EFDA Task Force
Integrated Tokamak Modelling
EUROPEAN FUSION DEVELOPMENT AGREEMENT

ITM

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Contents

1 Welcome to the Integrated Tokamak Modeling Task Force (ITM-TF)

1.1 The ITM-TF Mission

main mission of ITM-TF is to build a validated suite of simulation codes for ITER plasmas and to provide a software infrastructure framework for EU integrated modelling activities. In the short-term, the ITM-TF operates under a work plan aiming to offer a full simulation environment incorporating core-edge coupling and first-principles elements. The current work programme was formulated to support this goal, structuring the EU modelling effort around existing experiments and ITER scenario prediction while maintaining a long term strategic aim to provide a validated set of European modelling tools for ITER exploitation.

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last update: 2012-03-16 by coster

1.2 The European Integrated Modelling approach

The choice of Integrated Modelling made by the ITM-TF is unique and original: it entails the development of a comprehensive and completely generic tokamak simulator including both the physics and the machine which can be applied for any fusion device. The simulation platform is designed to be fully modular, flexible, and independent of a programming language. The choice of modularity implies that each module contains a single physical model and that the communication between the modules is standardised: a set of common rules (ontology) clearly specify the format of the data to be consistently exchanged between modules (data-structure). The complexity of coupling the codes together is therefore transferred to the definition of a generic data-structure (allowing to describe and exchange information concerning both physical quantities and technical objects, not assuming the origin of those), extensible to allow the integration of new physics, as well as more elaborate machine geometries and experimental data in the future. A central ITM-TF project is the development of the so-called European Transport Solver (ETS). aimed to meet all the ITM requirements, namely modularity, flexibility and standardized interfaces. In terms of the physics, the ETS is designed to solve the standard set of one-dimensional time dependent equations which describe the evolution of the core plasma. The solver itself is designed with a modular approach enabling the separation of the physics from the numerics, thereby facilitating the testing/usage of the numerical schemes that best suit a particular physical simulation.

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last update: 2011-04-19 by coster

1.3 ITM-TF Structure

ITM-TF is structured into four Integrated Modelling Projects (IMPs) focusing on the following physics areas:

- **IMP12** [1] plasma equilibrium and MHD
- **IMP3** [2] transport code and whole discharge evolution
- **IMP4** [3] transport and micro-instabilities
- **IMP5** [4] heating, current drive (H&CD) and fast particles

The "Infrastructure and Software Integration Project" (**ISIP** [5]) is in charge of developing, maintaining and operating the code platform structure and implementing the ITM data-structure. A key function of ISIP is to provide infrastructure support to the IMPs.

Two further projects ensure the link with the experimentalists and the provision of the experimental databases:

- **AMNS** [6] the "Atomic, Molecular, Nuclear Surface" Data
- **EDRG** [7] "Experimentalists and Diagnosticians Resource Group"

The "ITER Scenario Modelling Working Group" (**ISM** [8]) was established in 2007 as part of ITM-TF with the aim to assist in systematic predictive modelling of all ITER reference scenarios by using the major existing integrated modelling tools, whilst the ITM code platform was in development. ISM is also supporting the verification and validation of the ETS, which aims to become the main tool for EU modelling activity.

1.3.1 ITM

1.3.1.1 Public ITM pages

To access the public ITM pages [9], an ITM password is needed.

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last update: 2011-04-18 by gfalchet

1.3.2 AMNS

1.3.2.1 Scientific Rationale and Main Objectives

The ITM has a broad need for data relating to atomic, molecular, nuclear and surface data (AMNS). In particular, AMNS data are needed in several of the ITM modelling projects. A consistent approach, taking into account the specific requirements of the ITM while maintaining the work aligned with other European efforts in this area, is therefore required. As a consequence the AMNS tasks are implemented as Tasks under the TF leadership and has the following scope:

- Coordination of the work in the four different sub areas.

- Supply of data not presently residing in easily accessible data bases.

- Identify any Intellectual Property Rights (IPR) protection needs in view of a broader collaboration with ITER partners.

