
RECENT DEVELOPMENTS IN OPEN SOURCE LSE TECHNOLOGY AND THE OPENECA PROJECT

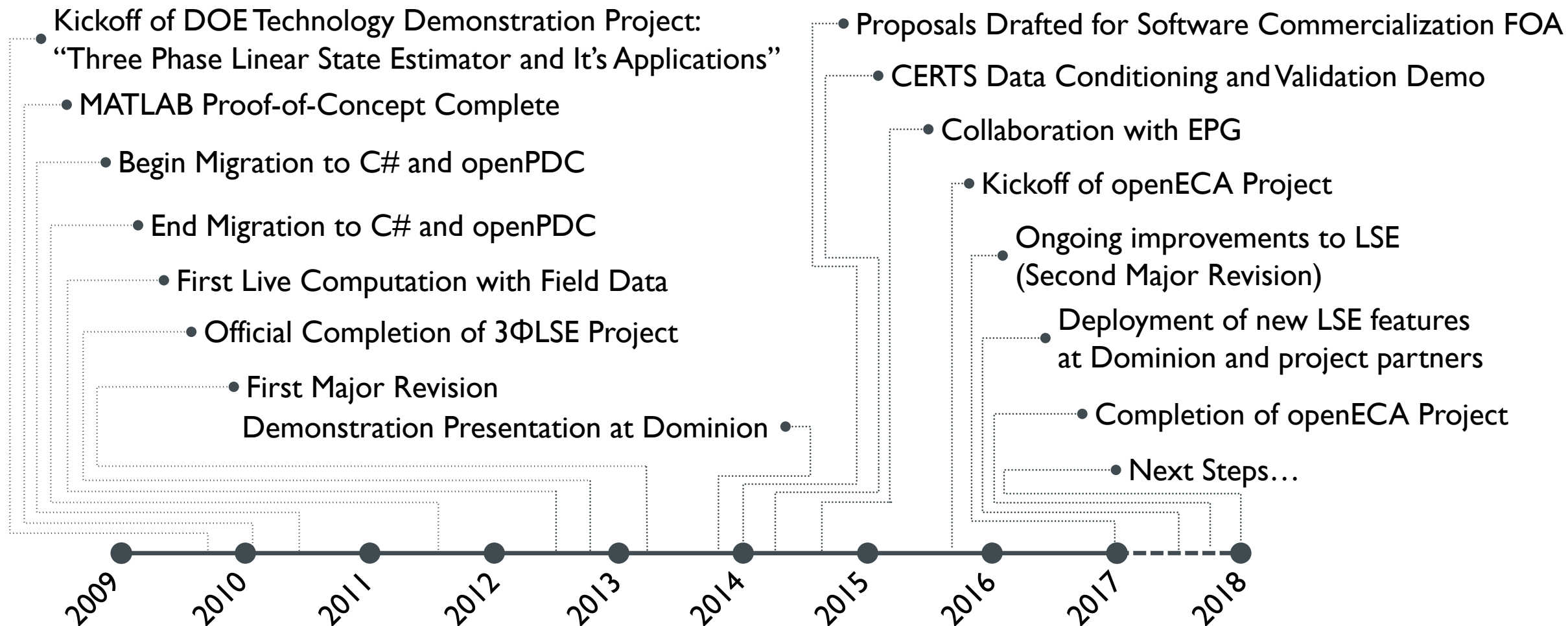
LINEAR STATE ESTIMATION SESSION | NERC SMS | MAY 16-18, 2017 | AUDUBON, PA



OUTLINE

- A short story and timeline
- As part of the openECA project...
 - Some shiny new features for LSE
 - All the cool things still left for this project
- Next Steps for LSE Post-Grant

