グランド再生可能エネルギー2018　国際会議

AIST-FREA スペシャルセッション

GRAND RENEWABLE ENERGY 2018

AIST-FREA Special Session

2018/6/20　パシフィコ横浜　会議センターにて

AIST-FREA Session, Room 501

International Workshop: “Challenges to Renewable Energy Penetration beyond conventional limits with advanced DER capabilities”

Smart Inverter: Advanced testing and validation platform

2018/06/20

National Institute of Advanced Industrial Science and Technology (AIST)

Fukushima Renewable Energy Institute, AIST (FREA)

Energy Network Team

Jun Hashimoto

Agenda

- **Motivation**
- **Today's topics**
  - **New developed steady-state simulation tool**
  - **Automated smart inverter testing**
  - **Advanced validation platform**
- **Summary**

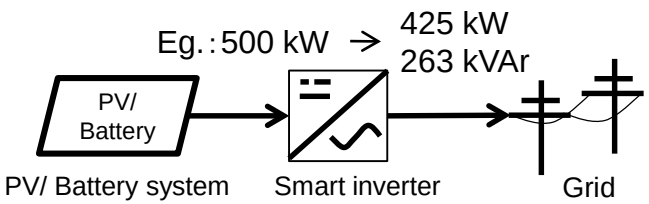
Motivation

Overview of Advanced “Smart Inverter” Capabilities

- More comprehensive planning and communications with DER systems
- Smart inverters can mitigate impact on power quality and reliability in response to local voltage and frequency issues as well as modify generation and storage actions based on communicated requests.
- To help manage increasing penetration of variable renewable energy generation

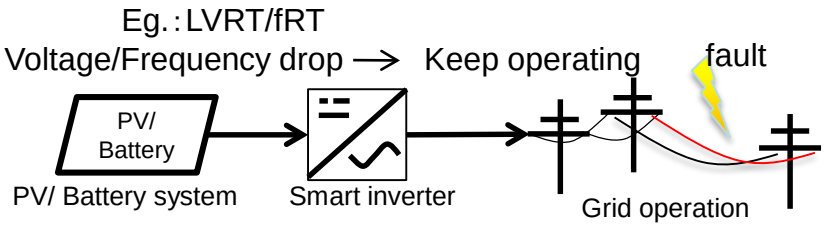
Advanced function for Grid stability

①Active/ Reactive power（P・Q）Control



Voltage/ Frequency support function

②Grid protection

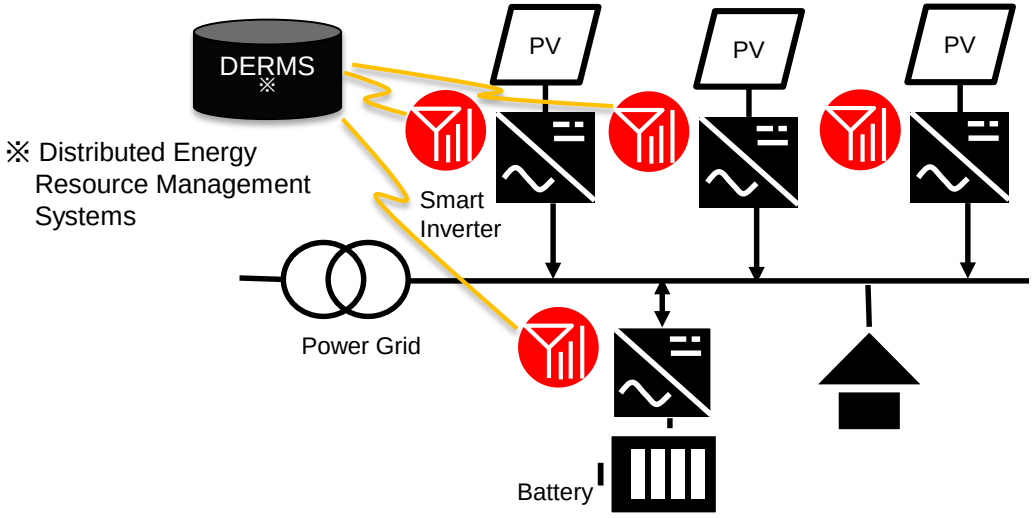


Grid protection function

DER/smart inverter operation

③Remote control

Communication capability
Use DER smarter



Motivation

- **Issues related to smart inverter and DER**
  - **How smart inverter impact on the Grid?**
  - **How can we test the smart inverter?**
  - **How can we understand and control smart inverter?**

- **Today's topics**
  - **New developed steady-state simulation tool**
  - **Automated smart inverter testing**
  - **Advanced validation platform**

1. Simulation tool for smart Inverter

Solar Resource Application (SoRA) platform

- ✓ In this platform, FREA will develop test environments and test tools as an important development base for both hardware and software solutions.
  - ✓ The keyword is **"safety, security and fairness".**
  - ✓ Future power grid is achieved by optimal utilization of distributed energy resources (DERs), e.g. smart grid and/or microgrid technology, system integration of multiple DER with energy storage systems.

