

# VOLTRON



PNNL

Jereme Haack, Project Manager

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PNNL-SA-165216

# Project Summary

## Timeline:

Start date: 10/1/2019

Planned end date: fy22

## Key Milestones

1. Yearly major release; 10/31/2019 - 2021
2. Guidehouse Market Assessment; 10/31/2020
3. Task 1.1a: Eclipse VOLTRON IP Review complete; 5/31/2021

## Budget:

### **Total Project \$ to Date:**

- DOE: \$3.1M
- Cost Share: \$0

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- Cost Share: \$0

## Key Partners:

University of Toledo	
Guidehouse	

## Project Outcome:

Build a robust community around an open-source software platform which provides national labs, universities, and commercial companies a base upon which to build energy efficiency and carbon reduction solutions. PNNL will provide security improvements and guidance as well as supporting enhancement of the platform to meet general community needs.

# Team

## PNNL



PM: Jereme Haack  
PI: Shwetha Niddodi



PNNL Campus Deployment  
Ben LaRoque,  
Wendy Cowley,  
Robert Lutes



Task Leads  
Craig Allwardt,  
Chandrika Sivaramakrishnan



Developers  
Spencer Gilbride  
Mark Bonicello

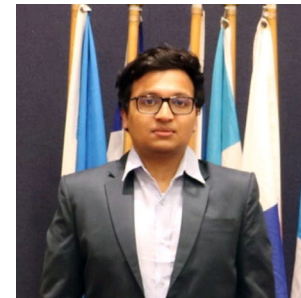
## Guidehouse

Jim Young, Ed Barbour



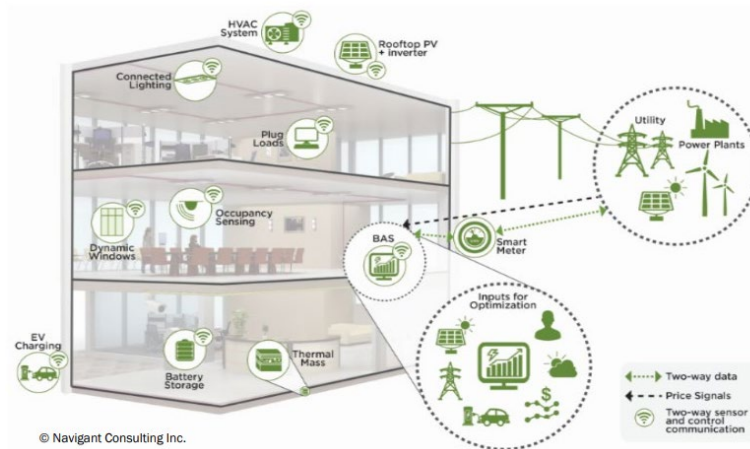
## University of Toledo

David Raker, Suba Sah,  
Sadab Mahmud



# Challenge

- Accelerate deployment of energy efficiency and decarbonization applications to achieve GEB Roadmap goal of triple building efficiency savings and flexibility by 2030
- Make 100% of buildings available for enlistment in these strategies including new construction and legacy buildings without “smart” devices
- Proprietary data collection systems have vendor lock-in, questions of data ownership, cost barrier to entry
- Can be difficult to transition technologies out of national laboratory and university space for deployment



# Approach

- **Open-source foundational platform for distributed sensing and control applications that enables vendor neutral control approaches and enlistment of legacy systems which can run on commodity hardware**
  - Provides an equitable starting point for organizations in buildings space. Allows startups to begin with a powerful, extensible, and open platform
  - Jumpstarts developers who can focus on turning their algorithms into deployable applications
  - Loosely coupled architecture enables reuse of individual components and applications to enhance other solutions
- **Build a community of users which can inform development directions, contribute back features, and collaborate with each other**
- **Workforce development, university students gain experience with development and deployment**
- **Leverage PNNL expertise in cybersecurity to ensure a secure platform and educate the community of users and their customers**
- **Transition codebase to an open-source community where PNNL continues to engage as a key contributor for DOE priority features**

