EDRG

Overview

The consolidation of the validated suite of simulation tools that the ITM aims to provide for ITER and existing experiments requires a strong interaction with the experimentalists and diagnosticians fusion community. The former are promoted by the Experimentalist and Diagnosticians Resource Group (EDRG). Acting as a contact point within the ITM towards the full range of experiments and some of the EFDA Topical Groups and Working Group initiatives, the EDRG group promotes the provision of a machine independent approach to modelling, to encompass realistic operational conditions and to facilitate verification and validation of the modelling codes. The groups action comprises developing a comprehensive set of Machine descriptions and data mappings to access experimental databases, the coordination of the overall plasma control activities to be carried within the ITM-TF and in liaison with other EFDA initiatives and the development and integration of synthetic
diagnostic modules, covering as broad range of European fusion devices as possible

Project highlights and achievements

Progress on the machine descriptions (MD) and data mappings (DM) from Tore Supra, JET, ASDEX-Upgrade and FTU/FAST, compliant with datastructure versions 4.08a and/or 4.08b have been achieved. New settings for the line integrated signals were derived and adopted from 4.08a dataversion onwards, enabling the integration of interferometry for ASDEX-Upgrade. Heating and current drive elements were integrated for two devices: LH antenna for ToreSupra and NBI for JET. Both devices also cover magnetics, interferometry, polarimetry, MSE (ToreSupra adds the ECE coverage), allowing an extended validation of the equilibrium reconstruction codes, under testing for Tore Supra shots. Integration of ASDEX-Upgrade progressed with the delivery of the first data mapping file (4.07b/4.08b compatible) covering presently only magnetics and interferometry data. Accessing to the local dataserver requires authentication and ISIP is upgrading exp2ITM accordingly. One problem hampering the testing of the MD/DM + exp2ITM chain on ASDEX-Upgrade and other well integrated devices (FTU and MAST) relates to the handling by exp2ITM of missing data on the local database and on the ability to perform algebraic operations on the imported signals (e.g. coil currents in pfsystems CPO for ASDEX-Upgrade). All MD and DM files are stored on the Gforge repository. Draft CPOs for Langmuir probes and plasma facing components were produced and a test tool for the visualization of the content of the MD XML file produced. Table 1 summarises the present CPO coverage status in the machine descriptions for the participating devices. Among the new diagnostic CPOs introduced in 2010 (Ece, Thomson scattering and Charge Exchange), only ToreSupra provided data (Ece).

JET	ToreSupra	AsdexUpgrade	FTU/FAST	MAST	TCV
Pfsystems	Pfsystems	Pfsystems	Pfsystems	Pfsystems	none
Iron	Iron				
Vessel	Vessel	Vessel	Vessel	Vessel	
Limiter	Limiter	Limiter	Limiter	Limiter	
Toroidfield	Toroidfield	Toroidfield	Toroidfield	Toroidfield	
Magdiag	Magdiag	Magdiag	Magdiag	Magdiag	
MSEdiag	MSEdiag	MSEdiag		MSEdiag	
Interfdiag	Interfdiag	Interfdiag	Interfdiag	Interfdiag	
Polardiag	Polardiag				
	ECE				
NBI	LH antenna				

Table 1: Machine description status for the participating devices.

Gas-tight ASDEX-Upgrade 3D wall rasterization and defeaturing tests were carried out with the workbench derived from augddd (local software at IPP) and IDL/MATLAB smoothing/splining software tools. The resulting wall has been successfully exploited in test particle simulations with the ASCOT code (see Figure 1).

A preliminary roadmap for control schema integration in Kepler workflows was outlined in 2010 as a joint effort of all the projects (ISIP, EDRG, EFDA Feedback Control WG …) and people involved.

A synthetic diagnostic (spectral MSE) based on strict forward modelling has been implemented. Keeping with the requirement to validate the model to attain high confidence in the virtual instrument, the concept of Integrated Data Analysis has been applied making use of a common set of validated physics software modules applicable both for virtual instruments and data analysis thereby validating the modules.

Development and optimization of the 3D kernel of the erc3d package was carried out, including alternative algorithms and signal injection techniques and strategies for 3D kernel parallelization. Benchmarking of the various reflectometry codes that are used inside the ERCC was pursued. However, little progress was achieved in the interfacing of the code with the ITM specific datastructure (dedicated CPOs required is under discussion) and modules thus delaying the realization of the deliverables to mid 2011.

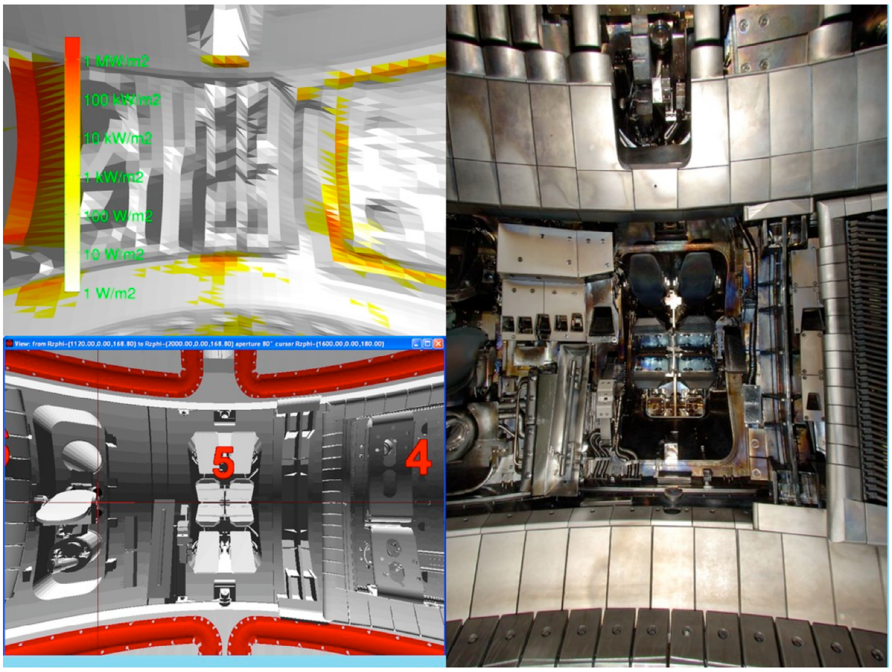

Figure 1 : ASCOT results of NBI wall loads and cold carbon ions testing using an ASDEX-Upgrade 3D-wall obtained from the STL rasterization and defeaturing toolset.

