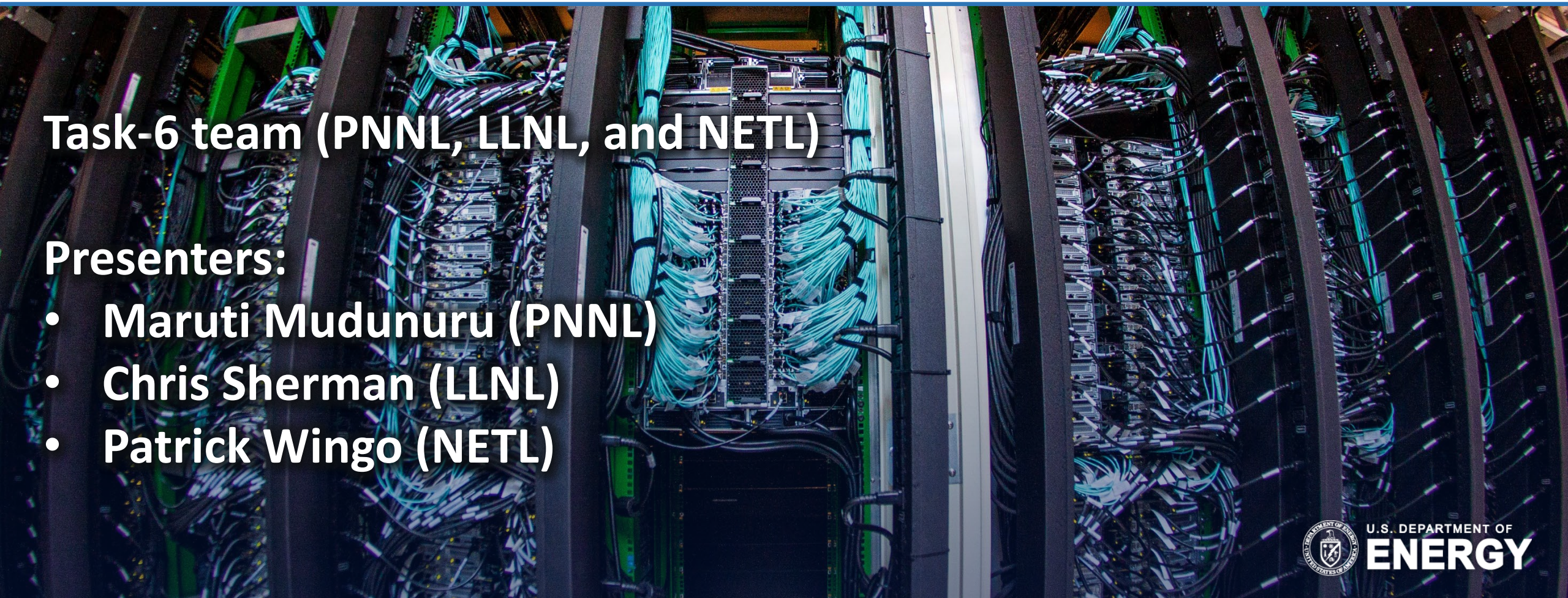
SMART Visualization and Decision Support Platform

Science-informed Machine Learning to Accelerate Real Time (SMART) Decisions in Subsurface Applications



Task-6 team (PNNL, LLNL, and NETL)

Presenters:

- **Maruti Mudunuru (PNNL)**
- **Chris Sherman (LLNL)**
- **Patrick Wingo (NETL)**

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Acknowledgments and disclaimers

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Outline of the talk

- Part-1: SMART platform (~5-6 minutes by Maruti Mudunuru)
  - Overview of the Platform and its ecosystem
  - EY24 early win
    - Platform's user-interface
    - Integration of key SMART modules into the Platform

- Part-2: STRIVE package -- SMART Tools Rapid Visualization Environment (~5-6 minutes by Chris Sherman)
  - Overview of STRIVE -- Modern-looking, flexible, fast, and efficient user interface
    - Benefits of using STRIVE
    - Platform, ORION, and VLE user-interfaces
  - Impact – How will the SMART modules/platform utilizing STRIVE help the CCS industry?