A BRIEF HISTORY





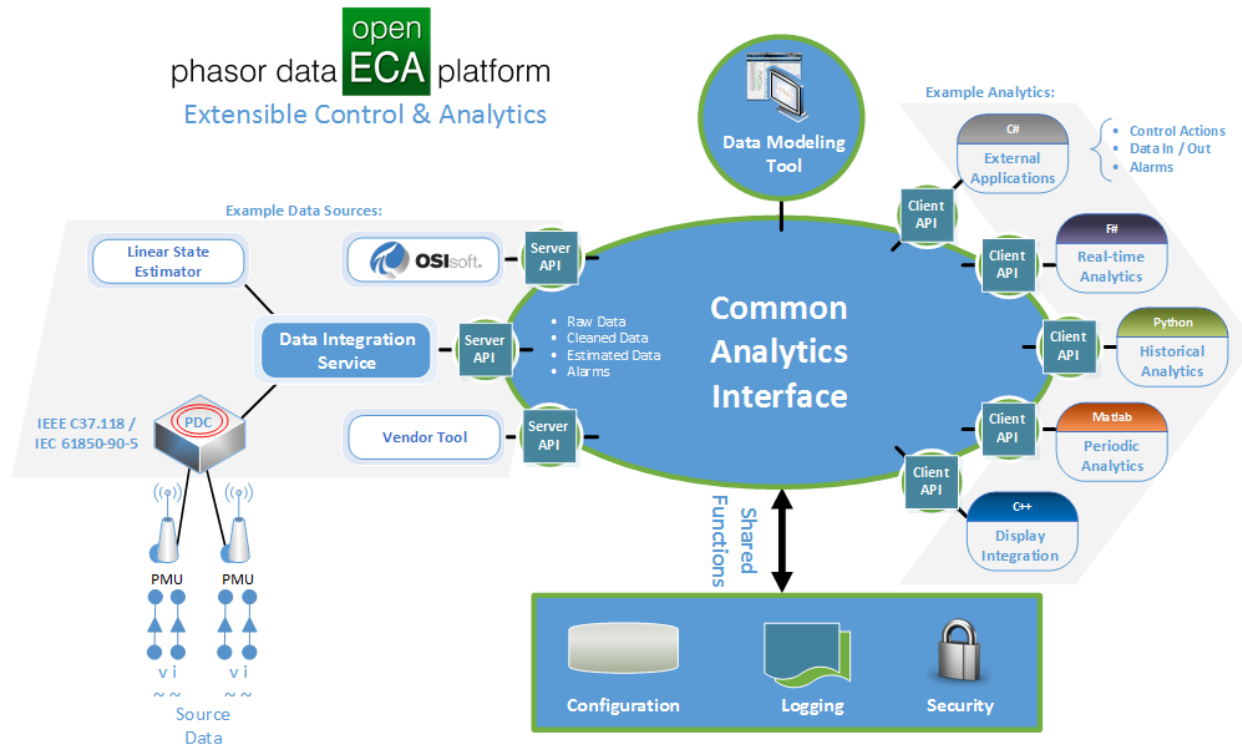
IMPROVEMENTS TO LSE AS PART OF THE OPENECA PROJECT

MAKING LSE EASIER TO TRY, DEPLOY, STAND-UP, AND MAINTAIN



OPENECA PROJECT SUMMARY

A 2-year project to provide a better way to connect phasor data to analytics.



Project Provided Analytics

- Linear State Estimation
- Oscillation Detection Monitor (ODM)
- Oscillation Mode Meter (OMM)
- Topology Estimation
- Regional Volt-Ampere-Reactive (VAR) Control
- Local VAR Control
- PMU Synchroscope
- Dynamic PMU Transducer Calibration
- Line Parameter Estimation
- Synchronous Machine Parameter Estimation Acceleration Trend Relay (ATR) Improvement



FOA 970
DE-OE-778



T&D Consulting Engineers



Southwest
Power Pool

OG&E



OSIsoft.



