RELAP5-3D and CASL Grid

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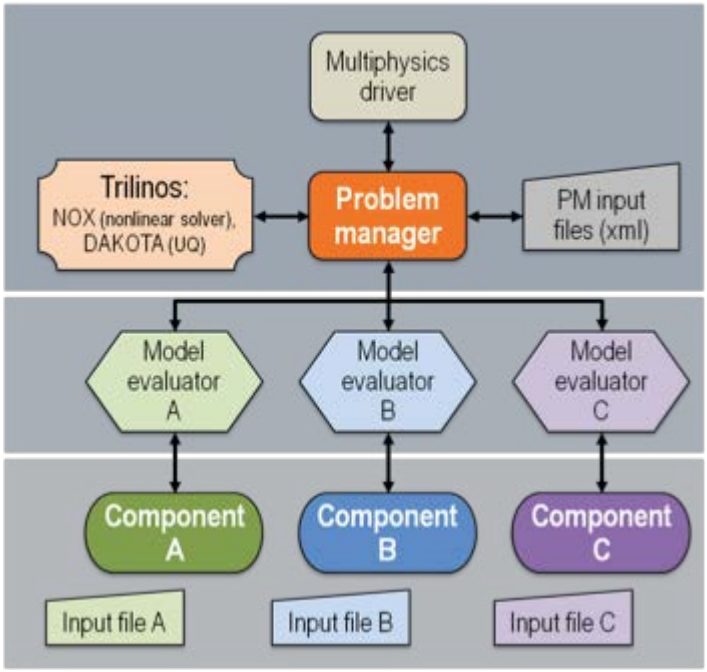
July, 2013

RELAP5-3D has been incorporated into VERA environment of the DOE CASL program.

The Consortium for Advanced Simulation of Light Water Reactors (CASL) is a program started by the U.S. Department of Energy to utilize modern modeling and simulation to develop a predictive capability for modeling light water reactors. A partnership of industry, academia, and national laboratories, its mission is to use this predictive capability to better understand operational and safety performance-limiting phenomena.

CASL is developing, integrating, and coupling state-of-the-art codes within a common multi-physics virtual environment, the Virtual Environment for Reactor Applications (VERA). The software framework used to couple codes within VERA is called LIME, the Lightweight Integrating Multi-physics Environment for coupling codes. LIME was designed to enable separate physics codes to be combined, whether they are legacy codes or of recent vintage, into a robust and efficient fully-coupled multi-physics simulation capability. LIME requires some changes to be made to the physics codes in order to couple them, as well as the creation of a customized "model evaluator," which describes how the coupled codes communicate with LIME and with each other.



RELAP5-3D was chosen as the initial safety analysis code for VERA. Each physics code in VERA is initially "integrated" (wrapped as a library to be called by LIME), then "coupled" (integrated with other physics

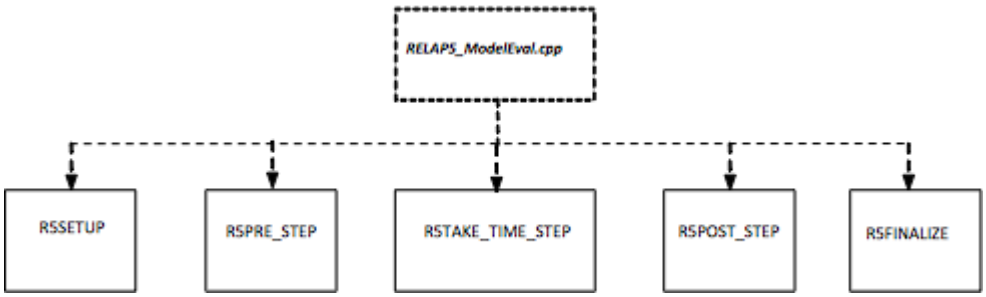
codes in VERA). RELAP5-3D has been integrated using pre-compiler directives to activate CASL-oriented coding when it is build for use by VERA. This coding involves:

- Redirecting all screen-writes to a file
- Shutting off the RELAP5 main subroutine
- Allowing the VERA model evaluator to call the underlying RELAP5-3D subroutines directly
- Create three subroutines that VERA requires to call
    - Initialize
    - Solve
    - Finalize the simulation
- Rearranging RELAP5-3D routines slightly to be called by these three VERA-oriented routines

These RELAP5-3D code modifications were incorporated into Idaho National Laboratory (INL) mainline version of RELAP5-3D under pre-compiler protection. Thus the code can be built for normal IRUG usage with these directives turned off, or built for CASL usage by turning the directives on.

After this was done, RELAP5-3D was considered to be "wrapped" by LIME, but RELAP5-3D still ran from start to finish using its own time step control algorithm. LIME had no control other than starting the simulation.

To complete the integration, further improvements needed to be made in order to move from a stand-alone to a coupled capability. LIME needs to be able to negotiate a common time step size and perform advancements synchronously for all the coupled codes it is controlling. Further refactoring of RELAP5-3D was done in order to allow LIME to control time steps (set time step size, initiate an advancement, etc.). Additionally, the LIME program manager (the main controlling routine) needed to be modified to handle cases where RELAP5-3D (or other codes) reduces the negotiated time step size or repeats an advancement, since LIME previously assumed all codes would run at the negotiated time step size.



This final set of changes to the RELAP5-3D code has not been incorporated into the INL-maintained version. Since CASL has been concentrating on modeling phenomena inside the pressure vessel, the next step of coupling RELAP5-3D with other codes has not been performed. Experience gained during the RELAP5-3D integration process has been utilized for coupling other codes with a similar solution scheme, specifically COBRA-TF. When CASL reaches the point of needing a system safety analysis capability, the new modifications will be integrated with the current RELAP5-3D development version.