

LA-UR-24-20769

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Title: The LANL Common Modeling Framework (CMF)

Author(s): Sherrill, Leslie Welser

Intended for: Unclassified CMF talk for local P/T Colloquium and later HQ use.

Issued: 2024-01-26



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The LANL Common Modeling Framework (CMF)

A collaborative software environment to set a new standard for knowledge capture, archiving, pedigree, and peer review

Leslie Sherrill

Deputy Division Leader, XTD

Co-Project Leader, CMF Project

January 25, 2024

With contributions from:

Gabe Rockefeller, Krista Stalsberg, Mike Ham

Carlos di Stefano, Sam Pellone, Lucy Frey, Mike Tamashiro, Ryan Scott, Darrin Visarraga, Jasper Thrussell, Bethany Pena, Tom Gianakon, Orion Lee, Dylan Gatlin, Claire Recamier, Ethan Stam, Josh Sauppe, Nathaniel Willis, Louie Long, Suzannah Wood, Alex Rasmus

Ryan Scott, Harry Robey, Sara Negussie

.....and many more

Overview

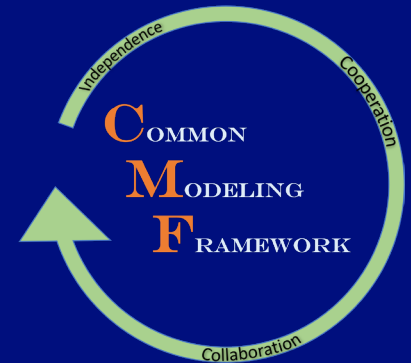
- CMF effort description and scope
 - philosophy behind CMF, history, goals of the project, communities, data access capability development
- Highlights
 - HED, double-shell ICF

Overview

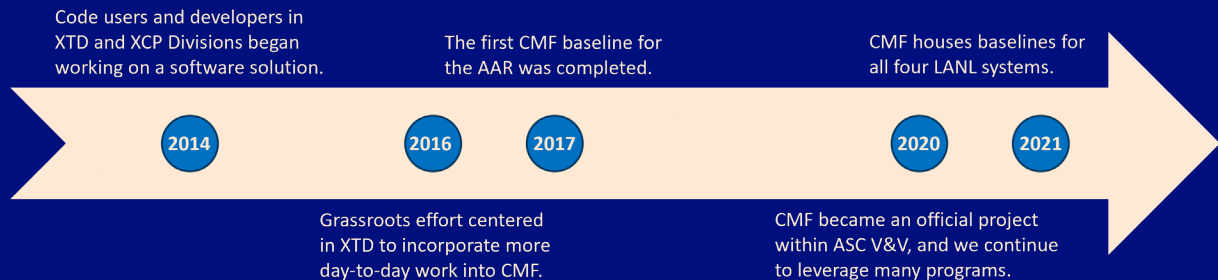
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The Common Modeling Framework is a modern software repository built and maintained by the LANL Weapons Physics Directorate (ALDX).

- ALDX's mission space is to develop and apply cutting-edge theory, computational models, and multi-physics simulation codes, and to design, execute, and analyze complex experiments.
- CMF gives our community a long-awaited opportunity to have a collaborative software environment that serves the following needs:
 - ❖ **Knowledge capture** (both at the staff and project level)
 - ❖ **Model archiving** (a modern repo to archive simulation setups for historical and new experiments)
 - ❖ **Setup pedigree** (a more consistent and quality-controlled solution to modeling for a large community)
 - ❖ **Peer review** (facilitates a healthy and transparent scientific discourse)
- CMF brings together many mission-critical projects and programs:
 - LANL Annual Assessment process (system baselines are all in CMF)
 - ASC modeling suites (both new and historical data)
 - OES experiments
 - OETM engineering connections



What is the Common Modeling Framework (CMF)?



CMF is an official project housed in the ASC V&V Program. It is funded by multiple programs:

- ASC V&V
- OES PAT and SAT programs
- DSW funding (indirect)

