My experience with IMAS

Alexei Pankin

IMAS working group
February 16, 2021

Integrated Modelling & Analysis Suite (IMAS)

Is developed to support plasma operation and research on the ITER tokamak experiment

Allows collaboration development, model coupling, and data exchange

Centerpiece of IMAS infrastructure is a standardized generic data model that represents simulated and experimental data with identical structures

Includes set of tools to access data and design integrated modeling workflows

F. Imbeauxet al, NF, 2015

M. Romanelli, 3rd IAEA TM on Fusion Data Processing, Validation and Analysis (2019)

ITER Physics Data Model (PDM)

Is standardized data model in IMAS

Ensures that input and output of physics components is saved in a standard way

Physics components, once interfaced to the data model, can be coupled into an Integrated Modelling workflow

Includes set of tools to access data and design integrated modeling workflows

Data model consists of data dictionary and data model (list of expressions to link between nodes of generic data dictionary and methods for accession data for a particular experiment)

https://sharepoint.iter.org/departments/POP/CM/IMDesign/Data%20Model/CI/imas-3.30.0/html_documentation.html

F. Imbeauxet al, NF, 2015

Interface Data Structure (IDS)

Is an entry point of the data dictionary such as full description of tokamak subsystems (diagnostic, heating, equilibrium, etc)

Is also a part of data dictionary

May contain time-dependent and time-independent information. For example, it might include diagnostic data and diagnostic description at the same time

F. Imbeauxet al, NF, 2015

Access Layer/Universal Access Layer (UAL)

Implements an access to data dictionary

Has application programming interfaces (APIs) for Fortran, C++, Python, Java and Matlab

Writes data files on disk and features also a memory cache mechanism for fast data transfer between workflow components

