# 3D tokamak Wall description within ITER Integrated Modelling and Analysis (IMAS) framework

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## Introduction

A set of SALOME platform [1] utilities have been developed for the purposes of data storage and access of the ITER fusion device 3D wall grid geometry within the Integrated Modelling Analysis Suite (IMAS) [2,3]. IMAS provides a framework for the the computation of numerous fusion codes and is based on an underlying Physics Data Model (PDM) that allows the coupling of codes via standardized data structures, named IDS (Interface Data Structures) [4] which provide standardized data archival and retrieval together with easier data sharing and distribution. Presently there is an ongoing effort to establish IMAS and its IDS databases as the only relevant framework for all ITER parties, including the EUROfusion Consortium and its members.

The IDSs contain a wide amount of physical quantities and machine systems data such as plasma equilibrium, heating and fueling sources, and a full description of the plasma state, including the electron temperature, ion temperature, electron density, ion density, etc. As the IDS can also contain grid geometry, the 3D wall grid geometry data is being stored with the use of the newly developed utilities to the IMAS IDS. The data can then be accessed and further processed in many post-process simulations and calculations. Besides, IMAS allows remote access to the IDS structures through universal data access (UDA) subsystem from federated servers available. This can bring provenance to the desktop users running such framework of codes with possibility to compute complex problems remotely on compute clusters.

To the modellers purposes, the main objective of the "IMAS 3D wall" SALOME platform utilities is to facilitate the access and usage of ITER 3D wall, stored within the IDS, together with ITER grid geometry model by numerical codes, for modelling applications that can span Resistive Wall Mode (RWM) models [5] e.g. the CarMa code [6–8] or halo-currents modelling codes, or else for other fusion devices. The done work that is presented in this paper relates specifically to the CarMa code input 3D wall mesh files written in the PATRAN file format [9].

*See http://www.euro-fusionscipub.org/eu-im

**Developed SALOME utilities**

All developed utilities are embedded within the SALOME platform as additional tools. They provide the means to extract the SALOME mesh object grid geometry and write it to the IDS and vice-versa, as shown in Fig. 1. In addition, tools for conversion between the SALOME mesh object and PATRAN file format were developed too, as the CarMa code uses PATRAN format for describing the 3D wall mesh.



Figure 1: Workflow from mesh file format to IDS.

The developed tools are:

- **SMESH2IDS**, a tool that extracts grid geometry description from the SALOME mesh object and stores it to the Wall IDS, specifically to the GGD (General Grid Description) IDS structure, within the IDS datatree structure.

- **IDS2SMESH**, a tool to read the grid geometry from the Wall IDS GGD structure and use it to construct the SALOME mesh object.

- **PATRAN2SMESH**, a tool to generate a SALOME mesh object out from the selected file containing grid geometry description in PATRAN format. CarMa code takes such mesh file as an input for further calculation.

- **SMESH2PATRAN**, a tool to export the SALOME mesh object grid description to a PATRAN file.

**Tools usage and results**

The procedure to transform the ITER tokamak 3D wall grid geometry that is being stored in a PATRAN or any other mesh file format to IDS would be to first import the mesh to the SALOME and creating the SALOME mesh object from it. In the SALOME interface the newly created mesh can be viewed or further modified by the user if needed. Then by running the **SMESH2IDS** tool on the new mesh object its 3D wall
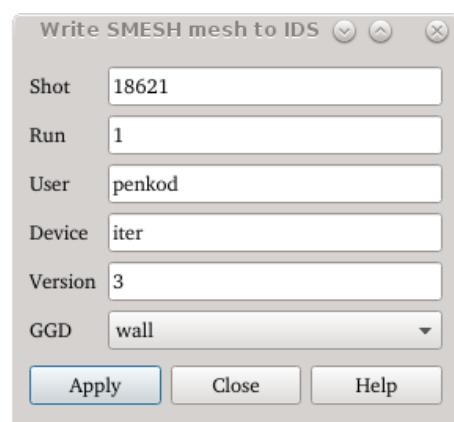


Figure 2: **SMESH2IDS** GUI window.

grid geometry is stored to the specified IDS by setting the parameters of the IDS, to which the grid is to be stored, in the **SMESH2IDS** GUI, as shown in Fig. 2.

The data stored within the IDS can then be exported back to SALOME with the use of the **IDS2SMESH** tool, again generating the SALOME mesh object. Then the mesh can be transformed back to either PATRAN file format with the use of the **SMESH2PATRAN** tool or exported to any other SALOME supported file format such as DAT, STL, MED etc. In Fig. 3 are presented simplified hexahedral and low-detailed triangular surface mesh of a single ITER tokamak 3D wall segment model. The simplified mesh was obtained by extracting the grid from the CarMa input PATRAN file using **PATRAN2SMESH**. Both meshes can be written to the Wall IDS with the **SMESH2IDS** tool. A simplified vessel mesh prepared for writing to the wall IDS is shown in Fig. 4.