SoRA | Solar Resouce Application platform
Renewable Energy & DER integration

https://www.renewable.pr.aist.go.jp/ent/

Data Base | Testing facility | Application

Power flow simulation tool for Smart inverter

New simulation tool called **“SoRA-Grid”**

- We developed new power flow simulation software for smart inverter impact assessment
- Most of all smart inverter functions were implemented based on IEC61850
- This tool can simulate both voltage and frequency impact on the grid

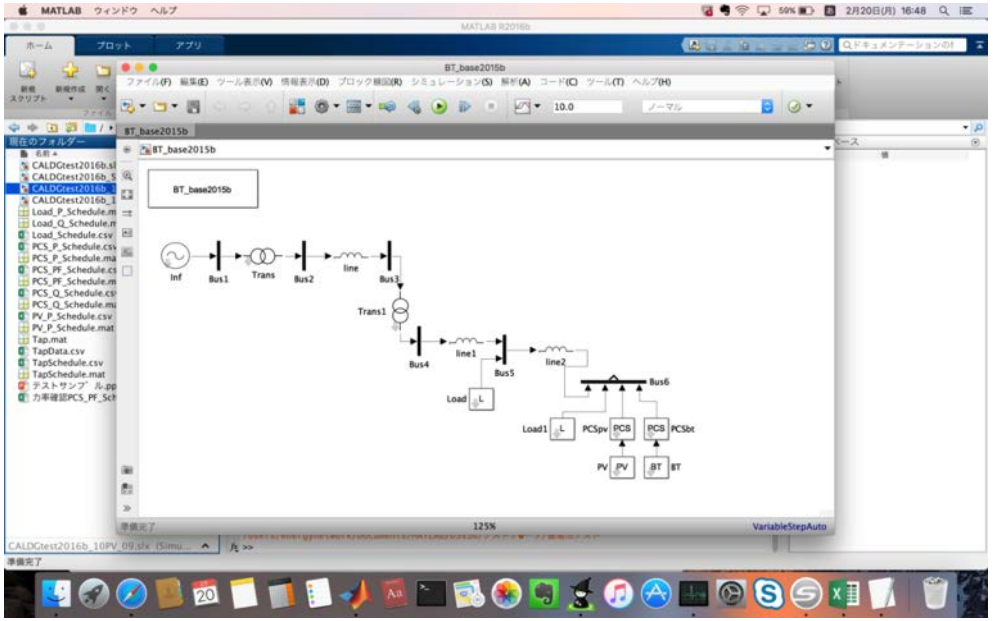


Fig 1：GUI based on Simulink

Concept and feature

- ✓ Easy to use and modify
  - ✓ Based on MATLAB/Simulink
  - ✓ Developed Smart inverter library
- ✓ Possible to simulate long term period
- ✓ Open source software
- ✓ Suitable for education and academia

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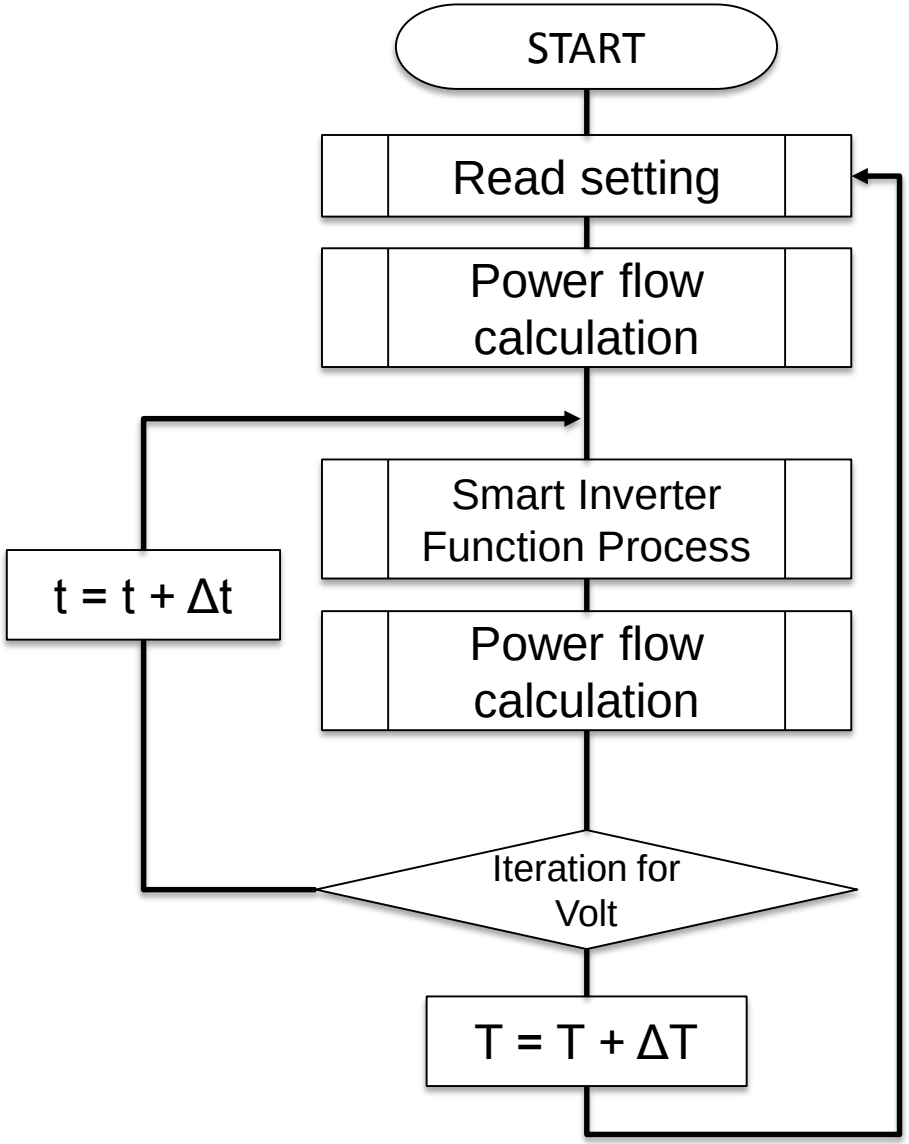
TEPSYS

