TRANSP, Simulink & IMAS

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TRANSP User Group (TUG) Meeting
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Overview

- TRANSP and Simulink [with Dan Boyer]
  - with a brief preview of the framework discussion scheduled for tomorrow at 2:45pm
- TRANSP and the Iter Integrated Modeling & Analysis Suite (IMAS) [with Marina Gorelenkova]

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Simulink and TRANSP componentization

- Like virtually every fusion code, TRANSP was developed to be in complete control of execution and data flow
- For TRANSP to be a component of larger, integrated modeling it will need the ability to hand off some control to an external driver (for example a framework)
- We have a user request for making TRANSP available from Simulink simulations
  - Integrated modeling environment running on top of Matlab
  - Predominant for Plasma Control Systems (PCS), including for Iter
- This is immediately useful AND an intermediate step toward componentization
- We will use the model of co-simulation: TRANSP and Simulink halt between time steps to exchange data

TRANSP/Simulink co-simulation approach

- Co-simulation is a symmetric approach: each code hands off the bare minimum amount of control
- TRANSP and Simulink are each in sole control, except when they pause at predetermined points in time to exchange data
- Each runs as a separate process (or multiple processes for parallel TRANSP)
- At the end of a time step, they wait for a data-exchange file to update
- The initial implementation is under active development
- We do not expect to invite beta testers until at least the end of the year

TRANSP/Simulink co-simulation next steps

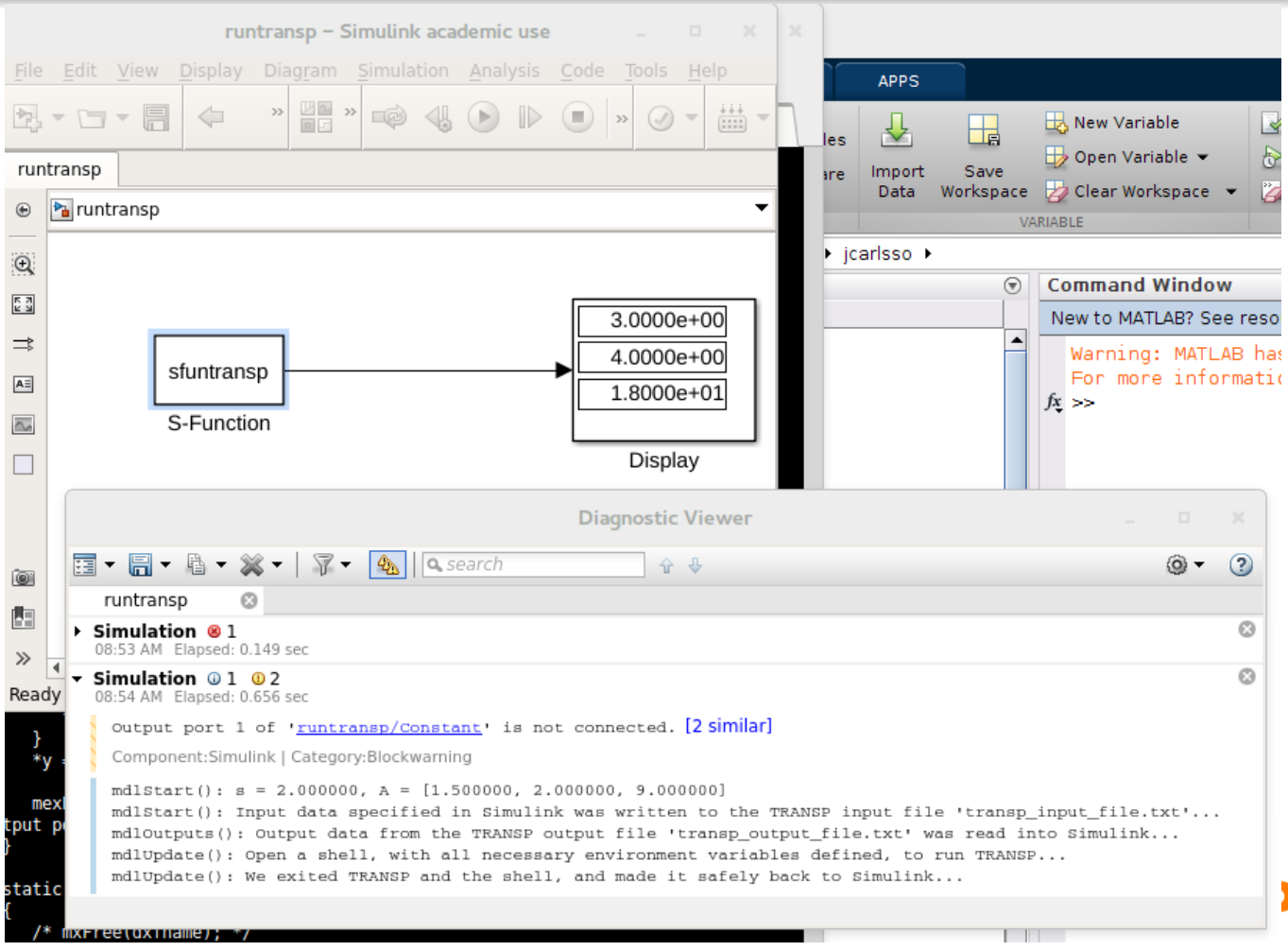
- Once the initial implementation is working, we plan to migrate to:
  - Proper (but old school) Inter-Process Communication (IPC) for better robustness and performance
    - POSIX MQ or UNIX domain sockets (the latter used by Chrome browser with great success)
  - Memory-based data exchange, when possible
    - mmap() for PlasmaState and POSIX shmem for trcom, both with semaphores
- Three main criteria for choosing IPC: is it part of the common Unices?, will it still be in 20 years?, is it easy to use?
- We have looked at newer IPC (ZeroMQ, nanomsg), but concluded that turn-of-the-millennium IPC meets our needs, without unnecessary complexity
- Final choices will be based on testing for actual use case