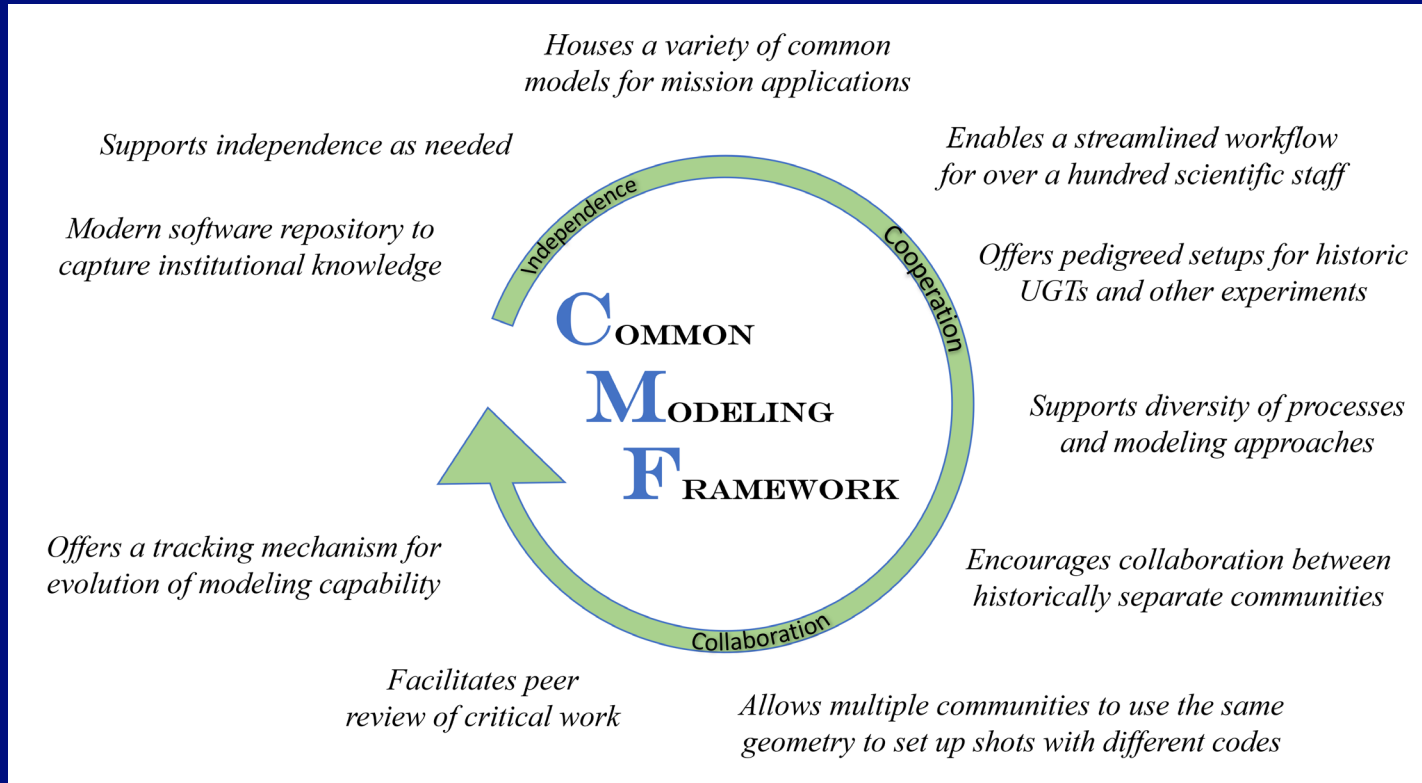
- **What CMF is:**

- A **software repository** to facilitate knowledge capture, model archiving, setup pedigree, and peer review.
- A modern software solution with a **consolidated parts and data library** for experimental setups and **global utilities** and drivers to promote ease of use and consistency.
- A **common model repository** to house a variety of modeling strategies for different applications and codes.
- A **collaborative effort** to connect multiple line organizations and programs.

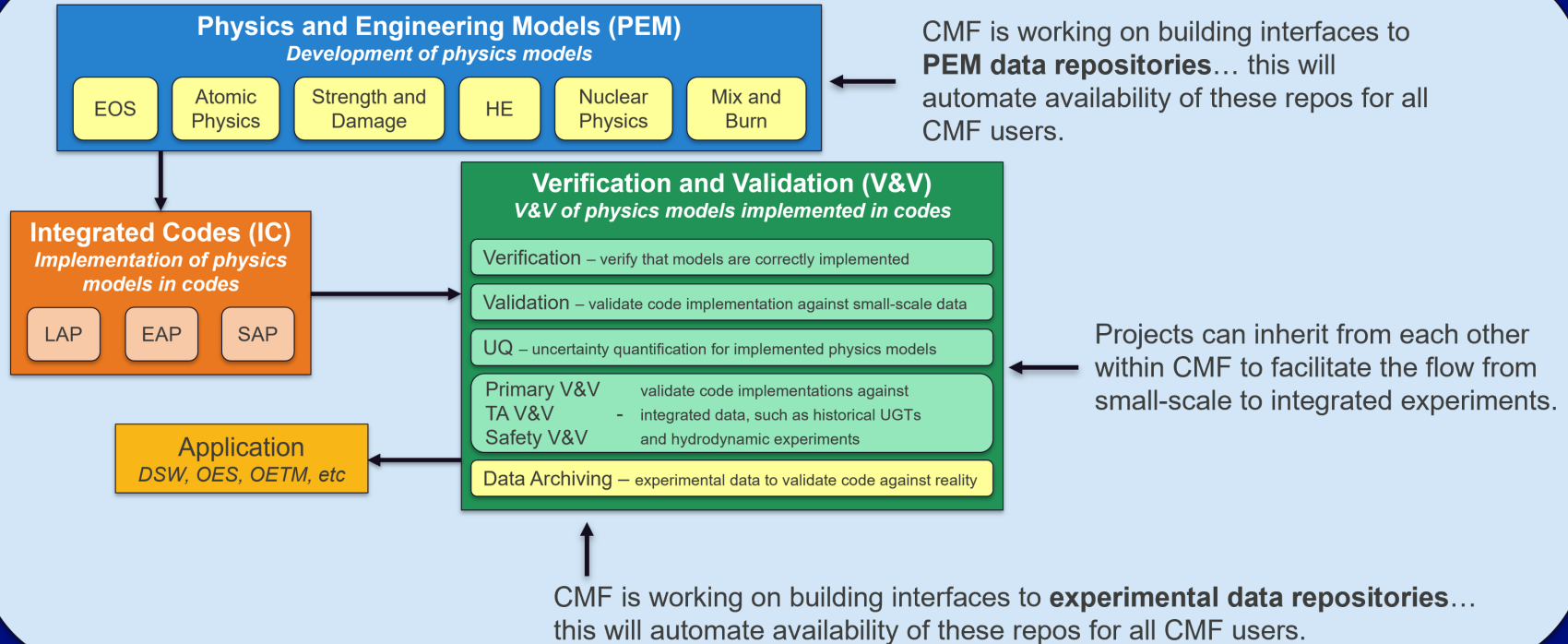
- **What CMF is not:**

- CMF does not mandate specific physics modeling strategies and choices.
- CMF is not “finished” – it is a tool used by the modeling community at LANL to enhance their workflow.