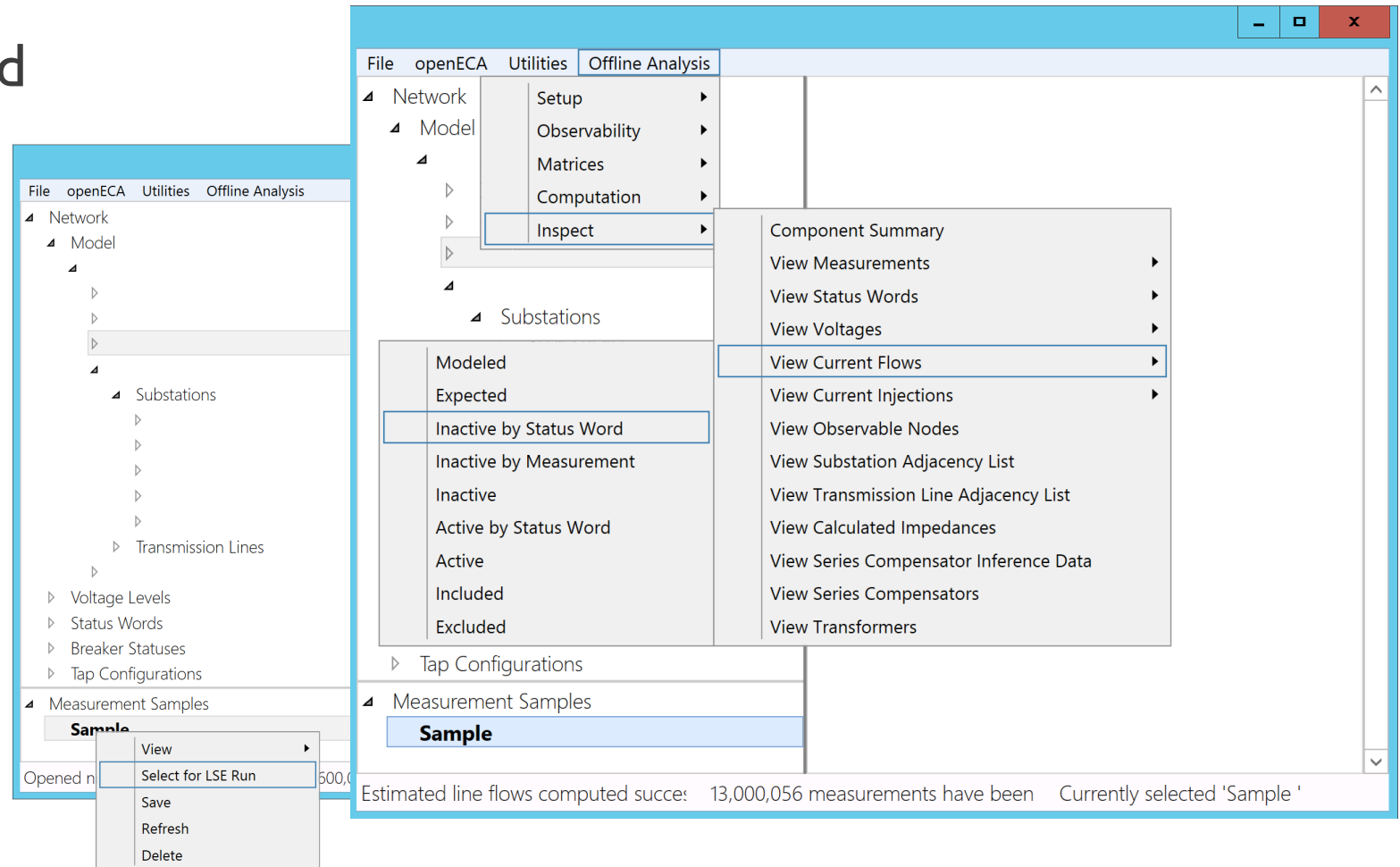
VirginiaTech



GRID
PROTECTION
ALLIANCE

IMPROVEMENTS TO MODELING/OFFLINE TOOL

- Most improvements based on improving workflow
- Integration of Network Model Editor and Offline Tool
- Integration of Measurement Sampler
- Integration of openECA Modeling API



IMPROVEMENTS TO MODELING/OFFLINE TOOL

- Automated Modeling Process for LSE “Hello, world!” in < 15 minutes.