- Provide software for delivery of AMNS data to ITM-TF codes

1.3.2.2 Public AMNS pages

To access the public AMNS pages [10], an ITM password is needed.

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last update: 2011-03-25 by konz

[1] https://www.efda-itm.eu/WORLD/html/.html#imp12
[2] https://www.efda-itm.eu/WORLD/html/.html#imp3
[3] https://www.efda-itm.eu/WORLD/html/.html#imp4
[4] https://www.efda-itm.eu/WORLD/html/.html#imp5
[5] https://www.efda-itm.eu/WORLD/html/.html#isip
[6] https://www.efda-itm.eu/WORLD/html/.html#amns
[7] https://www.efda-itm.eu/WORLD/html/.html#edrg
[8] https://www.efda-itm.eu/WORLD/html/.html#ism
[9] https://www.efda-itm.eu/ITM/html/index.html
[10] https://www.efda-itm.eu/ITM/html/amns_public.html

1.3.3 EDRG

EDRG (EXPERIMENTALISTS AND DIAGNOSTICIANS RESOURCE GROUP) is one of the two projects falling under the coordination of the Leadership of the EU Task Force for Integrated Tokamak Modelling (ITM) and is the privileged contact of the ITM with the experimentalists and diagnosticians community.

1.3.3.1 Scientific Rationale and Main Objectives

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 [11] and validation [12] of the modelling codes.

The groups action comprises

1. Developing a comprehensive set of Machine descriptions [13] and experimental data mappings [14] to access experimental databases from european devices.

2. The coordination of the overall plasma control activities to be carried within the ITM-TF and in liaison with other EFDA initiatives.

3. The integration of synthetic diagnostic modules to assist Verification and Validation of ITM modules and virtual PCS.

1.3.3.2 Public EDRG pages

To access the public EDRG pages [15], an ITM password is needed.

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last update: 2011-03-25 by konz

1.3.4 ISIP

ISIP (Infrastructure Support Project) is in charge of the infrastructure (soft + hard) for the ITM:

- Code platform: framework, simulation editor, ...
- Data handling: data structure, data storage & access, ...
- Tools: version handling, portal [16] , ...
- Hardware: gateway [17] , GRID/HPC, ...
- Support to users...

1.3.4.1 Public ISIP pages

To access the public ISIP pages [18], an ITM password is needed.

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last update: 2011-03-25 by konz

[11] https://www.efda-itm.eu/WORLD/html/.html#g_verification
[12] https://www.efda-itm.eu/WORLD/html/.html#g_validation
[13] https://www.efda-itm.eu/WORLD/html/.html#g_machine_description
[14] https://www.efda-itm.eu/WORLD/html/.html#g_data_mapping
[15] https://www.efda-itm.eu/ITM/html/edrg_public.html
[16] https://www.efda-itm.eu/WORLD/html/.html#g_portal
[17] https://www.efda-itm.eu/WORLD/html/.html#g_gateway
[18] https://www.efda-itm.eu/ITM/html/isip_public.html

1.3.5 IMP12

1.3.5.1 IMP12 - Equilibrium, MHD, and Disruptions

1.3.5.1.1 Scientific Rationale and Main Objectives of the Task

The goal of the IMP12 activity is to provide the ITM-TF with a comprehensive set of **equilibrium, linear stability, and non-linear MHD modelling tools** as well as the tools for a consistent free boundary equilibrium evolution with application to the study of plasma disruptions. The project aims at providing ITER relevant modelling capabilities covering essential areas in an MHD simulation chain, starting from equilibrium reconstruction and free boundary evolution under feedback control via linear and non-linear MHD stability to non-linear MHD stability and plasma disruptions.