Power flow simulation tool for Smart inverter



Small time step for smart inverter

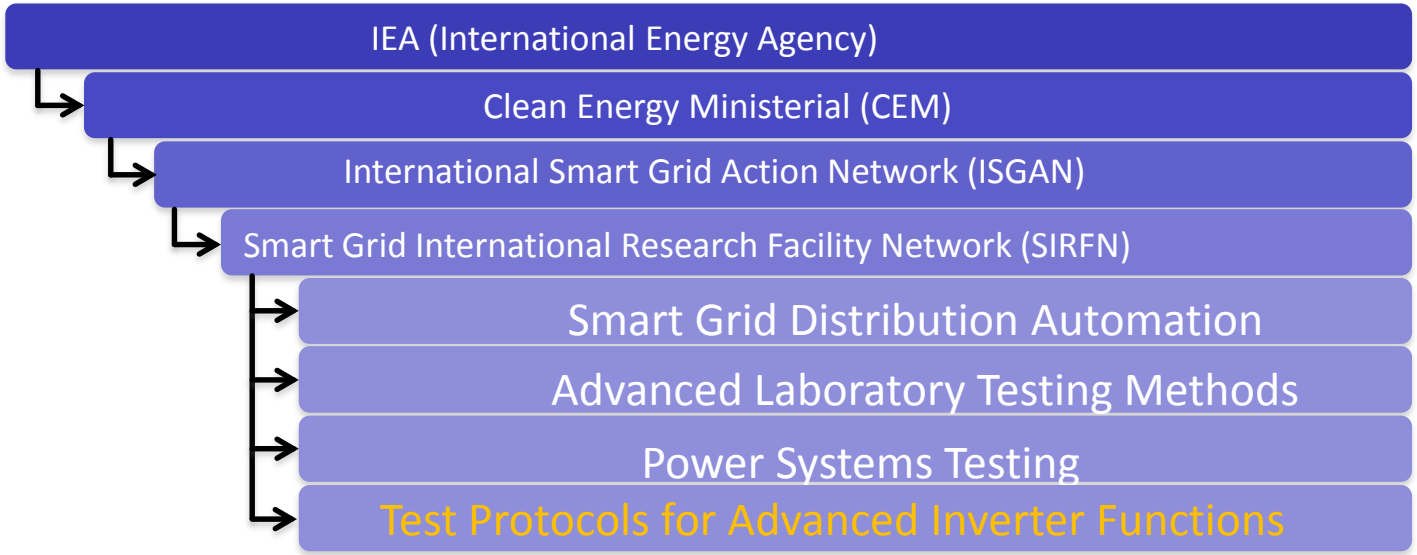
- ✓ Small time step (t) can calculate smart inverter impact for both voltage and frequency
- ✓ Normally we can set second order time step for t