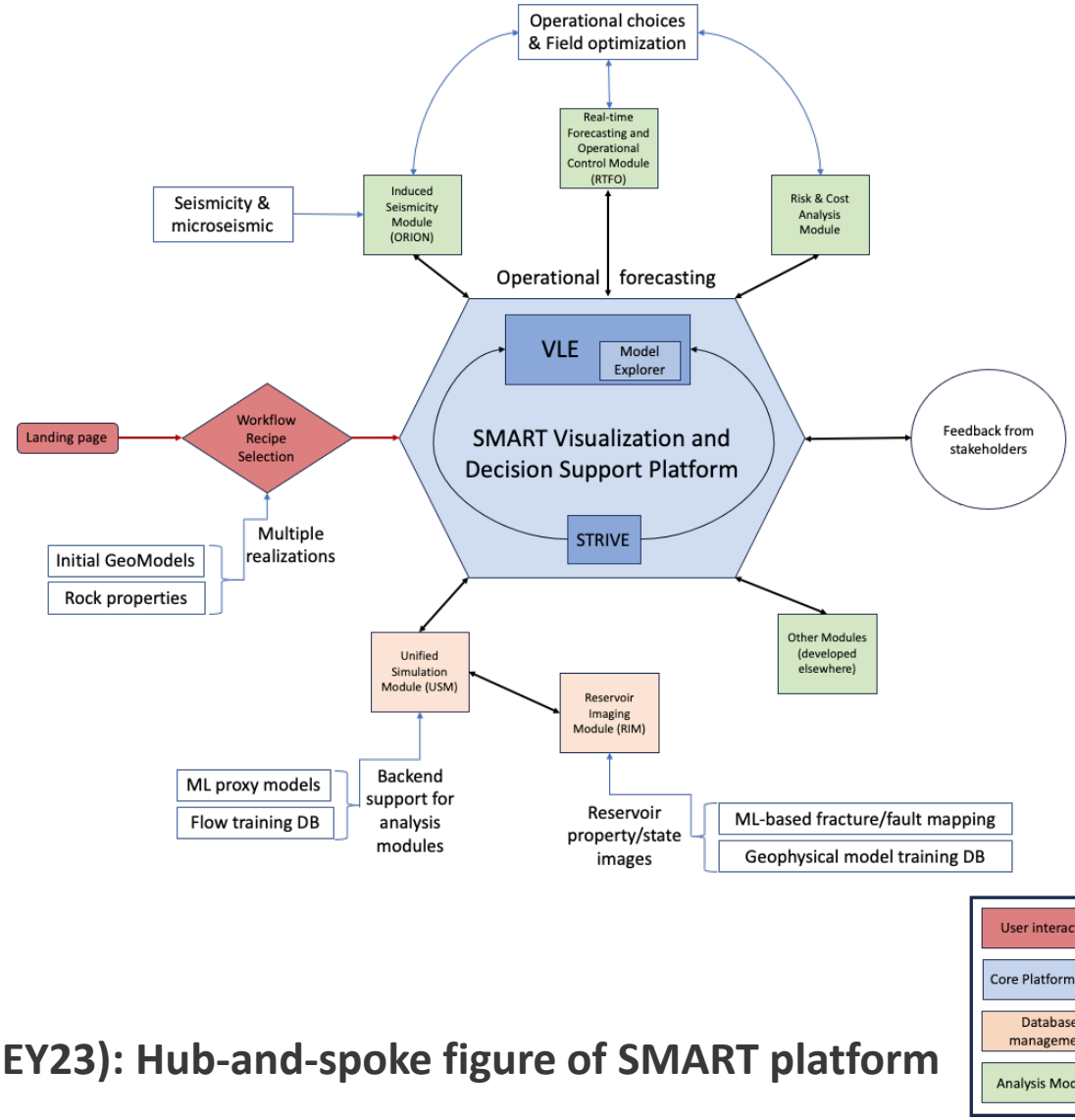
Part-1: SMART Visualization and Decision Support Platform