Open Modeling Tool

Import Model or HdbExport

Coarse Pruning

Connect to openECA

Create Status Word Model

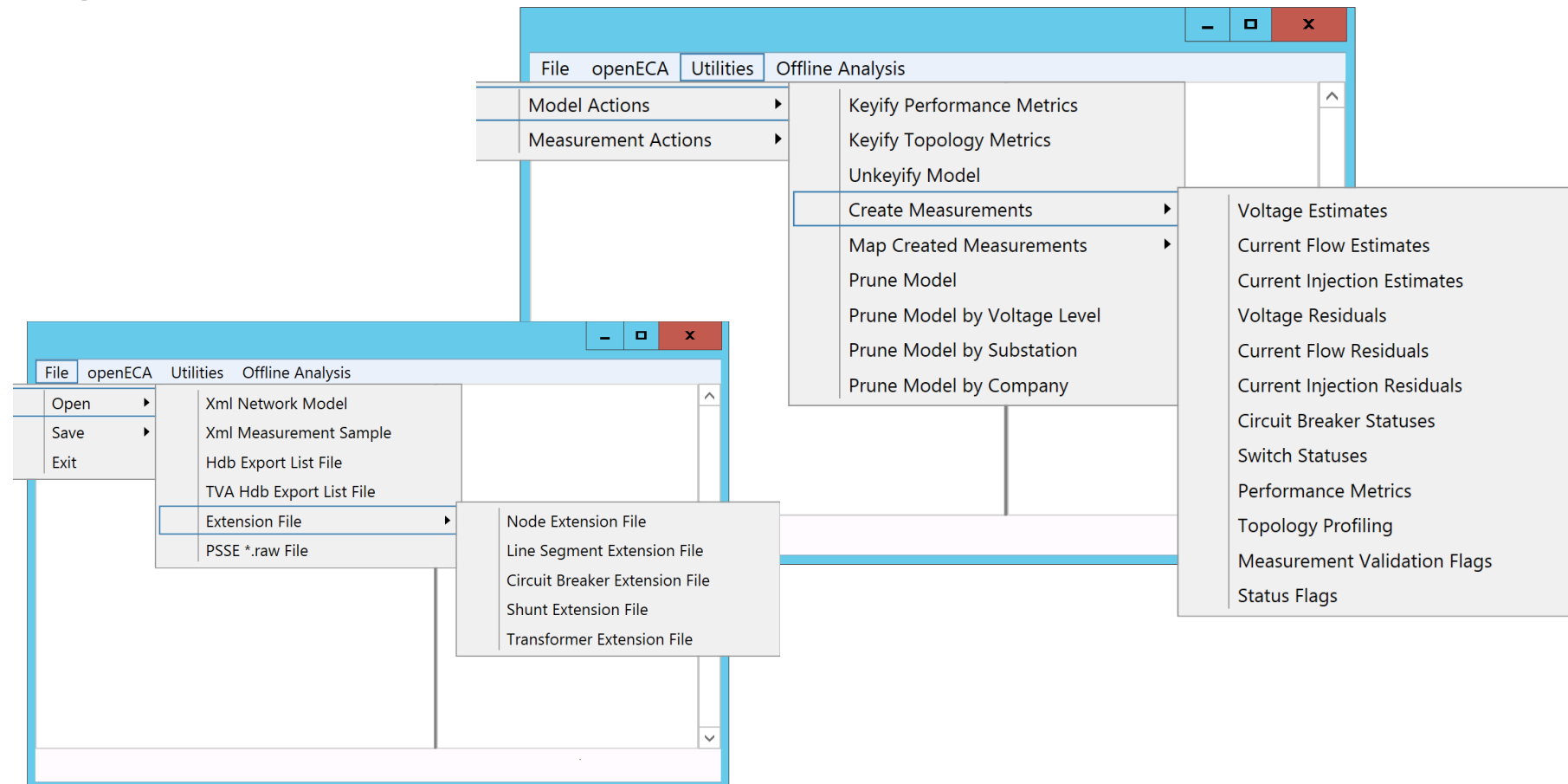
Import Extension Files

Fine Pruning

Create Output Measurements

Map Output Measurements

Save New Model



AUTOMATIC I/O WITH FILTER SYNTAX

```
LSE Input Input {  
    Digitals: AllDigitals  
    StatusWords: AllStatusWords  
    VoltagePhasors: AllVoltagePhasors  
    CurrentPhasors: AllCurrentPhasors  
}
```

```
ECA Digitals AllDigitals {  
    Values: { FILTER ActiveMeasurements WHERE SignalType='DIGI' }  
}
```

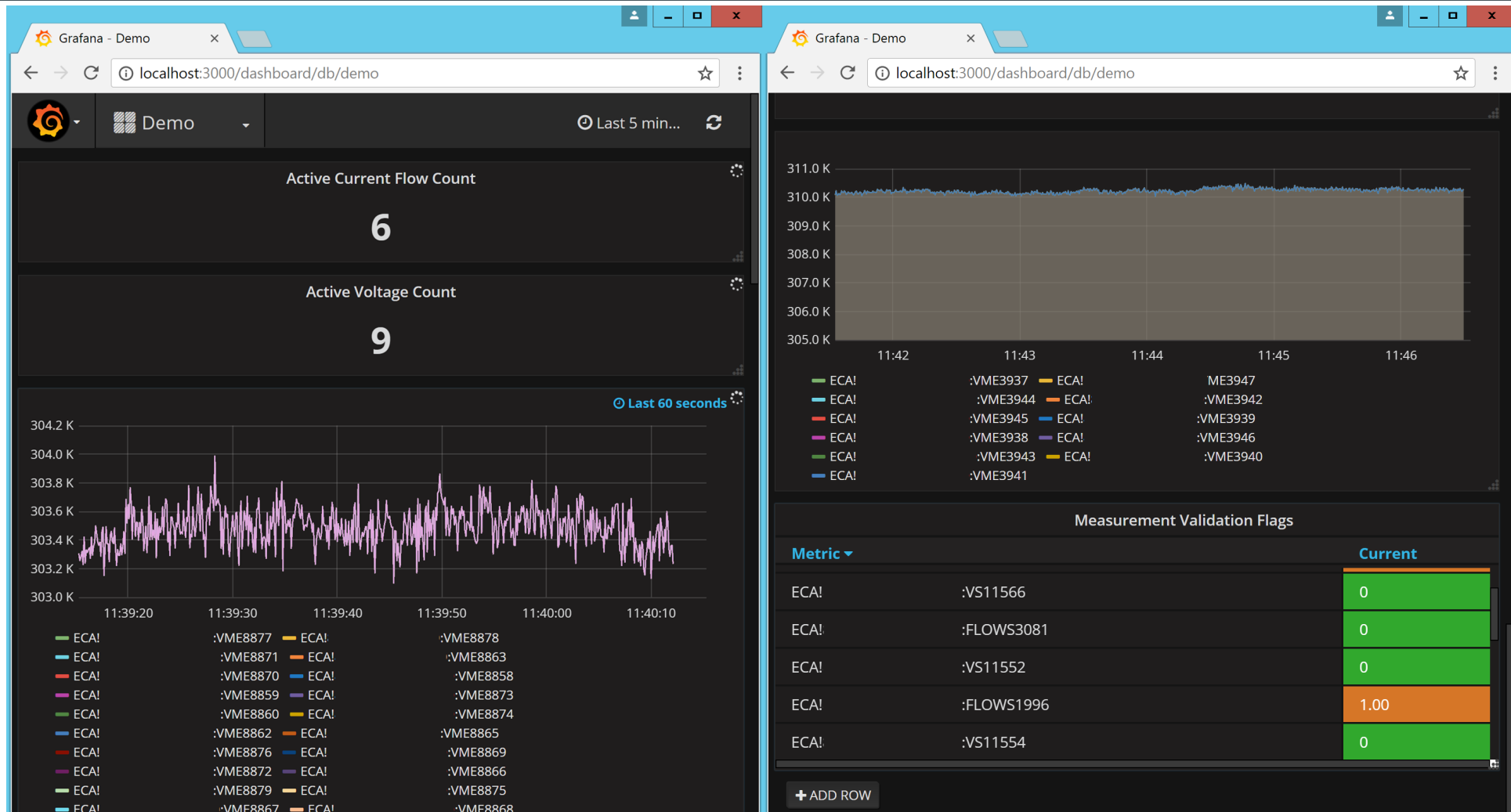
```
ECA StatusWords AllStatusWords {  
    Values: { FILTER ActiveMeasurements WHERE SignalType='FLAG' }  
}
```

```
ECA PhasorCollection AllVoltagePhasors {  
    Phasors: { FILTER Mappings WHERE TypeCategory='ECA' AND TypeIdentifier='Phasor' AND  
MappingIdentifier LIKE '%_V' }  
}
```


