GRID MODERNIZATION INITIATIVE PEER REVIEW

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Sheraton Pentagon City – Arlington, VA

GMLC 1.4.15 TDC Models
High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

This project aims to enable large-scale TDC interdependency studies through a flexible and scalable, open-source co-simulation platform for the following industry drivers

Project Objectives

- ✓ Provide foundational capabilities for grid planning, operation, and control
- ✓ Engage and educate grid developers on the value of multi-domain planning

Value Proposition

- ✓ There is currently a gap in simulation and modeling technology that inhibits integrated planning across multiple domains
- ✓ Left to it's own devices, the grid community is unlikely to develop capabilities to overcome planning stovepipes (in near term)
- ✓ The DOE plays a unique role in initiating this effort and creating foundational tools that support both research and industry

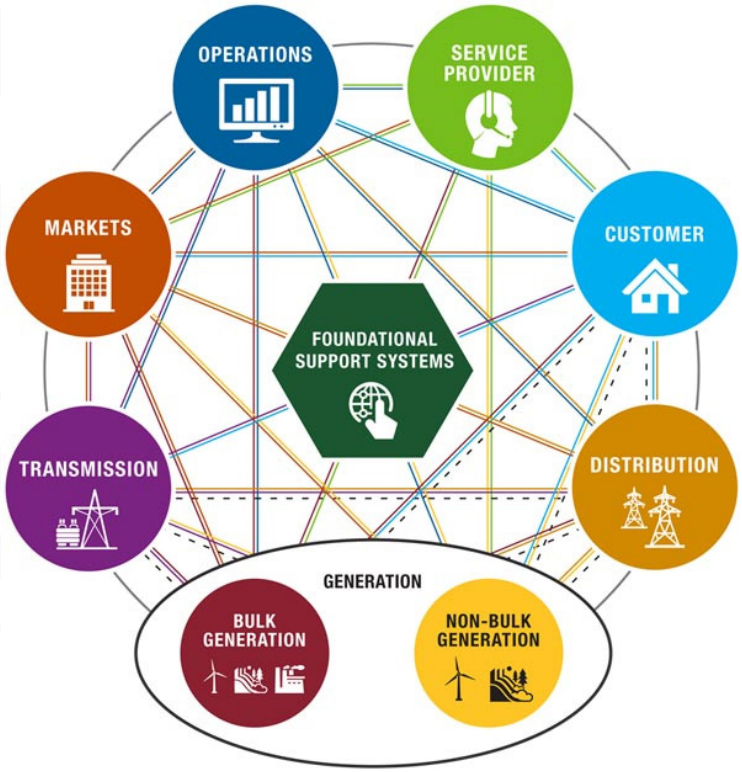

Image from smartgrid.ieee.org

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Project Team

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Project Participants and Roles

Pacific Northwest NATIONAL LABORATORY
Lawrence Livermore National Laboratory
NREL
Argonne NATIONAL LABORATORY
OAK RIDGE National Laboratory
Sandia National Laboratories
INL Idaho National Laboratory

PROJECT FUNDING			
Lab	FY16	FY17	FY18
PNNL	$430K	$430K	$430K
LLNL	$325K	$325K	$325K
NREL	$195K	$195K	$195K
ANL	$165K	$165K	$165K
ORNL	$95K	$95K	$95K
SNL	$60K	$60K	$60K
INL	$60K	$60K	$60K

+ 15-member Technical Review Committee (academia and industry experts)

Name	Organization
Jun Wen	SCE
Babak Enayati	National Grid
Jianzhong Tong	PJM
Slaven Kincic	Peak RC
Mike Zhou	InterPSS Systems
Ernie Page	The MITRE Corporation
Bernie Zeigler	U. Arizona
Calvin Zhang	Nexant
Anjan Bose	WSU
Aidan Tuohy	EPRI
Jens Boemer	EPRI
Craig Miller	NRECA
Cynthia Hsu	NRECA
David Pinney	NRECA
Devin Van Zandt	GE

