High Performance Agent-based Simulation (HiPAS) GridLAB-D

CEC EPC-17-046

LF Energy Project Status Report - 12 December 2022

David P. Chassin, PI

SLAC National Accelerator Laboratory

Menlo Park, California

SLAC National Accelerator Laboratory is operated by Stanford University for the US Department of Energy under Contract DE-AC02-76SF00515

Project goals and objectives

The Problem

- GridLAB-D vital in power system simulation
- Renewables, storage, demand response
- DOE version limitations hamper usability

Target Audience

- Utility planners
- Engineering consultants and researchers
- Hardware and software vendors
- Energy/climate regulators & policy-makers

Product Delivery

- Commercial partner for long-term support

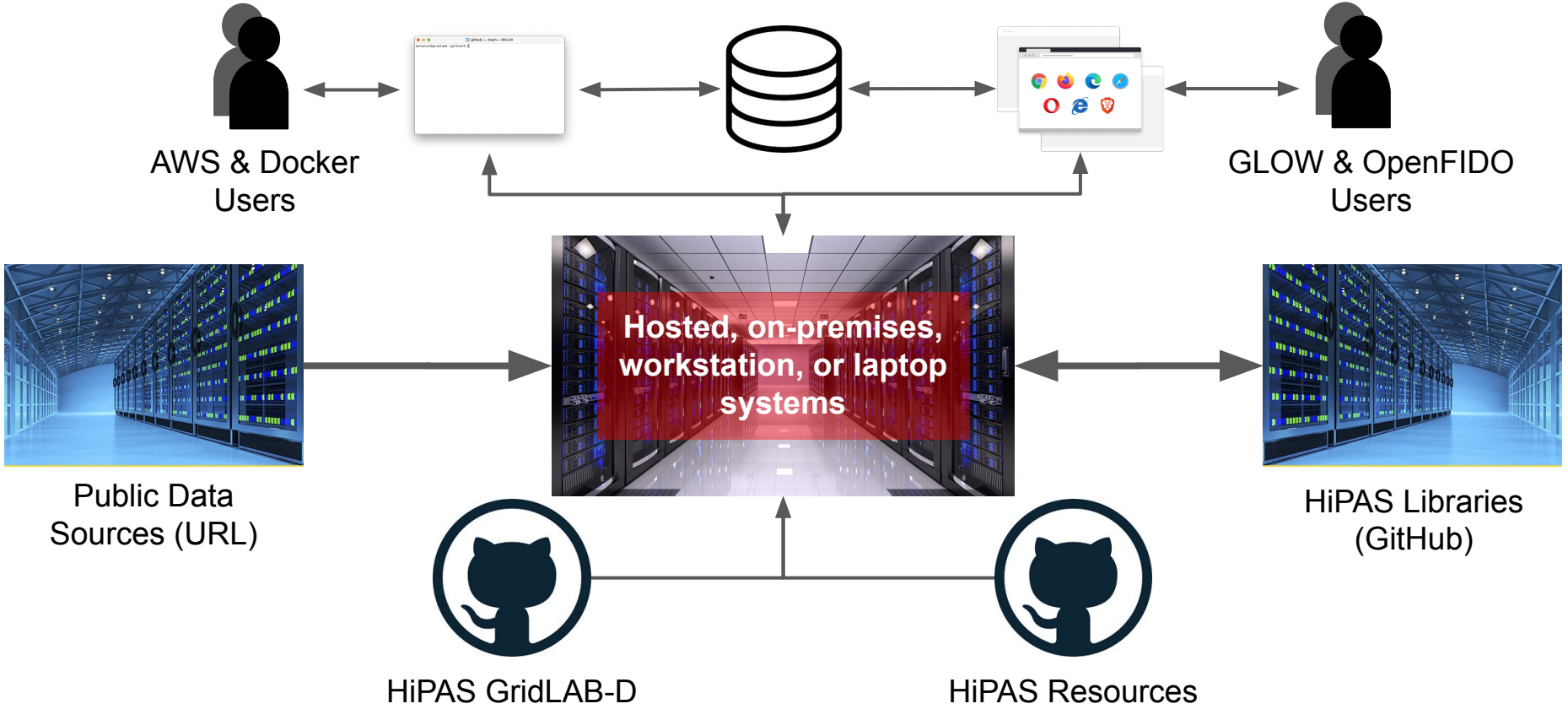
Goals

- More widely usable/functional version
- Broad set of performance enhancements
- Foundation for long term support

Objectives

- Identify and address key use-cases
- Evaluate performance improvements
- Open-source delivery and support
- Collaborations with CEC/DOE projects
  - OpenFIDO (CEC-17-047)
  - Hitachi GLOW (CEC-17-043)
  - GRIP (DOE GMLC climate resilience)

HiPAS GridLAB-D System Architecture



HiPAS Technical Approach: System Components

HiPAS Resources on GitHub

GridLAB-D: enhanced version of GridLAB-D

Templates: standard analysis methods

Weather: historical, current, and forecast data

Libraries: standard object data

Models: standard models for validation

Benchmarks: performance benchmark models

Examples: sample models used in tutorials

- All application resources are open source

GridLAB-D Components

Converters: automatic input/output converters

Geodata: GIS data handling

Python: Python code integration

Subcommands: embedded analysis resources

Tools: general purpose utility tools

- All public component code is open source
- Supports integration of private components

HiPAS Technical Delivery Approach: CI/CD

Continuous Integration

- Deliver apps from multiple developers/teams
- Introduces automation in development stages
- Solution to problem of integrating new code

Continuous Delivery

- Implements a pipeline of delivery/update tasks
- HiPAS uses GitHub "DevOps" methods

Repository	Status
GridLAB-D	master passing · develop passing
Templates	master passing · develop passing
Weather	validate passing
Library	validate passing
Models	validate passing
Benchmarks	Manual test (see README.md)
Examples	Manual test (see README.md)

Example CI/CD status report from HiPAS GridLAB-D on GitHub shows development and deployment status.