Large time step for long term calculation

- ✓ Large time step (T) can reduce calculation time for long term simulation

2. Smart Inverter Testing

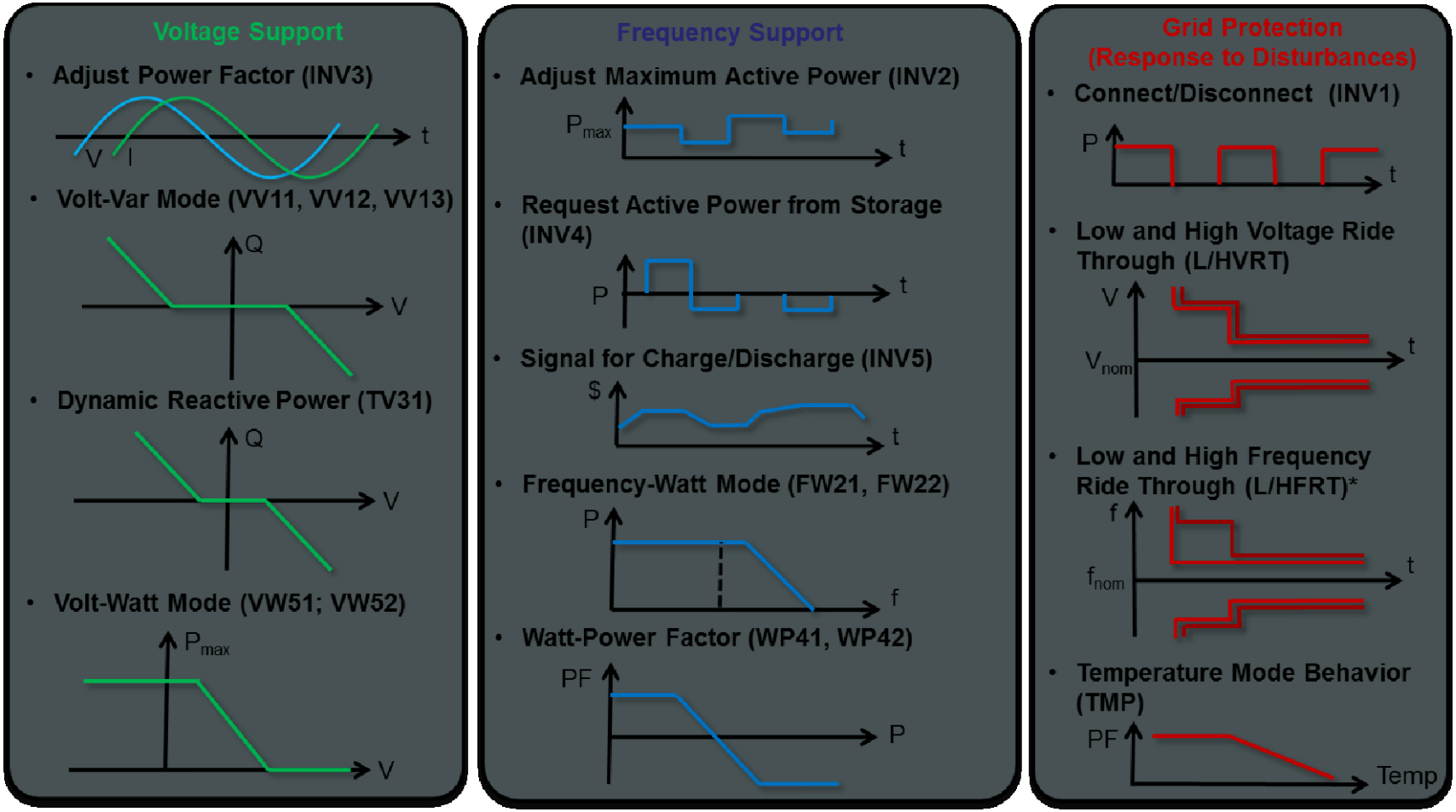
SIRFN Smart Grid Collaboration



SIRFN - A coordinated network of smart grid research facilities from:

- **Primary goal**: Develop and demonstrate a consensus-based interoperability certification standard for advanced Distributed Energy Resources (DERs).
  - Design and compare advanced interoperability test-beds.
  - Perform round-robin testing of advanced DER.
  - Compare test results, communications methods, and automation procedures.
  - Gradually improve draft test procedures for advanced DER with the goal of becoming an internationally-accepted standard.