# Approach: Balancing Act



## **Flexibility**

The platform should be flexible to meet requirements for a varied set of solution spaces

## **Usability**

The platform should be both easy to use and straightforward to develop

## **Scalability**

The platform should enable deployments at scale through proper deployment and division of resources

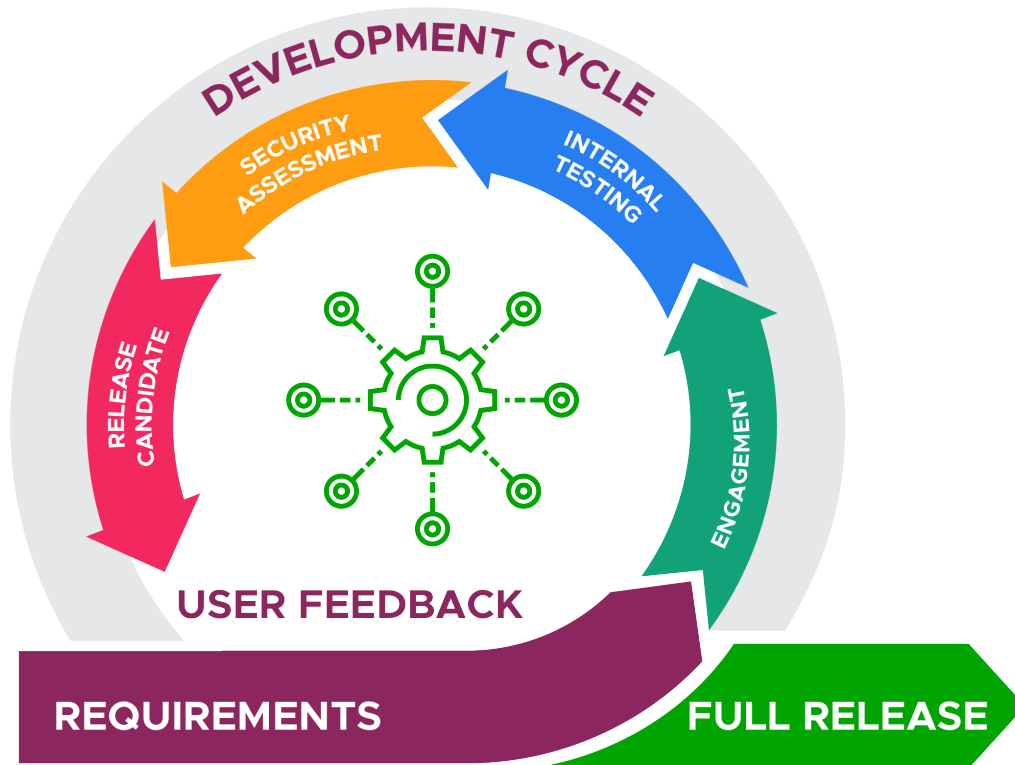
## **Security**

The platform must be secure to protect the devices being controlled and not provide a “backdoor”

## **Interoperability**

The platform must work across vendors and protocols and provide capabilities to simplify these interactions