AUTOMATIC I/O WITH FILTER SYNTAX

```
LSE EstimatorOutput Output {  
  CircuitBreakerStatuses: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='DIGI' AND PointTag LIKE '%_CB:S' }  
  TopologyProfilingData: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='DIGI' AND (PointTag LIKE '%TOPOLOGY_STATE%' OR PointTag LIKE '%TOPOLOGY_ID%') }  
  MeasurementValidationFlags: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='DIGI' AND (PointTag LIKE '%_ND:VS%' OR PointTag LIKE '%_ND:FLows%') }  
  VoltageMagnitudeEstimates: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='VPHM' AND PointTag LIKE '%:VME%' }  
  VoltageAngleEstimates: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='VPHA' AND PointTag LIKE '%:VAE%' }  
  VoltageMagnitudeResiduals: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='VPHM' AND PointTag LIKE '%:VMR%' }  
  VoltageAngleResiduals: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='VPHA' AND PointTag LIKE '%:VAR%' }  
  CurrentFlowMagnitudeEstimates: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='IPHM' AND PointTag LIKE '%:IME%' }  
  CurrentFlowAngleEstimates: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='IPHA' AND PointTag LIKE '%:IAE%' }  
  CurrentFlowMagnitudeResiduals: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='IPHM' AND PointTag LIKE '%:IMR%' }  
  CurrentFlowAngleResiduals: { FILTER ActiveMeasurements WHERE Device LIKE 'LSE!%' AND SignalType='IPHA' AND PointTag LIKE '%:IAR%' }  
  PerformanceMetrics: PerformanceMetrics  
}
```

LSE + OPENECA + GRAFANA DASHBOARDS



REMAINING MILESTONES WITH OPENECA

- Improving robustness of topology processor in absence of breaker statuses using voltage phasors
- Testing all new features with openECA and real-time simulator
- Deployment of openECA + LSE at Dominion
- Deployment of openECA + LSE at project partners



NEXT STEPS POST-GRANT

HOW TO MOVE LSE FORWARD POST-GRANT??