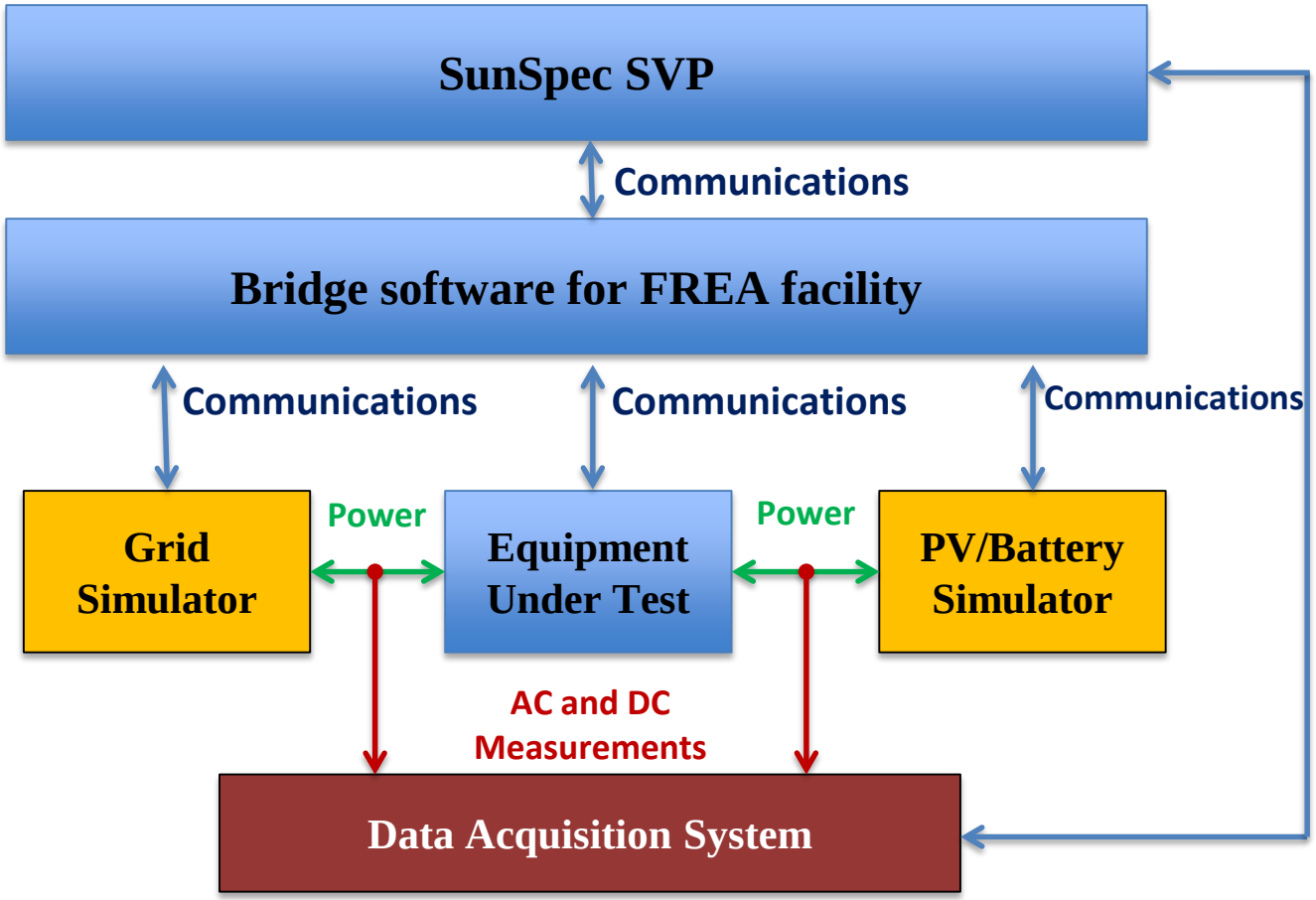
Target advanced inverter function



Autonomous: Inverter response to local voltage and frequency conditions
Commanded: Remote control (e.g., on/off, set power factor), and configure autonomous behavior
Question: How do we test and qualify inverter in an effective and efficient way?

Automated smart inverter testing technology

■ The **System Validation Platform (SVP)** is automated DER (smart inverter) interconnection and interoperability testing.