# Approach



## Community Engagement

- Online Office Hours
- Mailing List

## Internal Testing

- Automated Tests
- PNNL Campus

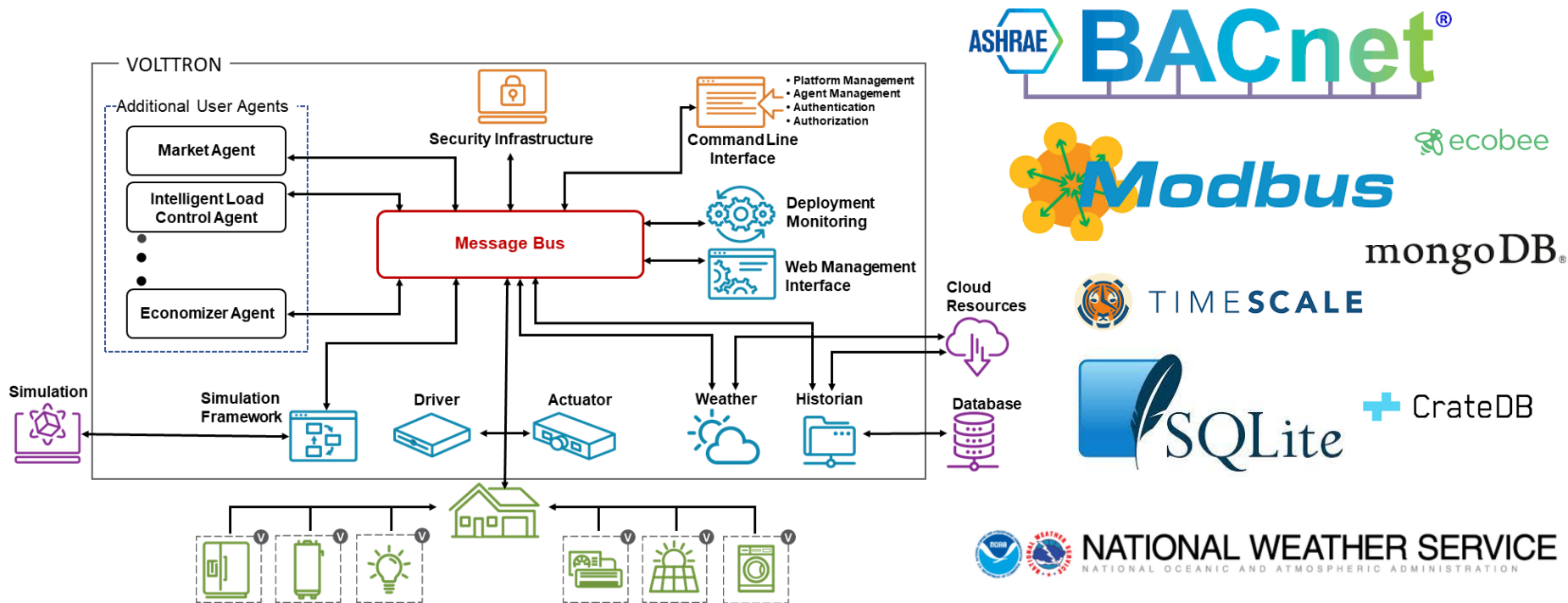
## User Feedback

- Bug reports
- Feature requests

## Security Assessment

- Threat Profile
- Code Review

# Approach: Platform Design



- Platform components interact via message bus
- Drivers handle device interaction and isolate protocol specific code
- Historian stores data in a variety of formats
- Interaction with external services such as weather
- Simulation integration for testing and experiments
- Supports researcher applications for energy efficiency, fault detection, etc.



# Diverse and Growing Community

## Commercial User



**ACE IoT**  
SOLUTIONS



**ecolong**



ENPHASE.

