

Grid Interaction Technical Team

2012 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

Keith Hardy

Argonne National Laboratory

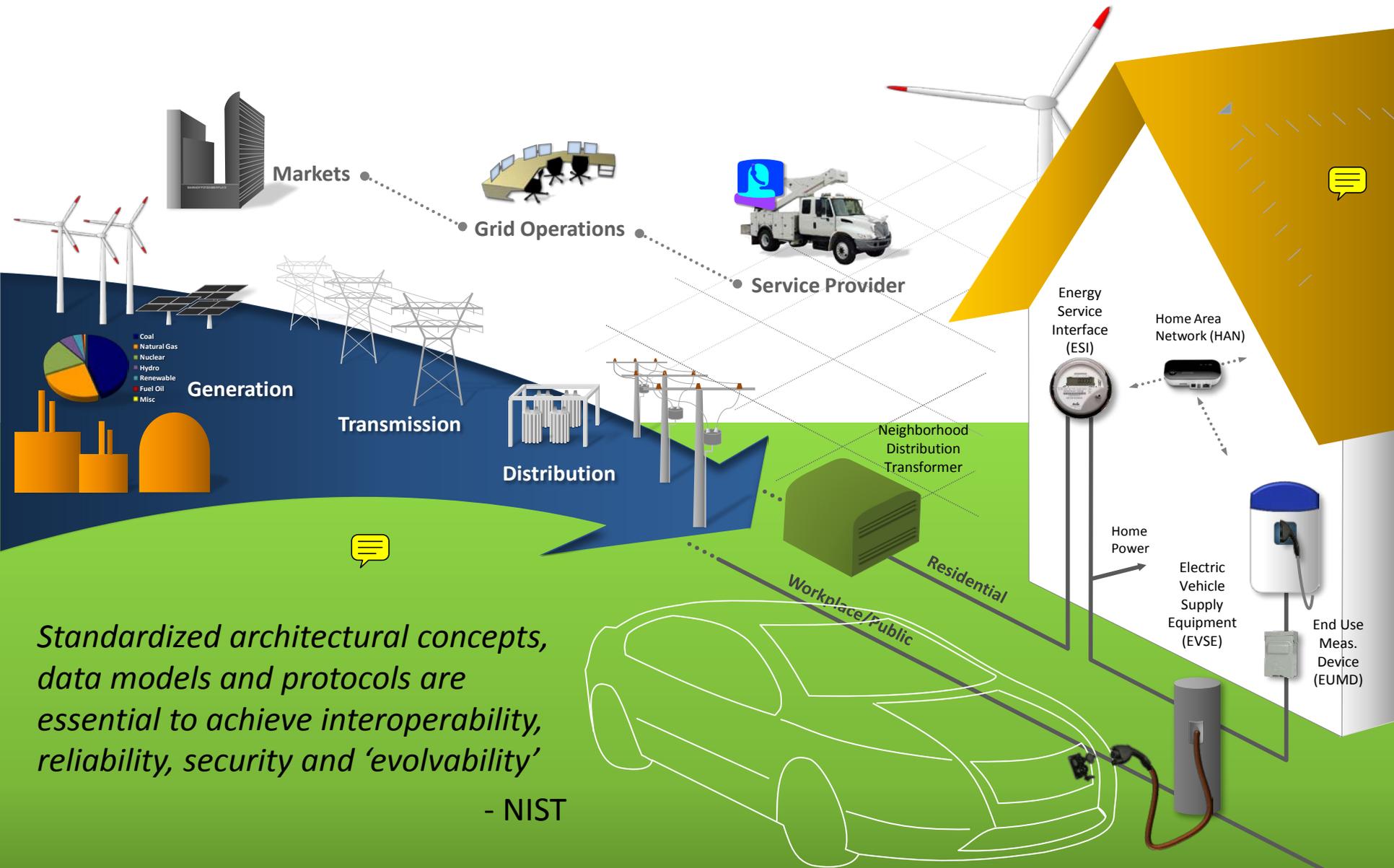
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DOE Technical Lead: Lee Slezak

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The Big (Infrastructure) Picture



Standardized architectural concepts, data models and protocols are essential to achieve interoperability, reliability, security and 'evolvability'

- NIST

Overview

Timeline

- Grid Interaction Tech Team (GITT) initiated in summer 2009
- Projects initiated in March 2010
- Initial results/prototypes in October 2010
- Hardware/software development continues
 - EUMD rev 2 hardware in January 2011
 - EUMD rev 3 hardware in July 2011
 - Network gateway in Feb. 2012
 - EUMD rev 4 hardware in June 2012
 - Multi-port router by July 2012
 - Network gateway w/flexible interface in Sept. 2012
 - Pilot projects in US and EU in FY 2013