Task-6 (EY23 and on-going EY24): Key Developers, Contributors, and Participants – PNNL, LLNL, NETL

POCs	Key developers and contributors	Other contributors
• Maruti Mudunuru • Chris Sherman • Hema Siriwardane	• Patrick Wingo • Eusebius Kutsienyo • Alex Hanna • Ashton Kirol • Wenjing Wang • Veronika Vasylkivska • Kolawole Bello • David He • *Mathew Harris* • *Ivani Patel* • *Armando Sanchez*	• Derek Vikara • David Morgan • Diana Bacon • Gavin Liu

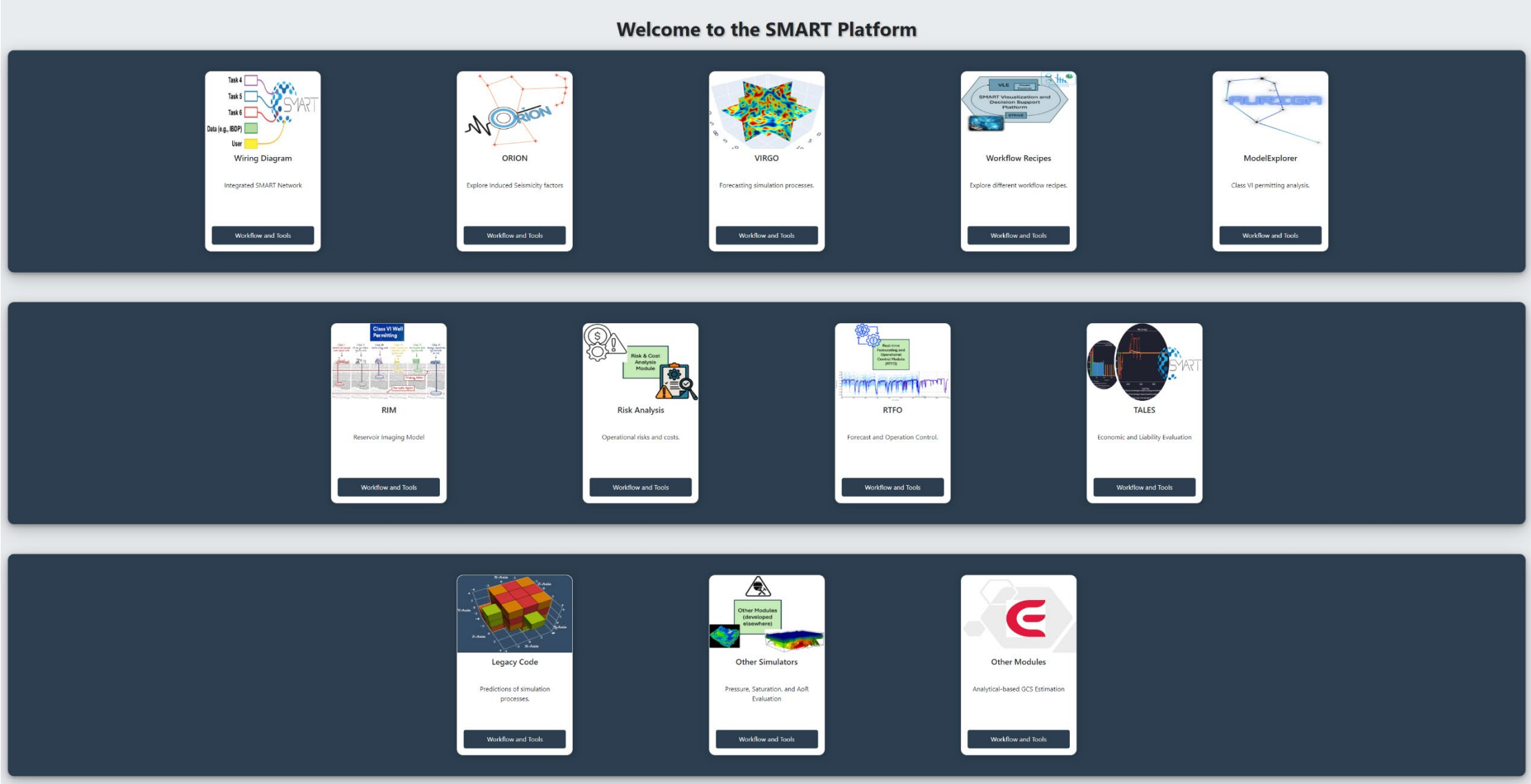
Part-1: SMART multiverse (end-to-end): Piecing everything together

