-profiles are simultaneously controlled in real-time with advanced algorithms that include the two different time scales for heat and current diffusion; (iv) with edge conditions appropriate for future modifications to the plasma facing components (ITER-like wall project) and for ITER advanced regimes.

This is a very challenging task that requires the full heating, fuelling and current drive capability of the JET systems. But even this would be insufficient to simultaneously achieve fully non-inductive operation at high beta and high fusion performance. The approach, therefore, will be to address the various critical issues separately during 2006, with a view to full scenario integration when the future JET upgrades are complete.

Task Force M – MHD
Simon Pinches and Rudi Koslowski

Magnetohydrodynamic (MHD) stability issues continue to be at the forefront of performance development at JET. The principal limitations of the S1 and S2 target plasmas are due to various types of MHD instability. To address the most important issues facing S1 a focused programme has been formulated looking at Neoclassical Tearing Modes (NTMs, both 3/2 and 2/1) and their triggering by (fast particle stabilised) sawteeth. In addition to advancing the physics understanding, this work also includes the development of active avoidance and removal techniques. For the S2 scenario, the Resistive Wall Mode will be further studied to advance the physics understanding of this beta limiting phenomena and to provide diagnostic information on the proximity to instability. For both scenarios the MHD understanding of ELMs will be studied. Plasma disruptions and the generation and mitigation of runaway electrons will also form part of the focus of the programme. The newly installed enhanced halo sensors will provide important data on the toroidal and poloidal asymmetries of the halo currents that flow in the vessel walls as a result of a disruption. In parallel, the development of real-time neural networks promises to provide sufficient advanced warning of a coming disruption to allow time for mitigation steps to be taken, e.g. with the new disruption mitigation valve. The confinement of fast ions and the stability of fast ion driven modes is an area of importance for future ignited devices and one that will be addressed in the coming programme. Experiments will look at diagnosing the instabilities using new diagnostics techniques (e.g. reflectometry measurements) and measuring their stability with the new Toroidal Alfven Eigenmode (TAE) antenna system in both standard and advanced tokamak scenarios.
Task Force T – Transport  
Paola Mantica, Volker Naulin and Tuomas Tala

Task Force T activity during C15-C17 will continue to focus on the understanding of transport processes, with close comparison between experimental results and theoretical modelling. Electron transport studies will be extended to hybrid regimes and to a larger variety of Internal Transport Barrier (ITB) plasmas. Thanks to improved diagnostic resolution, the new topics of ion heat transport and momentum transport will be addressed with focussed experiments. Experimental assessment of momentum transport and its modelling are of special importance, as this is a major player in the process of ITB formation. The issue of density peaking due to turbulence generated pinches will be further investigated at ITER relevant collisionality, within the frame of an ITFA (International Tokamak Physics Activity) coordinated experiment. Also an extensive experimental characterization of impurity transport in various regimes for a wide range of impurity species is planned. More detailed experimental data on pedestal and ELMs will allow for comparison with available models of edge transport.

Task Force D – Diagnostics  
Andrea Murari, Elena De La Luna and Jerzy Brzozowski

One of the main aspects of the recent JET enhancements was a significant upgrade of JET diagnostic capability, to better support JET’s broad scientific programme in preparation for ITER. The main lines of development were the diagnostics for a burning plasma, a better characterisation of the profiles, particularly at the edge, and some advanced diagnostics, in particular of the field of fast instability and turbulence measurements. Since all the foreseen systems are due to be commissioned, in the next campaign we expect a very significant increase in the amount of data per shot. During the 2004 experimental campaigns, the maximum amount of data acquired per shot was about 2 Gbyte, while now 10 Gbyte or more are expected. Since the quality of the data should also improve, JET diagnostics should be able to provide a wealth of interesting information to support the scenario development and allow progress on the most advanced physical studies in Tokamak physics on the route to ITER.

Task Force E – Exhaust  
Richard Pitts, Wojtek Fundamenski and Volker Philipps

Task Force Exhaust has identified four main areas of investigation in the coming campaigns: (i) characterising ELM power exhaust in high triangularity ITER-like shaped plasmas, (ii) designing integrated scenarios with tolerable (Type-III) ELMs, obtained by increasing the radiative fraction with the help of nitrogen seeding, (iii) investigating plasma-wall interaction and the associated migration of first wall material, and (iv) mitigating the effect of disruptions by massive gas injection. The first two goals are made possible by the installation of the MkII-HD divertor, including a new array of divertor Langmuir probes, as well as the main chamber infra-red endoscope was advanced. The JET restart campaign is planned to start on 10 November 2005, the JET Restart is expected to continue in January 2006. The High Level Commissioning is planned to start on 6 February followed by the Experimental Campaigns C15-C17 from 20 February to 23 June 2006.