Updates on major project tasks

Task 2 - Requirements Analysis (Done)

- HiPAS GridLAB-D Release Requirements Presentation (Done)

Task 2.1 - Use Case Requirements (Done)

Task 2.2 - Performance Baseline (Done)

Task 2.3 - Software Upgrade Design (Done)

Task 2.4 - Performance Specifications (Done)

Task 2.5 - Testing Plan (Done)

Task 2.6 - Software Design (Done)

Task 3 - Software Implementation (Done)

- Release Candidate 1 (Done)
- Software Design Implementation CPR (Done)
- Software Implementation Presentation (Done)

Task 3.1 - Multi-threading Iterators (Done)

Task 3.2 - Job Control (Done)

Task 3.3 - Multi-threaded Solvers (Done)

Task 3.4 - Stochastic Properties (Done)

Task 3.5 - Fast Data Access (Done)

Task 3.6 - Fast Powerflow Solver (In progress)

Task 3.7 - Online Documentation (Done)

Task 3.8 - Candidate Release 1 (Done)

Update on major project tasks (continued)

Task 4 - Performance Analysis

- Release Candidate 2 (Pending)
- Performance Evaluation Presentation (Done)
- Performance Analysis CPR Report (Pending)

Task 4.1 - Performance Evaluation 1 (Done)

Task 4.2 - Issues Tracking and Resolution (Pending)

Task 4.3 - Analysis (Pending)

Task 4.4 - Performance Evaluation 2 (Pending)

Task 4.5 - Release Candidate 2 (Pending)

Task 5 - Integrated Production Release

- Final Production Release Presentation (Pending)

Task 5.1 - Support Release Production (Pending)

Task 5.2 - Final Product Documentation (Pending)

Task 5.3 - Final Release Product (Pending)

Task 6 - Evaluation of Project Benefits

Task 7 - Technology Transfer

HiPAS Use-Cases

Use-Cases Identified by TAC

1. Hosting Capacity (ICA)
2. Tariff Design
3. Electrification
4. Resilience (GRIP)

Notes: these are delivered using templates

Other Use-cases

1. CYME Converters (Version 5, 8, 9)
2. NERC Load Composition Analysis
3. Weather history, typical, current, forecast
4. Geographic datasets
    a. Vegetation
    b. Census regions & address resolution
    c. Distance calculations
    d. Fire hazards
    e. Powerline sag, clearance, and contact
    f. Utility/service providers
    g. Weather (local, regional)

Key Findings

Requirements

Open Source Software

- Users want open-source software
- Utilities wary of open-source support

Deployment Flexibility

- Utility migration to cloud is going slowly
- On-premise servers still preferred
- Local workstation/laptop still desired

Result Reproducibility

- Must retrieve/reproduce old results

Implementation

Deployment Platform

- Cloud and docker use extensively

CI/CD Modernization

- Older CI/CD tools unstable/dropped
- GitHub is preferred

Commercializability

- Limited open-source licenses (no GPL)
- LF Energy application approved

Results from testing and validation: Approach

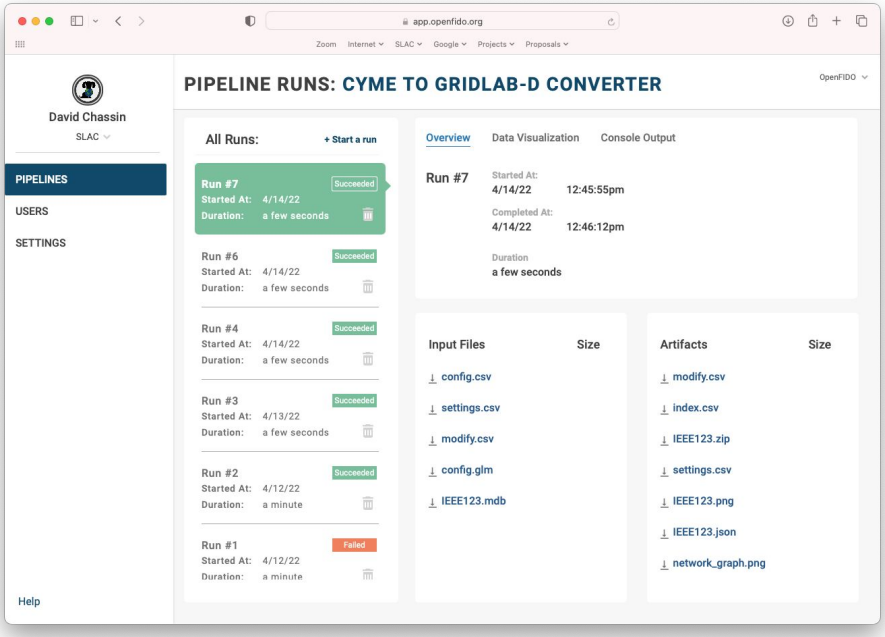
Methodology

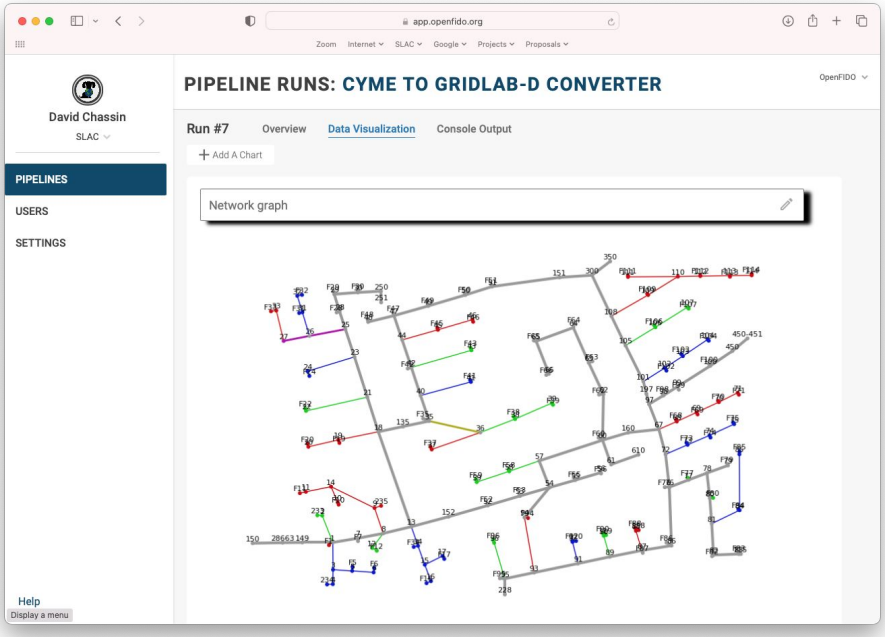
- CI/CD-based testing/validation (GitHub)
  - Test and validate all repositories
- GridLAB-D validation
  - Check GLM syntax
  - Check module classes and objects
  - Check results of solvers
  - Check results of analyses
- Component validation
  - Converters
  - Geographic information system (GIS)
  - Python interface
  - Subcommands
  - Tools