(a)                                                                 (b)
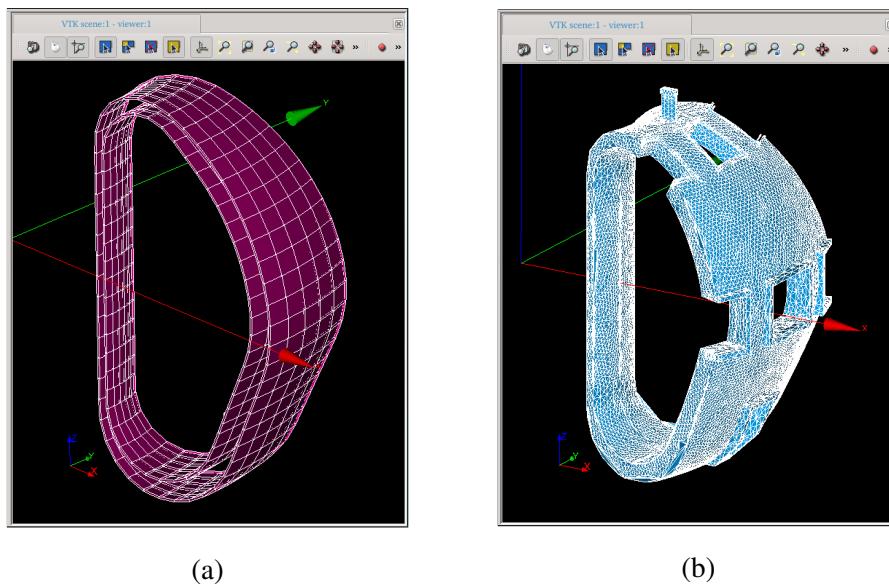
Figure 3: Representation of a simplified hexahedral (a) and low-detailed triangular surface (b) mesh of a single ITER tokamak 3D wall segment model.
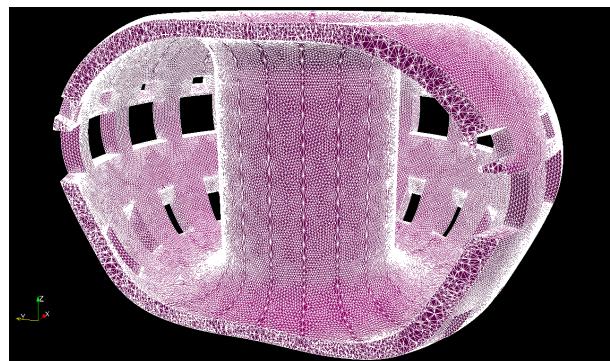


Figure 4: Mesh of a low feature vessel.

## Conclusion

The presented additions contribute to the overall usability and compatibility of IMAS with other plasma codes and provide a convenient way of storing the tokamak 3D wall grid geometry to IDS. Furthermore, the IDSs GGD structure proved as a valuable asset as its structure allows storage of any grid geometry mesh of any type. By taking that into consideration, the new provided tools have the potential to be further improved to a stage that they allow storage of any grid geometry such as vacuum vessel and other structures to any corresponding IDS if required, as many of the IDSs contain the GGD structure.

IMAS included in the SALOME framework allows us to run different codes in a coupled mode though IDS structures. The final aim is to implement within the IMAS framework a workflow for the study of the stability of RWM, starting with CHEASE equilibrium code and including self-consistent coupling between the linear MHD model solved by the MARS-F code [10] and the 3-D eddy current integral formulation of the CARIDDI code [11], which give rise to the CarMa code.

## Acknowledgement

## References

[1]  Official SALOME Website, `http://salome-platform.org/`

[2]  F. Imbeaux et al., Nuclear Fusion 55 (12), 123006, (2015)

[3]  S. Pinches, 44th EPS Conference on Plasma Physics P4.155, Europhysics Conference Abstracts Vol. 41F ISBN: 979-10-96389-07 (2017)

[4]  IDS Data Dictionary, `https://git.iter.org/projects/IMAS/repos/data-dictionary`

[5]  F. Villone , Y. Q. Liu, G. Ambrosino, A. Pironti, Theory of fusion plasmas, Varenna, (2008)

[6]  Villone F. et al., Phys. Rev. Lett., 100 255005 (2008)

[7]  Villone F. et al., Nucl. Fusion, 50 125011 (2010)

[8]  Portone, F. Villone, Y. Q. Liu, R. Albanese, G. Rubinacci, Plasma Phys. Control. Fusion 50 (2008) 085004

[9]  PATRAN format description, `http://www.g-boege.de/english/makrosae/Manual/PATRAN.htm`

[10]  Y. Q. Liu, A. Bondeson, Phys. Rev. Lett., vol. 84, pp. 907 (2000)

[11]  R. Albanese, G. Rubinacci, Adv. Im. El. Phys., vol. 102, pp. 1-86 (1998)