Task status

ACT1: Contact Person in fusion experiments

Coordination of the MD and DM activities engaged with good commitment from three of the participating devices (FTU/FAST, ToreSupra, AUG) and JET. Verification and Validation activities with experimental data is essentially limited to TS and JET data and equilibrium and linear MHD stability analysis chain (access to ASDEX-Upgrade to be available soon).

ACT2: Machine Descriptions and data mapping

Progress was achieved on ToreSupra, AUG, FTU and JET devices although some imbalances in machine descriptions and data mapping (MD&DM) completeness are still observed but attenuating. Tore Supra MD&DM for 4.08a have been installed in the public ITM database and in Gforge repository. Validation of ToreSupra version 4.08a is ongoing with EQUAL tests. Excellent progress on JET has been significant and JET MD&DM are now updated to 4.08b, include interfdiag/polardiag/mse settings and mappings and have been extended with NBI settings. Entries for 4.08a/b are stored on Gforge repository. Progress on ASDEX-Upgrade and FTU devices was achieved with interfdiag CPO added on ASDEX-Upgrade and a thorough revision for bug tracking on MD&DM for both ASDEX-Upgrade and FTU on dataversion 4.07b and subsequently on 4.08b. Data mapping of test shot 133354 of FTU has been delivered. Preliminary testing of the data mappings for FTU and ASDEX-Upgrade was initiated in close collaboration with ITM ISIP Core Programming Team (Support Action). MD data visualization tool from XML was produced and Langmuir probe and plasma facing component schemas were promoted.

ACT3: 3D Machine descriptions

Gas-tight ASDEX-Upgrade wall was imported, rasterized and defeatured with the workbench derived from augddd (local software at IPP) and IDL/MATLAB smoothing/splining software tools. The resulting wall has been successfully exploited in test particle simulations with the ASCOT code.

ACT4: Coordination of plasma control activities

Control coordination activities continued in 2010 providing an effective link between different ITM tasks related to control issues. Common issues were identified and possible solutions were agreed. Appropriate training on first test cases was provided in order to encourage both developers and possible users. A common view on an ITM roadmap for full control schema integration in Kepler workflows has been built taking into account many complementary points of view.

ACT5: Diagnostic related activities

A synthetic diagnostic (spectral MSE) based on strict forward modelling has been implemented. Keeping with the requirement to validate the model to attain high confidence in the virtual instrument, the concept of Integrated Data Analysis has been applied making use of a common set of validated physics software modules applicable both for virtual instruments and data analysis thereby validating the modules. Coordination of the activities of the ERCC (European Reflectometer Code Consortium) activities was ensured.

ACT6: 3D reflectometer modelling framework

The development and optimization of the erc3d code package was pursued. Alternative algorithms to the conventional Runge-Kutta (SE solver for the plasma current allowing full finite difference time domain implementations) kernels were investigated as well as alternative signal injection techniques adopting a Perfect Matching Layer approach. Strategies for 3D kernel parallelization were discussed and data communication identified as a probable bottleneck hindering a good scalability of the code. Parallelization has also been tested on a 2D code using both openMPI and openMP. While openMP is straightforward, MPI paralellization has required more work. Preliminary work has been done to incorporate C code in the Kepler interface. The benchmarking of the various reflectometry codes that are used inside the ERCC was pursued. They are geared towards the fundamental properties of simulations and feature a variety of scenarios that all codes are tested in. In 2010, first useful comparisons in some scenarios were done. Preliminary discussions regarding the dedicated CPOs to be developed to suit erc3d needs were carried out. This activity is delayed.

<table>
<tr><td colspan="3">Report for TA WP10-ITM-EDRG-ACT1</td></tr>
<tr><td>Reference:</td><td colspan="2">Task Force: ITM
Area:
Task: WP10-ITM-EDRG-ACT1-T1</td></tr>
<tr><td>Document:</td><td colspan="2">Contact Person in fusion experiments</td></tr>
<tr><td>Author(s):</td><td colspan="2">A. R. Coelho (IST)</td></tr>
<tr><td>Start/End dates:</td><td colspan="2">1st January – 31st December</td></tr>
<tr><td>Distribution list:</td><td>Project Leader: R. Coelho
Task Force Leader: G. Falchetto
CSU Responsible Officer: D. Kalupin</td><td>Contributors: (refer to Task Agreement)
<table>
<tr><td>ENEA</td><td>Onofrio Tudisco (0.08 ppy BS actually committed to task)</td></tr>
<tr><td>IPP</td><td>Hartmut Zohm (0.025 ppy BS actually committed to task)</td></tr>
<tr><td>CEA</td><td>Vincent Basiuk (0.08 ppy BS actually committed to task)</td></tr>
<tr><td>CCFE</td><td>David Muir (0.005 ppy BS actually committed to task)</td></tr>
<tr><td>CRPP</td><td>Olivier Sauter (0.01 ppy BS actually committed to task)</td></tr>
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<tr><td>Content:</td><td colspan="2">

a. Task description as given in Task Agreement (copy from table 4.1)

A local responsible officer from each of the participating major European experiments is envisaged. The called contact person will provide the liaison between the affiliated laboratory and the ITM and will be in charge of:
i) Coordinating the machine description (MD) and data mapping activities to be carried out in the affiliated laboratory by designated staff (see WP10-ITM-EDRG-ACT2,T3).
ii) Proposing verification and validation (V&V) activities to be carried on the experimental data of the affiliated laboratory, in collaboration with the relevant IMPs of ITM.
iii) Coordinate the development of ITM-TF tools within the Associations once workflows and tools are set for release.

b. Deliverables/Milestones as given in Task Agreement (table 4.1)

Report on V&V activities proposed and agreed to take place. Report on the progress made on the MD&DM. Report on the ITM-TF tools home development/integration.

c. Work description and outcome (results / particular highlights)