Intellimation

**slipstream**

**Verdicity**  
The Marketplace for Smart Buildings



Alto Tech



ECORITHM

**SINC** ENERGY



## Hardware Vendor

**intwine** connect

**skyCentrics**

## University



THE UNIVERSITY OF  
**TOLEDO**  
1872



**MONASH**  
University



**PennState**

## National Laboratory



Pacific  
Northwest  
NATIONAL LABORATORY

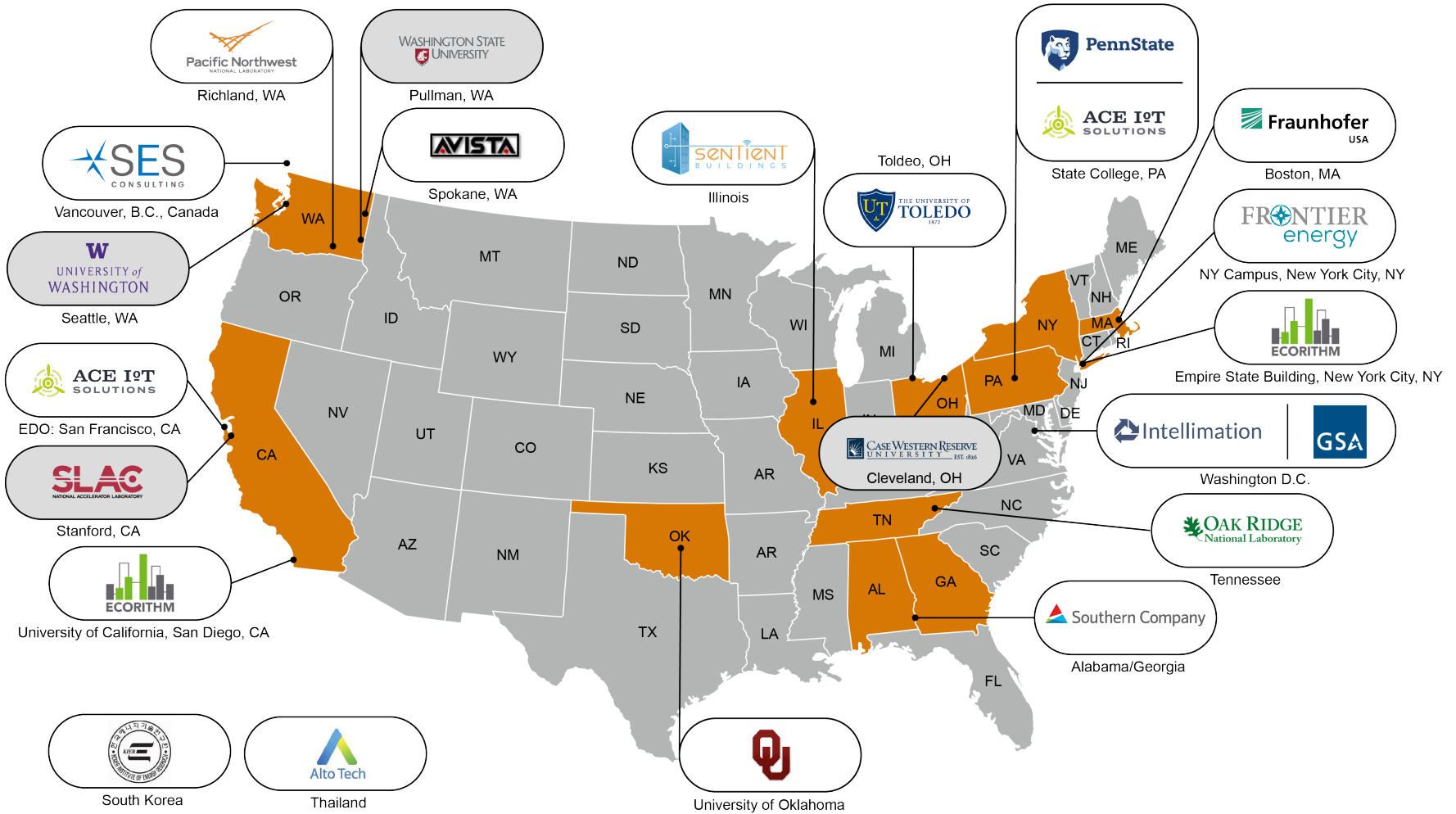


**NREL**  
National Renewable  
Energy Laboratory

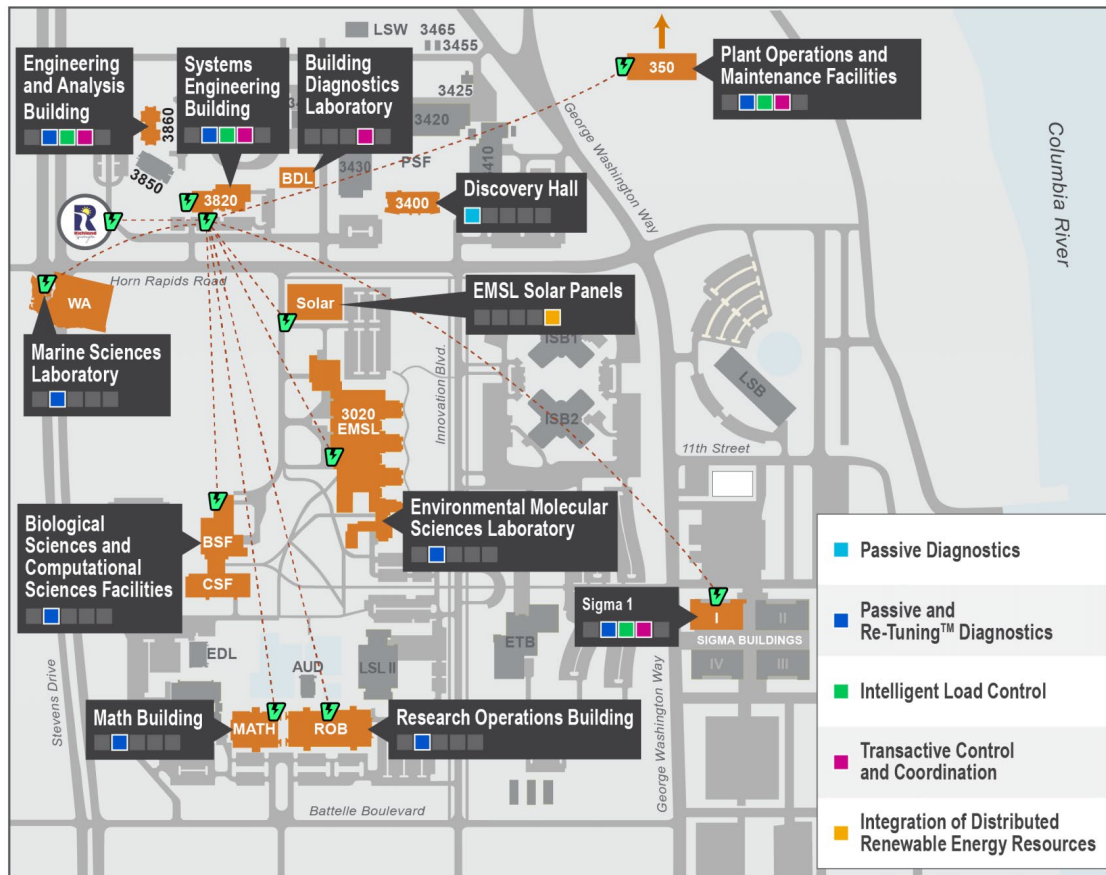
**OAK RIDGE**  
National Laboratory