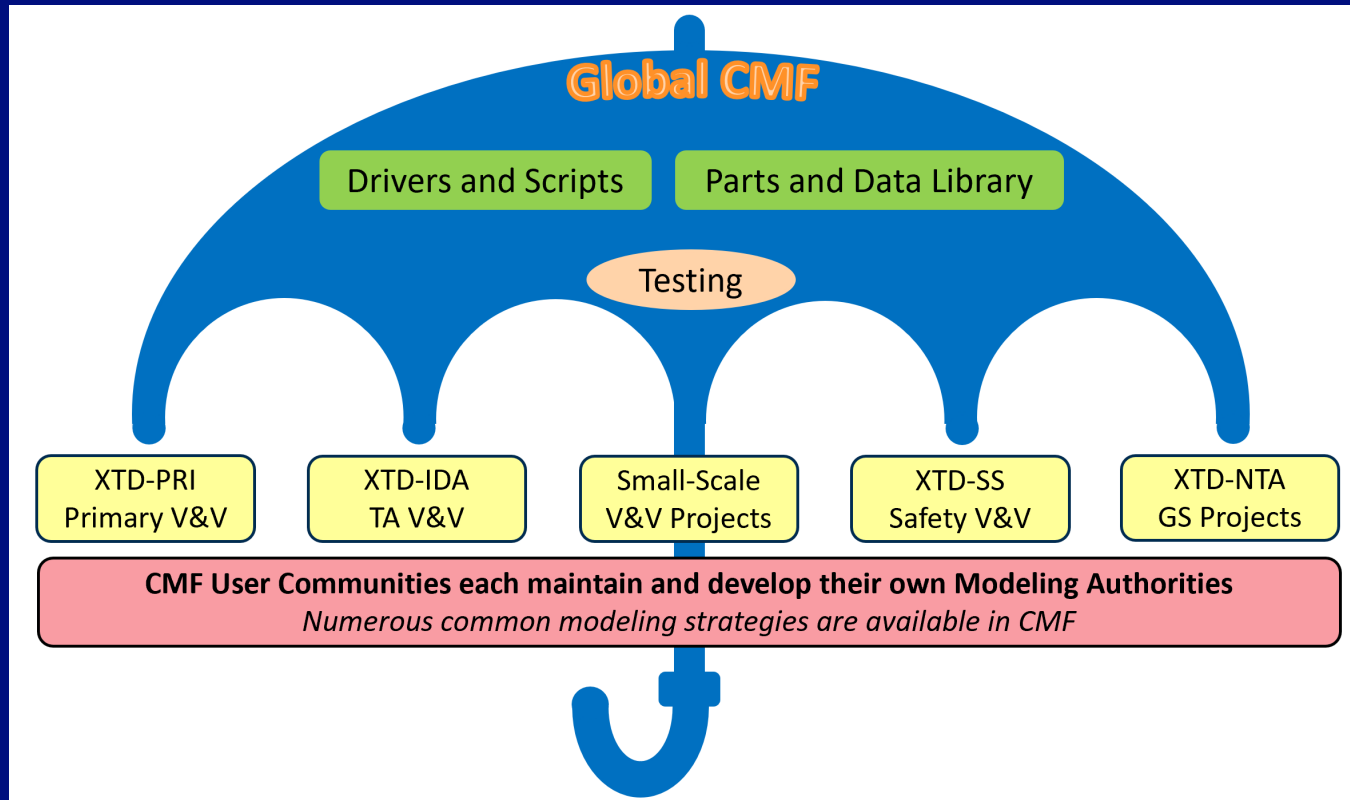
The Common Modeling Framework represents an evolution in the way LANL's modeling community does business.



CMF is designed to work in concert with ASC PEM, IC, and V&V to provide a better connection between projects and with the applications.



CMF has a flexible infrastructure that provides version control and pedigree for LANL modeling capabilities.



The CMF Framework Advisory Board (FAB) is the body that facilitates interactions in this interdisciplinary project.

- The FAB helps all users work together efficiently in order to make progress.
 - representation from every user community
 - originally convened in 2018 to solve conflicts due to the large number of CMF users in multiple communities
 - responsible for collecting, prioritizing, and helping de-conflict request for CMF changes that will impact multiple users and groups
 - representatives keep their respective organizations informed

CMF Project Leaders
Gabe Rockefeller (CS Lead) and Leslie Sherrill (Design Lead)

Primary
community
Nick Denissen

Full-system
community
Carlos Di Stefano

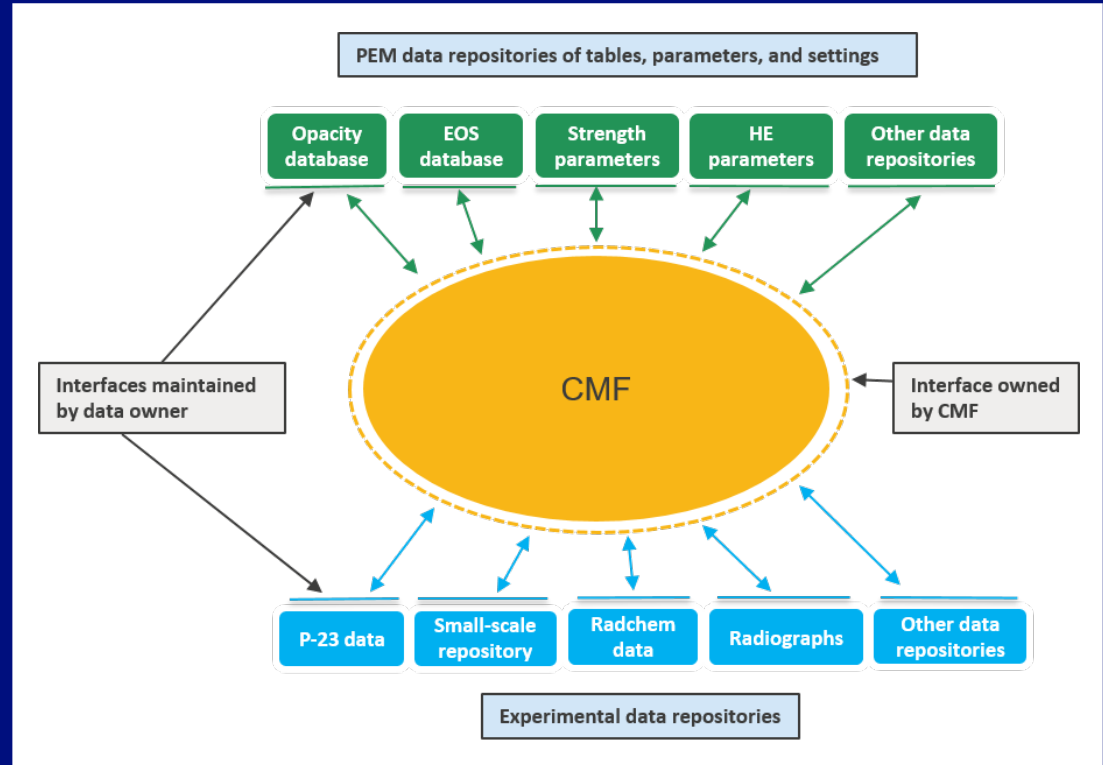
Small-scale
community
David Sigeti

Safety
community
Andy Thien

Global security
community
Rob Pelak

An FY24 milestone is focused on developing the interface between the CMF infrastructure and external data repositories.

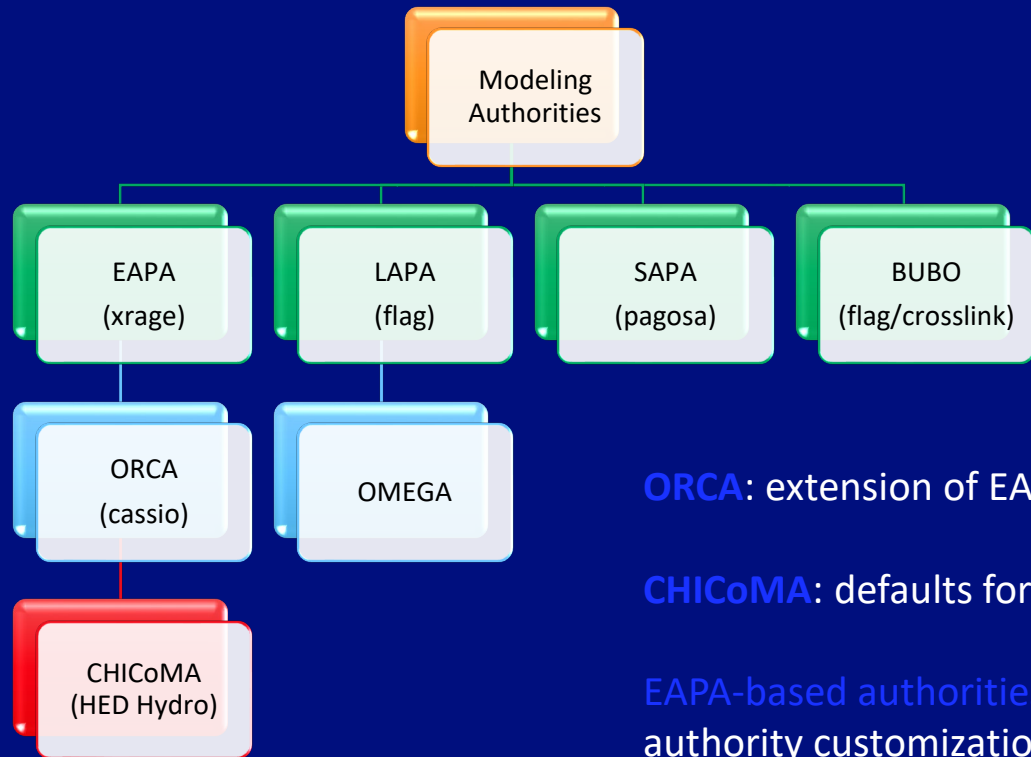
- **Theoretical data repositories**
 - Prototyping a shared material model database capability
 - SME official recommendations
 - Available to all CMF users
- **Experimental data: focus of L2**
 - Creating an interface between CMF and the NSDS
 - Institutional cataloging of decades worth of experimental data



Overview

- CMF effort description and scope
 - philosophy behind CMF, history, goals of the project, communities, data access capability development
- Highlights from the Yellow CMF
 - HED, double-shell ICF

The yellow CMF currently supports several modeling strategies, a.k.a. authorities, for use with different codes.



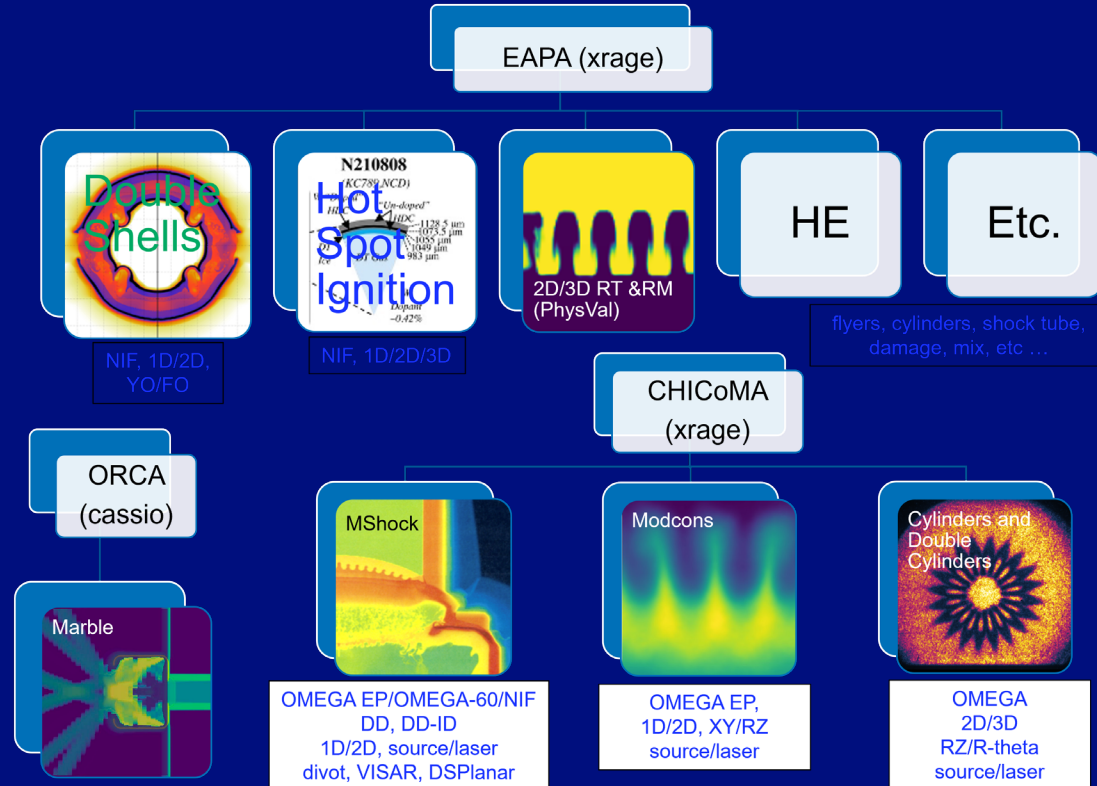
ORCA: extension of EAPA to include IMC Radiation and CPT

CHICoMA: defaults for HED Hydro models

EAPA-based authorities can inherit experiments and authority customizations from each other

EAPA fully supports physics used in laser-driven HED hydro experiments, as well as for other models.

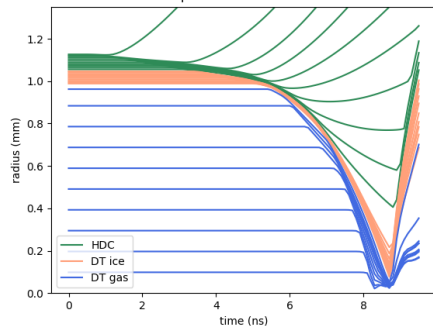
Krista Stalsberg spearheaded the HED/ICF CMF effort



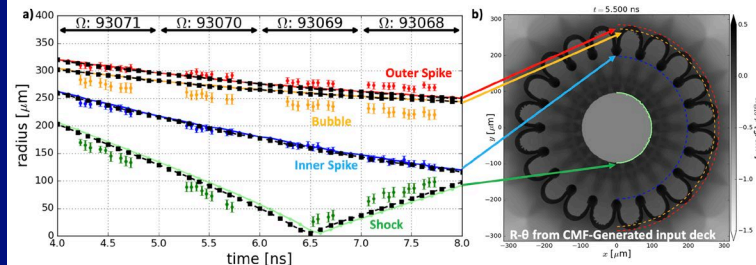
Post-processing and automated scripts have been developed for all types of experiments and simulations.