Coordination of the activities relating to machine descriptions and data mappings was provided where appropriate. Valuable contribution from IPP (AUG) allowed the net progress on the effort to integrate the AUG device. Coordination from ENEA (FTU/FAST) and CEA (ToreSupra) representatives was very effective in addressing emerging obstacles and providing validated MD and DM files. Contribution from JET representatives (dealt outside the Task Agreement) was very positive and in close coordination with contributor in ACT2-T1. Contribution from CRPP (TCV) and CCFE (MAST) was very marginal, the former since no MD has ever been provided and the latter since it anticipates progress in some exp2itm features (dealing with missing data). No official V&V activities were proposed although there is the prospect of carrying out EQUAL validation on Tore Supra.

d. Achievement of objectives / deliverables

Coordination of the MD and DM activities engaged with good commitment from 3 of the participating devices. Verification and Validation activities with experimental data is essentially limited to TS and JET data and equilibrium and linear MHD stability analysis chain (access to AUG to be available soon).

e. Outstanding issues

Lack of engagement from other devices.

f. Summary paragraph

Coordination of the MD and DM activities engaged with good commitment from three of the participating devices (FTU/FAST, TS, AUG) and JET. Verification and Validation activities with experimental data is essentially limited to TS and JET data and equilibrium

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Report for TA WP10-ITM-EDRG-ACT1

Reference:	Task Force: ITM Area: Task: **WP10-ITM-EDRG-ACT1-T1**
	and linear MHD stability analysis chain (access to AUG to be available soon). g. Publications
Revision No:	Changes:
Date:	17/01/2011

Association	Written by:	Revised by:	Approved by:
	R. Coelho	R. Coelho	R. Coelho

<table>
<tr><td colspan="3">Report for TA WP10-ITM-EDRG-ACT2</td></tr>
<tr><td>Reference:</td><td colspan="2">Task Force: ITM
Area:
Task: WP10-ITM-EDRG-ACT2-T1</td></tr>
<tr><td>Document:</td><td colspan="2">Machine Descriptions and data mapping</td></tr>
<tr><td>Author(s):</td><td colspan="2">A. R. Coelho (IST)</td></tr>
<tr><td>Start/End dates:</td><td colspan="2">1st January – 31st December</td></tr>
<tr><td>Distribution list:</td><td>Project Leader: R. Coelho
Task Force Leader: G. Falchetto
CSU Responsible Officer: D. Kalupin</td><td>Contributors: (refer to Task Agreement)
<table>
<tr><td>ENEA</td><td>Cesidio Cianfarani (0.10 ppy BS actually committed to task)
Giuseppe Calabro (0.05 ppy BS actually committed to task)
Edmondo Giovannozzi (0.05 ppy BS actually committed to task)
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<tr><td>CRPP</td><td>Andreas Pitzschke (0.005 ppy BS actually committed to task)</td></tr>
<tr><td>CCFE</td><td>David Muir (0 ppy BS actually committed to task)</td></tr>
<tr><td>IST</td><td>Rui Coelho (0.15 ppy BS actually committed to task)</td></tr>
<tr><td>CEA</td><td>Frederic Imbeaux (0.05 ppy BS actually committed to task)
Philippe Moreau (0.05 ppy BS actually committed to task)
Julien Hillairet (0.05 ppy BS actually committed to task)</td></tr>
<tr><td>IPP</td><td>Christoph Fuchs (0.05 ppy BS actually committed to task)</td></tr>
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<tr><td>Content:</td><td colspan="2">
a. Task description as given in Task Agreement (copy from table 4.1)
Machine descriptions (MD) and data mapping (DM) build the backbone of the ITM datastructure, enabling simulations on each device to be performed. Completion and revisions (if appropriate) of the machine description version 4.07a and coming developments, for all participating devices and new devices that haven't yet taken part, is asked for. Developments will include, among others, more complete antenna datastructure and other heating and current drive systems, 2D vessel qualifying for discontinuous elements, necessary adjustments to the pfsystems CPO and additional diagnostic CPOs to be developed (EDRG-ACT5).

b. Deliverables/Milestones as given in Task Agreement (table 4.1)
Provide validated MD file for current and future versions of the datastructure

c. Work description and outcome (results / particular highlights)
CEA has delivered Tore Supra MD&DM for data structure version 4.08a. These data have been installed in the public ITM database as machine description runs 4 and 5 and in Gforge repository under tags/4.08a. This includes:
a. Changes in geometry definitions for interferometer CPO
b. Correction of errors in magdiag CPO
c. Filling the Antennas CPO

ENEA generated a dedicated Data Base for FTU shot no. 133354 coherent with the MD&DM structures. The accessibility to this database via ITM calls has been tested successfully. The DM includes only magnetic and interferometric measurements, at the moment. The machine description was updated to 4.08b.

IPP provided a data mapping for 4.07b dataversion and provided valuable support on
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<tr><th colspan="2">Report for TA WP10-ITM-EDRG-ACT2</th></tr>
<tr><td>Reference:</td><td>Task Force: ITM
Area:
Task: WP10-ITM-EDRG-ACT2-T1</td></tr>
</table>

correcting bugs on the 4.07b MD&DM. A new setting for line integrated signals was required and requested to accommodate AUG diagnostic. This new settings became valid from 4.08a onwards. MD&DM upgraded to 4.08b.

Good progress was achieved in the JET MD&DM (courtesy of Christian Perez von Thun and diagnostic/H&CD experts). Interfdiag/Polardiag diagnostic settings were provided for 4.07b and upgraded to 4.08a and 4.08b. MSE data mapping was included for 4.08a/b and the MD entry upgraded for the new MSE settings. NBI CPO settings provided for 4.08b.

No progress on obtaining the Machine Description for TCV though some assistance was given on accessing experimental data. No further progress on MAST since exp2ITM is yet to cope with missing signals in local databases.

An IDL tool for the visualization of the MD files from the XML source was produced. XML schemas for a Langmuir probe diagnostic and 2D plasma facing structures using either 2D arrays or arrays of structures were produced.

d. Achievement of objectives / deliverables

Objectives achieved and delivered for version 4.08a of ToreSupra. FTU Machine description updated to 4.08b. Data mapping of shot 133354 of FTU has been delivered. Data mapping for AUG 4.07b received and upgraded to 4.08b as well as the machine description. JET is now updated to 4.08b, includes interfdiag/polardiag/mse settings and mappings and has been extended with NBI settings.

e. Outstanding issues

Further validation of 4.08a MD&DM will be done as Tore Supra data is exploited. Need to provide MD&DM for Tore Supra at 4.08b. Maintenance and support on the MD&DM of the FTU device. ECE and TS diagnostics are still missing in FTU MD&DM. Testing for 4.07b and 4.08b for FTU and AUG pending upgrade of exp2ITM (dealing with missing data and algebraic operations with imported signals). The present mapping for NBI is not compatible with JET (beam current fractions in separate entries vs single ppf). The MD&DM at 4.08b has not yet been validated.

f. Summary paragraph (to be copied to main project report section as the task summary!)