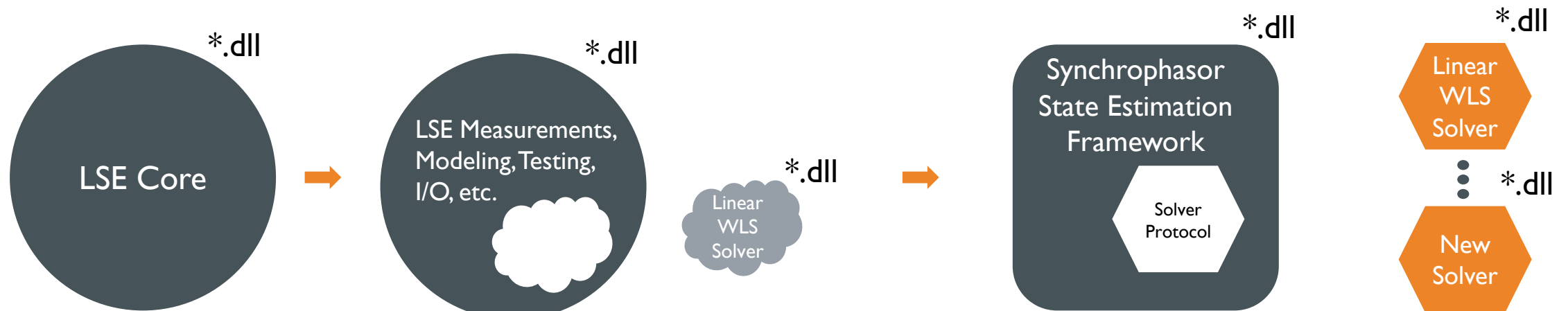


NEXT STEPS POST-GRANT

- Establish mechanisms to provide support
 - Always the hurdle in the past
 - Setup services
 - Standard support contracts

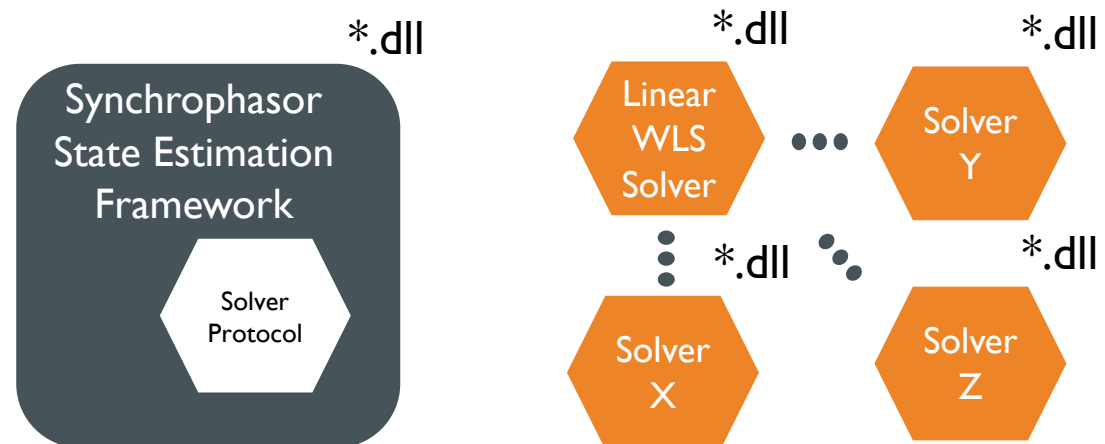
NEXT STEPS POST-GRANT

- Establish mechanisms to provide support
- Extract solver and implement a 'Solver' protocol:
 - Synchrophasor State Estimation Framework (open source)
 - Linear WLS Solver (open source)



NEXT STEPS POST-GRANT

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- Implement additional solvers (open and closed source)



NEXT STEPS POST-GRANT

- Establish mechanisms to provide support
- Extract solver and implement a 'Solver' protocol.
- Implement additional solvers (open and closed source)
- Create a professional modeling and troubleshooting tool (closed source)
 - *An Integrated Modeling Environment?*
 - Wish List:
 - Data Formats → other EMS formats, *translational* CIM compatibility
 - Functions as a streaming analytic, controller for real-time LSE
 - Everything is a time series value
 - Better reports in different formats
 - Locally visualize key parameters in real-time
 - Better skin

NEXT STEPS POST-GRANT

How to move technology forward post-grant?

- Establish mechanisms to provide support
- Extract solver and implement a 'Solver' protocol.
- Implement additional solvers (open and closed source)
- Create a professional modeling and troubleshooting tool (closed source)

CONTACT INFORMATION

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- <https://github.com/kdjones/linear-state-estimator>