Automated tracer plotting

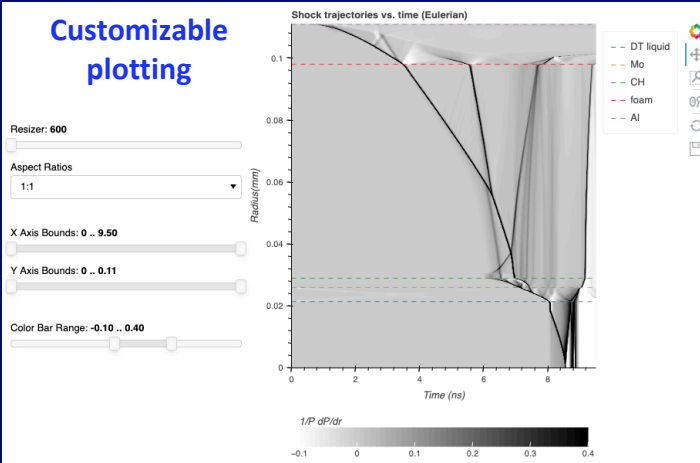
Capsule Radii Over Time



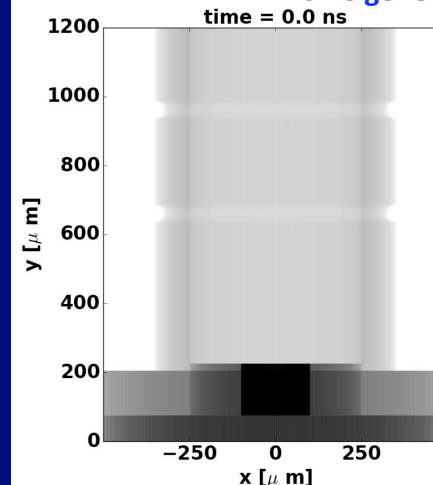
CMF-generated Cylinder results



Customizable plotting



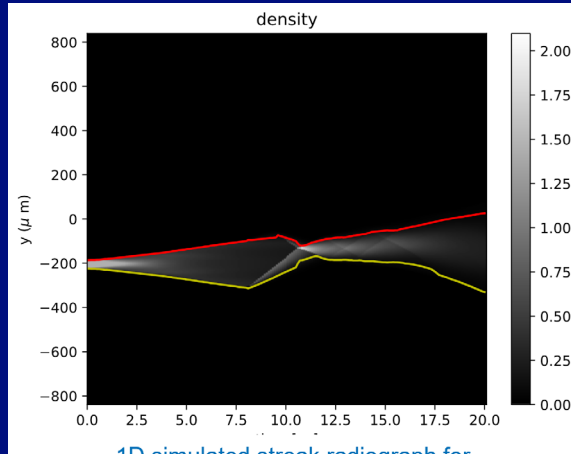
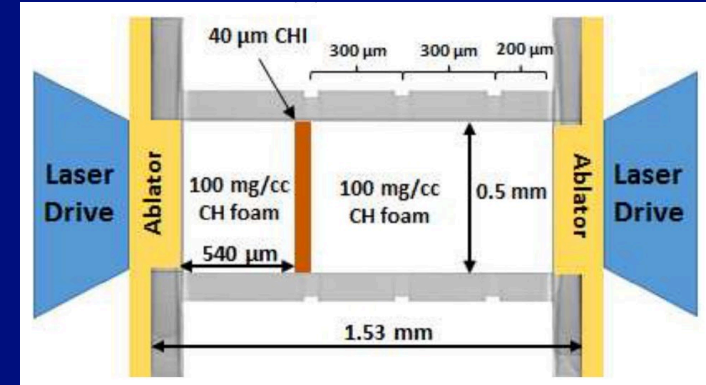
Movie generation



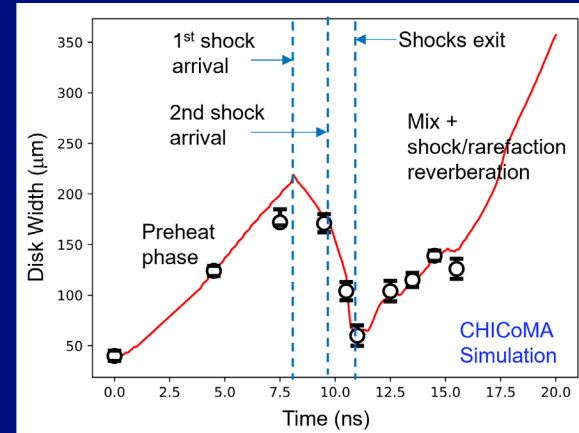
Bethany Pena
Dylan Gatlin
Ryan Scott
Nathaniel Willis
Orion Lee

EAPA/CHICoMA fully support physics used in laser-driven HED hydro experiments.

- OMEGA Mshock
 - Planar instability experiment: preheat-shock-reshock
 - Study feed-through effects under reshock (not independent surfaces)
- CHICoMA 1D model captures physical processes



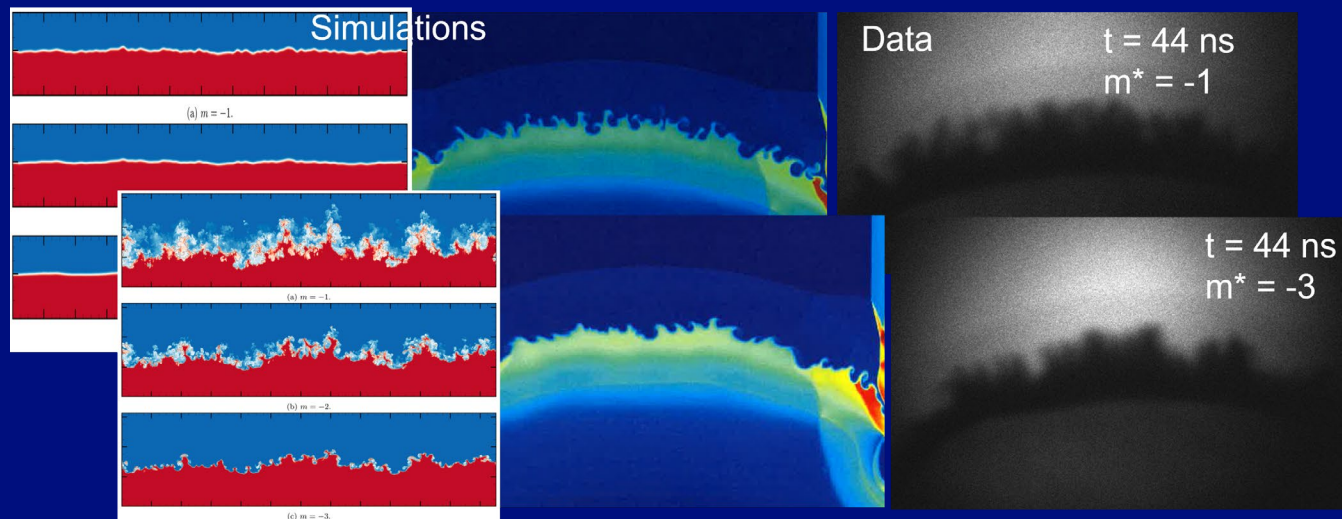
1D simulated streak radiograph for OMEGA Mshock experiment (disk framed by yellow and red lines)