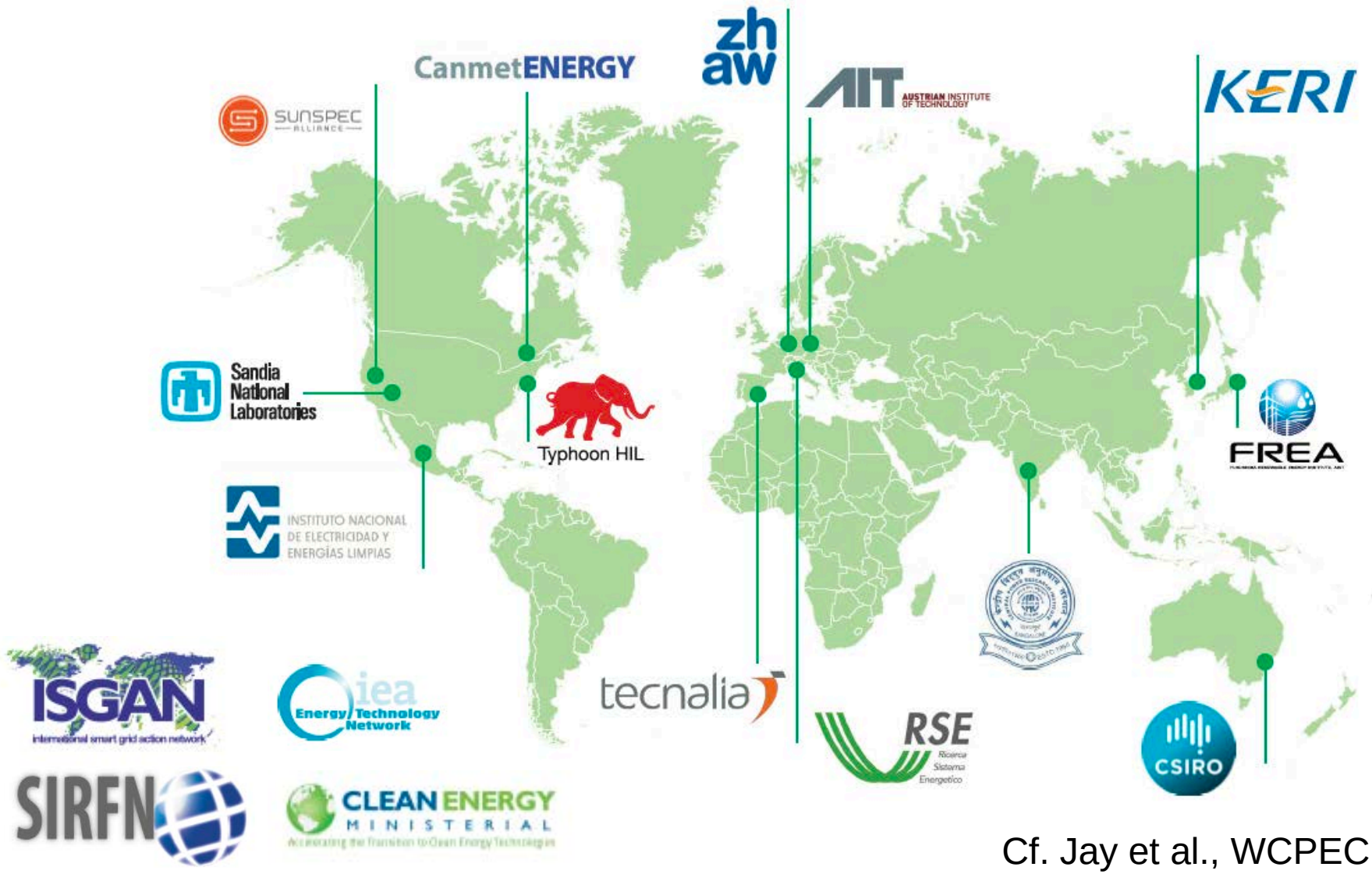
Testing time

Manually:
about 1 month

Semi-auto: (now)
few weeks
25% reduction

Full-auto: (future)
Few days
80% reduction

International Collaboration



Cf. Jay et al., WCPEC 2018

3. Advanced validation platform

Smart system validation platform

There are many demonstration project for;

- ✓ Smart grid/ inverter
- ✓ Virtual power plant (VPP) etc.

Question is;

- ✓ How can we integrate each unique concepts to the market?
- ✓ How can ”Utility” and/or “Stakeholder” accept new concept to their system?

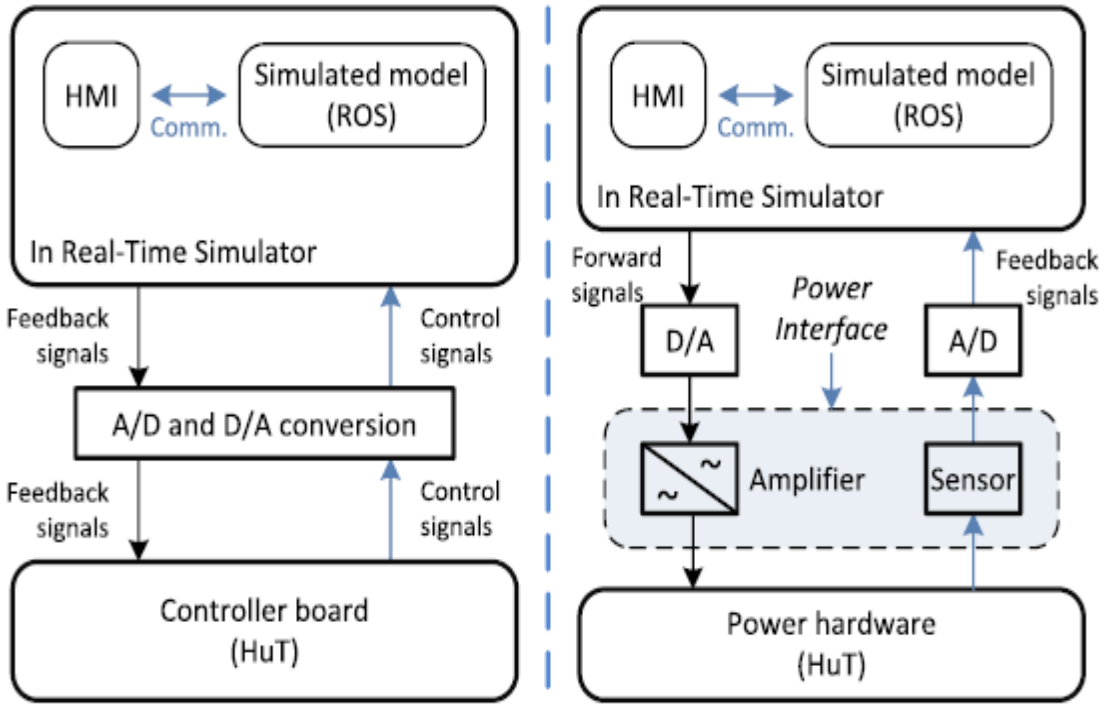
We propose validation platform for new concept or/and system

Hardware-In-the-Loop (HIL) technology is one of the KEY technology to proof the system

- ✓ Make a realistic environment in the Laboratory for pre-testing based on HIL
- ✓ Feedback the key finding to the developer or manufacture before the installation phase
  - ✓ Device and system acceptance test
  - ✓ Interoperability test
  - ✓ Operation test or/and operator training
- ✓ This procedure can achieve
  - ✓ **Time saving, Cost and Risk reduction**

What is HIL?