Good overall progress achieved on ToreSupra, AUG, FTU and JET devices although some imbalances in MD&DM completeness still observed but attenuating. Tore Supra MD&DM for 4.08a have been installed in the public ITM database as machine description runs 4 and 5 and in Gforge repository under tags/4.08a. Validation of ToreSupra version 4.08a is ongoing with EQUAL tests. Excellent progress on JET has been significant and JET MD&DM are now updated to 4.08b, include interfdiag/polardiag/mse settings and mappings and have been extended with NBI settings. Entries for 4.08a/b are stored on Gforge repository as RUN4/5 on /trunk. Good progress on AUG and FTU devices was achieved with interfdiag CPO added on AUG and a thorough revision for bug tracking on MD&DM for both AUG and FTU on dataversion 4.07b and subsequently on 4.08b (RUN 1 and 2 on the Gforge repository on /trunk). Data mapping of test shot 133354 of FTU has been delivered. Preliminary testing of the data mappings for FTU and AUG was initiated in close collaboration with ITM ISIP Core Programming Team (Support Action). MD data visualization tool from XML was produced and Langmuir probe and plasma facing component schemas were promoted.

g. Publications

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<tr><th colspan="4">Report for TA WP10-ITM-EDRG-ACT2</th></tr>
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<tr><td></td><td>R. Coelho</td><td>R. Coelho</td><td>R. Coelho</td></tr>
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<tr><td colspan="3">Report for TA WP10-ITM-EDRG-ACT3</td></tr>
<tr><td>Reference:</td><td colspan="2">Task Force: ITM
Area:
Task: WP10-ITM-EDRG-ACT3-T1</td></tr>
<tr><td>Document:</td><td colspan="2">3D Machine descriptions</td></tr>
<tr><td>Author(s):</td><td colspan="2">A. R. Coelho (IST)</td></tr>
<tr><td>Start/End dates:</td><td colspan="2">1st January – 31st December</td></tr>
<tr><td>Distribution list:</td><td>Project Leader: R. Coelho
Task Force Leader: G. Falchetto
CSU Responsible Officer: D. Kalupin</td><td>Contributors: (refer to Task Agreement)
<table><tr><td>IPP</td><td>Tilmann Lunt (0.1 ppy PS actually committed to task)</td></tr><tr><td>TEKES</td><td>Simppa Äkäslompolo (0.1 ppy PS actually committed to task)</td></tr></table></td></tr>
<tr><td>Content:</td><td colspan="2">
a. Task description as given in Task Agreement (copy from table 4.1)
Providing a full 3D description of a fusion device first wall is a major endeavour. The work to be carried out in this task should therefore follow the tentative breakdown:
a) Provision of a tool able to read a master CAD drawing and perform adjustable defeaturing on the output walls surface (STL format).
b) Report on acceptability of the defeatured surface mesh considering requirements of: MC codes, RWM codes, other.
c) Full scale mesh development for devices.
d) Adaptation of the 3D wall mesh to the GRID-CPO framework.

b. Deliverables/Milestones as given in Task Agreement (table 4.1)
Provision numerical tool for reading/defeaturing. First trial defeaturing reports reflecting on requirements. Defeatured meshes of pending type for some devices. Adapt mesh to GRID-CPO structure.

c. Work description and outcome (results / particular highlights)
Breakdown part:
1) A file format was defined, for storing the intermediate results of the rasterization and defeaturing. The rasterization is performed with a tool (augddd) that finds the first intersection of a ray with the machine geometry stored in the STL format. A MATLAB routine was implemented that reads the newly defined file format, defeatures the wall mesh with user definable intensity, and writes the output in the file format. Optionally, if additional parametrization information is given, the routine can also interpolate the wall data. Mathematically the routine uses C. Reinsch, "Smoothing by spline functions", Numer. Math. 10 (1967), 177–183.
2) Implemented a MATLAB routine that creates wall input file for the test-particle code ASCOT. The "3d-wall"-input for ASDEX Upgrade was defeatured and tested for NBI wall loads and cold carbon ions. Additionally, a routine that quickly produces sector-wise summaries of the ASCOT results which facilitate easy comparison of simulation results, photographs and the original STL data (figure shows an example.)
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Report for TA WP10-ITM-EDRG-ACT3

Reference:	Task Force: ITM Area: Task: **WP10-ITM-EDRG-ACT3-T1**

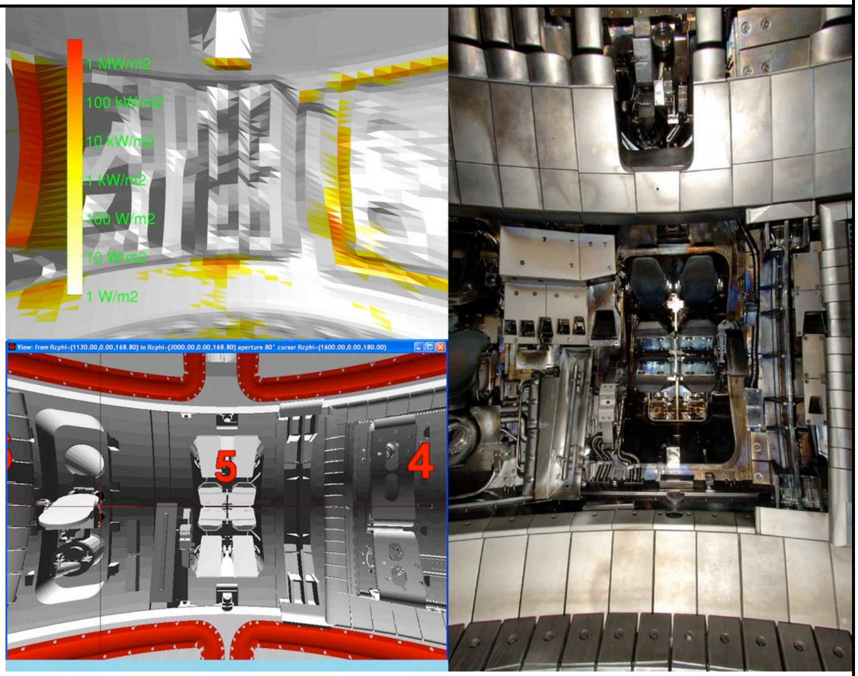

Figure 2 ASCOT results of NBI wall loads and cold carbon ions testing using an AUG 3D-wall obtained from the STL rasterization and defeaturing toolset.