Carlos di Stefano

The ModCons-23D campaign on OMEGA-EP was designed using the CMF suite manager tool.

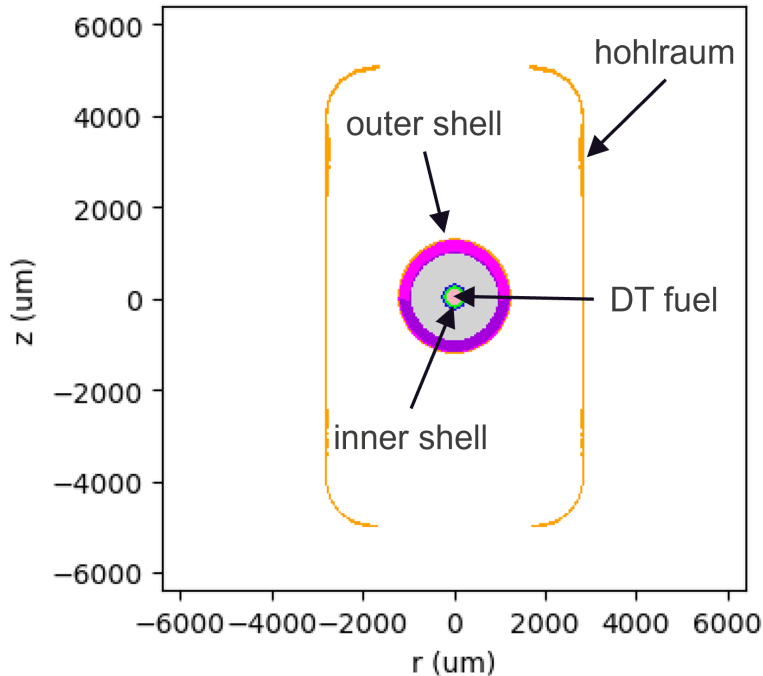
- Efficiently produced a design space suite spanning overall mode wavelengths, mode amplitudes, wavelength-to amplitude relationship, and number of modes.
- Test ability to discern changes in asymptotic RM growth rate with changes in power law corresponding to interface perturbation.



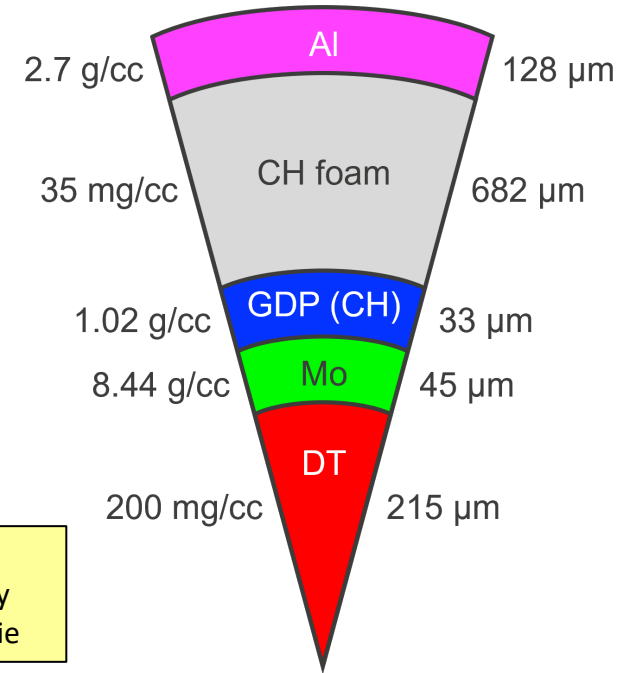
Carlos di Stefano
Alex Rasmus
Sam Pellone

An extensive effort is underway to develop modeling capabilities in the CMF for the first DT-filled double shell ICF implosions, which will begin in April 2024.