- Key terminology
  - **SMART Platform**
    - SMART visualization and decision support platform
    - **STRIVE interface** allows to develop consistent look and formatting for SMART modules
  - **SMART Modules**
    - USM, ORION, RTFO,
    - VLE, ModelExplorer
    - Risk and Cost Analysis

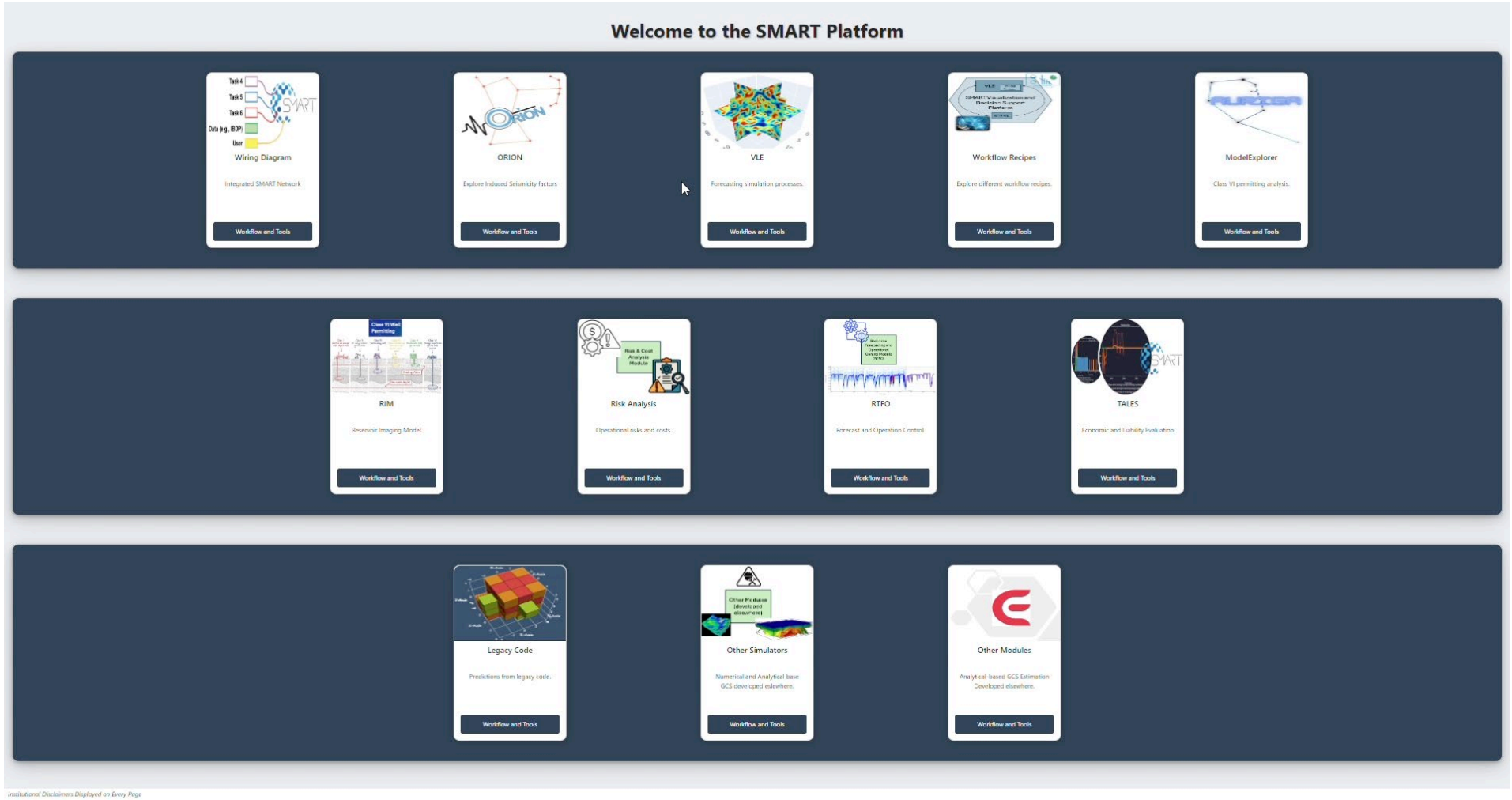


Version-1 (EY23): Hub-and-spoke figure of SMART platform

Part-1: EY24 Early win – SMART platform's graphical user interface



Part-1: EY24 Early win – SMART modules integration into overall platform (video)



Part-2: STRIVE – SMART Tools Rapid Visualization Environment Package

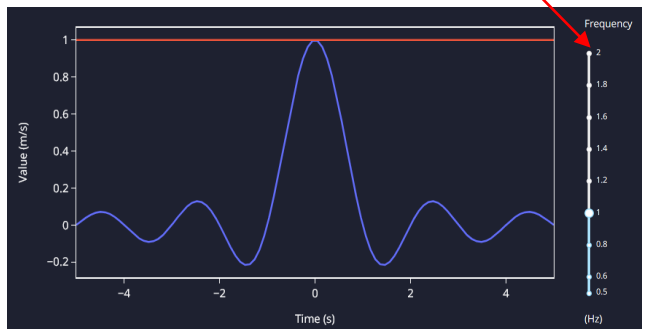