1.3.5.1.2 Scope and Long Term Perspective

The mature consolidation of a substantial part of the tools developped by IMP1 (equilibrium reconstruction and linear MHD stability) prompts for continued maintenance and integration.
Because of the synergy between equilibrium/linear stability and non-linear MHD modelling integration, IMP1 and IMP2 have been merged as off 2010.
Adopting a unifying strategy, the project therefore now consolidates the coverage of essential MHD numerical tools. Validation [19] of the *full chain of equilibrium reconstruction* and *linear stability* codes has started in 2009 and will proceed in collaboration with the MHD Topical Group, addressing relevant experimental scenarios (disruptive limits, edge stability limits,...). Collaborations with additional experiments is planned.
Extension of the equilibrium and linear stability codes as well as the data structures to include *plasma flow* and *3D effects* will consolidate the scope of the present tools.
Validation of the existing modules for modelling of a *free boundary equilibrium on experiments* and *integration with the ETS* , mediated by *feedback control schemes* , will enhance the whole device modelling capabilities of ITM tools.
Interfacing with *non-linear stability modules* dedicated to *sawtooth, NTM, ELMs, error fields* , and *beta limit pertinent modules* , such as the *RWM* will be facilitated.
Alongside such efforts, both *2D and 3D MHD non-linear stability modules* will be integrated in the platform, with privileged application to further development for *VDE/disruption* capability, including work towards a ”real time” disruption predictor for ideal MHD limits.

1.3.5.2 Public IMP12 pages

To access the public IMP12 pages [20], an ITM password is needed.

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last update: 2011-03-25 by konz

1.3.6 IMP3

1.3.6.1 IMP3 - Transport Code and Discharge Evolution

The Integrated Modelling Project #3 on ”Transport Code and Discharge Evolution” plays a central role in the Integrated Tokamak Modelling Task Force (ITM-TF): virtually all the other modelling projects will need information on the plasma state (densities, temperatures etc.) simulated by IMP3 modules; at the same time these modules require data from the other projects’ modelling codes, e.g. auxiliary heating deposition profiles. The ultimate goal of the IMP3 activity, and the ITM-TF in general, is whole device modelling, i.e. integrating modelling of all the essential processes relevant for a fusion plasma. Within IMP3 itself the major challenge is to integrate modelling of different transport processes and regions of a fusion device. For instance the core transport needs to be coupled to the edge transport, which in its turn must be integrated with models for the thermal properties of targets etc. Moreover, the developed transport code interfaces must be adapted to incorporate the data structures that provide the necessary information, e.g. sources and sinks, simulated by codes from the other IMPs. In fact, models of different complexity and scope are needed for the ITM-TF, ranging from 0D modelling for fast routine assessments of various scenarios to 2D-3D models that integrate all the relevant regions of a fusion plasma.

[19] https://www.efda-itm.eu/WORLD/html/.html#g_validation
[20] https://www.efda-itm.eu/ITM/html/imp12_public.html

1.3.6.2 Public IMP3 pages

To access the public IMP3 pages [21], an ITM password is needed.

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last update: 2011-03-25 by konz

1.3.7 IMP4

1.3.7.1 IMP4

The IMP4 web pages are here [22]

1.3.7.2 Scientific Rationale and Main Objectives

Please see above.

1.3.7.3 Public IMP4 pages

To access the public IMP4 pages [23], an ITM password is needed.

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last update: 2011-04-15 by bscott

1.3.8 IMP5

1.3.8.1 IMP5 - Heating, current drive and fast particles

The aim of the Integrated Modelling Project #5 on Heating, Current Drive and Fast Particles is to develop a package of codes for prediction [24] and interpretation of heating, current drive and fast particle effects. The areas to be covered include ECRH, ICRH, NBI, LH, alpha particles and fast particle interaction with instabilities. The ultimate goal is to enable self-consistent simulation of heating and current drive in the presence of fast particle instabilities, especially for ITER.

A self-consistent treatment of all possible heating scenarios is a very challenging problem with current modelling capabilities. Owing to the vastly different time scales for wave propagation and the evolution of distribution functions, simulations of heating and current drive can, in general, be obtained by combining codes solving the wave fields at time slices with codes evolving the distribution functions between the time slices. The goal is to have at least one module for each physics area at two levels: one basic and less detailed enabling fast computations, and one advanced, but computationally expensive, enabling detailed computations of the distribution functions of electrons and ions during heating and current drive, ultimately incorporating non-linear effects of instabilities and their redistribution fast ions.