Hohlraum for 1st DT shots

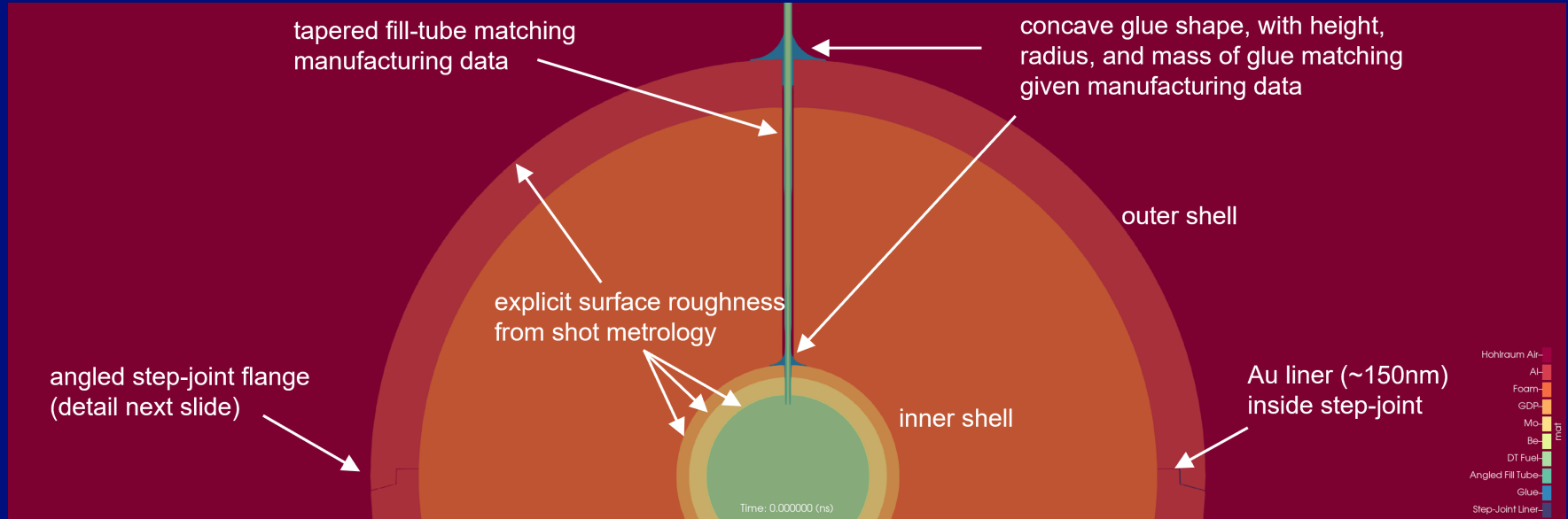


Capsule for 1st DT shots



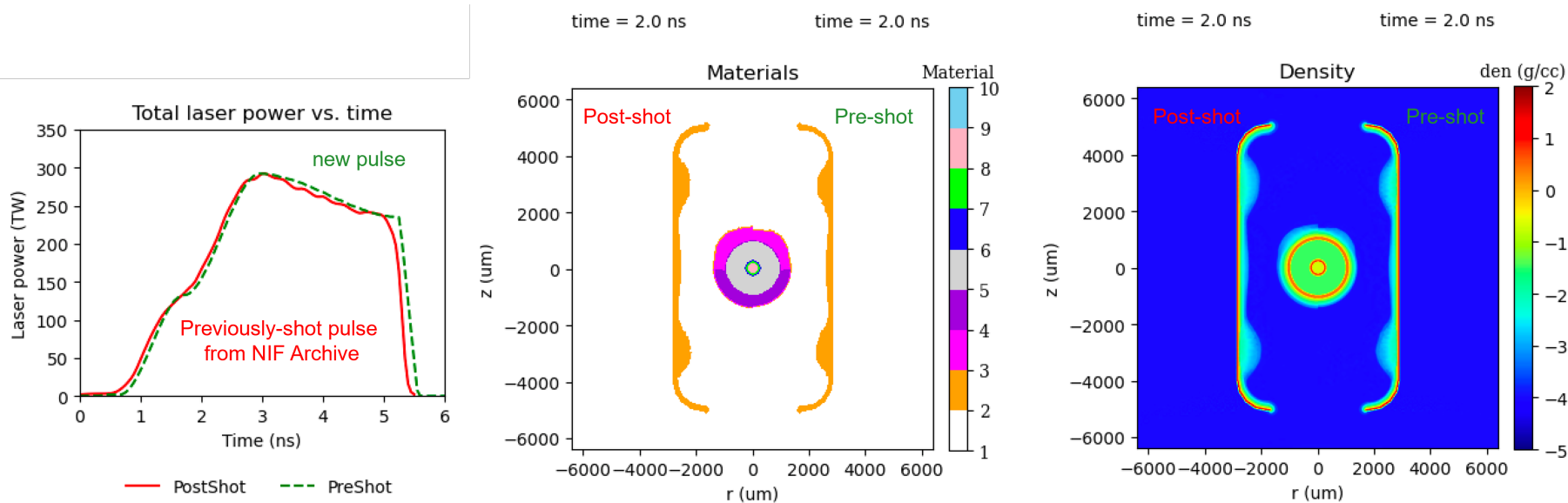
Ryan Scott
Harry Robey
Sara Negussie

The CMF holds the most advanced ICF capsule geometry creation / modeling tools in existence.



Ryan Scott
Harry Robey
Sara Negussie

The capability to simulate both pre- and post-shot configurations has been developed & employs a widely-used format identical to that of LLNL codes & NIF.



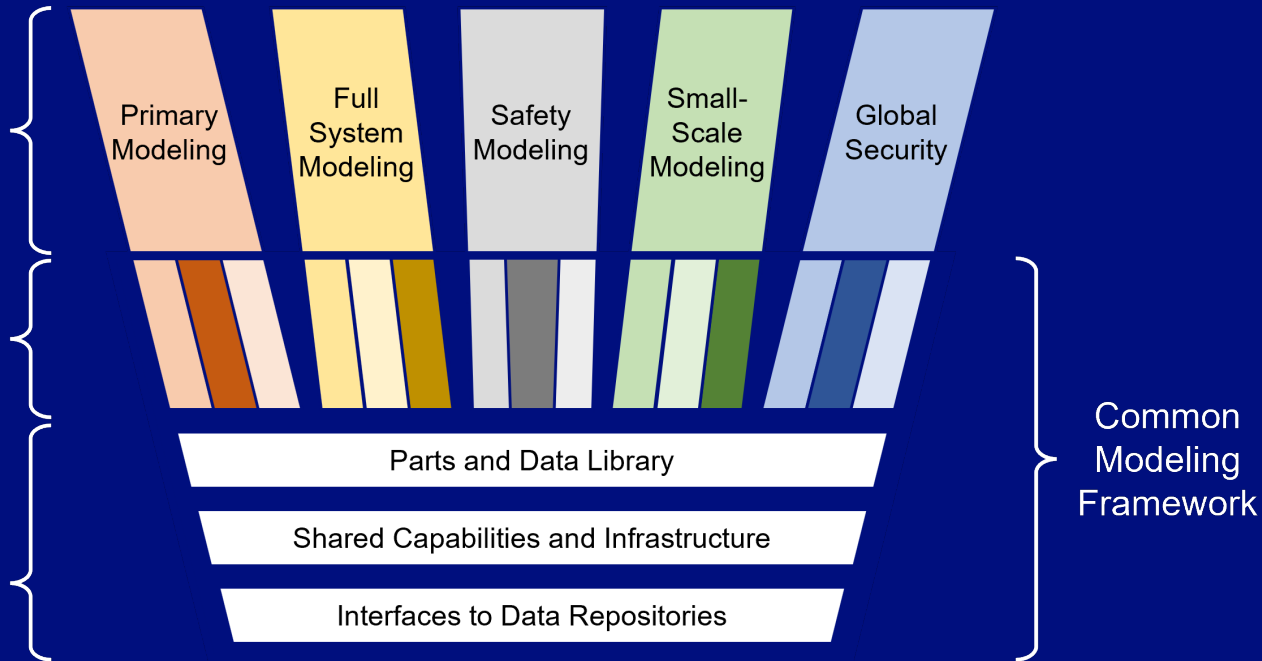
Ryan Scott
Harry Robey
Sara Negussie

The Common Modeling Framework represents an evolution in the way LANL's

Diverse application domains require diverse modeling strategies.