# Impact: VOLTRON Deployments



# Impact: PNNL Campus Deployment



- **VOLTRON deployed on PNNL campus**
  - Provides long running dataset for machine learning approaches
  - Testbed for experiments
  - Enables NetZero campus
  - Managing and maintaining deployment gives team experience necessary to serve the needs of external users
- **Details**
  - 16 Buildings
  - > 10,000 Sensor Points
  - ~14,000,000 daily records
  - > 20,000,000,000 records to date

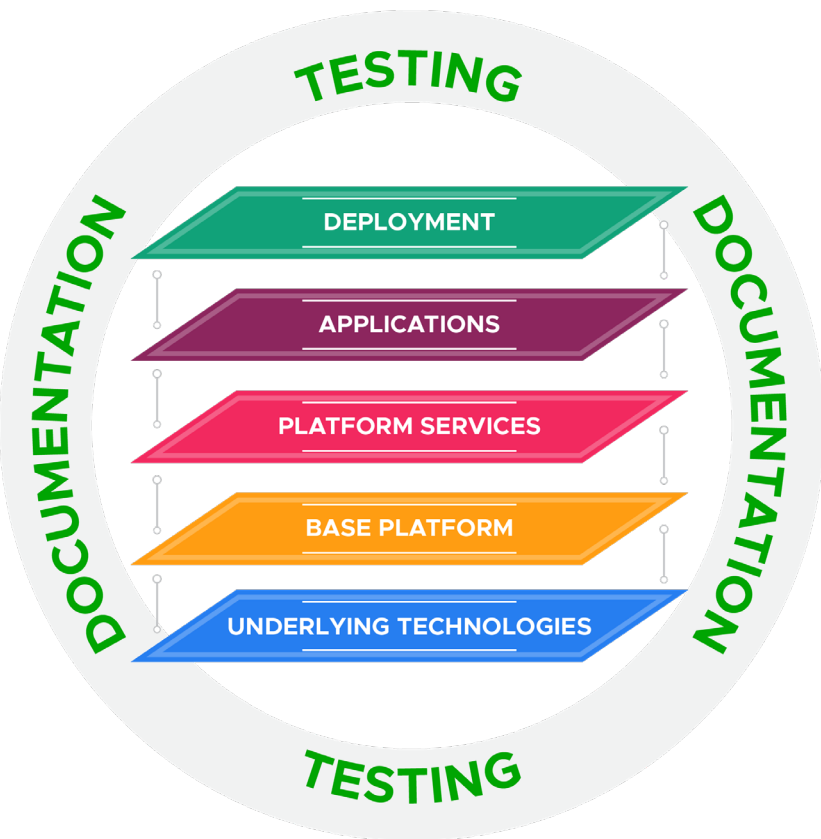
# Impact: Industry Building Block Examples