d. Achievement of objectives / deliverables

Only the creation of a gas-tight AUG wall was attempted. The resulting wall has been successfully exploited in test particle simulations with the ASCOT code.

e. Outstanding issues

The automatic defeaturing software routine is written in MATLAB, which is not endorsed by ITM. No work on the CPOs took place (nor was planned to).

f. Summary paragraph

Gas-tight AUG wall was imported, rasterized and defeatured with the workbench derived from augddd (local software at IPP) and IDL/MATLAB smoothing/splining software tools. The resulting wall has been successfully exploited in test particle simulations with the ASCOT code.

g. Publications

The fast ion test was presented as a part of the speech by A. Snicker on T. Kurki-Suonio's behalf in ITPA 2010 Energetic Particles, Seoul. The carbon simulations will be presented in PFMC 13 by J. Miettunen et al.

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Date:	17/01/2011		
Association	Written by:	Revised by:	Approved by:
	R. Coelho	R. Coelho	R. Coelho

Report for TA WP10-ITM-EDRG-ACT4

Reference:	Task Force: ITM Area: Task: **WP10-ITM-EDRG-ACT4-T1**
Document:	Coordination of plasma control activities
Author(s):	A. R. Coelho (IST)
Start/End dates:	***1st January – 31st December***
Distribution list:	Project Leader: R. Coelho Task Force Leader: G. Falchetto CSU Responsible Officer: D. Kalupin Contributors: (refer to Task Agreement) RFX — **Tommaso Bolzonella** (0.33 ppy PS actually committed to task)

Content:

a. Task description as given in Task Agreement (copy from table 4.1)

An integrated suite of modelling tools targeting the simulation of a magnetically confined plasma discharge, in realistic free boundary equilibrium experimental conditions, requires the integration of plasma feedback control elements. Specifically, plasma position and shape feedback controllers and actuators as well as active magnetic feedback systems for MHD control are foreseen in the ITM platform. A control expert is therefore called to coordinate the activities related to control within the ITM:

- Feedback plasma position&shape control using Free-boundary equilibrium codes
- Extension to MHD plasma control
- SCICOS based Control toolbox deployment and integration of existing or newly developed control schemas based on Simulink.
- Paving layout for prospective PCS layout

Provide an external connection to other EFDA related control activities and coordinated the collaborative effort. Building on 2010 response from Associations on general information about feedback control schemes in use, plans for scheme integration in view of prototype KEPLER workflow development should be discussed.

b. Deliverables/Milestones as given in Task Agreement (table 4.1)

Preliminary roadmap for control schema integration. Preliminary Progress Report on overall IMP activities + external connection + WS/code camp. Final report + suggested roadmap for 2011.

c. Work description and outcome (results / particular highlights)

In 2010 the work relative to task WP10-ITM-EDRG-ACT4-T1 focussed mainly on the sharing of the main issues on control implementation in ITM tools that are spread in several projects/tasks and in the search for agreed solutions. A preliminary roadmap for control schema integration in Kepler workflows was a natural outcome of the 2010 work (see point d below).

This lead to the participation (partly remote) to all the meetings organized by the different projects and to the direct organization of a joint Control working session and Code camp in Cadarache, 28 June - 1 July.

The participation and the achievements of the Cadarache WS+CC were very positive and we believe provided the most important highlights related to the 2010 task. Ongoing activities related to control on the ITM-TF (at both project and task level) were discussed and training was provided with the first test cases of the Control Toolbox, for both SCICOS and SIMULINK born control diagrams. Simple PID cases were used for training purpose and evidenced the valuable ongoing effort. The timeline for fully integrating a free boundary equilibrium code under feedback shape control was defined. Improvements on the Kepler actor management methods, on Kepler director possible choices and on the automation of the actor creation from C code emanating from the SCICOS/SIMULINK diagrams were discussed. The working session was also the moment for keeping active the contacts already established with other EFDA TFs/TGs. The positive interaction with the Feedback Control WG was confirmed, while unfortunately we had less interest from other EFDA groups (that were in any case well informed on our activities).

The final discussion lead to the identification of critical areas of the different ITM tasks involved and an integration of possible solutions was found. Results presented at the 2010 ITM general meeting reflected the work directions as discussed in the Cadarache meeting.