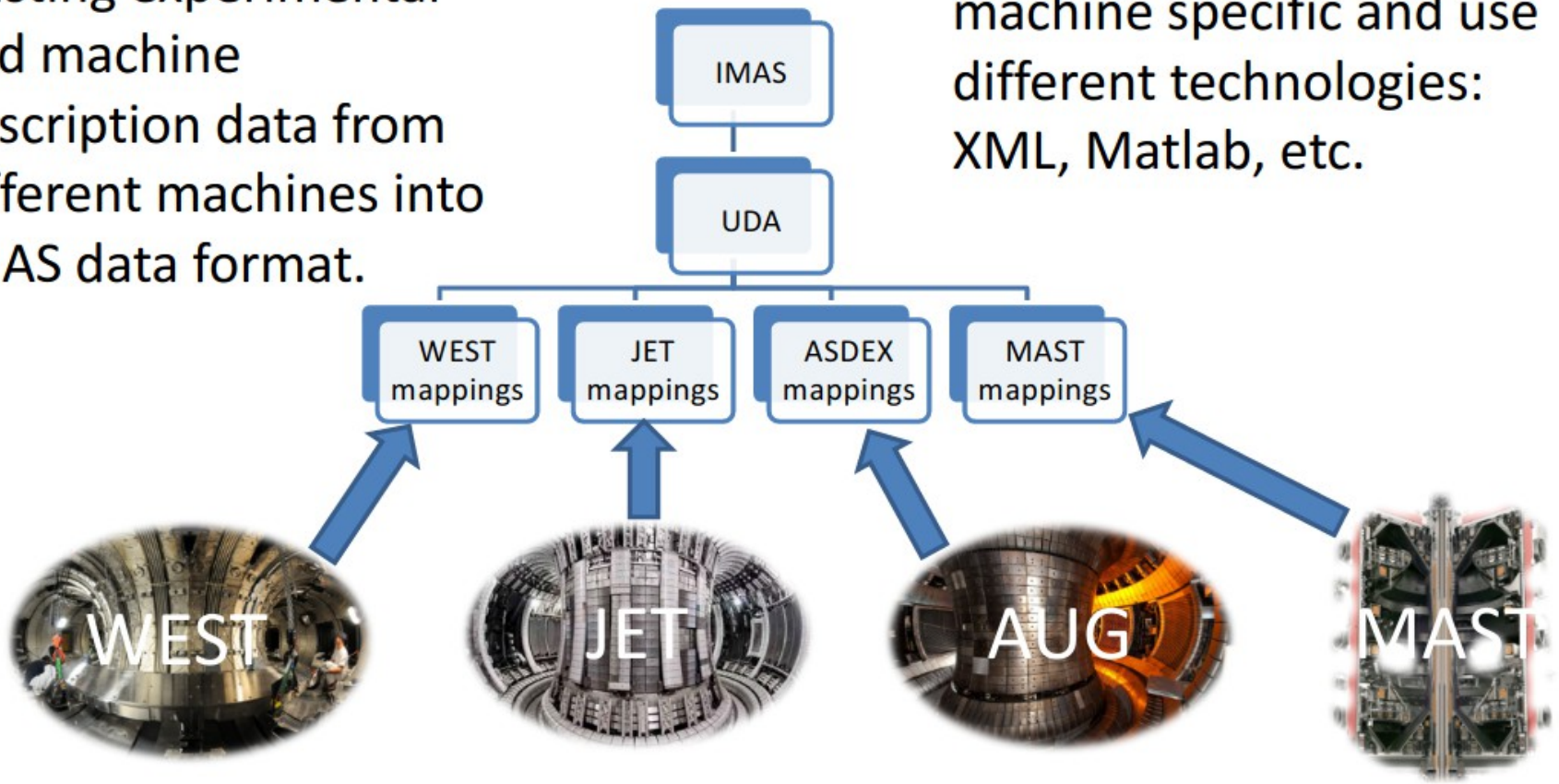
Support MDSPlus, HDF and other backends

F. Imbeauxet al, NF, 2015

The Universal Data Access library

UDA* is used to map existing experimental and machine description data from different machines into IMAS data format.

The mappings are machine specific and use different technologies: XML, Matlab, etc.