In 2010, the work on adapting code modules to ITM requirements will be consolidated such that essential modules are available for providing the necessary input to the transport solver ETS (IMP3 [25]). The data structures relating to the physics of Heating & Current drive and fast particle physics will be improved further. New modules will be considered and adapted to the ITM standards. When more than one module of a certain type is available, work on cross verification [26] will start.

1.3.8.2 Public IMP5 pages

To access the public IMP5 pages [27], an ITM password is needed.

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last update: 2011-03-25 by konz

[21] https://www.efda-itm.eu/ITM/html/imp3_public.html
[22] http://www.rzg.mpg.de/~bds/cyclone/
[23] https://www.efda-itm.eu/ITM/html/imp4_public.html
[24] https://www.efda-itm.eu/WORLD/html/.html#g_prediction
[25] https://www.efda-itm.eu/WORLD/html/imp3_public.html
[26] https://www.efda-itm.eu/WORLD/html/.html#g_verification
[27] https://www.efda-itm.eu/ITM/html/imp5_public.html

1.3.9 ISM

ISM
under construction

1.3.9.1 Scientific Rationale and Main Objectives

under construction

1.3.9.2 Public ISM pages

To access the public ISM pages [28], an ITM password is needed.

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last update: 2011-03-25 by konz

1.3.10 EUFORIA

EUFORIA (EU Fusion fOR Iter Applications) is a project funded by European Union under the Seventh Framework Programme (FP7) which will provide a comprehensive framework and infrastructure for core and edge transport and turbulence simulation, linking grid and High Performance Computing (HPC), to the fusion modelling community.

1.3.10.1 Scientific Rationale and Main Objectives

The EUFORIA project will enhance the modelling capabilities for ITER sized plasmas through the adaptation, optimization and integration of a set of critical applications for edge and core transport modelling targeting different computing paradigms as needed (serial and parallel grid computing and HPC). Deployment of both a grid service and a High Performance Computing services are essential to the project. A novel aspect is the dynamic coupling and integration of codes and applications running on a set of heterogeneous platforms into a single coupled framework through a workflow engine a mechanism needed to provide the necessary level integration in the physics applications. This strongly enhances the integrated modelling capabilities of fusion plasmas and will at the same time provide new computing infrastructure and tools to the fusion community in general.

1.3.10.2 EUFORIA Resources

- The main EUFORIA Website [29]
- The EUFORIA Public Wiki [30]
- The EUFORIA Internal Wiki (password protected) [31]
- JRA3 (Workflows) Wiki [32]
- Support [33]
- The EUFORIA Wikipedia entry in English [34], Deutsch [35], Español [36], Français [37], Slovenian [38] and Suomi [39]

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[28] https://www.efda-itm.eu/ITM/html/ism_public.html
[29] http://www.euforia-project.eu/EUFORIA/
[30] http://wiki.euforia-project.eu/
[31] http://iwiki.euforia-project.eu/
[32] http://scilla.man.poznan.pl:8080/confluence
[33] https://support.euforia-project.eu/
[34] http://en.wikipedia.org/wiki/EUFORIA_project
[35] http://de.wikipedia.org/wiki/EUFORIA-Projekt
[36] http://es.wikipedia.org/wiki/Proyecto_EUFORIA
[37] http://fr.wikipedia.org/wiki/Projet_EUFORIA
[38] http://sl.wikipedia.org/wiki/Projekt_EUFORIA
[39] http://fi.wikipedia.org/wiki/EUFORIA-projekti

1.3.10.3 Public EUFORIA pages

To access the public EUFORIA pages [40], an ITM password is needed.