TRANSP in Simulink

- We are enabling TRANSP as synthetic plasma in Simulink PCS in piecemeal and general approach (useful also for other frameworks)
- The Simulink building blocks (models and Level-2 C S-functions) to enable co-simulation with TRANSP have been implemented
- The Simulink model runtransp.slx passes user specified input to an S-function that:
  - creates an input file
  - launches an executable (not yet real TRANSP) and waits for it to finish
  - reads an output file
  - passes the data back to the Simulink model
- Another Simulink model, wait4file.slx, does time stepping and waits for a data-exchange file to be updated at the end of each time step

Screenshot of TRANSP in Simulink

- When TRANSP is ready, we will put all these pieces together and perform co-simulation
- Screenshot of the runtransp model in use:



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Co-simulation with TRANSP

- We plan to enable co-simulation with TRANSP by providing users with a CoSim module and library that handle IPC
- Callable from expert file
- Screenshot of log file from test of initial, file-based implementation:

```
 *** FULL NEUTRAL SOURCE CALCULATION PERFORMED ***         NSTEP=     12
 TA= 4.00000E-02 CPU TIME= 9.31931E-02 SECONDS.  DT= 7.50000E-03
  %check_save_state: nbflag               =  T
  %check_save_state: iwrite_now           =  F
  %check_save_state: check at wall_hours =    8.7149999999951433E-002
 --> plasma_hash("gframe"): TA= 4.000000E-02 NSTEP=    12 Hash code:  102013058
 ->PRGCHK: bdy curvature ratio at t= 4.5000E-02 seconds is:  5.4779E-02
% MHDEQ: TG1=     0.040000 ; TG2=     0.045000 ; DTG=  5.000E-03
  *** Isolver ***
  Avg. GS error:     8.827E-03
  Plasma Current:    9.999E+05,   target:   1.000E+06,   error:   0.007%
  Edge Q:               23.182,   target:      23.728,   error:   2.304%

 * MHD EQUILIBRIUM CALCULATED, CPU TIME =  2.4058E+00 SECONDS
   DATA R*BT AT EDGE:  9.0591E+01
 ->EQBDY_CHECK: last flux surface curvature ratio is:  6.1199E-02
 teped=  3.694967E+01 neped=  8.114725E+13 width=  2.367699E+00
 % GFRAME - GEOMETRY TIMESTEP TG1=    0.040000 TO TG2=    0.045000 @ NSTEP       12
   GFRAME TG2 MOMENTS CHECKSUM:  1.1100893944771D+04
 CoSim, waiting for file update: current time is Fri Apr 28 14:32:40 2017, data-exchange file was modified on Fri Apr 28 14:32:16 2017
 CoSim, waiting for file update: current time is Fri Apr 28 14:32:50 2017, data-exchange file was modified on Fri Apr 28 14:32:49 2017
 CoSim, data-exchange file was updated
 %MFRCHK - LABEL "BALE0_SGF", #       1= -1.30321E-42 RESET TO ZERO
```