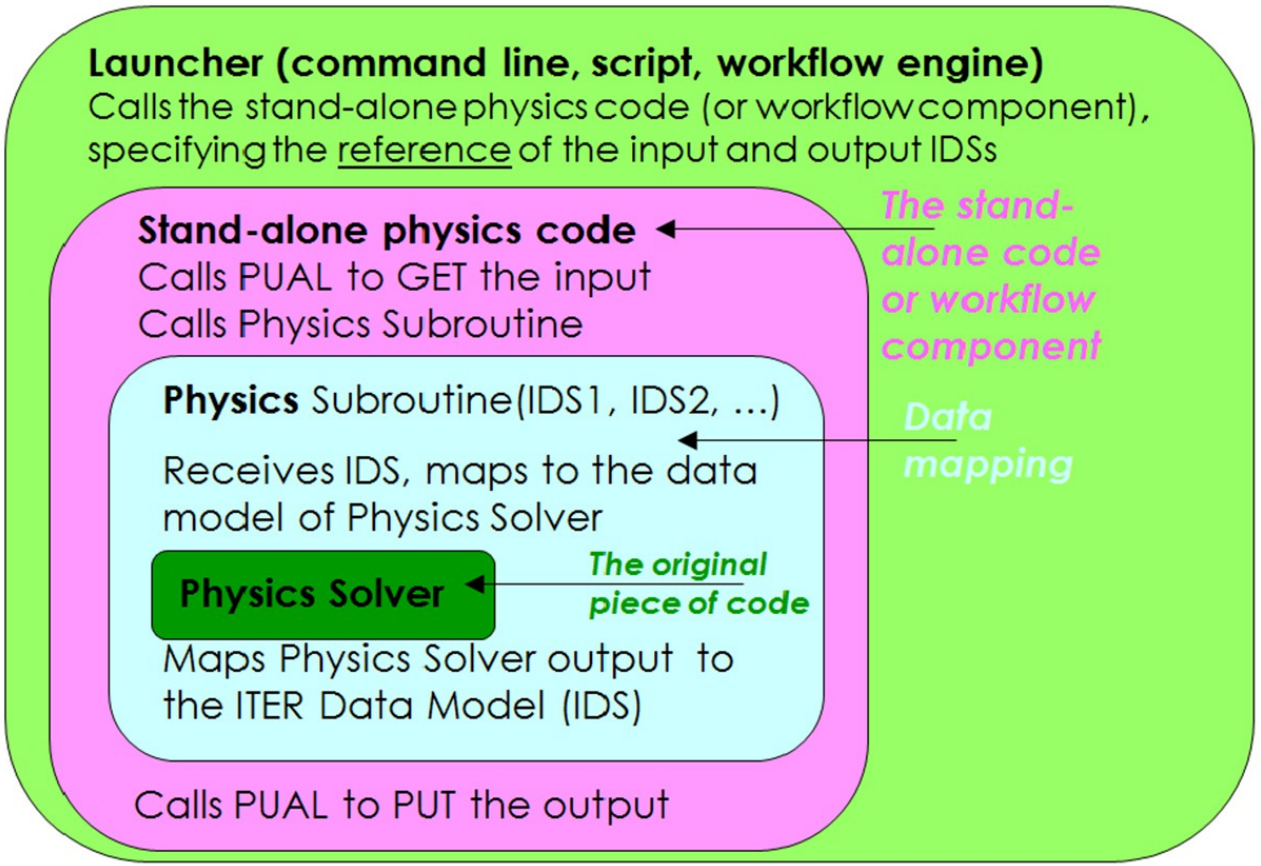


*Universal Data Access: Data access and transformation tool originally created for the MAST data systems

J. Hollocombe and D. Muir
M. Romanelli, 3rd IAEA TM on Fusion Data Processing (2019)

Data exchange for a physics solver

Layered structure in IMAS to enable the execution of a physics solver utilizes Physics User Access Language (PUAL)



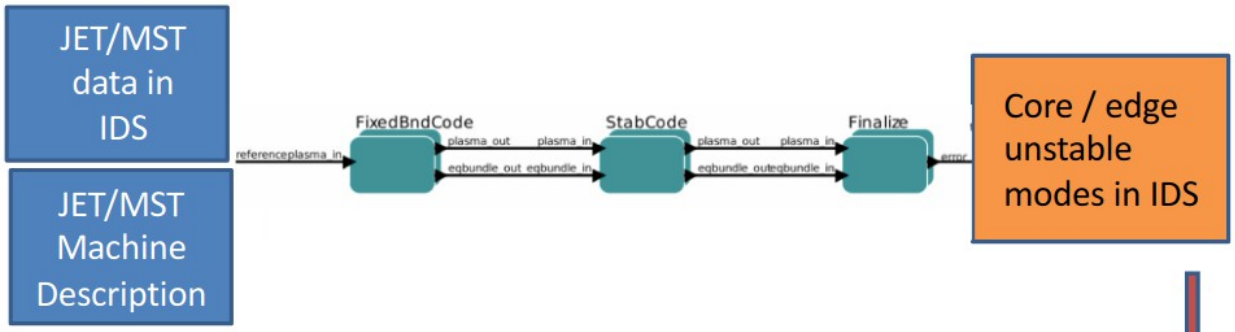
F. Imbeauxet al, NF, 2015

Code Development for Integrated Modelling (WPCD)

Several workflows have been developed and tested

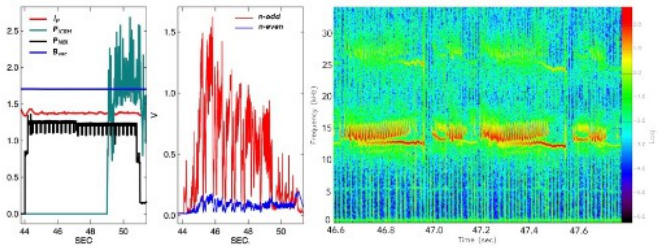
- The Equilibrium and MHD stability workflow
- The European Transport Simulator (ETS)
- The edge turbulence with synthetic diagnostic workflow

➢ **The Equilibrium and MHD stability workflow uses IMAS IDS for the coupling of arbitrary equilibrium and stability codes**



INPUT data / interfaces for MST prepared in EWE tasks

Equilibrium modules will include CLISTE. and EFIT++ in IMAS in 2019



R. Coelho, IAEA FEC 2018
M. Romanelli, 3rd IAEA TM on Fusion Data Processing (2019)

Compiling of IMAS on a Linux workstation

https://git.iter.org/projects/IMAS/repos/access-layer/browse

- Data Dictionnary https://git.iter.org/scm/imas/data-dictionary.git
- MDSplus backend https://github.com/MDSplus/mdsplus
- HDF5 backend (compiled with latest release)
- UDA backend https://git.iter.org/scm/imas/uda.git
  - PostgreSQL https://github.com/postgres/postgres.git
  - NetCDF
- C++ Interface https://github.com/blitzpp/blitz

```
sudo apt update -y
sudo apt install gcc -y
sudo apt install gdb -y
sudo apt install build-essential -y
sudo apt install cmake -y
sudo apt install byacc -y
sudo apt install libssl-dev -y
sudo apt install libboost-all-dev -y
sudo apt install swig -y
sudo apt install libxml2-dev -y
sudo apt install python2.7 -y
sudo apt install python3.7 -y
sudo apt install python-pip -y
sudo apt install python3-pip -y
sudo apt install unzip -y
sudo apt install libreadline-dev -y
sudo apt install gfortran -y
sudo apt install autoconf -y
sudo apt install doxygen -y
sudo apt install xsltproc -y
sudo apt install flex -y
sudo apt install environment-modules -y
sudo apt install ghostscript -y
sudo apt install texlive-font-utils -y
sudo apt install curl -y
sudo apt install libcurl4-openssl-dev -y
sudo apt install nsis -y
sudo apt install bison -y
sudo apt install libjpeg-turbo8 -y
sudo apt install libopenjp2-7 -y

sudo add-apt-repository ppa:webupd8team/java
sudo apt update -y
sudo apt install oracle-java8-installer -y
sudo apt install oracle-java8-set-default -y
```

Compiling of IMAS on IRIS at GA

/fusion/projects/codes/imas/pankin/software/AL.3_30

```
export PATH=/fusion/projects/codes/imas/pankin/software/bin:~/.local/bin:$PATH
module unload python/2.7
module load python/3
module unload mdsplus hdf5/1.8.14-pgf13.2 mpich/pgf pgf/13.2 gcc-4.7.2
module unload gcc-4.9.2 mpich/3.2-gcc4.9.2 fftw/3.3.6-mpich3.2-gcc4.9.2  hdf5/1.8.19-mpich3.2-gcc4.9.2
module unload netcdf/4.4.1-mpich3.2-gcc4.9.2
module load env/gcc9.2
module unload matlab
module load matlab/2019b
export SOFT_PATH=/fusion/projects/codes/imas/pankin/software
export PATH=$SOFT_PATH/cmake/bin:$SOFT_PATH/hdf5-1.8.19-sersh/bin:$PATH
export HDF5_DIR=$SOFT_PATH/hdf5-1.8.19-sersh
export HDF5ROOT=$HDF5_DIR
export JAVA_HOME=$SOFT_PATH/jdk-15.0.2
export MDSPLUS_DIR=$SOFT_PATH/mdsplus
export MATLABPATH=/fusion/projects/codes/imas/pankin/IMAS/AL/matlabinterface
export LD_LIBRARY_PATH=/fusion/usc/opt/MATLAB/R2019a/bin/glnxa64:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=/fusion/usc/opt/gcc/gcc-9.2.0/lib64:$LD_LIBRARY_PATH
export MATLAB_ROOT=/fusion/usc/opt/MATLAB/R2019b
export MATLAB=$MATLAB_ROOT

export IMAS_VERSION=3.30.0
export IMAS_PREFIX=$SOFT_PATH/AL.3_30
export PYTHONPATH=$SOFT_PATH/AL.3_30/python/lib:$SOFT_PATH/AL.3_30/python/lib.linux-x86_64-3.8:$PYTHONPATH
export LD_LIBRARY_PATH=$SOFT_PATH/uda-2.3.1/lib:$SOFT_PATH/AL.3_30/lib:$MDSPLUS_DIR/lib:$LD_LIBRARY_PATH
export PATH=$MDSPLUS_DIR/bin:$PATH

. /fusion/projects/codes/imas/pankin/IMAS/AL/lin_setenv.sh
. /fusion/projects/codes/imas/pankin/IMAS/AL/set_ual.sh
```