Modeling authorities within CMF give each community the **flexibility** to express its current modeling strategies and the power to **track institutional knowledge** over time.

Shared components and interfaces support reuse and collaboration.



Backups

CMF provides many capabilities to the LANL modeling community.

Several have already been achieved.

- **Provide a centralized location for model archiving.**
 - CMF offers a single location that is backed up regularly in which to store both problem setups and modeling strategies.
- **Offer modern version control.**
 - CMF uses standard Git and Bitbucket tools to provide version control, allowing tracking of experimental setups and modeling strategies over time.
- **Provide accessibility to simulation strategies for peer review purposes.**
 - Users can check the work of others, incorporating more sophisticated peer review into the modeling community.
- **Facilitate direct interactions between historically separated communities.**
 - Improve interconnection and inheritance between models developed by PEM, models validated by small-scale V&V, and simulations performed on integrated weapons tests, including the link between different groups in XTD.

CMF provides many capabilities to the modeling community.

Many are in progress.

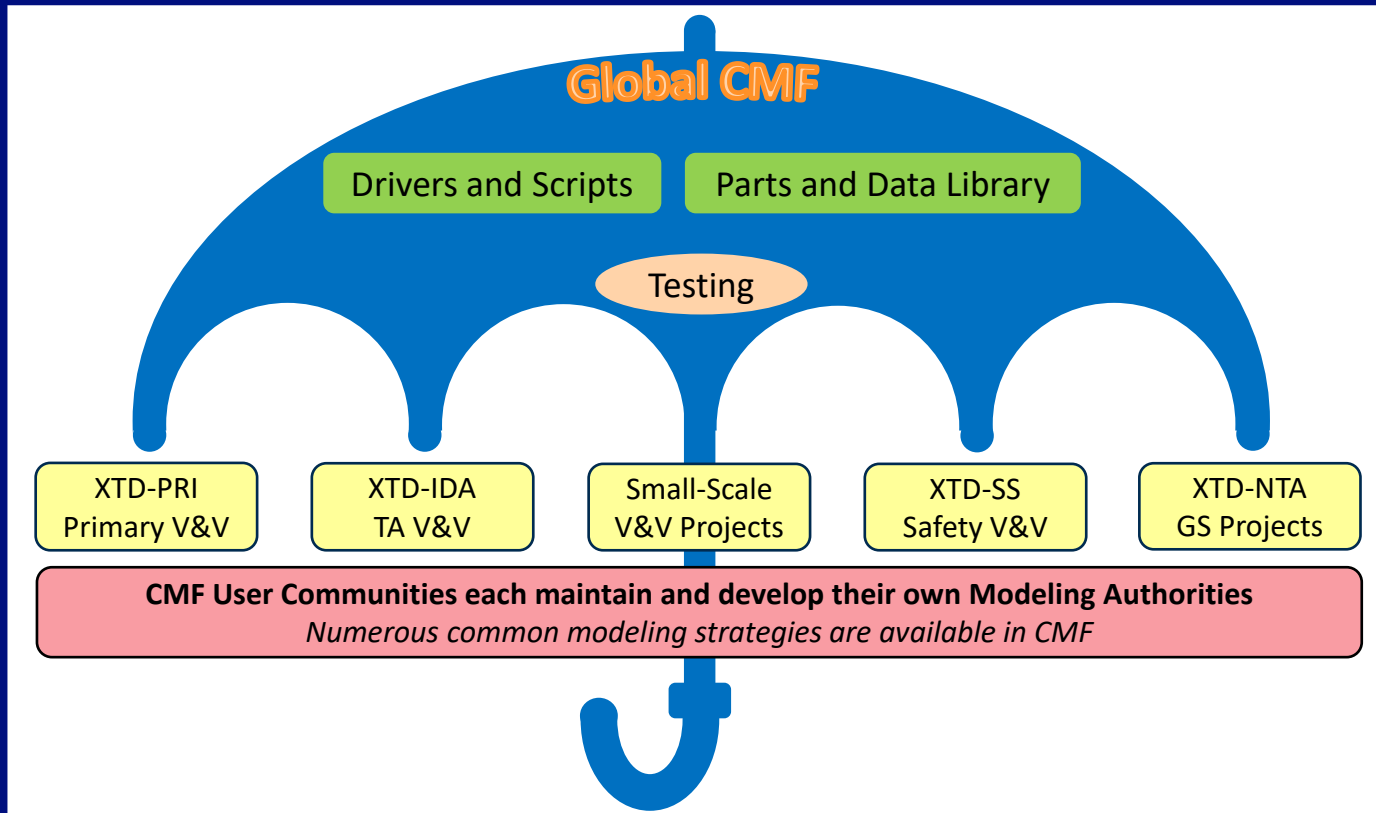
- **Facilitate comparison of competing notions of best practices for common modeling.**
 - Modeling strategies can be directly compared based on the identical geometry setup, leading to an evolution in our understanding of best practices over time.
- **Capture knowledge of subject matter experts.**
 - Ensure that completed work is not lost, but is instead archived in a standardized format that everyone can use.
- **Avoid duplication of effort.**
 - Library for geometric setups should contain one pedigreed version of every shot.
- **Enable pedigree of problem setups.**
 - Geometric and part setups in CMF should be pedigreed by multiple staff to ensure quality control.
- **Weapons Program data access.**
 - Automated access to weapons program data from a common interface.
- **Provide documentation for every capability and modeling authority in CMF.**

CMF has many activities and improvements planned over the next five years.

Long-term goals are numerous.

- **Parts and Data Library improvements**
 - Ensure pedigree for all parts, materials, models, and systems.
 - Fully shared and compatible parts and data repository across all authorities.
- **Global shared methodologies**
 - Materials and material model parameters should be shared and accessible by all authorities.
 - Common methods for post-processing analysis and parameter studies should be developed and shared.
 - Consistent meshing strategy appropriate for all users should be identified.
- **Comprehensive code and experiment test coverage**
- **Unified engineering and model development process**

CMF has a flexible infrastructure that provides version control and pedigree for LANL modeling capabilities.



Overview

