

Integrated Modelling & Analysis Suite: Developments to Address ITER Needs

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The Integrated Modelling & Analysis Suite (IMAS) is the software infrastructure that is being developed building upon the modelling expertise from across the research facilities within the ITER Members to support the execution of the ITER Research Plan 1. It is built around a standardised representation of data described by a Data Dictionary that is both machine independent and extensible. Machine independence is important since it allows tools and workflows developed in IMAS to be tested and refined on existing devices, whilst extensibility allows the Data Dictionary to grow and evolve over time as more Use Cases are addressed. The use of standardised Interface Data Structures (IDSs) fosters the creation of modular physics components and (sub-)workflows that can be flexibly re-used to address different needs.

One of the focal points driving development within IMAS is the creation of a high-fidelity plasma simulator that can be used to predict ITER plasma performance. The DINA code [2,3] has been extensively used to validate the capability of the ITER poloidal field system to support the plasma scenarios foreseen in the ITER Research Plan. It includes a free-boundary equilibrium evolution solver implementing feedback control of the plasma current, position and shape, taking into account eddy currents in the vacuum vessel, as well as numerous engineering limits imposed on the coils, their power supplies, and plasma-wall gaps. The JINTRAC code [4] refines the physics description in the plasma core and also couples its behaviour with that in the plasma edge. It can describe plasma heating, fuelling and transient behaviour.

Both the DINA and JINTRAC codes have been adapted to use the IMAS Data Model [5], and are now being further modularised to allow exchanging IDSs with additional external physics modules to enable the incorporation of other higher-fidelity physics models.

One such high-fidelity physics workflow that has been developed over the last year by a combination of ITER Staff, ITER internships, ITER Scientist Fellows and voluntary contributions, is a comprehensive heating and current drive (HCD) workflow that is capable of describing all of the ITER heating systems as well as synergistic effects between them [6]. This workflow exemplifies the IMAS integrated modelling paradigm and has driven further refinements in the IMAS infrastructure. The workflow builds upon the extensive work carried out within the EUROfusion Work Package for Code Development (WPCD). Whilst IMAS is independent of any particular choice of workflow engine, this HCD workflow has been implemented in Python to facilitate distributed development and portability.

The IDS-based database of ITER scenario simulations is continuously expanding and is used to support ITER design activities including assessments of the ITER heating systems and diagnostics. Recent additions include the set of SOLPS4.3 simulations of ITER edge conditions and JINTRAC simulations of ITER L [7] and H-mode [8] conditions.

In preparation for the Live Display of information during ITER operations, work has started on the creation of displays using the scenario information contained within the ITER scenario database together with synthetic diagnostics. Figure 1 shows a still frame of an evolving Live Display derived from data calculated with the METIS [9] and SOLPS-ITER [10] physics codes.

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Development is also underway on a workflow to assess the energetic particle stability of IDS-based plasma scenarios on computational timescales that enable relatively extensive studies to be performed and for it to be embedded within other workflows. The workflow is based upon the LIGKA [11] and HAGIS [12] physics codes and is being validated against other results and predictions for ASDEX Upgrade and JT-60SA [13].

In preparation for ITER operations, work has started on the development of experimental data processing and analysis pipelines. These are essential since in contrast to existing machines upon which they can be tested, on ITER they will form the only way to process raw experimental data for subsequent processing, analysis and interpretation. A key element of this activity to allow testing is dynamic access to existing experimental data in the form of IDSs. This has been enabled by the creation of local plug-ins that handle the reading and mapping of experimental data into IDSs such as have been created by EUROfusion WPCD for the EU MST1 and JET devices, and Korea for KSTAR [14]. The above dynamically mapped data has been used as input in the form of IDSs to the European Transport Simulator (ETS) for modelling JET and KSTAR scenarios [15].

The (typically static) Machine Description metadata, which is also included in IDs and enables the creation of device-generic workflows, must also be locally curated. At ITER, a separate Machine Description database has been set up and integrated into the Universal Data Access (UDA) data server architecture.

The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

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