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TRANSP & IMAS

- We are developing data translators between TRANSP and IMAS
- Source code is available at

  `https://github.com/transp/transp-imas-translator`
- Data translation in each direction is done by a standalone executable
- Implemented in Fortran90 and making calls to TRANSP and IMAS libraries
- The transp2imas translator is complete enough to allow NUBEAM simulations using input data from IMAS
  - Is being tested by comparing two NUBEAM simulations, one directly using TRANSP output data, the other with the same data first translated to IMAS format
  - See Marina's presentation

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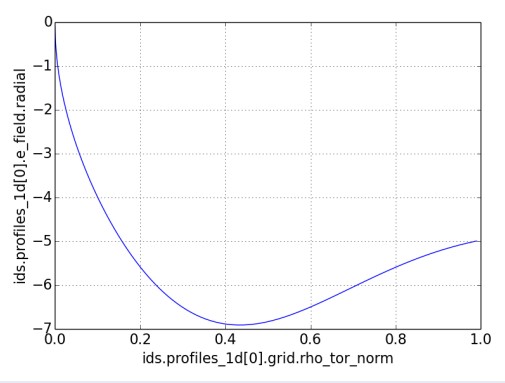
Problems with differences between IMAS versions

- Plot of core_profiles%profiles_1d(nfinal)%e_field%radial:



- Data written on my desktop by transp2imas linked with IMAS from git repo August 29, 2016
- Error message when trying to build transp2imas with IMAS version 3.2.2ual3.3.2 (the latest version on PPPL cluster):

```
transp2imas.f90(1365): error #6460: This is not a field name that is defined in
the encompassing structure.   [E_FIELD]
           allocate(cp%profiles_1d(it)%e_field%radial(offset))
-----------------------------------------^
transp2imas.f90(1365): error #6460: This is not a field name that is defined in
the encompassing structure.   [RADIAL]
           allocate(cp%profiles_1d(it)%e_field%radial(offset))
-------------------------------------------------^
```

- There are other similar changes that break code linked with IMAS

Preview of tomorrow's framework discussion

- The goal will be to solicit input from the user community
  - Do you use TRANSP coupled to other codes, using OMFIT, Simulink or similar?
  - If not, do you see a need for it?
  - Anything else that is relevant we should know about?
- Some previous framework efforts had mixed success
- We plan to take pragmatic approach, driven by user needs
- Discussion tomorrow at 2:45pm, bring your wish list and we will mull it over

Summary

- We are developing a TRANSP-Simulink co-simulation capability
  - Directly useful for Simulink PCS with TRANSP as synthetic plasma
  - Also a pilot project for using TRANSP in framework
- IMAS data can currently be tentatively used with TRANSP and NUBEAM
- We can not recommend it for general use until IMAS updates stop breaking our translators

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Extra slide: Screenshot of TRANSP in Simulink

- Specifying input: