

EXPERIMENTAL DESIGN APPLICATIONS FOR MODELING AND
ASSESSING CARBON DIOXIDE SEQUESTRATION IN SALINE
AQUIFERS
DEFE 0004510

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U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and Building the Infrastructure for CO₂ Storage
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OUTLINE

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- Project Overview
 - BP1 Overview completed
 - Goals and Objectives BP2
 - Company SIGMA³
 - BP2 Overview
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- Summary

BENEFITS TO THE PROGRAM

- The project contributes to technical improvement of techniques to improve storage efficiency while ensuring containment effectiveness.
- The project is a software development and computer modeling effort to integrate well completion design including effects of geochemical and geomechanical stresses into the business as usual engineering design and operations of an oil/gas CO₂ utilization and storage site.
- The integration of various wellbore, dynamic, and static reservoir simulation tools will allow the evaluation of impacts of fractures on the engineering of injection well configuration, construction, and well placement as a valuable engineering aid for optimizing CO₂ injectivity, capacity, plume migration, and seal integrity in a CO₂ utilization/storage site.

Project Overview BP1 completed

- Objective: Reactive Transport Simulation
 - Reviewed Last Year
- Baseline Reservoir Model Defined
 - Detailed reservoir characterization model defined
 - Detailed Rock mineralogy/assemblage defined
- Commercial third party reactive transport simulator tested
 - Severe limitations of reactive transport simulation software for engineering purposes

Goals and Objectives -- BP2

- Computer modeling effort to integrate well completions design of geomechanical stresses
 - Oil/gas CO₂ utilization and storage site
- Design Placement and completion of wells
 - Impacts of natural fractures and induced fractures on the engineering of injection well configuration, construction, and placement
 - Injectivity, Capacity, plume migration and seal integrity in CO₂ utilization/storage site

Project Overview -- SIGMA³

- Purchased FPTI (FRESI) Feb 2011
- Delivers integrated reservoir solutions
- Bridging Geosciences and Engineering with Strategic Acquisitions
 - Completion Engineering (Pragmatic, Applied Geomechanics modeling)
 - Microseismic Acquisition & Processing
 - Borehole Seismic Imaging
 - Reservoir Modeling & Geophysics
 - Pore Pressure and Geohazards
 - Migration & Traditional Seismic Imaging

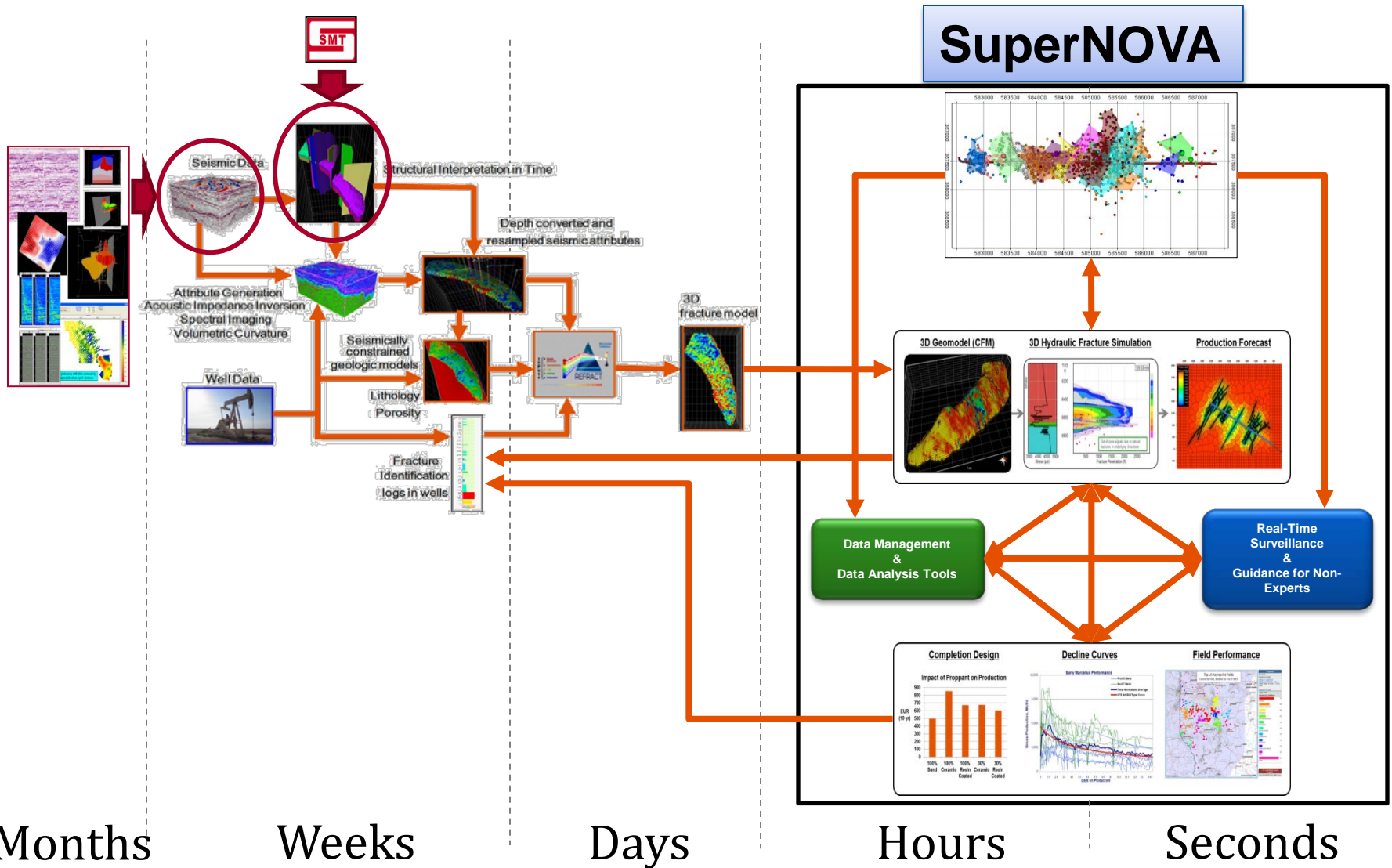
Project Overview -- BP2

- SuperNOVA -- Internal Platform Integrating GeoEngineering subsurface data acquisition
- DOE DEFE0004510 is small but important aspect of this project
 - BP 2
 - Geomechanics Rock and Petro- physics work flow
 - Leveraged to develop the technical geomechanical R&D portion of the project
 - Develop methods and techniques for completions practices for wells in carbon utilization and sequestration sites primarily in storage of mature oil and gas fields
 - Well placement and stimulation techniques as well as over all geomechanical workflows will be evaluated as scheduled in the original proposal

Project Approach BP2

- All geomechanical and software will be developed in-house with SIGMA³ developers and Geoscience and engineering expertise.
- All intellectual property will remain with SIGMA³ and/or its partners
- Oil and Gas Commercialized technology can enable carbon utilization and storage
- Agile project management system is used

SIGMA³ Services & Software Life-Cycles



SuperNOVA Enables New Workflows

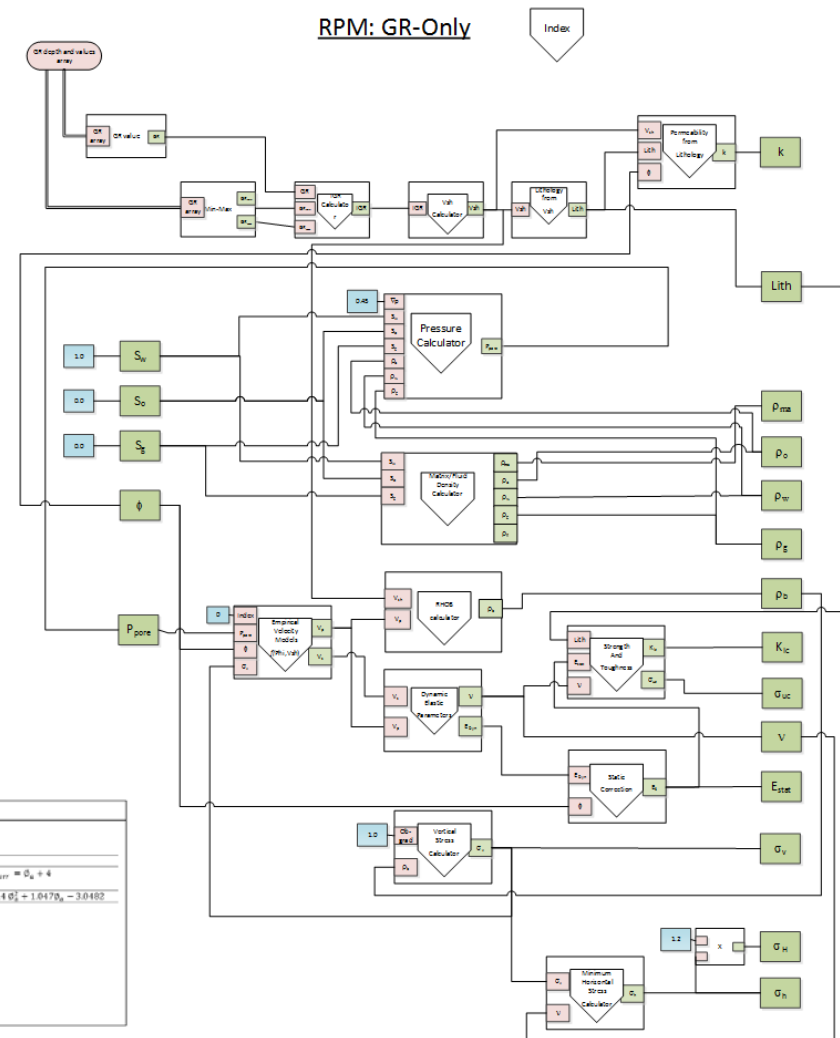
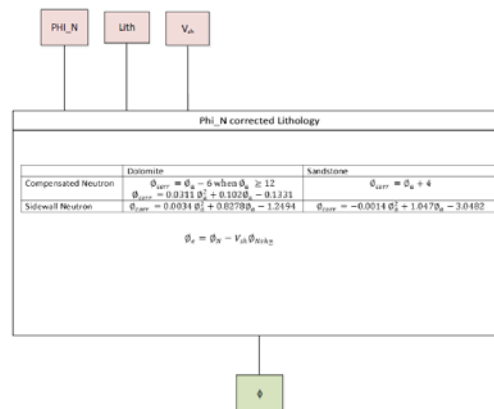
- **Field Development**
 - Integrate 3D faulted grids, petrophysics, attributes, microseismic data, well performance (injectivity), etc.
 - Connect to multiple engineering and geoscience data sources on-the-fly
 - Design wells / schematics in 3D with geopressure and “sweet-spot maps”
 - Perform decline curve (or injectivity) analysis & production (capacity) forecasting
 - Study “what if?” scenarios with economic modeling
- **Field Operations**
 - Analyze real-time well performance and microseismic data during injection
 - Perform injection simulations & completions optimization
- **Real-Time Collaboration**
 - Leverage cloud-based, multi-point communication for decision making
 - Share views, critical data, and video between the office and field

Accomplishments to Date

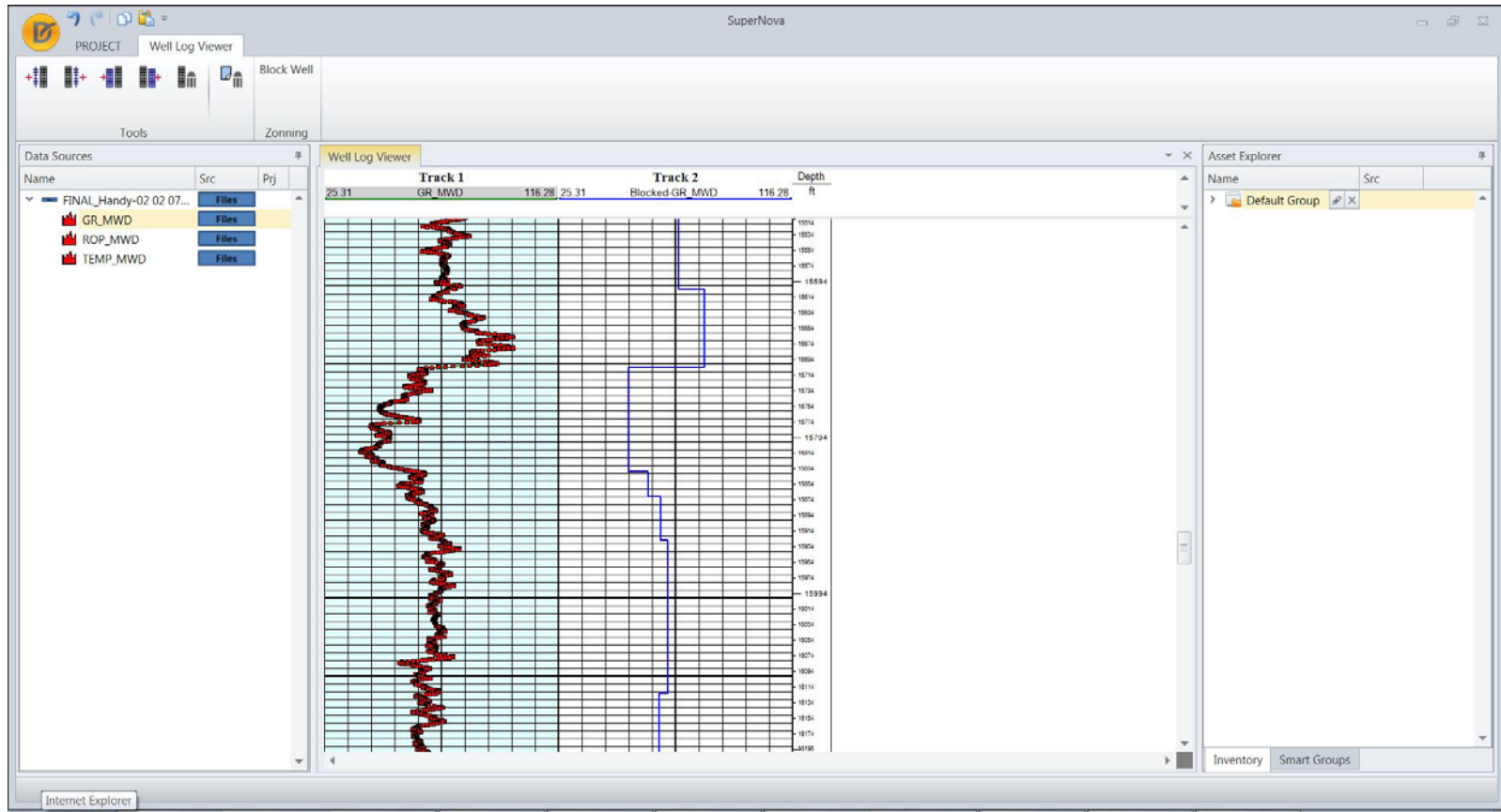
- User Interface
- Data base exchange architecture and protocols
 - Preliminary stimulation and reservoir models (not implemented)
 - Realtime acquisition of microseismic and completion data
- Petro- and Rock physics analysis inputs and workflow protocols for implementation in geomechanics models
- Well bore schematic modules and preliminary wellbore modeling

Rock Physics Modeling

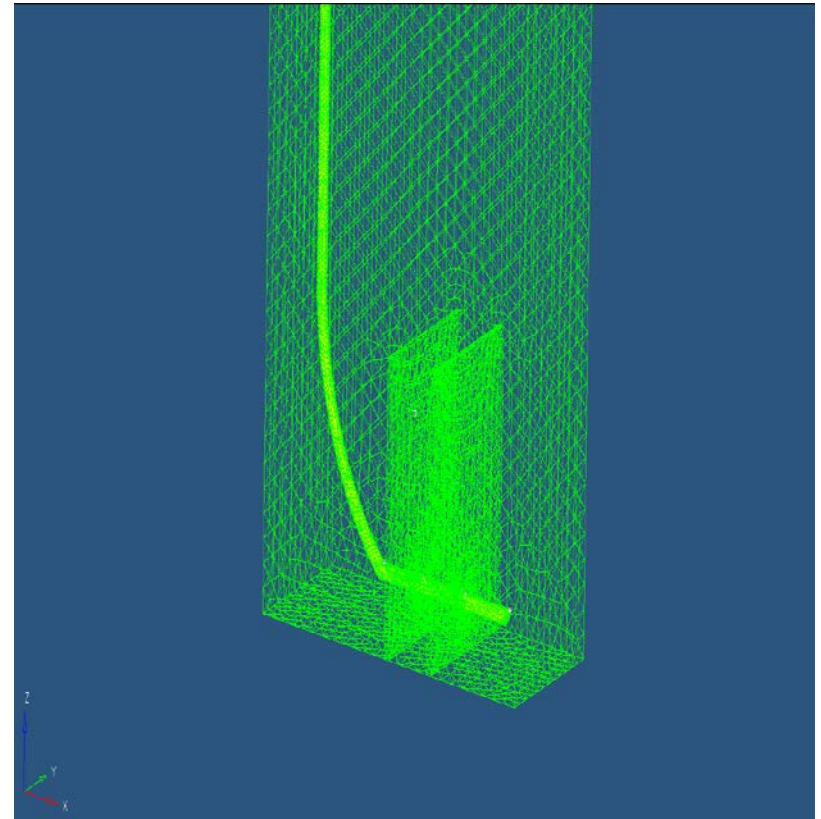
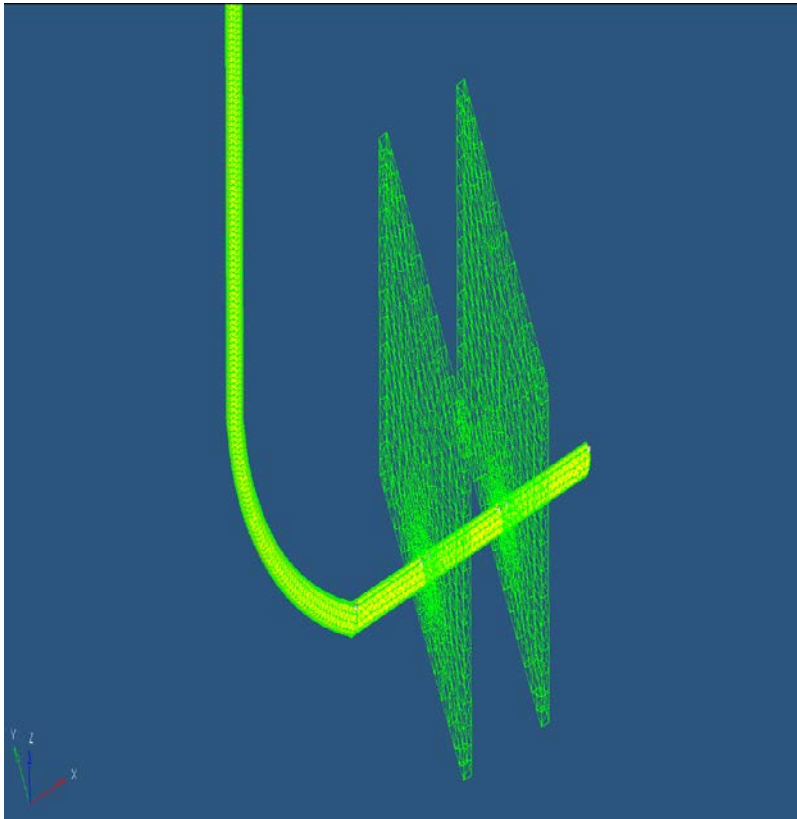
- Goal: Produce *standard set* of reservoir properties using whatever logs are available
- Purpose: Create pseudo-logs and extrapolated data (via Kriging, etc.) for use in field studies, reservoir and frac simulators, and data analytics
- 24 permutations of six types of logs
 - Gr
 - SP/resistivity
 - Density
 - Neutron
 - Acoustic



Well Log Blocking



Wellbore Modeling Meshing



Summary and Future Work

- Project is strategically parallel with company direction and purpose
- Use of Agile project management style
- User interface and data base architecture protocols designed
- Rudimentary/basic wellbore modeling efforts
- Rock physics concepts modeling
- Completion well simulation

END

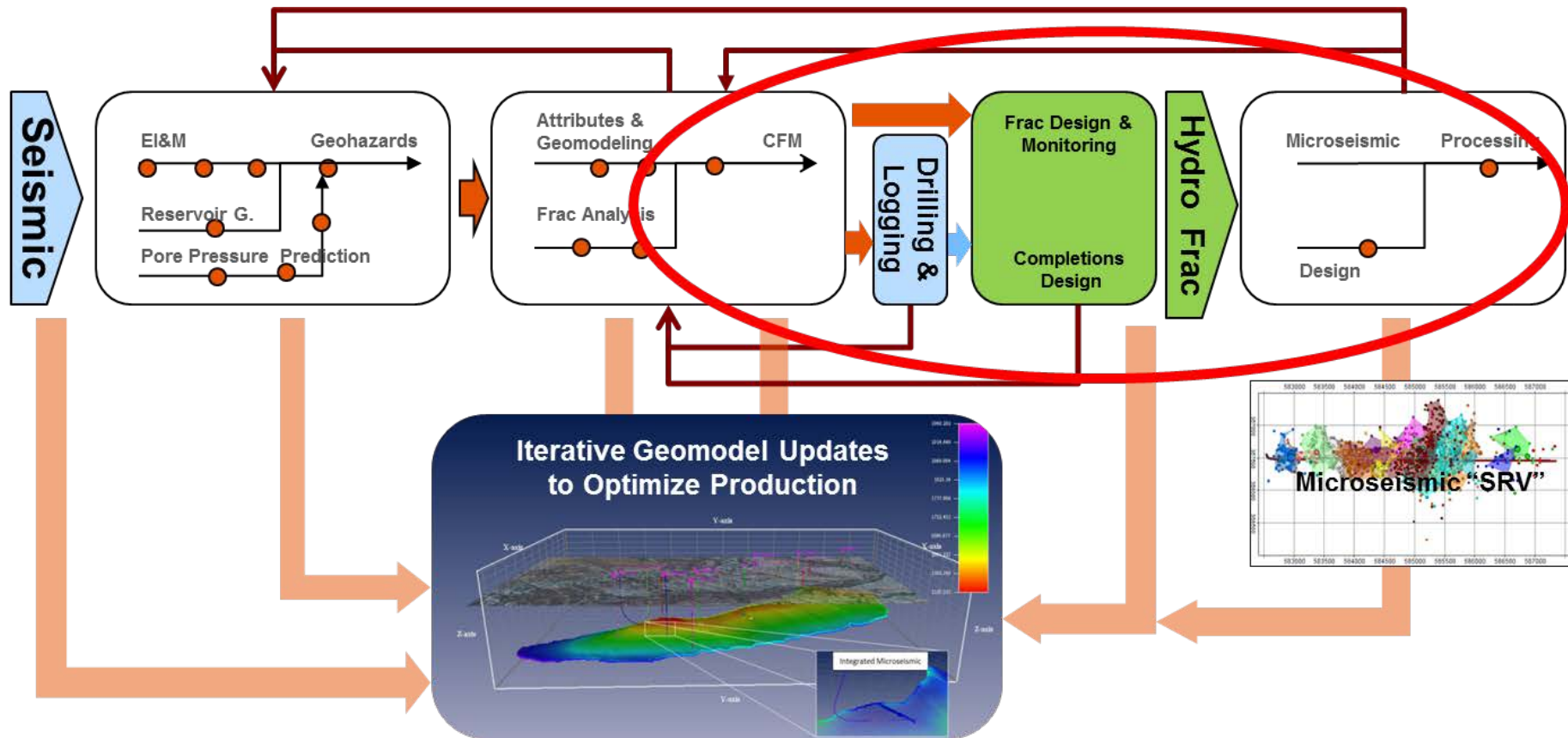
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Appendix