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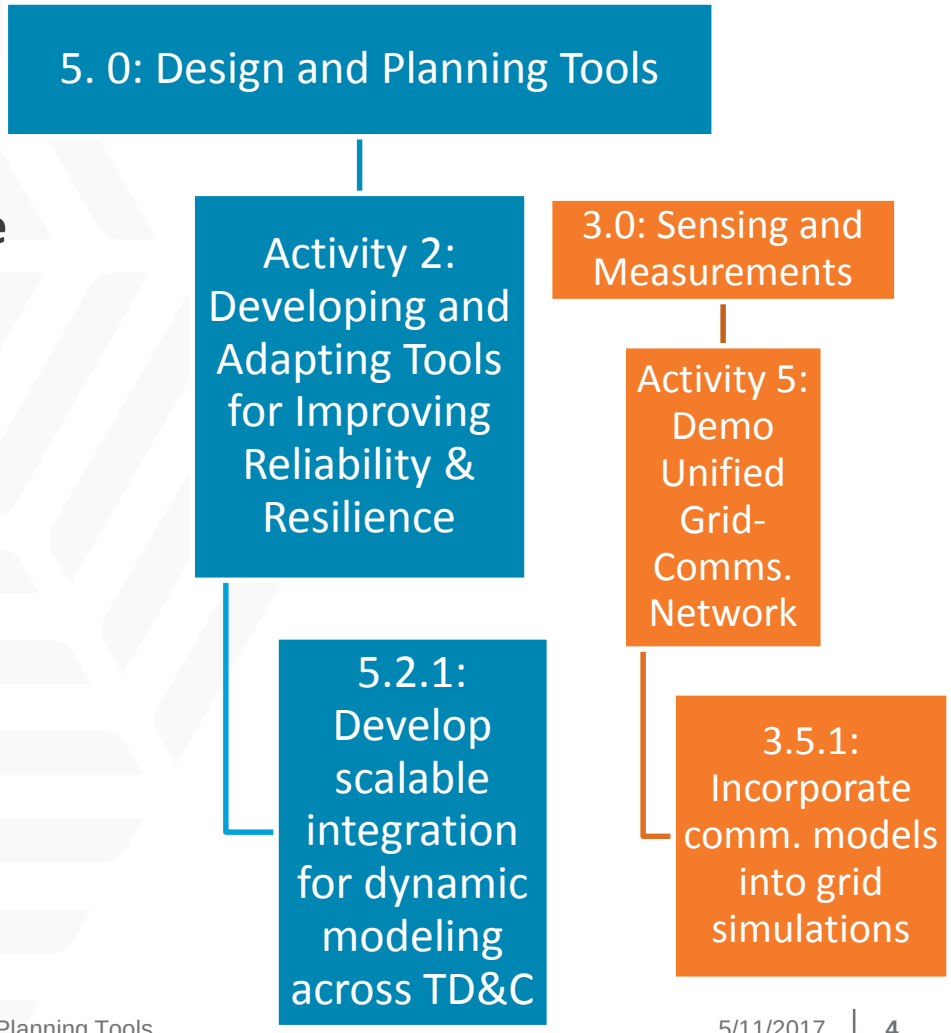
Relationship to Grid Modernization MYPP

A high-fidelity TDC integrated simulation capability will help address MYPP national outcomes:

- to **design, with confidence, the future grid** to minimize outages and outage costs;
- operate the grid with a leaner reserve margin and still maintain reliability **through holistic analysis**; and
- increase penetration of DERs by **informing decision-makers with quantified impacts** on the system reliability and economics.