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last update: 2011-03-25 by konz

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last update: 2011-04-20 by coster

1.4 ITM-TF Achievements

During the first phase of the ITM-TF, surveys and cross-verification of the available European models and numerical codes were performed within the individual IMPs and the data-structure was extensively discussed and defined. Equilibrium, linear MHD stability, core transport and RF wave propagation, as well as the poloidal field systems and a few diagnostics were the first topics addressed. Data structures have been finalised for these and are being expanded to address, among others, non-linear MHD, edge physics, turbulence and neutral beam propagation. In parallel to the development of the physics concepts, ITM-TF has developed the tools to manipulate the data structure and use it in fully flexible and modular simulation workflows. The ITM-TF has now achieved the development of the first release version of a fully modular and versatile simulator with all the essential functionalities, which is ready to be used for the first physics applications. In 2010 the validation of the tools start: ITM database contains machine descriptions from JET, Tore Supra, MAST, FTU, FAST and AUG as well as some experimental data from Tore Supra and JET, modules from the different IMPs are available and are being integrated in the transport solver. The following years will see the validation of the simulator for a complete discharge on existing experimental data with the available modules, the integration of more quantitative physics models ("ab-initio") and the integration of the whole modelling of the device.

Some posters that describe the ITM were presented at an ITM EXPO at the 2011 EPS fusion conference in Strasbourg. Copies can be found here [41].

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last update: 2011-07-02 by coster

1.5 ITM-TF Contributors

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last update: 2011-04-19 by coster

2 Posters prepared for the 2011 EPS ITM Expo

- *ITM* [42]
- *ITM Code Camps* [43]
- *ISIP* [44]
- *ISIP + IMP12: Control* [45]
- *EDRG* [46]
- *AMNS* [47]
- *ISM* [48]
- *IMP12 Equilibrium and Stability* [49]
- *IMP3 Core* [50]

40 https://www.efda-itm.eu/ITM/html/euforia_public.html
41 https://www.efda-itm.eu/WORLD/html/.html#world_eps2011expo_posters
42 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/ITM_poster_EPS2011_n1.pdf
43 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/ITM_poster_CCs_n2.pdf
44 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/ISIP_poster_EPS2011_n3.pdf
45 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/ISIP_IMP12_Control_poster_EPS2011_n.pdf
46 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/EDRG_poster_EPS2011_n4.pdf
47 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/AMNS_EPS2011__n13.pdf
48 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/ISM_poster_EPS2011_n12.pdf
49 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/IMP12_EPS2011_equil+stab_n5.pdf
50 https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/IMP3-Core_EPS2011_n7.pdf

- *IMP3 Edge* [51]
- *IMP4* [52]
- *IMP5-I* [53]
- *IMP5-II* [54]
- *EUFORIA* [55]
- *MAPPER* [56]

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last update: 2011-07-02 by coster

3 ITM Overview Talks

3.1 2010

- Overview of the European Integrated Tokamak Modelling Task Force [57] (EU-US Workshop on Software Technologies for Integrated Modelling, Gothenburg, 2010-12-01 – 2010-12-03)

3.2 2009

- Fusion, EFDA, ITM and EUFORIA [58] Presented at the "Grids and e-Science 2009 Advanced Workshop on the future and sustainability of production Grids" (15-19 June 2009)
- Plasma Physics: Scientific and Computational Challenges: Fusion, EFDA, ITM and EUFORIA [59] Presented at "Grid Computing: a new tool for Science and Innovation - IX International Conference on Science, Arts and Culture - ECSAC, Losinj Croatia" (2009-08)
- Scientific Workflows in Fusion: EUFORIA & EFDA-TF-ITM [60] Presented at "ParCo2009, International Conference on Parallel Computing 1-4 September 2009, cole Normale Suprieure de Lyon, Lyon, France"

3.3 2008

- The European turbulence code cross-verification effort: turbulence driven by thermal gradients in magnetically confined plasmas [61]presented at EPS 2008 by G. Falchetto - on behalf of EFDA-TF-ITM-IMP#4

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last update: 2011-04-19 by coster

4 ITM Publications

4.1 Journals

1. D.P. Coster, V. Basiuk, G. Pereverzev, D. Kalupin, R. Stankiewicz, P. Huynh, F. Imbeaux, Members of the Integrated Modelling Project III of the EFDA Task Force on Integrated Tokamak Modelling and Members of the Task Force of Integrated Tokamak Modelling, The European Transport Solver submitted for publication in IEEE Transactions on Plasma Science.