Implementation

- Support repository validation
  - Templates
  - Weather data
  - Libraries
  - Models
  - Benchmarks (manual)
  - Examples (manual)
- Validation by external tools
  - CEC/OpenFIDO
  - CEC/GLOW
  - DOE/GRIP
  - DOE/TESS
  - DOE/ALM

HiPAS Use-Case: Cyme Model Conversion





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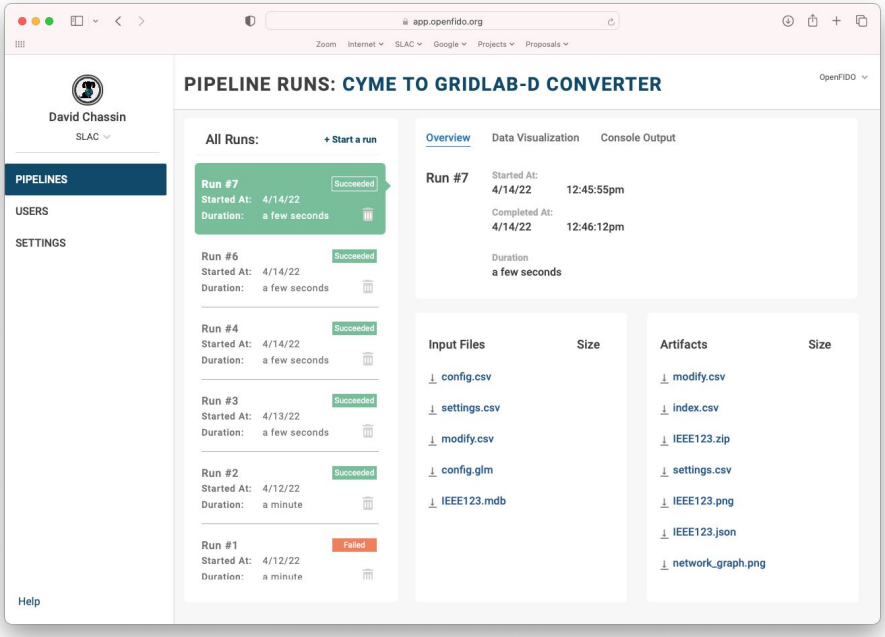
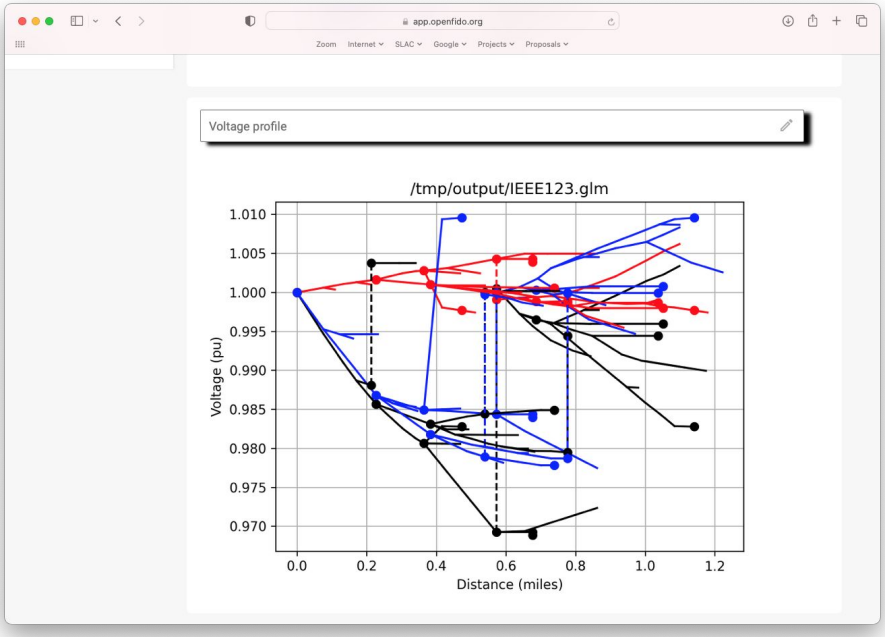
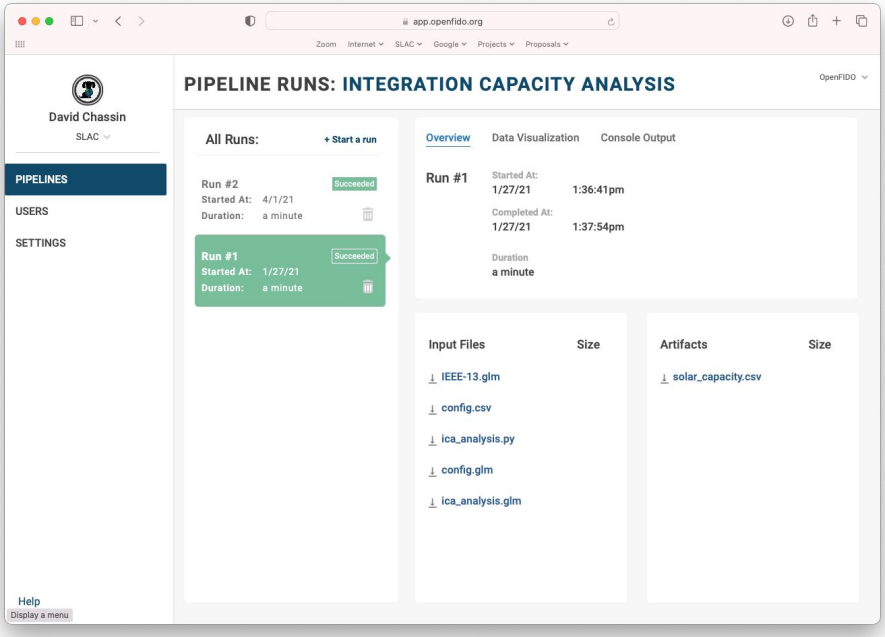
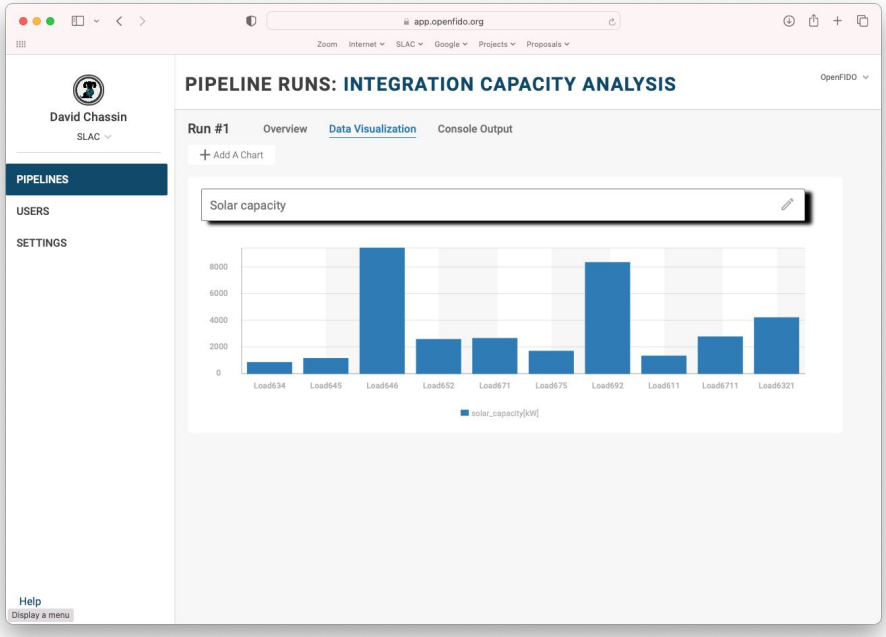