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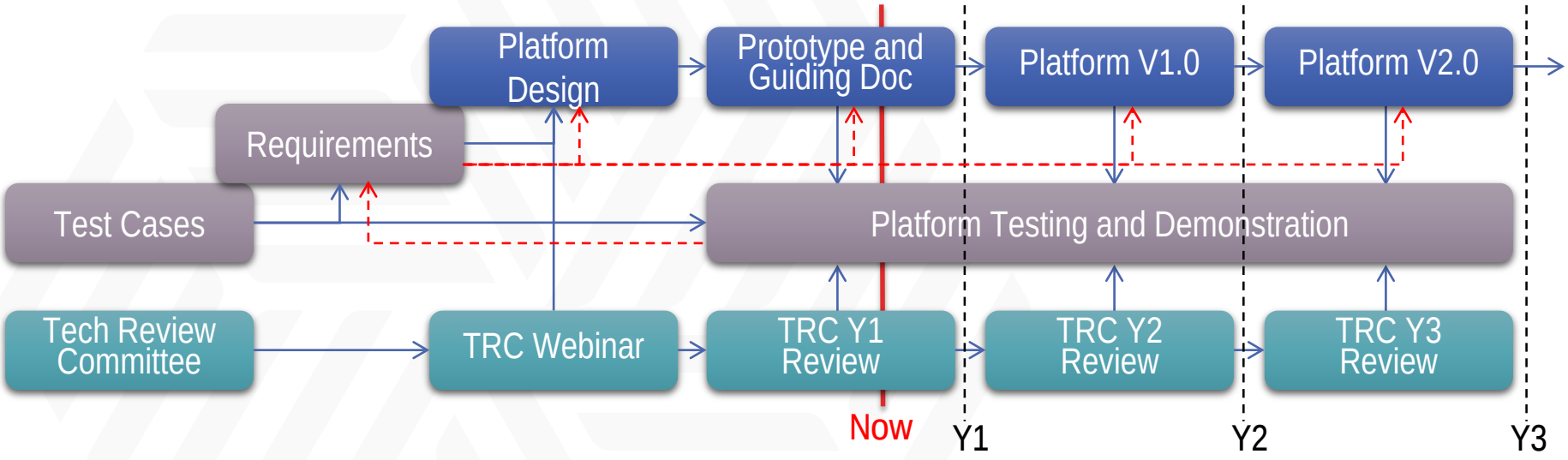
Approach

Three tracks (test case driven):

TEST CASES, PLATFORM DESIGN AND DEVELOPMENT, OUTREACH



Development plan targets open-source release of the co-simulation platform

HELICS – Hierarchical Engine for Large-scale Infrastructure Co-Simulation

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Approach – Use Case Driven

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Support a variety of simulation types:

- Discrete Event
- Time Series
- QSTS
- Dynamics
- Transients

Evaluate systems of unprecedented scale:

- 2-100,000+ Federates
- HPC, including cloud
- But also workstations and laptops

No	Title	Description
1	**Impacts of DER's on Bulk Systems Reliability**	The test case will analyze a combined T&D test system with and without advanced distributed systems with high penetrations of distributed solar PV. Studying the impact on reliability metrics such as the NERC Control Performance Standards 1 and 2 as well as other main metrics can quantify the impacts of advanced distribution systems.

	Domain				Simulation			Comm	
	Transmission	Distribution	Communication	Market	Steady State	Dynamic	Transient	Latency	Packets
DER's on Bulk Systems Reliability	X	X			X				
Load Modeling under high penetration of DERs	X	X				X			
Wide Area Voltage Stability Support Using DERs	X	X	X		X			X	
Voltage and Frequency Ride-Through Settings for Smart Inverters	X	X	X			X			
Real-time Co-simulation of Power Systems and Communication Networks for Transient Assessment	X	X	X				X	X	
Communications Architecture Evaluation for High-Pen Solar	X	X	X		X				X
New Control Paradigm – Centralized vs Distributed to Prevent Voltage Stability Collapse	X	X	X			X		X	
Wide Area Monitoring, Protection, and Control (WAMPAC)	X		X			X		X	X
Impacts of Distributed Energy Resources on Wholesale Prices	X	X		X	X				
Mitigating T/D Interface Congestion Through Demand Side Management	X	X		X	X			X	
Regional Coordinated Electric Vehicles Charging	X	X		X	X			X	
Real-time Coordination of Large Scale Solar PV and Energy Storage	X	X			X			X	