[51] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/IMP3-Edge_EPS2011_n8.pdf
[52] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/IMP4_poster_EPS2011_n6.pdf
[53] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/IMP5_poster1_EPS2011_n9.pdf
[54] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/IMP5_poster2_EPS2011_n10.pdf
[55] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/EUFORIA_ITMEXPO_n14.pdf
[56] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_EXPO_EPS2011/MAPPER-Combined2_n15.pdf
[57] https://www.efda-itm.eu/WORLD/imports/world/public/ITM_Overview_GF.pdf
[58] https://www.efda-itm.eu/WORLD/imports/world/public/Santander_2009-06_Coster.pdf
[59] https://www.efda-itm.eu/WORLD/imports/world/public/Coster_ECSAC_2009-08v1.pdf
[60] https://www.efda-itm.eu/WORLD/imports/world/public/Coster_ParCo_2009-09v1.pdf
[61] https://www.efda-itm.eu/WORLD/imports/world/public/FalchettoEPS2008_I2.023.pdf

2. F. Imbeaux, J.B. Lister, G.T.A. Huysmans, W. Zwingmann, M. Airaj, L. Appel, V. Basiuk, D. Coster, L.-G. Eriksson, B. Guillerminet, D. Kalupin, C. Konz, G. Manduchi, M. Ottaviani, G. Pereverzev, Y. Peysson, O. Sauter, J. Signoret, P. Strand and ITM-TF work programme contributors "A generic data structure for integrated modelling of tokamak physics and subsystems". Computer Physics Communications, Volume 181, Issue 6, June 2010, Pages 987-998

3. D. Tskhakaya, A. Soba, R. Schneider, M. Borchardt, E. Yurtesen, J. Westerholm, PIC/MC code BIT1 for plasma simulations on HPC, accepted for publication at IEEE, 2010.

4. A. Cardinali et al., Minority heating by ICRH: a tool for investigating burning plasma physics in FAST, Nuclear Fusion, 49:095020, 2009.

5. I.M. Ivanova-Stanik, D. Kalupin, R. Stankiewicz, M. Tokar, R.Zagrski, Verification and Benchmarking of the Impurity Transport Solver, presented at ICNSP-2009 in Lisbon and submitted to IEEE Transactions on Plasma Science.

6. V. Kotov, D. Reiter, Plasma Phys. Control. Fusion, 51 (2009) 115002.

7. V. Kotov, D. Reiter, D.P .Coster and A.S. Kukushkin, 12th International Workshop on Plasma Edge Theory in Fusion Devices, September 2009, Rostov, Russia, Paper O3-03, to appear in Contributions to Plasma Physics

8. E.Lazzaro and S. Nowak, ECCD control of dynamics of asymmetric magnetic islands in a sheared flow, Plasma Phys. Control. Fusion 51 (2009) 035005

9. V. Parail, P. Belo, P. Boerner, X. Bonnin et al., Nuclear Fusion 49 (2009) 075030.

10. R. Stankiewicz, D. Coster, A. Figueiredo, D. Kalupin, G.Pereverzev, M. Tokar, D. Twarg, R.Zagrski, Verification of the European Transport Solver for Transport Barriers, presented at ICNSP-2009 in Lisbon and submitted to IEEE Transactions on Plasma Science.

11. Tokar et al: accepted for publication in Journal of Computational Physics

12. G. Vlad et al., Particle simulation of energetic particle driven Alfvn modes in NBI heated DIII-D experiments, Nuclear Fusion, 49:075024, 2009.

13. J. Zaleny et al., Mechanical analogy of the nonlinear dynamics of a driven unstable mode near marginal stability, Physics of Plasmas 16, 022110 (2009).