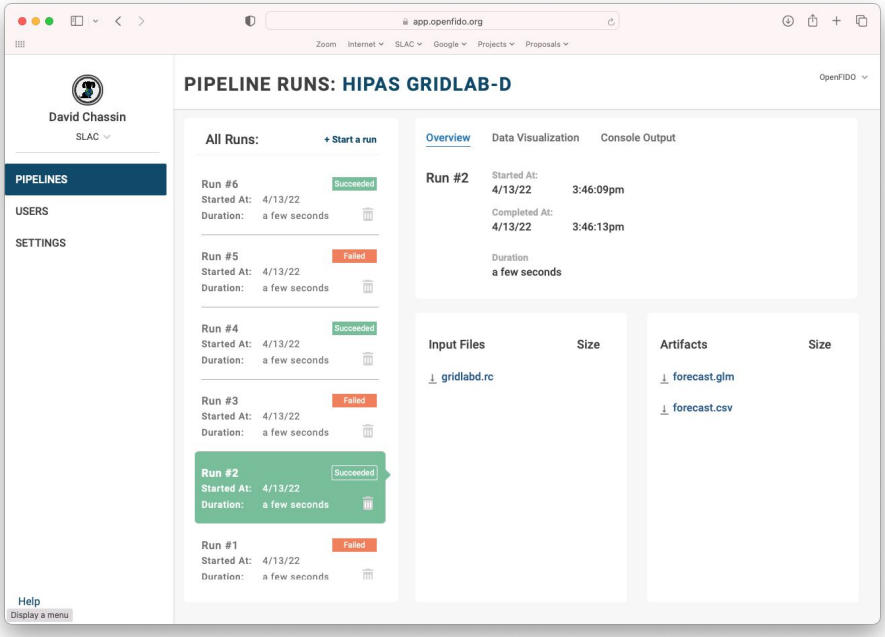


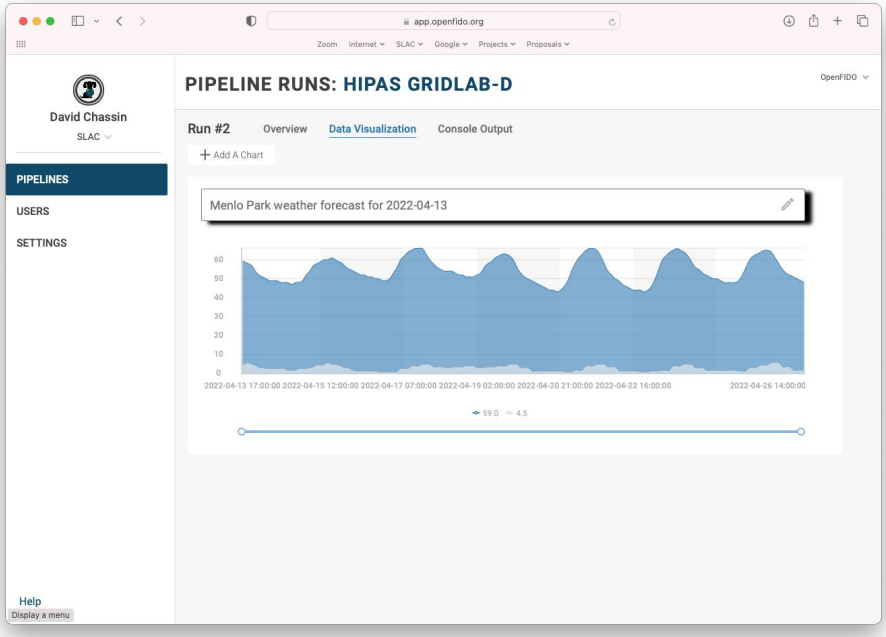
HiPAS Use-Case: Integration Capacity Analysis



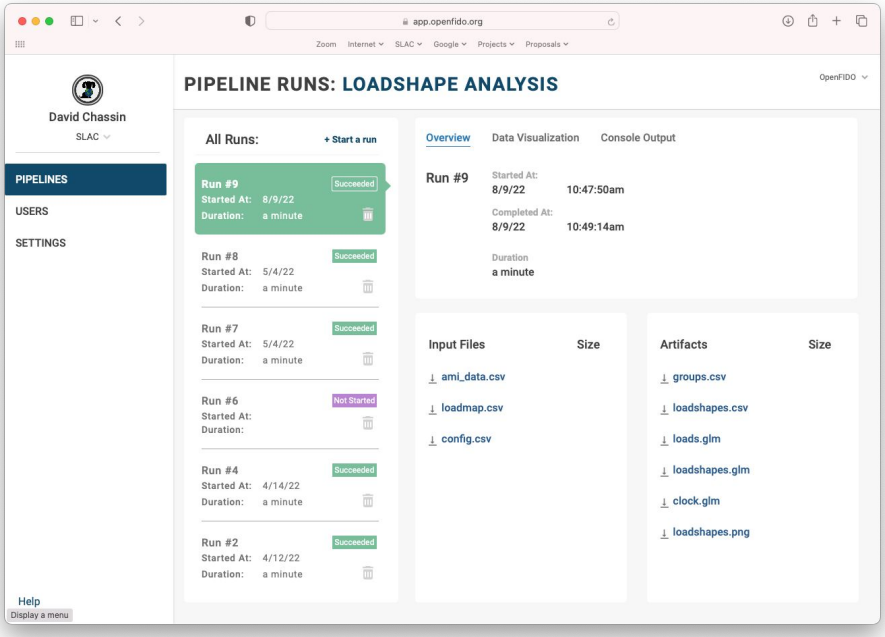


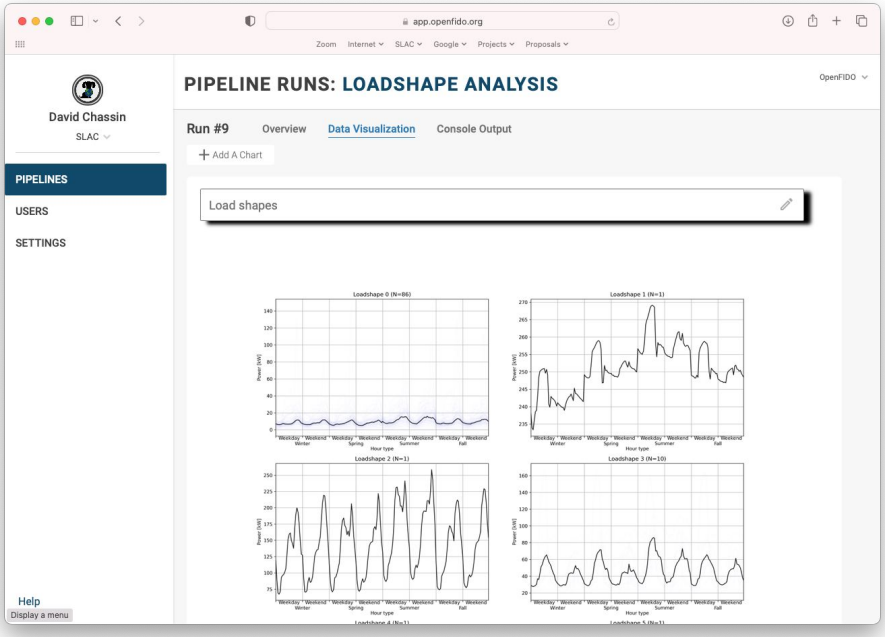
HiPAS Use-Case: Weather forecasting



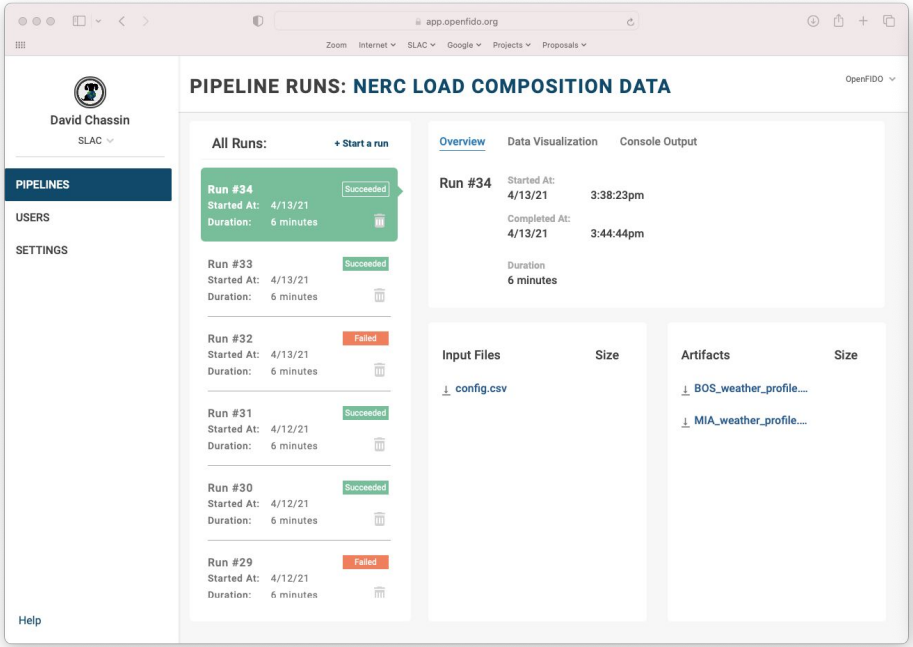


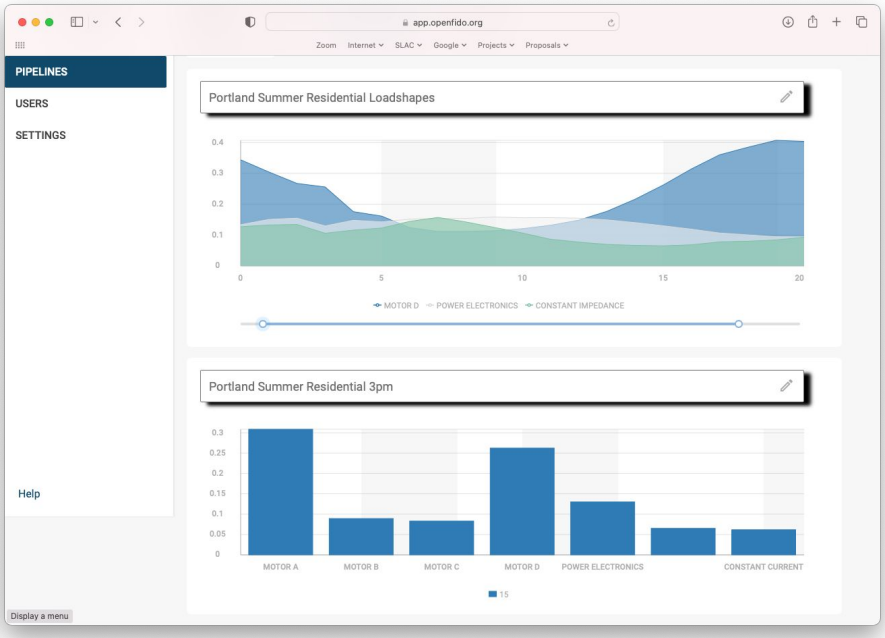
HiPAS Use-Case: Loadshape Analysis



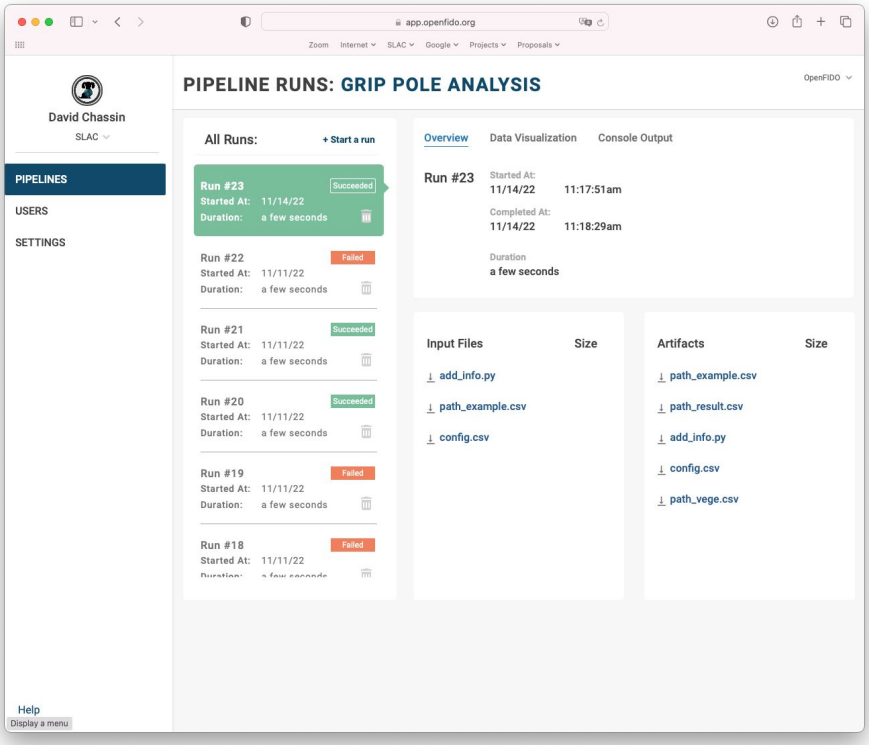


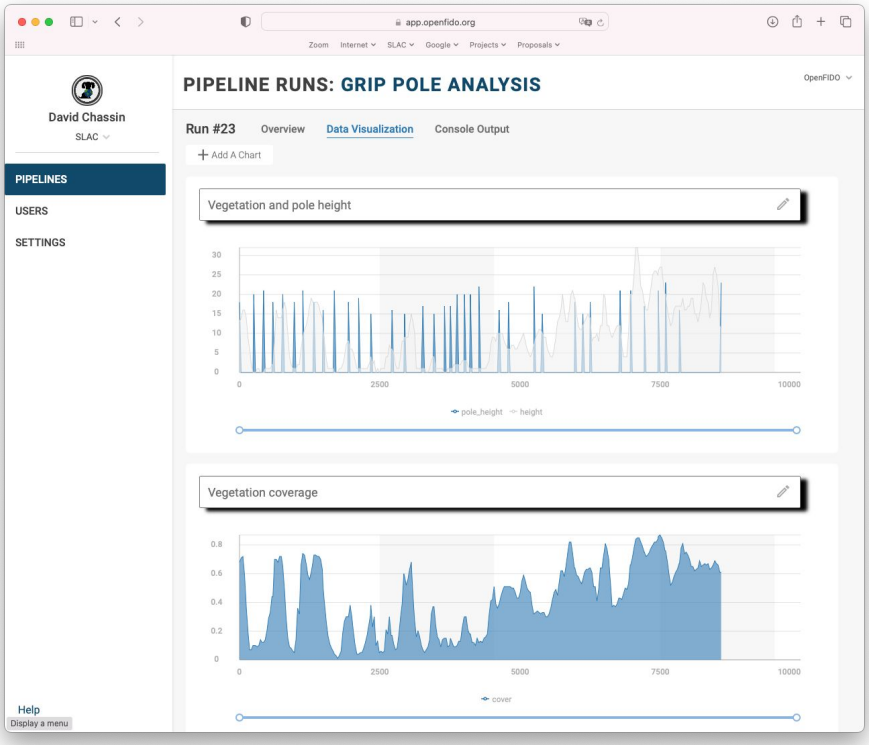
HiPAS Use-Case: Load Composition Analysis





HiPAS Use-Case: Pole Vulnerability Analysis





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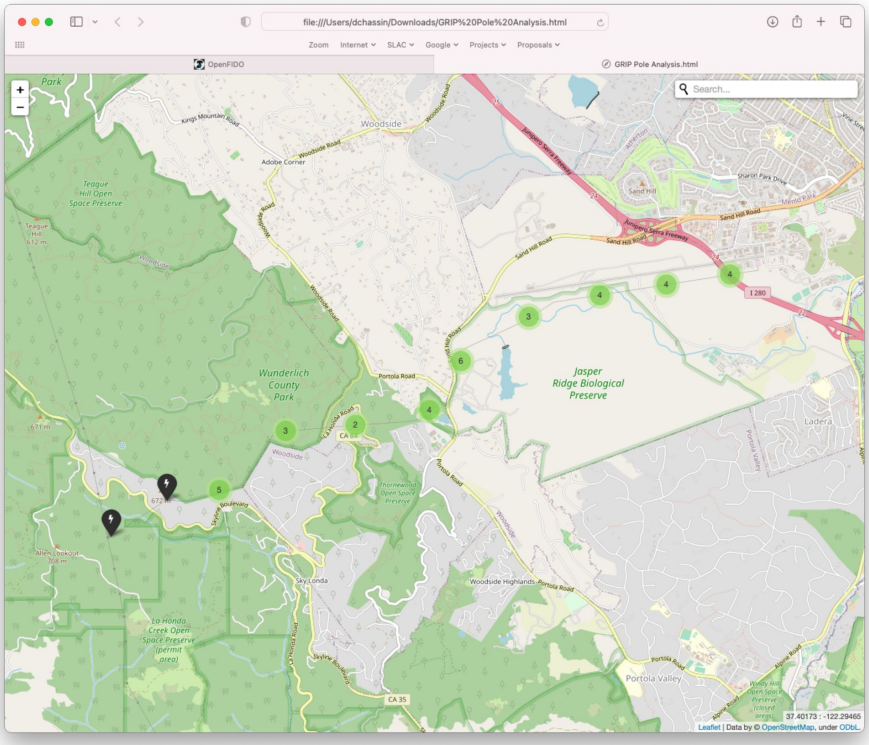
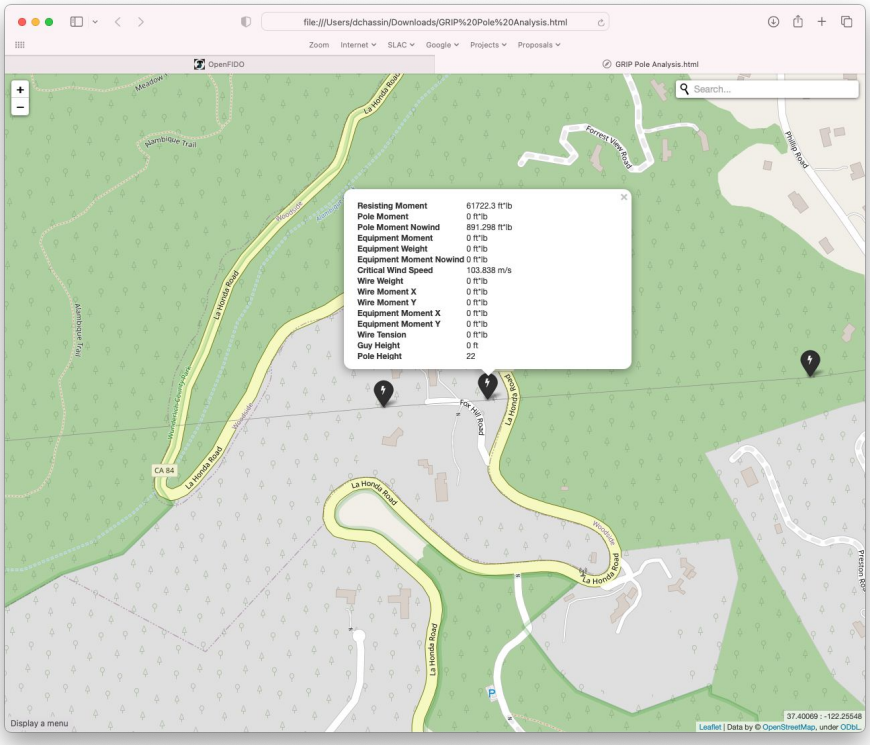
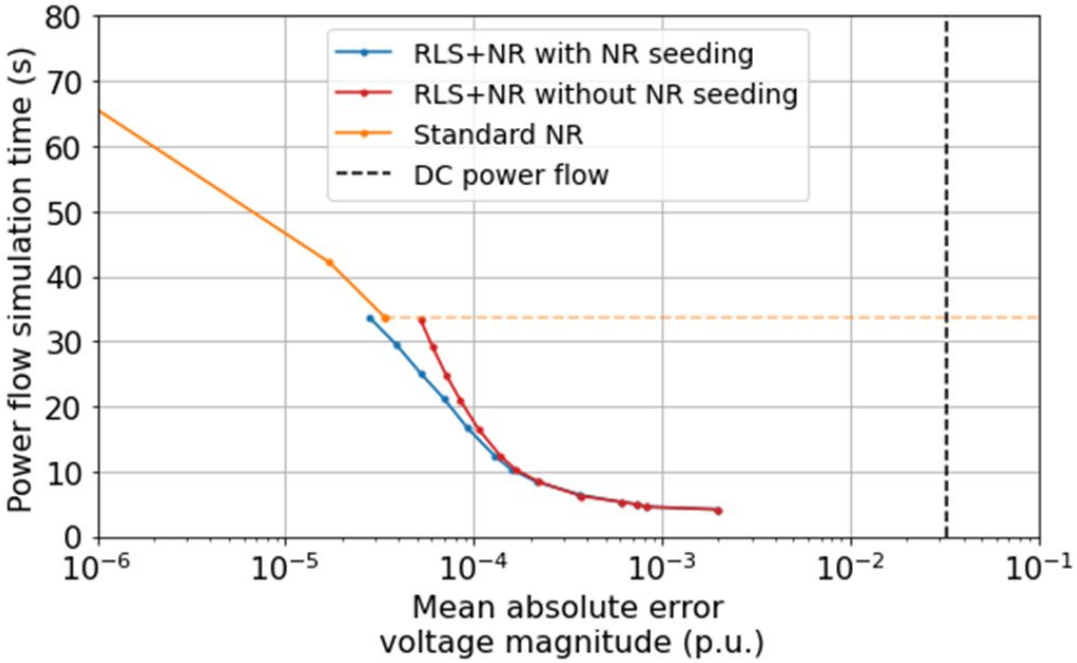