PPPL

Compiling of IMAS on IRIS at GA

/fusion/projects/codes/imas/pankin/software/AL.3_30

```
export PATH=/fusion/projects/codes/imas/pankin/software/bin:~/.local/bin:$PATH
module unload python/2.7
module load python/3
module unload mdsplus hdf5/1.8.14-pgf13.2 mpich/pgf pgf/13.2 gcc-4.7.2
module unload gcc-4.9.2 mpich/3.2-gcc4.9.2 fftw/3.3.6-mpich3.2-gcc4.9.2  hdf5/1.8.19-mpich3.2-gcc4.9.2
module unload netcdf/4.4.1-mpich3.2-gcc4.9.2
module load env/gcc9.2
module unload matlab
module load matlab/2019b
export SOFT_PATH=/fusion/projects/codes/imas/pankin/software
export PATH=$SOFT_PATH/cmake/bin:$SOFT_PATH/hdf5-1.8.19-sersh/bin:$PATH
export HDF5_DIR=$SOFT_PATH/hdf5-1.8.19-sersh
export HDF5ROOT=$HDF5_DIR
export JAVA_HOME=$SOFT_PATH/jdk-15.0.2
export MDSPLUS_DIR=$SOFT_PATH/mdsplus
export MATLABPATH=/fusion/projects/codes/imas/pankin/IMAS/AL/matlabinterface
export LD_LIBRARY_PATH=/fusion/usc/opt/MATLAB/R2019a/bin/glnxa64:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=/fusion/usc/opt/gcc/gcc-9.2.0/lib64:$LD_LIBRARY_PATH
export MATLAB_ROOT=/fusion/usc/opt/MATLAB/R2019b
export MATLAB=$MATLAB_ROOT

export IMAS_VERSION=3.30.0
export IMAS_PREFIX=$SOFT_PATH/AL.3_30
export PYTHONPATH=$SOFT_PATH/AL.3_30/python/lib:$SOFT_PATH/AL.3_30/python/lib.linux-x86_64-3.8:$PYTHONPATH
export LD_LIBRARY_PATH=$SOFT_PATH/uda-2.3.1/lib:$SOFT_PATH/AL.3_30/lib:$MDSPLUS_DIR/lib:$LD_LIBRARY_PATH
export PATH=$MDSPLUS_DIR/bin:$PATH

. /fusion/projects/codes/imas/pankin/IMAS/AL/lin_setenv.sh
. /fusion/projects/codes/imas/pankin/IMAS/AL/set_ual.sh
```

PPPL

Compiling of IMAS on IRIS at GA

/fusion/projects/codes/imas/pankin/software/AL.3_30

```
import omas, imas
ods = omas.ODS()
s = ods['wall.description_2d.0.limiter']
s['type.description'] = 'first wall'
s['type.name'] = 'first_wall'
s['type.index'] = 0
# set values of xarray and zarray
s['unit.0.outline.r'] = [0,1,2,3,4]
s['unit.0.outline.z'] = [0,1,2,3,4]
omas.save_omas_imas(ods, user='pankin', machine='d3d', imas_version='3.30.0', pulse=174819, run=1, new=True);
#
shot            = 174819
run_in          = 0
input_user = 'pankin'
input_database    = 'd3d'
time_slice       = 3.02
input = imas.ids(shot, run_in)
#input.setBackend(10)
ods2=omas.load_omas_imas(user=input_user, machine='d3d', imas_version='3.30.0', pulse=shot, run=run_in);
omas.save_omas_imas(ods2, user='pankin', machine='d3d', imas_version='3.30.0', pulse=174819, run=8, new=True);
```

Fortran Interface

Based on presentation of M. Schneider at IMAS Training camp 2020 (IDM_2M82)

```
program wrapper
  use ids_schemas
  use ids_routines

  implicit none
  type(ids_equilibrium):: equi_in, equi_out
  character(len=200):: user,machine
  integer:: idx

  ! DEFINE LOCAL DATABASE
  call getenv('USER',user)
  machine = 'iter'

  ! OPEN INPUT DATAFILE FROM OFFICIAL ITER DB
  call imas_open_env('ids' ,131024,1,idx, &
       'public','iter','3')
  call ids_get(idx,'equilibrium',equi_in)
  call imas_close(idx)

  ! EXECUTE PHYSICS CODE
  call physics_i(equi_in,equi_out)

  ! EXPORT RESULTS TO LOCAL DATABASE
  call imas_create_env('ids',131024,2,0,0,idx, &
       trim(user),trim(machine),'3')
  call ids_put(idx, 'equilibrium' ,equi_out)
  call imas_close(idx)

end program wrapper
```

```
subroutine physics_i(equi_in, equi_out)

  use ids_schemas
  use ids_routines
  implicit none
  type(ids_equilibrium), intent(in):: equi_in
  type(ids_equilibrium), intent(out):: equi_out
  double precision:: rmaj_in, rmaj_out

  ! MAP YOUR INPUT
  rmaj_in = equi_in%time_slice(1)%boundary%geometric_axis%r

  ! MODIFY PLASMA MAJOR RADIUS
  write(*,'(a31,f7.3)') 'Initial major radius =', rmaj_in
  rmaj_out = r_maj_in * 1.5
  write(*,'(a31,f7.3)') 'Final major radius   =', rmaj_out

 ! MAP YOUR OUTPUT
 equi_out%time_slice(1)%boundary%geometric_axis%r = rmaj_out

end subroutine physics_i
```