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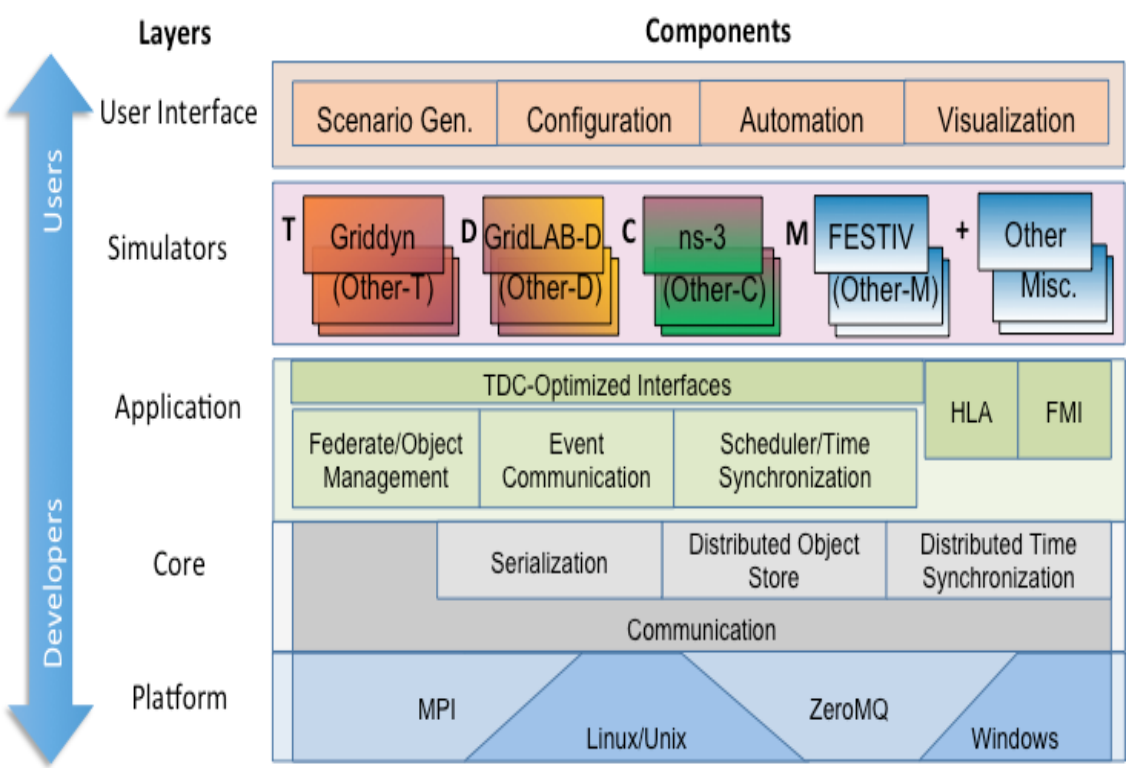
Approach – Use Case Driven

Layered and modular architecture to support:

- Laboratory, open-source, and commercial tools
- Interchangeable time synchronization algorithms (depending on use case)
- Reiteration, when necessary

Support standardized interfaces:

- HLA, FMI, etc.
- Tuned APIs for highly used tools (e.g., GridLAB-D, ns-3)



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Key Project Milestones

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Milestone (FY16-FY18)	Status	Due Date
M1: Document initial test cases	100%. Delivered 19 test cases and reviewed at the TRC webinar.	9/1/2016
M2: Organize a TRC webinar to review test cases and initial TDC platform design	100%. Held the TRC webinar on 11/14/2016. Completed the draft of the summary report .	12/1/2016
M3: Report documenting test case studies	100%. Derived requirements and metrics from 12 test cases.	3/1/2017
M4: Deliver a guiding document for TDC simulation	90%. Draft document complete, under review.	6/1/2017
M5: Organize a industry stakeholder workshop to review the guiding document	90%. Scheduled, agenda developed. Preparation is ongoing.	6/1/2017
M6: Deliver an initial prototype platform to open source	90%. Platform developed, under testing with three example cases.	6/1/2017
M7: Deliver ver1.0 platform to open source	50%. Prototype operational.	12/1/2017
M8: Host an industry stakeholder meeting to review ver1.0	0%.	6/1/2018
M9: Deliver ver2.0 platform to open source	0%.	12/1/2018
M10: Demonstrate ver2.0 platform with selected use cases	0%.	12/1/2018

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Accomplishments to Date – Use Cases & Outreach

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- Developed "use case" document with 12 detailed use cases to drive software design.
  - Mapped the use cases to high-level MYPP outcomes.
  - Mapped the use cases to requirements for the software platform.
- Received feedback on use cases from TRC.
- Created a series of use cases to-be-tested on the HELICS platform when available.
- Completed TRC webinar in November 2016. TRC meeting scheduled for May 2017.