d. Achievement of objectives / deliverables

Report for TA WP10-ITM-EDRG-ACT4

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<tr><td>Reference:</td><td colspan="3">Task Force: ITM
Area:
Task: WP10-ITM-EDRG-ACT4-T1</td></tr>
<tr><td></td><td colspan="3">A preliminary roadmap for control schema integration was outlined in 2010 as a joint effort of all the projects and people involved. This involves in particular the integration of ETS and free boundary codes with particular attention to closed loop issues. It was also highlighted that more sophisticated control tools should also be developed, both in Scicos and in Simulink, with the hope that an increasing part of them will reproduce the tools used in existing devices, implying also an increasing participation of Associations.
In view of realistic simulations, new modules should be able to provide input to control loops or to act as actuators and this calls for the development of synthetic diagnostics and of heating and current drive simulation tools. It would be very useful also to develop synthetic descriptions of actuators like active coils, very often used in MHD control and ELM mitigation techniques.
As additional deliverable a final summary of the Cadarache joint working session and Code camp (28 June - 1 July) has been provided.
e. Outstanding issues
The effective connection between all the different aspects involved in the implementation of control modules in a Kepler workflow remains a key point for future developments. If in 2010 the first test cases of control loop integration in free boundary evolution examples were presented, the implementation of more complex workflows including transport and/or heating and CD modules in closed loop still represent a very challenging objective. It has to be kept in mind that an effective simulation of discharge evolution that includes closed loops (e.g. feedback control of plasma current/shape, but also of density in presence of different particle sources or of profiles having NBI or wave launchers as actuators) needs that all the modules share the same “philosophy” in terms of time dependence and advancement. Already a very simple question such as the variable initialization proved to be potential problem. Mastering plasma evolution simulations could also involve a non trivial use of different Kepler directors in the overall workflow.
Another key issue for the future is the enlargement of the number of associations and EFDA TFs/TGs interested in using the tools already developed, but also in testing the control schemes already in use in the different existing devices. Some work has been already done on this subject, but more is expected for the future.
f. Summary paragraph (to be copied to main project report section as the task summary!)
Control coordination activities continued in 2010 providing an effective link between different ITM tasks related to control issues. Common issues were identified and possible solutions were agreed. Appropriate training on first test cases was provided in order to encourage both developers and possible users. A common view on an ITM roadmap for full control schema integration in Kepler workflows has been built taking into account many complementary points of view.
g. Publications</td></tr>
<tr><td>Revision No:</td><td colspan="3">Changes:</td></tr>
<tr><td>Date:</td><td colspan="3">17/01/2011</td></tr>
<tr><td>Association</td><td>Written by:</td><td>Revised by:</td><td>Approved by:</td></tr>
<tr><td></td><td>R. Coelho</td><td>R. Coelho</td><td>R. Coelho</td></tr>
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<tr><th colspan="3">Report for TA WP10-ITM-EDRG-ACT5</th></tr>
<tr><td>Reference:</td><td colspan="2">Task Force: ITM
Area:
Task: WP10-ITM-EDRG-ACT5-T1</td></tr>
<tr><td>Document:</td><td colspan="2">Diagnostic related activities</td></tr>
<tr><td>Author(s):</td><td colspan="2">A. R. Coelho (IST)</td></tr>
<tr><td>Start/End dates:</td><td colspan="2">1st January – 31st December</td></tr>
<tr><td>Distribution list:</td><td>Project Leader: R. Coelho
Task Force Leader: G. Falchetto
CSU Responsible Officer: D. Kalupin</td><td>Contributors: (refer to Task Agreement)<table><tr><td>IPP</td><td>Garrard Conway (0.1 ppy BS actually committed to task)
Rainer Fischer (0 ppy BS actually committed to task) *
Andreas Dinklage (0 ppy BS actually committed to task) *</td></tr></table>* work covered within WP10-DIA-05-01-03/IPP</td></tr>
<tr><td>Content:</td><td colspan="2">
a. Task description as given in Task Agreement (copy from table 4.1)
Extension of the present set of CPOs characterizing diagnostic data to provide the necessary coverage of coming V&V activities needs. In particular, Strike point, Bremsstrahlung, LIDAR, neutral particle analyser, X-ray and fusion product diagnostics are requested. In view of both the verification and validation of ITM-TF codes and preparing for real-time discharge evolution capabilities, the opportunity for the adaptation/integration on the ITM platform of the appropriate synthetic diagnostics will be explored.
b. Deliverables/Milestones as given in Task Agreement (table 4.1)
Develop datastructure for additional diagnostics. Code Inventory on Synthetic diagnostics developed at each Association. Adaptation/integration of synthetic diagnostic modules (except those pertaining to EDRG-ACT6) in the ITM platform.
c. Work description and outcome (results / particular highlights)
The collaboration with this task has been described in the report on task WP10-DIA-05-01-03/IPP. Referring to WP10-ITM-EDRG-ACT5, the use of CPOs has been discussed and assessed. Summarizing, the implementation of CPOs appears to be feasible. The software architecture (for WP10-DIA-05-01-03/IPP) considered CPO logics. Direct application, however, is left to developments after the ongoing refactoring efforts also accounting for the ITM requirement to avoid legacy software.
A synthetic diagnostic (spectral MSE) based on strict forward modelling has been implemented. Keeping with the requirement to validate the model to attain high confidence in the virtual instrument, the concept of Integrated Data Analysis has been applied making use of a common set of validated physics software modules applicable both for virtual instruments and data analysis thereby validating the modules.
The capability to employ the same software modules for analysis and forecasting became possible by a systematic modularization of the software. The implemented concept was to break-down the software structure according to a forward model chain consisting of different parts as they appear in a physical description of the measurement: the cause for the physics effect, the measure and the detection of the signal (see Figure 2). The modularization has been performed by creating data structures representing a stand-alone physical or mathematical entity. Functionalities have been assigned to act on these entities. This object-oriented approach results in interfaces which were found to be compatible with interfaces as used in the ITM projects (CPOs).
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Report for TA WP10-ITM-EDRG-ACT5

Reference:	Task Force: ITM Area: Task: **WP10-ITM-EDRG-ACT5-T1**

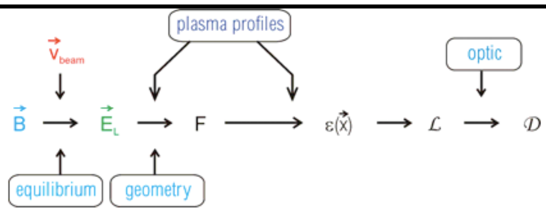

Figure 2 – Forward model schematics for the MSE diagnostic evidencing modular approach.

Discussions with ITM-EDRG posed the requirement to provide software modules written in a non-legacy programming language. Therefore, the prototype code is being transferred from a MATLAB implementation to FORTRAN90 (F90) modules. For rapid refactoring of the MATLAB code, the interfaces have been decided to be logically compliant with corresponding CPOs, but the detailed implementation is aligned to the specific requirements of this development. The resultant refactoring also allows the combination of different, existing forward modules. This is a prerequisite to follow-up an integrated diagnostic design in forthcoming work

G. Conway was Chairman of the ERCC (European Reflectometer Code Consortium) and provided overall coordination of the 2D reflectometer full-wave code benchmarking activities. Progress was reported at the ITM annual meeting.

d. Achievement of objectives / deliverables

CPO assessment has been made. The development has been communicated to the ITM general meeting. The deliverable of WP10-DIA-05-01-03/IPP has been fully attained. Coordination of the ERCC activities was ensured.

e. Outstanding issues

Regarding the synthetic MSE module, refactoring of the module in Fortran90 ongoing and dedicated manpower to port and integrate it not available/decided yet.

f. Summary paragraph

A synthetic diagnostic (spectral MSE) based on strict forward modelling has been implemented. Keeping with the requirement to validate the model to attain high confidence in the virtual instrument, the concept of Integrated Data Analysis has been applied making use of a common set of validated physics software modules applicable both for virtual instruments and data analysis thereby validating the modules. Coordination of the activities of the ERCC (European Reflectometer Code Consortium) activities was ensured.

g. Publications

Dinklage, R. Reimer, R. Wolf, M. Reich, Fusion Sci. Technol. ***59**, 410 (2011 – in press)*.