14. G.L. Falchetto, B.D. Scott, P. Angelino, A. Bottino, T. Dannert, V. Grandgirard, S. Janhunen, F. Jenko, S. Jolliet, A. Kendl, B.F. McMillan, V. Naulin, A.H. Nielsen, M. Ottaviani, A.G. Peeters, M.J. Pueschel, D. Reiser, T.T. Ribeiro and M. Romanelli "The European turbulence code benchmarking effort: Turbulence driven by thermal gradients in magnetically confined plasmas". Plasma Phys. Control. Fusion 50, 124015 (2008).

4.2 Conference Papers

1. D. Tskhakaya, S. Jachmich and JET-EFDA Contributors, Interpratation of divertor Langmuir probe measurements during the ELMs at JET, abstract submitted to PSI conference, San Diego 2010.

2. New Information Processing Methods for Control in Fusion - A. Murari, J. Vega, D. Mazon, G.A. Ratt, J. Svensson, G. Vagliasindi, J. Blum, C. Boulbe, B. Faugeras and JET EFDA contributors - Proceedings of the 7th Technical Meeting on Control, Data Acquisition and Remote Participation for Fusion Research Aix-en-Provence France 2009

3. Development of a 2D full-wave JE-FDTD Maxwell X-mode code for reflectometry simulation, F. da Silva, S. Heuraux, T. Ribeiro, B. Scott, Proc. 9th Intl. Reflectometry Workshop - IRW9 (Lisboa, May 2009), IPFN Report (nr), URL: http://www.ipfn.ist.utl.pt/irw9/proceedings.html

4. C.V. Atanasiu, A. Moraru, L.E. Zakharov, Response of a resistive wall with holes to an external kink mode in a tokamak, 21st International Conference on Numerical Simulation of Plasmas, Lisbon, Portugal, 6-9 October 2009.

5. C.V. Atanasiu, A. Moraru, L.E. Zakharov, Influence of a Nonuniform Resistive Wall on the RWM Stability in a Tokamak, American Physical Society Plasma Meeting, Atlanta, USA, 2-6 November 2009.

6. A. Cardinali et al., Minority heating by ICRH: a tool for investigating burning plasma physics in FAST. In RADIO FREQUENCY POWER IN PLASMAS: Proceedings of the 18th Topical Conference. Gent (Belgium), 2426 June 2009, AIP Conference Proceedings 1187, pages 101104, 2009

7. B.Guillerminet et al, High Performance Computing tools for the Integrated Tokamak Modelling project, IAEA TM 2009 on Control, Data Acquisition and Remote Participation, Aix-en-Provence, France, June 2009, submitted to Fusion Engineering and Design

8. G.M.D. Hogeweij et al, EPS, 35th Conf on Plasma Physics , Hersonissos, Crete, Greece;

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5 Glossary

Collaborative Development Environment (CDE)

A **collaborative development environment (CDE)** is an online meeting space where a software development project's stakeholders can work together, no matter what timezone or region they are in, to discuss, document, and produce project deliverables. The name was coined by Grady Booch [62].

Consistent Physical Object (CPO)

A Consistent Physical Object (CPO) is a physics based, hierarchical data structure employed by the ITM-TF for a complete description of a physics area, e.g. `equilibrium` . All ITM-TF code modules interact through the exchange of CPOs. The CPOs also form the basic block of data written to the ITM database.

Content Management System (CMS)

A **content management system (CMS)** is the collection of procedures used to manage work flow in a collaborative environment. These procedures can be manual or computer-based. The procedures are designed to:

- Allow for a large number of people to contribute to and share stored data
- Control access to data, based on user roles. User roles define what information each user can view or edit
- Aid in easy storage and retrieval of data
- Reduce repetitive duplicate input
- Improve the ease of report writing
- Improve communication between users

In a CMS, data can be defined as nearly anything - documents, movies, pictures, phone numbers, scientific data, etc. CMSs are frequently used for storing, controlling, revising, semantically enriching, and publishing documentation.