- **STRIVE provides tools for building a modern-looking, flexible, and efficient GUI in Python**

- **To implement STRIVE a user/developer needs to:**
  - Use the provided object base class
  - Write simple API instructions to create figures, widgets
  - STRIVE parses these objects and creates the GUI at run-time

- **This approach provides these benefits:**
  - Simplifies the development process
  - Minimizes redundant code
  - Potential to target multiple front-end engines
  - Approach was adapted from the previous ORION GUI framework, which used Tkinter

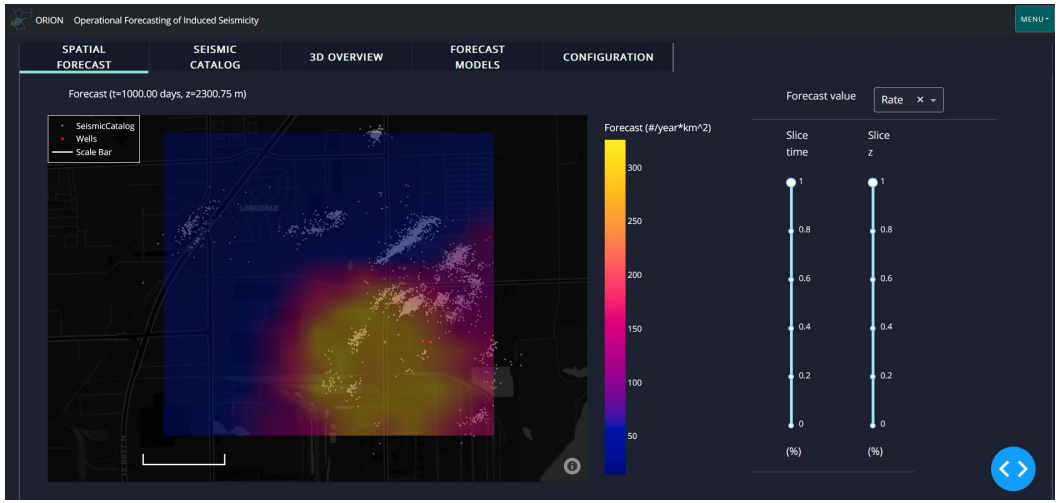
- **Current front-end selection: Plotly/Dash**
  - Browser-based and scalable
  - Can be hosted on the cloud or the user's desktop