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Association	Written by:	Revised by:	Approved by:
	R. Coelho	R. Coelho	R. Coelho

Report for TA WP10-ITM-EDRG-ACT6	
Reference:	Task Force: ITM Area: Task: **WP10-ITM-EDRG-ACT6-T1**
Document:	3D reflectometer modelling framework
Author(s):	A. R. Coelho (IST)
Start/End dates:	***1st January – 31st December*** ***A delay is anticipated, foreseen new deadline : 31st May 2011***
Distribution list:	Project Leader: R. Coelho Task Force Leader: G. Falchetto CSU Responsible Officer: D. Kalupin

Contributors: (refer to Task Agreement)

IPP	**Carsten Lechte** (0.33 ppy PS actually committed to task)
IST	**Filipe Silva** (0.33 ppy PS actually committed to task)
CEA	**Sébastien HACQUIN** (0.1 ppy PS actually committed to task) **Stéphane HEURAUX** (0.15 ppy PS actually committed to task)
CIEMAT	**Emilio Blanco** (0.3 ppy PS actually committed to task) **Antonio Gomez** (0.1 ppy PS actually committed to task)
CCFE	**Antoine Sirinelli** (0.1 ppy PS actually committed to task)

Priority Support not yet accepted by the ITM-TF Leadership

Content:

a. Task description as given in Task Agreement (copy from table 4.1)

Building on what was achieved during 2009, the following activities are planned : optimization of the finite difference kernel; Parallelization of the kernel code module; Continuation of the parallel effort of developing alternative solvers and, where appropriate, their implementation in the code; Extension of the interface module to allow integration with ITM equilibrium codes; Implementation of "realistic" numerical turbulence models; General integration of the code into the ITM framework; Development of the complementary code suite and post-processor tool-box. In addition, a series of programmes will be undertaken, including: Extensive validation and verification of the code, including benchmarking activities; Simulation studies with ITER relevant geometries and parameters; Continue the programme of physics and fundamental issue studies.

b. Deliverables/Milestones as given in Task Agreement (table 4.1)

Optimization/Paralellization. Interface module to integrate ITM equilibrium. codes. General code Integration into the ITM. Code verification/validation and interfacing with turbulence models/spectra.

c. Work description and outcome (results / particular highlights)

Carsten Lechte (IPF/IPP): The design and implementation of a 3D reflectometer code and integration into EFDA-ITM frameworks is one of the main objectives of the ERCC group. The goal is to have a versatile, modular code that is at the state of the art in microwave propagation simulation. The skeleton code is implemented and porting to the gateway servers is foreseen to be complete in January 2011.

Integration into the ITM framework of CPOs has been more complicated than anticipated, but work along these lines is progressing. The attendance of an ITM working session at IPP Garching in July 2010 was used to clarify many issues concerning the CPOs.

The other main subject is the benchmarking of the various reflectometry codes that are used inside the ERCC. They are geared towards the fundamental properties of simulations and feature a variety of scenarios that all codes are tested in. In 2010, first useful comparisons in some scenarios were done, and also presented at the 2010 ITM-TF General Meeting in Lisbon, Portugal.

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Filipe Silva (IST) : Concerning the study of alternative algorithms to those traditionally used in reflectometry simulations of the X-mode, mainly Runge-Kutta, a 2D kernel using the Xu-Yuan JE solver has been tested. This proves faster than RK and more stable under a wider range of turbulence. For very low magnetic fields it shows a higher level of numerical noise.
On the signal injection techniques, work was done to evaluate the possibility of extending the use of Unidirectional Transparent Sources. The technique of UTS, as is, requires that both the emitting structure (waveguide/antenna) and the injected fundamental mode be aligned with the Cartesian mesh. An angular injection (e.g. for Doppler) involves the additional use of some means to diverge the emitted beam like a prism. This solution, however is restricted to small angles (<15º) and takes grid space (traduced in a larger time of calculation and use of memory). The use of an asymmetrical horn tapering was tested and successfully extends the injection angle up to 20º/25º taking with less grid space. However the injection beam becomes asymmetric. Also, the injection for higher angles is not possible. The ideal solution is the use of an antenna misaligned with the mesh points. With this solution, however, a all new set of problems not faced before, arises. The injection of the fundamental mode must be phase corrected in order to have a proper orientation and to eliminate spurious modes in the waveguide. This has been achieved. To major problem to be solved has to do with maintaining the UTS, a vital technique for signal decoupling. A complete new conception of the impulsive response used has to be implemented and work is being done to access the viability of such. So far the work has shown that instead of using the magnetic field as the correction field (as done presently), the electric field will have to be used.