Hardware-in-the-Loop (HIL) simulation is a technique that is used for the development and testing of these control systems.



c.f. IEEE PES Task Force on Real-Time Simulation of Power and Energy Systems, CORRESPONDING AUTHOR: T. STRASSER
Real-Time Simulation Technologies for Power Systems Design, Testing, and Analysis

What is HIL?

Definition of HIL (cf. IEEE P2004 draft*)

1. A simulation model of a physical system (power circuit, car engine, ship's hydrodynamics, etc., i.e.) executed on a digital real-time simulator (DRTS) in real-time mode, i.e. the "plant" simulation
2. One or more salient components of that system existing outside of that DRTS, including controller code executed in real time on suitable computing platform (does not need to be the field deployed hardware!): i.e. the "device(s) under test" (DUTs)
3. The DRTS plant simulation is interfaced with the DUTs at all relevant signals/quantities with appropriate closed loop feedback between the plant and the DUTs as such representing the real-life implementation

*IEEE Standard Association, IEEE P2004: HIL - Hardware-in-the-Loop (HIL) Simulation based Testing of Electric Power Apparatus and Controls

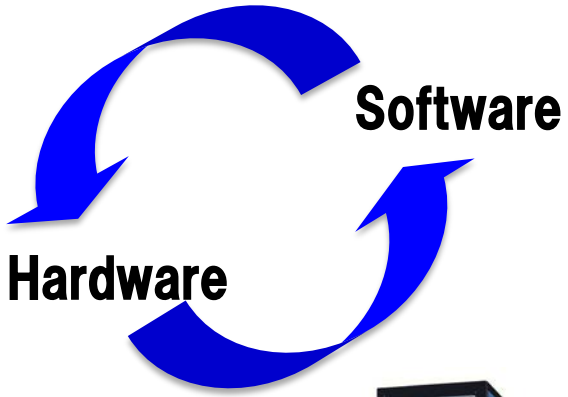
①Device testing ②Interoperability testing ③System proofing