Results of ML Powerflow Performance Evaluation

IEEE PES GM paper:

- Recursive least squares method
- ML powerflow partly coded in Python
- Validation still in progress
  - Topology changes
  - Capacitors controls
  - Regulators controls



Results of testing and validation: Cyme Converter

National Grid Load Forecast (LGF) Study

- 15 year load growth projection
- Analysis is updated annually
- 2021 LGF done w/DOE GridLAB-D
- 2022 LGF done w/HiPAS GridLAB-D
- Converted ~2000 Cyme feeders
- Used built-in Cyme converter
- Included weather and solar PV

Results of National Grid LGF Study

- Generated HiPAS GridLAB-D models
- 97.5% success unsupervised conversion
- 2.5% required manual intervention
  - Cyme network model errors
  - Cyme load model errors
  - Cyme-GridLAB model mismatches
- Validated based on energy consumption relative to 2021 within load growth

Result of testing and validation

Tariff Design

Solution speed

- 100 homes
- 1 year billing simulation at 1hr timestep
- 10 min (vs. 45 sec for non-billing run)

Accuracy

- 1 house
- 1 month billing simulation
- No measurable error

Electrification

Solution speed

- 90 homes
- 1 year billing simulation at 1hr timestep
- 10.3s

Accuracy

- 1 house
- 1 month electrification simulation
- N/A

Results of testing and validation: Resilience

Docker in-house testing

Pole Analysis Validation w/Spidacalc

- Single pole analysis 4.3 sec
- Five poles 7.4 sec

Southern California Edison

Evaluation currently underway

- Bulk pole analysis
- Pole analysis with network
- Vegetation contact w/incident training
- PSPS analysis pending

Upcoming evaluations

EPB (Chattanooga, Tennessee)

- Deploying GRIP on HiPAS (w/OpenFIDO)
- Pole analysis
- Vegetation contact
- Additional analytics for climate change resilience upon development.

Results from testing and validation: Lessons Learned

Requirements

- Use-cases evolve quickly
- Data for use-cases is hard to find
- Vendors can be uncooperative/resistant
- Need standard approach to validation
- Need legal framework for data sharing

Implementation

- Dependencies across tools is challenging
- Python changes/updates frequent issue
- Utilities need more rapid tool deployment
- Utilities need time to validate tools
- Utilities rather host code than share data
- Security compliance not part of CI/CD

Contribution Acknowledgments

Southern California Edison

Anthony James (Resilience)
Frank Gonzales (Resilience)
Stacie Bartholow (Cyber-security)

National Grid

Pedram Jahangiri (Load forecast baseline)
Balaji Doraibabu (Load forecast study)
Sayonsom Chando (Load model validation)

Hitachi America Laboratories

Yanzhu Yu (ICA, model validation)
Joseph Chongfuongprinya (Cyme model)
Natsushiko Futamara (AWS performance)

US Department of Energy SULI Program

Johnson Hsiung (Electrification)

Jewel Newman (Tariff Design)

Michelle Huang (Electrification)

Jorge Higuera (Electrification)

Veronika Lubeck (Load modeling)

Wonseok Choi (ICA)

Contribution Acknowledgments (continue)

SLAC National Accelerator Laboratory

Alyona Teyber (technical manager)

Mitchell Victoriano (software engineer)

Duncan Ragsdale (software engineer)

Anna Peery (software engineer)

Jimmy Leu (software engineer)

Derin Serbetcioglu (former software engineer)

Jonathan Goncalvez (former software engineer)

Stanford University

Xiaochu Wang (Postdoc)

Fuhong Xie (former postdoc)

Lily Buechler (PhD student)

Marie-Louise Arlt (former visiting PhD student)

Sheila Naby (RA)

Kamran Tehranchi (RA)

Mohammed Nijad (RA)

Sara Borchers (RA, now at Tesla)

Adhithya Antonysamy (RA, now at Tesla)

Developer and user training

Developer Documentation

- Online documentation browser (done)
- Contribution policy (done)
- Build system documentation (done)
- Validation system documentation (done)
- AWS deployment documentation (done)
- Docker deployment documentation (done)

Training Videos

- Developer training videos (8/12 done) (http://tutorials.gridlabd.us)

Use-case Documentation

Templates

- Hosting capacity (done)
- Tariff design (done)
- Electrification (done)
- Resilience (done)

Subcommands and Tools

- Loadshape (done)
- Weather (done)
- OpenFIDO link (done)
- Census (done)
- Address (done)
- Cyme extract (done)

Benefits and Technology Transfer

Benefits Evaluation

- Joint reporting coming in December

Linux Foundation Energy

- Adopted HiPAS GridLAB-D July 2022
- Technical Steering Committee
  - TSC Members identified
- Meeting scheduled for Nov

Next steps

Task 4 - Performance Analysis

- Release Candidate 2 (Mar 2023)
- Performance Analysis CPR Report (Nov 2022)

Task 5 - Integrated Production Release

- Final Production Release Presentation (Mar 2023)

Task 5.1 - Support Release Production (Ongoing)

Task 5.2 - Final Product Documentation (Mar 2023)

Task 5.3 - Final Release Product (Mar 2023)

Task 6 - Evaluation of Project Benefits

Included in final report (Dec 2022)

Task 7 - Technology Transfer

- First TSC meeting planned for Nov 2022
  - Formal creation on NP/LLC
  - Product name
  - Roadmap and technical agenda/plan

Questions / Discussion

Contacts:
David P. Chassin (PI) - dchassin@slac.stanford.edu
Alyona Teyber - ateyber@slac.stanford.edu