- **ACE IoT Solutions**
  - Announced formation at VOLTTRON User Meeting
  - Leverages VOLTTRON to “provide our customers with low cost approaches to acquire, access and manage data from distributed control systems and sensors”
- **Intellimation**
  - VOLTTRON data collection solution to feed web analytics service
  - Utilizing VOLTTRON to deploy PNNL developed applications in real world settings
- **Ecolong LLC**
  - Leveraging VOLTTRON as part of peer-to-peer energy trading system as stated in Congressional testimony
  - VOLTTRON engagement leads to additional technology transfer: GridApps-D, Intelligent Load Control, Transactive utility signal, ConnectedHomes, etc.

# Impact: National Laboratory Projects

- **ORNL**
  - Connected Neighborhoods
  - Integration of Responsive Residential Loads into Distribution Management Systems
  - Universal Hybrid Inverter Driver Interface
- **PNNL**
  - Scaling of Building Transactive Control and Coordination to Support Grid Operations
  - Increasing Distribution System Resiliency using Flexible DER and Microgrid Assets Enabled by OpenFMB
  - Connected Homes
  - Transactive Campus Project
  - 2 Technology Commercialization Fund projects for FY22

# Progress



## Testing

- Unit tests
- Integration tests
- Simulation tests

## Documentation

- Tutorial Video Series
- Update and expand docs

## Deployment

- Ansible and Docker deployment
- Making agent service protections deploy time decisions

## Applications

- Intelligent Load Control
- Automated Fault Detection

## Platform Services

- Simulation Integration
- Driver protocol additions

## Base Platform

- Modularize Code
- Rabbit MQ Expansion

## Underlying Technologies

- Python 2 to 3
- New OS versions

# Stakeholder Engagement



- **Community Engagement**
  - Eclipse Foundation Engagement
  - Biweekly Online Office Hours
    - Invite list: 60+, 20+ regular attendees
    - 5 years of recordings
- **Guidehouse Community Report**
  - Feedback from the community on strengths and opportunities for improvement
  - Code Modularization
  - Eclipse engagement
- **Open Source Repository**
  - 845 Clones, 163 Unique cloners: 7/24 - 8/6 2021
  - 40+ contributors
  - 180+ forks
- **Mailing list: ~400, 40+ new this year**
- **Annual Users Meeting**
  - 2021 Virtual Meeting
    - 85 registered, 25 - 40 online

# Remaining Work

- **FY21**

- Simulation support enables tying in DOE Ecosystems such as Energy+, HELICS, and other engines used by researchers
- Data Benchmark data source to provide dynamic dataset
- Utility signal integration as chosen by community
- Eclipse Transition
- VOLTTRON 9.0 release

- **FY22**

- Thriving VOLTTRON ecosystem
  - Robust collaborative community
  - Services to support deployments at scale for a variety of use cases
- PNNL providing software expertise, cybersecurity guidance, equitable improvements
- Quarterly virtual meetings to drive direction and build community