FREA-G test bed

・Single EUT testing

FREA-G with HILs

・EUT test with HILs

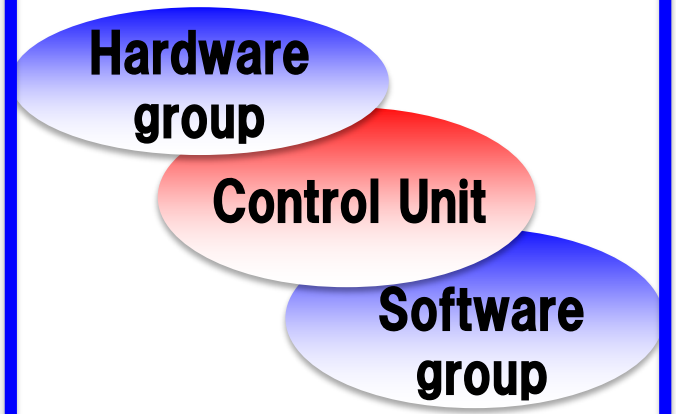


Flexibility

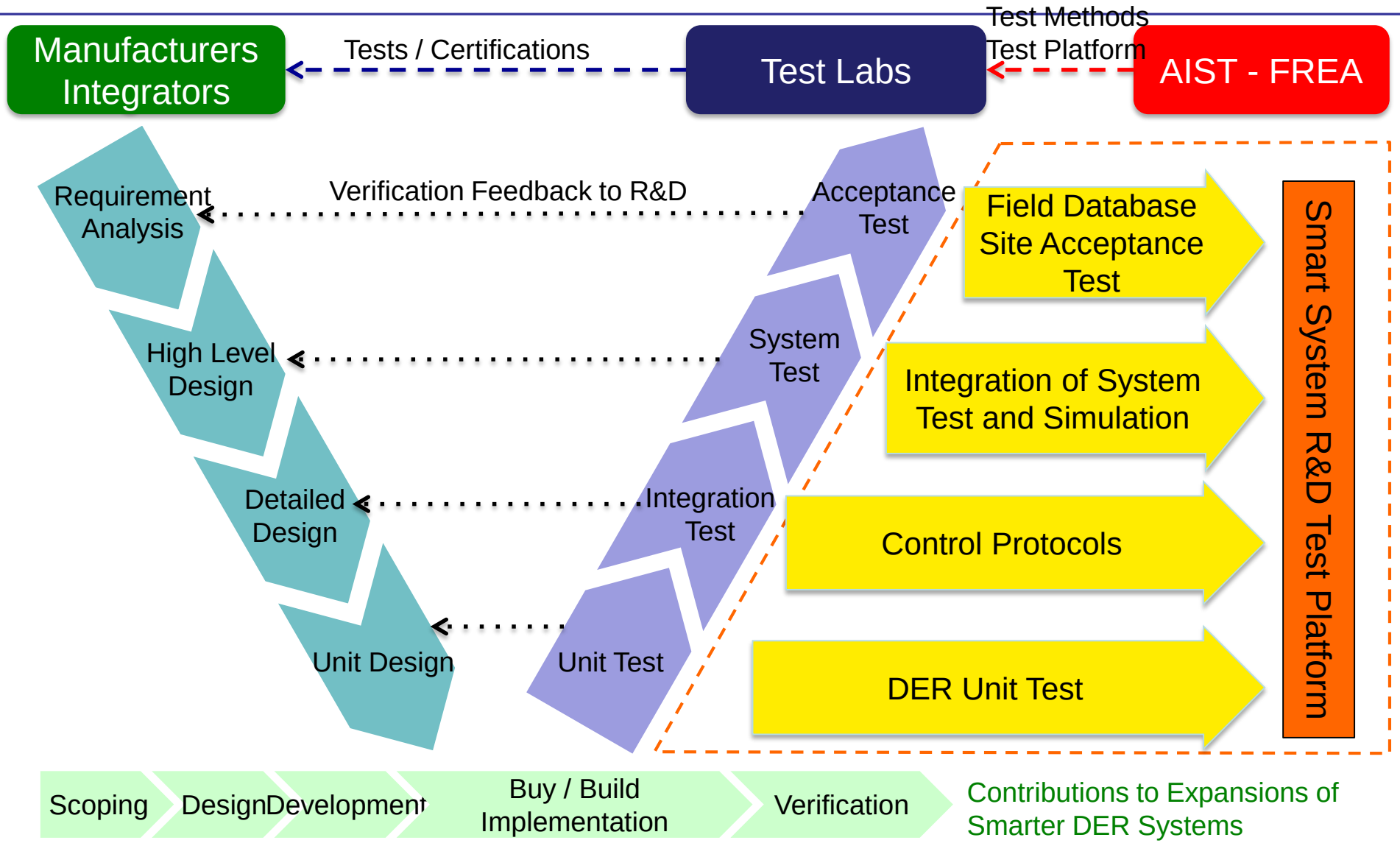
Real Time Digital Simulator

System validation field

・DER testing platform



Smart system validation platform



Impact assessment test with HIL for HECO

About collaboration between Hawaiian Electric Company, Inc. (HECO) and AIST

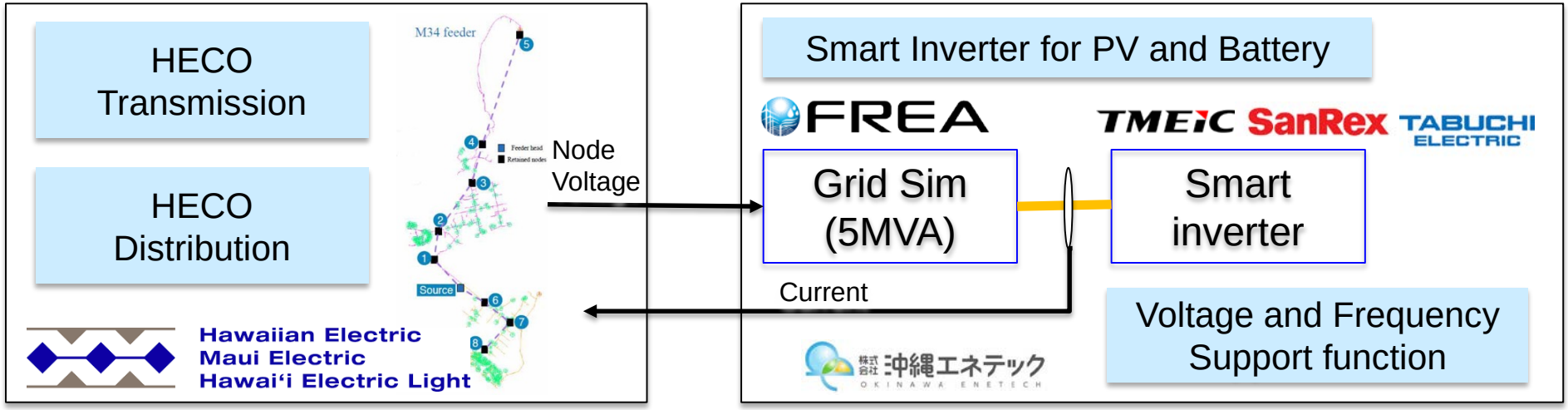
- Based on continue the partnership on technology exchange between Okinawa and Hawaii.
- In this project, we aim to create innovative energy technologies for smart grid.

Work items

- Impact assessment of advanced inverter placement on feeder operation and sensitivity
  - PV and Battery with smart inverter assessment test with HIL
  - How much smart inverter capability affect to the HECO grid
  - Both voltage and frequency support function

Virtual simulation in the HIL

Real hardware (DUT & Grid simulator)



Summary

- **New smart inverter assessment simulation tool (SoRA-Grid) was developed**
  - SoRA-Grid can simulate multiple DERs setting impact on the Grid
  - This is open software and welcome the collaboration
- **Automation technology for smart inverter has been developed**
  - This is one of the international activities called SIRFN
  - Possible to reduce 80% of testing time
- **Smart System Validation Platform Concept for Energy Network Infrastructures is proposed**
  - HIL is one of the KEY technologies to reduce Time, Cost and Risk
  - We would like to harmonize with other international projects


Thank you!
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