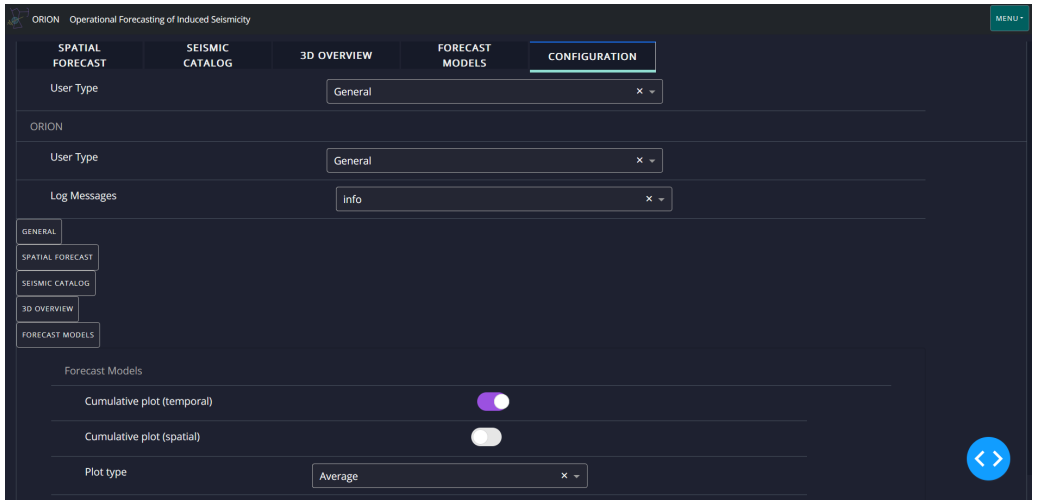
```python
class Example(data_manager_base.DataManagerBase):

    def set_class_options(self, **kwargs):
        self.name = 'Child'
        self.float_value = 1.0

    def set_gui_options(self, **kwargs):
    self.gui_elements['float_value'] = {
        'element_type': 'entry',
        'label': 'Frequency',
        'position': [0, 0],
        'units': '(Hz)'
    }
```



Part-2: STRIVE-based ORION user-interface

- **ORION serves as the Induced Seismicity Module for Platform**
- **Key inputs:**
  - Observed seismic activity
  - Pressure model
  - Geologic model
- **Outputs:**
  - Independent seismic forecast models that are based off different physical assumptions, statistics, and ML (in development)
  - An ensemble seismic forecast
  - Visualizations to assist end-users understanding of seismic activity / risks