Stéphane Heuraux and Sébastien Hacquin (CEA): In collaboration with Filipe Silva (IST), the UTS technique was optimized and extended to the case of oblique launching of the probing wave. The implementation in the 3D reflectometer code is under way.
During the benchmarking works a lot of questions have been asked and answered. A lot of exchanges have been done to define very precisely the set of cases we want to compare but in fact the case we are able to compare due to the intrinsic difference of the ERCC set of codes. Remember that the comparison concerns the algorithm used for the wave solver to choose the most efficiency one for the 3D synthetic reflectometry code to implement in ITM framework. This comparison reveals that the Perfect Matching Layer should be implemented in ERCC code and two possibilities of wave injection should be also implemented. One using the Huygens or equivalent method for basic Physics studies, and the other, the UTS to describe all the environment of the simulated reflectometer (surrounding walls, ….) and all kind of reflectometer (frequency sweep reflectometer, correlation reflectometer, Doppler reflectometer and so on). Other questions to answer deal with the outputs of the code that can be saved. There are different options and this point is underway to be fixed. This question is not simple and the answer depends of the user, part of them want raw data (only returned signal), other want different level of data processing each having is own tools to post-process the signals and the last group want just the results (density profile, fluctuation density profile, correlation length, wavenumber spectrum, …). These points show that the consistent physical object CPO is difficult to define and is the subject of lot of discussions and generate disagreements. We need to consult the potential user to finalize this CPO. A code camp meeting of 2 days in Garching was devoted to that. At the same time the 3D ERCC code is putting the ITM gateway and the encountered problems solve one after each other. For our contribution the generalized UTS including oblique wave injection is underway. A stay of 10 days of F. da Silva in Nancy and one week stay of S. Heuraux and S. Hacquin have permitted to precise the way to follow to implement that. Some ideas have been tested and give some possible way to reduce the spurious mode generation. One day visit at Stuttgart has permitted to look at a stable J-solver and a set of tests have been defined. The choice of J-solver is needed to adapt the UTS for this J-solver. Some work has to be done on this point. In conclusion the work to do is not only a simple implementation of the code on the ITM gateway and the definition of CPOs. These works corresponds to an agreement following results of a lot of exchanges and comparisons and in fact take more time than the expected one.

Emilio Blanco (CIEMAT):Existing full-wave codes are able to solve Maxwell equations in two

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dimensions (2D) with high accuracy and provide a guideline to develop more complex three dimensional (3D) full-wave codes. Unfortunately, the extension of 2D kernels to 3D is not straightforward as it involves a huge amount of computational resources and very large computational times. A rough estimation of computational resources in 3D shows that about 500 cores and 900GB of RAM memory are needed to simulate a small region of about 30 cm x 30cm x 30cm. Concerning the computational time a significant increase, more than one order of magnitude, is expected. The number of floating point operations increases about three orders of magnitude when compared with 2D simulations. Therefore, code parallelization and optimization are mandatory in 3D. During 2010 period the following activities have been performed:
a) 2D code parallelization studies and b) Development of a 3D simplified kernel to study parallel performance in 3D.

a) 2D code parallelization studies.

These studies provide useful information on parallel performance of 2D kernels and show the path for parallelization of the 3D kernel. Therefore, they must be considered as a first step towards code parallelization in 3D.
The basic approach consists of dividing the 2D computational domain into smaller sub-domains which are computed in parallel by different processors. Data communication between the processors is needed to evolve Maxwell equations in time; one communication per time step is needed. Such communication has been found to be the main limitation in the performance of 2D kernels. Numerical studies show a good scaling with the number of processors up to a very low number: only 4 processors. Above this value data communication between processors degrades the scalability of the code. This finding makes not very useful to spend a great amount of time optimizing the 2D code in such a way. However, it is expected that data communication will play no significant role up to a much higher number of processors in 3D. Preliminary estimations show that most of the time will be spent in computing the electromagnetic field within each sub-domain up to a relatively large number of processors (about 1000). Therefore, a good scalability of the code is expected.

In addition, a complementary parallelization has been identified and proposed to the ERCC: the so-called SPMD (Single-Program Multiple-Data) programming paradigm. Within the 2D benchmark activities of the ERCC it became clear that each turbulence realization must be performed independently from each other. Therefore, multiple turbulence realizations can be assigned to multiple processors using the same program. The main advantage of this approach is that a perfect scaling with the number of processors occurs since no communications are needed.

The proposed path for 3D kernel development is: optimization and parallelization for one turbulence realization and SPMD parallelization for multiple turbulence realizations.

b) Development of a 3D simplified parallel kernel.

Based on our experience with the activities mentioned above we started studies on how to extend the results to 3D. A 3D simplified kernel has been developed and optimized for this purpose during 2010. The kernel captures the essential algorithm's difficulties found in a complete 3D modeling but aspect like absorbing boundary conditions, launching and receiving antenna, plasma turbulence, etc. have been avoided. These aspects which are needed for a complete 3D modeling have no significant impact in the code parallelization stage. Presently, the kernel runs only on a single processor machine, i.e. no parallelization has been performed.

Antoine Sirinelli (CCFE):Parallelization has been tested on a 2D code using both openMPI and openMP. While openMP is straightforward, MPI parallelization has required more work. The test has been completed for the plasma grid. For 2D code, parallelization of the PML boundary was not necessary. It may be required for the 3D code. The performances obtained on a simple local cluster shows that some optimization is still needed (maybe due to the bad cluster latency). Preliminary work has been done to incorporate C code in the Kepler interface.

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<tr><td></td><td colspan="3">Dedicated C libraries are now callable from Java. Due to the lack of documentation of the ITM equilibriums, the interface between ITM CPO and C code is not yet completed.

d. Achievement of objectives / deliverables
Good progress on the fundamentals of the development and optimization of the 3D kernel, signal injection techniques and strategies for 3D kernel parallelization.
e. Outstanding issues
Not enough progress has been achieved on the interfacing with ITM equilibrium codes nor on the integration of any of the existing modules. Integration of the ITM CPOs has proven to be a complex issue, since the ERC3D code is written in C, while the ITM interface is available, amongst other languages, only in C++. This prompted for the incurred delay in the deliverables.
f. Summary paragraph
The development and optimization of the 3D kernel was pursued. Alternative algorithms to the conventional Runge-Kutta (SE solver for the plasma current allowing full finite difference time domain implementations) kernels were investigated as well as alternative signal injection techniques adopting a Perfect Matching Layer approach. Strategies for 3D kernel parallelization were discussed and data communication identified as a probable bottleneck hindering a good scalability of the code. Paralellization has also been tested on a 2D code using both openMPI and openMP. While openMP is straightforward, MPI paralellization has required more work. Preliminary work has been done to incorporate C code in the Kepler interface. The benchmarking of the various reflectometry codes that are used inside the ERCC was pursued. They are geared towards the fundamental properties of simulations and feature a variety of scenarios that all codes are tested in. In 2010, first useful comparisons in some scenarios were done. Preliminary discussions regarding the dedicated CPOs to be developed to suit erc3d needs were carried out.

g. Publications</td></tr>
<tr><td>Revision No: 0</td><td colspan="3">Changes: Preliminary report. Final report estimated by 31st May 2011</td></tr>
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<tr><td>Association</td><td>Written by:</td><td>Revised by:</td><td>Approved by:</td></tr>
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