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# Thank You

Pacific Northwest National Laboratory  
Jereme Haack, Project Manager  
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# REFERENCE SLIDES

# Project Budget

**Project Budget:** Total project funding is \$3.1M (FY19-21) with FY22 budget TBD.

**Variances:** In FY21, project has been spending within 6% of plan.

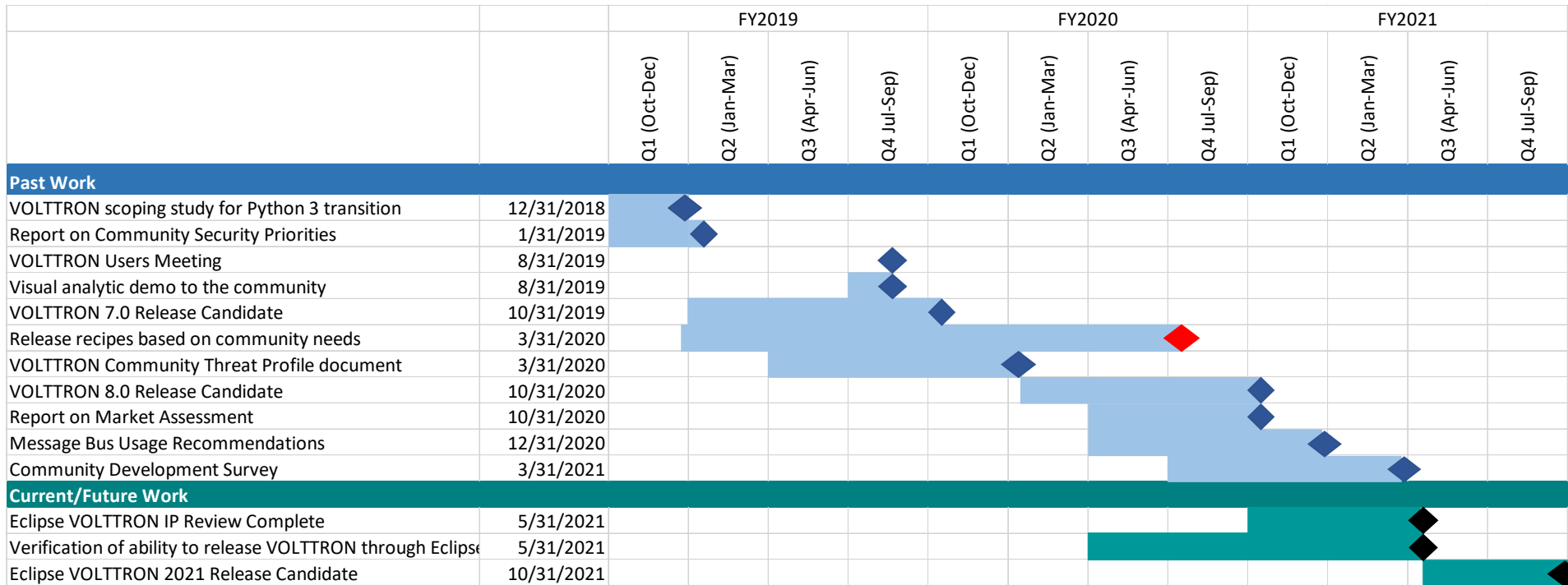
**Cost to Date:** Cost through month-end July totals \$1.05M

**Additional Funding:** Korea Institute of Energy Research (KIER) \$388K / GMLC FCTO \$520K / BTO & Washington State Clean Energy Fund - Scaling of Building Transactive Control and Coordination to Support Grid Operations \$4M Technology Commercialization Funds – 2 projects totaling \$900k

## Budget History

FY 2019– FY 2020 (past)		FY 2021 (current)		FY 2022 – TBD (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$2.01M	\$0	\$1.09M	\$0	TBD	TBD

# Project Plan and Schedule



“Release recipes based on community” needs was delayed to 6/19/2020 due to losing key staff. Delay was used to refine the approach based on community engagement