Reliability/Sustainability
Test Case 1: Impacts of DER's on Bulk Systems Reliability
Test Case 5: Evaluate modeling adequacy of composite load model under high penetration of DERs
Test Case 12: Wide Area Voltage Stability Support Using DERs
Test Case 11: Adaptive Voltage and Frequency Ride-Through Settings for Smart Inverters

Security/Sustainability
Test Case 9: Real-time Co-simulation of Power Systems and Communication Networks for Transient Assessment
Test Case 10: Communications Architecture Evaluation for High-Pen Solar

Resilience/Sustainability
Test Case 7: New Control Paradigm – Centralized vs Distributed to Prevent Voltage Stability Collapse
Test Case 8: Wide Area Monitoring, Protection, and Control (WAMPAC)

Affordability/Sustainability
Test Case 2: Impacts of Distributed Energy Resources on Wholesale Prices
Test Case 6: Mitigating T/D Interface Congestion Through Demand Side Management

Flexibility/Sustainability
Test Case 3: Regional Coordinated Electric Vehicles Charging
Test Case 4: Real-time Coordination of Large Scale Solar PV and Energy Storage

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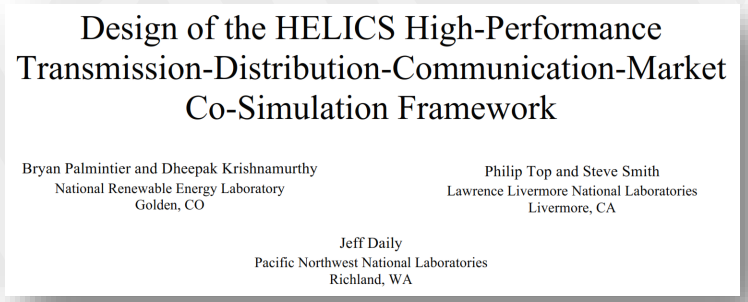
Accomplishments to Date – Platform Design

- Held a team workshop to extract platform requirements from use cases.
- Developed a platform specification and design document to align software development across three laboratories.
- Received feedback on design elements from TRC.
- Created a GitHub project and repository to start collaborative software development.
  - >200 commits
- Completed the HELICS platform prototype with three test case examples.
- Publication on the HELICS platform design accepted to *2017 Workshop on Modeling and Simulation of Cyber-Physical Energy Systems.*


Design of the HELICS High-Performance Transmission-Distribution-Communication-Market Co-Simulation Framework

Bryan Palmintier and Dheepak Krishnamurthy
National Renewable Energy Laboratory
Golden, CO

Philip Top and Steve Smith
Lawrence Livermore National Laboratories
Livermore, CA

Jeff Daily
Pacific Northwest National Laboratories
Richland, WA

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Response to December 2016 Program Review

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Recommendation	Response
Please share the 19 test cases with DOE program managers. Many other projects are using test cases, and it is important that others are aware of your approach.	Yes. We have 12 cases fully developed and are posted on an accessible SharePoint site. These will be made publically available when the GitHub project is made open source in May.
Getting relevant data to use is critical for the success of this project. While it was mentioned in the meeting that ARPA-E grid data could be used as a backstop, it is not clear that this is true for communications data. Please be ready to discuss your data sources moving forward at the Annual Peer Review in April 2017.	Communication data is hard to obtain due to strict adherence to CIP. Have gathered a shortlist of public resources, but they are insufficient. Working with P&DT WG on Data and Software, fellow researchers, program offices, TRC, etc. to fill gap.
While it was mentioned that applying this work to grid operations was “outside the scope of this project,” please coordinate with the operations projects 1.4.10 and 1.4.11. We need to make sure there is synergy in the use cases being developed between the operations and planning and design tools technical areas.	Jason (PNNL PI) developed the Year 2 test plan for project 1.4.10; this will co-sim JuliaOpt, MATLAB, and GridLAB-D. Liang (LLNL PI) is lead for 1.4.11; use cases for operations include EMS-DMS-BMS and will use TDC platform to validate controls before deployment.