Not to be shown

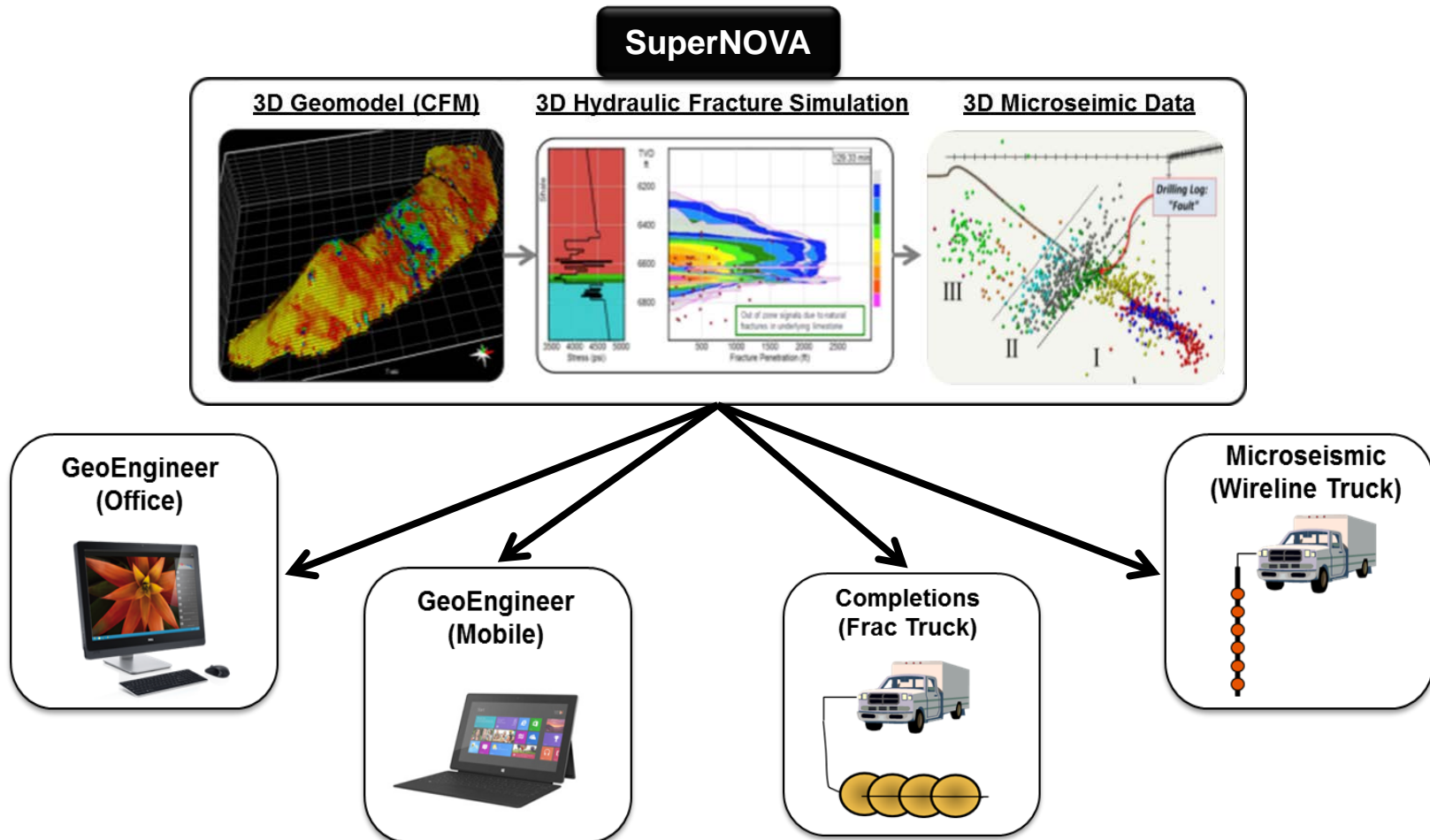
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SIGMA³ Technologies Span the Entire E&P Workflow, and Hydraulic Fracturing is Key



“SuperNOVA” is our New Integration Platform for Subsurface GeoEngineers

- Lite application that integrates SIGMA³ technology and enables real-time collaboration between field and office GeoEngineering teams



Gantt Chart