Task Force H – Heating  
Jef Ongena and Joëlle Mailloux

We all look forward to an exciting and challenging set of experiments for Task Force H in the coming campaigns. The technical emphasis this year is to deliver a maximum amount of Ion Cyclotron (IC) and Lower Hybrid (LH) wave power to ITER like plasmas in use by the other Task Forces. Several developments will help to reach this goal, but a new one is the availability of 3dB couplers for one of the IC antennae this campaign. Dedicated experiments to study IC and LH wave coupling issues relevant to ITER, including non-linear effects in the scrape-off layer and edge plasma during gas puffing near the antennas, are also planned. Feedback controlled phaseing of the waveguides of the LH system is another study topic and – if successful – promises to be very useful for all scenarios relying on the presence of non-inductive plasma currents. In addition to optimizing power delivery or current drive to the plasma, Task Force H plans a variety of experiments aimed at a better understanding of the physical mechanisms underlying the various heating methods. Highlights are (i) the study of the origin of plasma rotation in the presence of IC resonance heating, a puzzle waiting for a solution for a long time, (ii) on and off-axis heating by Neutral Beam Injection (NBI) in order to try to elucidate the discrepancy in NBI power deposition and current drive, first observed in ASDEX-Upgrade, and (iii) varying the position of the q=1 surface in real time with IC Current Drive using the newly developed extreme shape controller, to understand the role of fast particle populations in stabilizing/desstabilizing sawteeth and Neoclassical Tearing Modes.

Figure: infra-red image of the JET main vessel during X-point operation. Note the localised heating on the inner divertor baffle and the horizontal divertor plate. Courtesy of Ph. Andrew.
MSc in Nuclear Fusion and Engineering Physics

EFDA JET welcomes the introduction of the Joint European Master’s Degree in Nuclear Fusion Science and Engineering Physics in the framework of the EU Erasmus Mundus programme. The Joint Master course is offered by seven European universities from Belgium, France, Sweden, Spain and the deadline for applications for the next academic year is 27th January 2006. For details visit http://www.em-master-fusion.org/

Belgian Ambassador visits JET

Baron Thierry de Gruben, Belgian Ambassador to the UK, and his son Baron Christopher de Gruben visited the JET facilities on 22nd November. His Excellency was very pleased to have the opportunity to learn about JET and to meet the JET collaborators from the Belgian Association, including Task Force H Leader Dr. Jef Ongena. From left to right, bottom row: Dr. Jérôme Paméla, Baron Thierry de Gruben, Baron Christopher de Gruben, Dr. Jef Ongena; top row: Dr. Sebastien Huygen, Dr. Georges Bonheure, Dr. Jerry Maagdenberg, Dr. Mark Vrancken, Dr. Stefan Jachmich

Czech MEP V Remek visits JET

Vladimir Remek MEP visited the JET facilities on 20th October with Dr. Milan Řípa from IPP Prague. Mr Remek, who was the first non-US non-USSR astronaut in 1978, had an opportunity to watch one of the first restart plasma discharges in real-time (photo left). “This reminds me so much of my space mission”, he told us, “when I saw an Aurora Borealis which looks similarly beautiful – and not every astronaut has a chance to see it, either.”

Director of the School for ITER visits JET

Mr Jean-Pierre Hardy, the Director of the International School for ITER, visited the JET facilities on 21st November with Dr. Akko Maas, Assistant to the Project Leader for ITER Site Studies in Cadarache. Photo (right): Mr J-P Hardy with Mrs J Hay, the UKAEA Media Relations Manager.

Culham Cycle Ride

On 25th September 2005, almost exactly one year after the 2004 event, our group of 24 bicycles and 26 riders set on the road for another 50-mile sponsored cycle ride. This one will be remembered mostly for the exceptionally heavy rain – but spirits were not dampened and it was still a very enjoyable experience for a good cause: it raised more than £2450 for “The Abingdon Bridge” youth project.