FC2K

FC2K is a tool for wrapping a Fortran or C++ source code into a Kepler actor. Before using it, your physics code should be ITM-compliant (i.e. use CPOs as input/output).

Gforge

Gforge [63] hosts all projects (software and infrastructure) under the ITM-TF.

ITM Gateway

The ITM Gateway is a compute cluster located at Portici (near Napoli in Italy). It is uses for development and fusion simulations in the ITM-TF.

ITM Portal

The ITM Portal [64] is the web portal for the ITM-TF, i.e. it hosts the ITM-TF web pages and projects under Gforge.

Integrated Simulation Editor (ISE)

The Integrated Simulation Editor ISE allows you to visualize and edit data from an ITM database entry. It also allows running a Kepler workflow based on the opened data entry.

Universal Access Layer (UAL)

The UAL (Universal Access Layer) is a multi-language library that allows exchanging Consistent Physical Objects (CPOs) between various modules, and to write to an ITM database.

actor

[62] http://en.wikipedia.org/wiki/Grady_Booch
[63] https://gforge.efda-itm.eu
[64] https://portal.efda-itm.eu

Actors take execution instructions from a director. In other words, actors specify *what* processing occurs while the director specifies *when* it occurs.
In the ITM-TF, actors are usually modules which contain physics codes like `EQUAL` or `HELENA`.

calibration

The process of adjusting numerical or physical modelling parameters in the computational model for the purpose of improving agreement with experimental data.

data mapping

An XML file containing all the mapping essentials for mapping from a local experimental database for a specific tokamak device to the ITM database. The mapping essentials include for instance the download method, local signal names, gains and offsets, time base, and eventual interpolation option to ensure that only one time base is set for each CPO that is built from multiple local signals. A java code (exp2ITM developed under ISIP), with the MD and DM files as inputs, is then run to connect to the local device database, retrieve the required experimental data and populate the ITM database instance for that shot/device and dataversion.

director

A director controls (or directs) the execution of a workflow, just as a film director oversees a cast and crew.

error

A recognisable deficiency in any phase or activity of modelling and simulation that is not due to lack of knowledge.

kepler

Kepler is a software application for the analysis and modeling of scientific data. Kepler simplifies the effort required to create executable models by using a visual representation of these processes. These representations, or ”scientific workflows”, display the flow of data among discrete analysis and modeling components.

machine description

The machine description (MD) of a device basically builds on the set of engineering and diagnostic settings characterising a tokamak device. This includes, for instance, the vessel/limiter description, the PF coils and circuiting and lines of sight of diagnostics. In practice, all MD information is encapsulated in an XML file that emanates from the MD tagged datastructure schemas. An MD instance of a given device is then stored into the ITM database as shot 0 for that device database.

model

A representation of a physical system or process intended to enhance our ability to understand, predict, or control its behaviour.

- A **conceptual model** consists of the observations, mathematical modelling data, and mathematical (e.g., partial differential) equations that describe the physical system. It will also include initial and boundary conditions.
- The **computational model** is the computer program or code that implements the conceptual model. It includes the algorithms and iterative strategies. Parameters for the computational model include the number of grid points, algorithm inputs, and similar parameters, etc.

modelling

The process of construction or modification of a model

prediction

Use of a model to foretell the state of a physical system under conditions for which the model has not been validated.

simulation

The exercise or use of a model.

uncertainty

A potential deficiency in any phase or activity of the modelling process that is due to the lack of knowledge.

validation

The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.

verification

The process of determining that a model implementation accurately represents the developer's conceptual description of the model and the solution to the model.

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6 Links to related external projects

- EUFORIA Project [65]
- MAPPER Project [66]
- EFDA High Level Support Team (HLST) [67]
- EFDA Goal Oriented Training in Theory (GOTiT) [68]

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last update: 2011-04-19 by coster

[65] http://www.euforia-project.eu/
[66] http://www.mapper-project.eu/
[67] http://www.efda-hlst.eu/
[68] http://solps-mdsplus.aug.ipp.mpg.de/GOTiT/