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Project Integration and Collaboration

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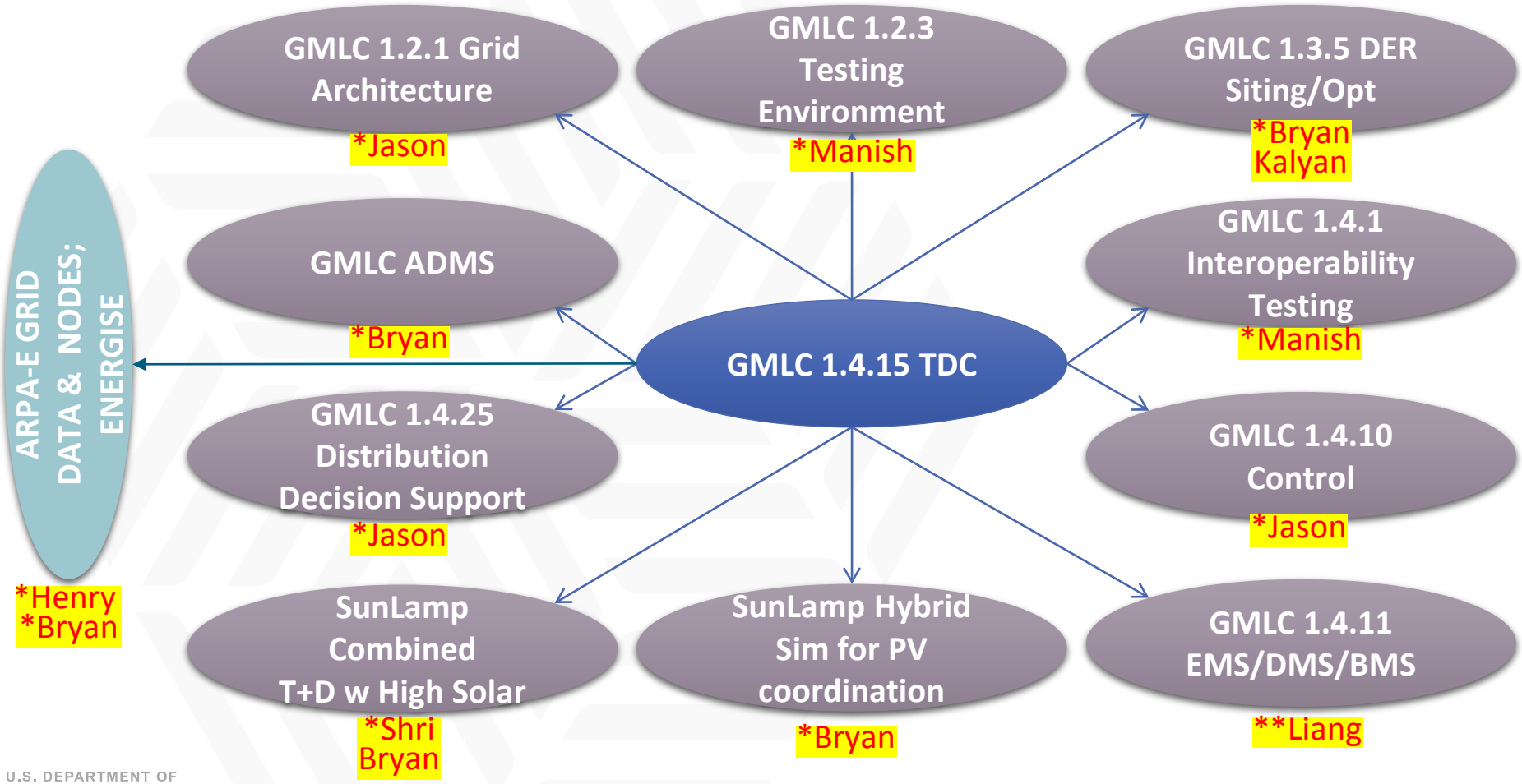
TDC Modeling and Simulation is Foundational



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Next Steps and Future Plans

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- Release v0.1 of HELICS to the open source in May 2017, including Guiding Document and example use cases
  - Currently securing licensing and copyright agreements
- TRC Meeting in May 2017 in Richland, WA
- Add additional simulators as identified by working with other GMLC projects and TRC members
- Implement HPC Platform Layer (MPI-based) to address large numbers of federates
- Develop use cases to explore limits of tool (and address) and increase value
- Develop (and release) tools to increase usability of tool
- Release subsequent versions to open source