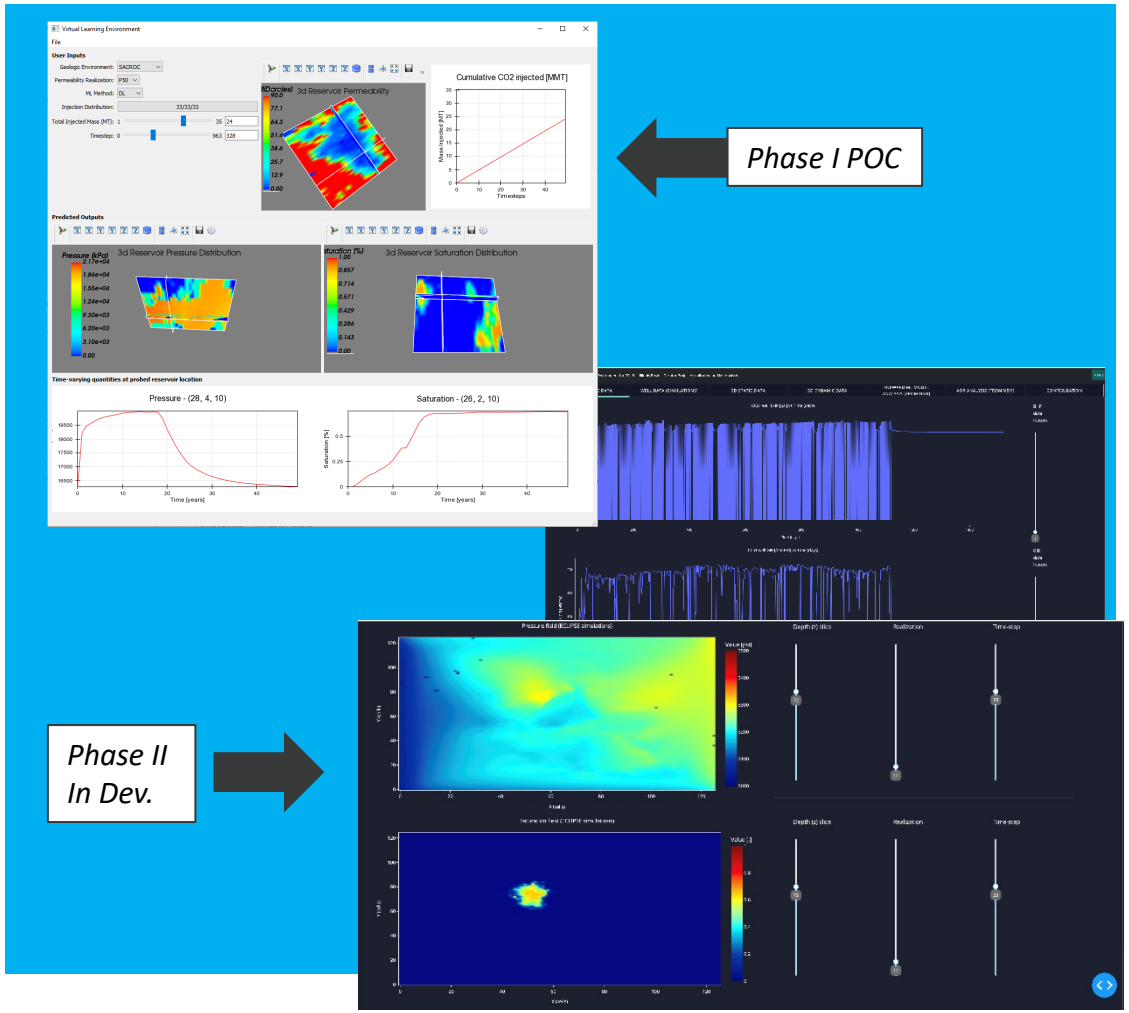


Part-2: STRIVE-based Virtual Learning Environment (VLE) Module

*The **Virtual Learning Environment (VLE)** is an exploratory module which uses ML predictions to rapidly inform an end user of how a given reservoir simulation would likely change in response to altered inputs (i.e., "What-if" scenarios)*

Phase II development utilizing STRIVE progress includes:

- Encompass Phase I behavior
  - Explore *predicted* changes in pressure and saturation over time given injection rate and permeability profile
  - Additional framing data (AoR) is integrated
  - ML model analysis and visualizations
- Be migrated to an online environment
- Import ML data from Unified Simulation Module (USM)
- Exploring the during and post-injection scenarios



Benefit to CCS industry:

- **Virtual learning:** Computer-based experiential learning environment to improve field development and monitoring strategies
- **Real-time visualization:** Visuals of key subsurface features and flows by exploiting ML to substantially increase speed and enhance detail

Conclusion – Impact of SMART platform & its modules to CCS Industry

- SMART platform + STRIVE will help us rapidly create, test, and deploy tools developed under SMART
- By design, tools can be tailored to the end-user's needs and level of expertise
- Figure indicates how a recipe could be used to map the platform to a target workflow

Example Recipe:

1. [USM] Parse results from a FMM-based pressure model
2. [USM] Convert model to VTK and interpolate onto a regular 4D grid
3. [DATA] Send the pressure model from USM to ORION
4. [ORION] Load a second pressure model (in ORION's preferred .hdf5 format)
5. [ORION] Load seismic data from a local catalog
6. [ORION] Build a seismic forecast and ensemble model
7. …

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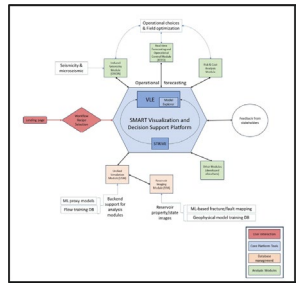

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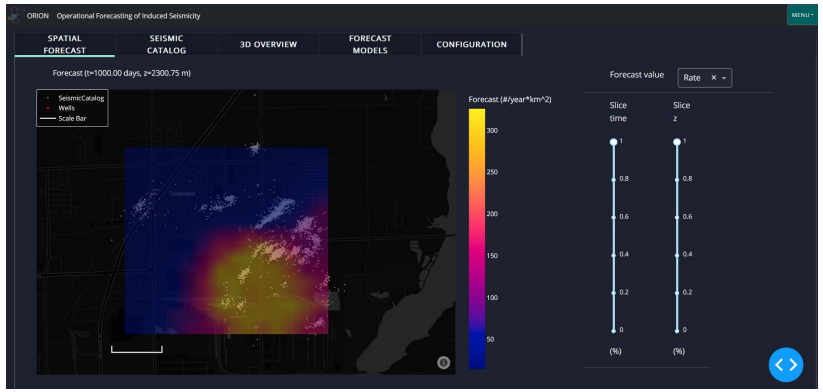

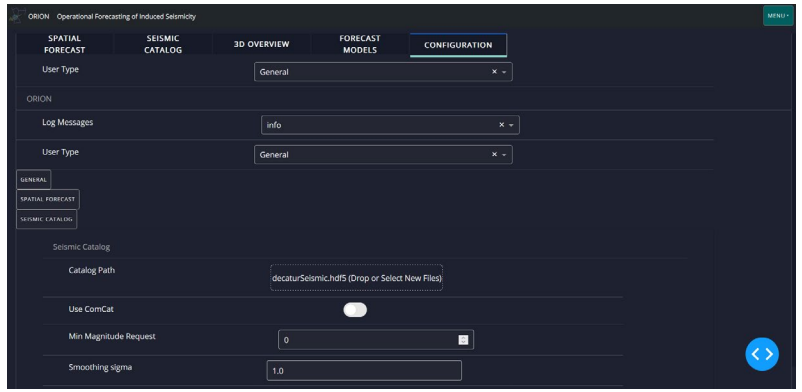

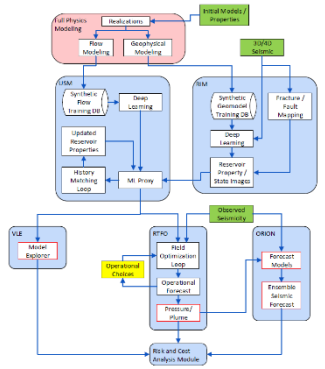

Live-demos and posters on SMART platform & its modules

- Live-demos and posters of SMART tools
  - SMART Tools Rapid Visualization Environment (STRIVE) Package – Chris Sherman
  - Operational FoRecastIng Of INduced Seismicity (ORION) – Kayla Kroll and Chris Sherman
  - Model Explorer module – Ashton Kirol and Ivani Patel
  - Real-time Forecasting and Operational Control (RTFO) module – Alex Hanna
  - Virtual Learning Environment (VLE) Module – Maruti Mudunuru
  - Unified Simulation Module (USM) – Wenjing Wang
  - Engineering Economics Module (TALES) – Dave Morgan
  - SMART platform (EY24 early win) – Eusebius Kutsienyo

Questions?

Thank you!

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