Barriers/Key Challenges

- EV-grid connectivity and communication
Development and verification of EV-grid connectivity technology, communication protocols and standards with adequate lead time to support OEM/supplier production schedules
- EV-grid interoperability
Ability to charge any vehicle ... with any charger ... and any service provider ... with a smart grid or not
- Regional standards/recommendations
ACEA recommendations (Europe)
GB standards (China)

Budget

- FY 2010: \$930K(incl. codes & standards)
- FY 2011: \$650K for GITT; \$200K for Intl. Coop.
- FY 2012: \$300K for GITT; \$200K for Intl. Coop.

Partners

- Utilities: DTE Energy, So. Cal. Edison, EPRI
- Automotive OEMs: Ford, GM, Chrysler, Tesla
- Project Lead: ANL
- Collaborators: Automotive, semiconductor, network and meter suppliers, DOE (OE & PI), DOC, DOS, TEC plus International

Objectives

Support a transition scenario to large scale grid-connected vehicle charging with transformational technology, proof of concept and information dissemination

The GITT addresses connectivity between light duty plug-in vehicles, the charging infrastructure and the electric power grid, focusing on the following:

- Reduced Cost of Electric Charging Infrastructure
- Harmonization of Global Connectivity Standards
- Enabling Technology Development
- Enhanced Viability of Fast/Consumer-Friendly Charging
- Managed Vehicle Charging Loads Consistent with Smart Grid

GITT Activities Leveraged to Support International Initiatives

The International Cooperation task utilizes resources of the GITT and the ARRA-sponsored EV Project to support policy initiatives, promote harmonization and technical cooperation in support of vehicle electrification:

- Facilitate cooperative technical activities in Europe and China
- Support DOE Policy & Intl. Affairs, EU-US Energy Council, Transatlantic Economic Council (TEC), US Mission to the EU and US-China EV initiative
- Provide technical resources for USG-sponsored international events



Approach - Address Urgent Needs of the Vehicle-Charging Infrastructure Interface

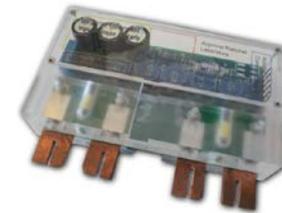
- **Support SAE connectivity/communication committees**
 - Combo coupler (UL certification)
 - Communication technology and messaging protocols (verification)
 - Wireless charging test fixture (requirements, fabrication and de-bug at ANL)
- **Sub-metering/communication modules**
 - Auto-rem, EUMD, home gateway and multi-port router development
 - Focus on technology options and compatibility with ACEA recommendations
- **Demonstrate/assess interoperability**
 - Demonstrated EV-EVSE-network-meter-grid communication
 - Developed/implemented a tool set/test bench for SAE J2953 interoperability
 - Refining and specifying for general/global application
- **Global harmonization/cooperation**
 - DOE-JRC Letter of Intent to establish EV-Smart Grid Interoperability Centers
 - Defining laboratory requirements and pilot projects for US and EU



Accomplishments

- **Compact metrology**

- EUMD measures and communicates charge energy

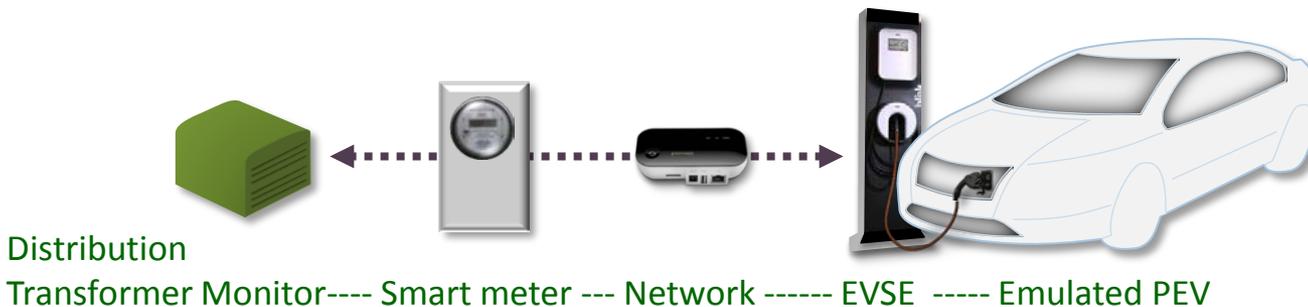


- **Auto-rem communication module**

- Enables messaging from vehicle to EVSE



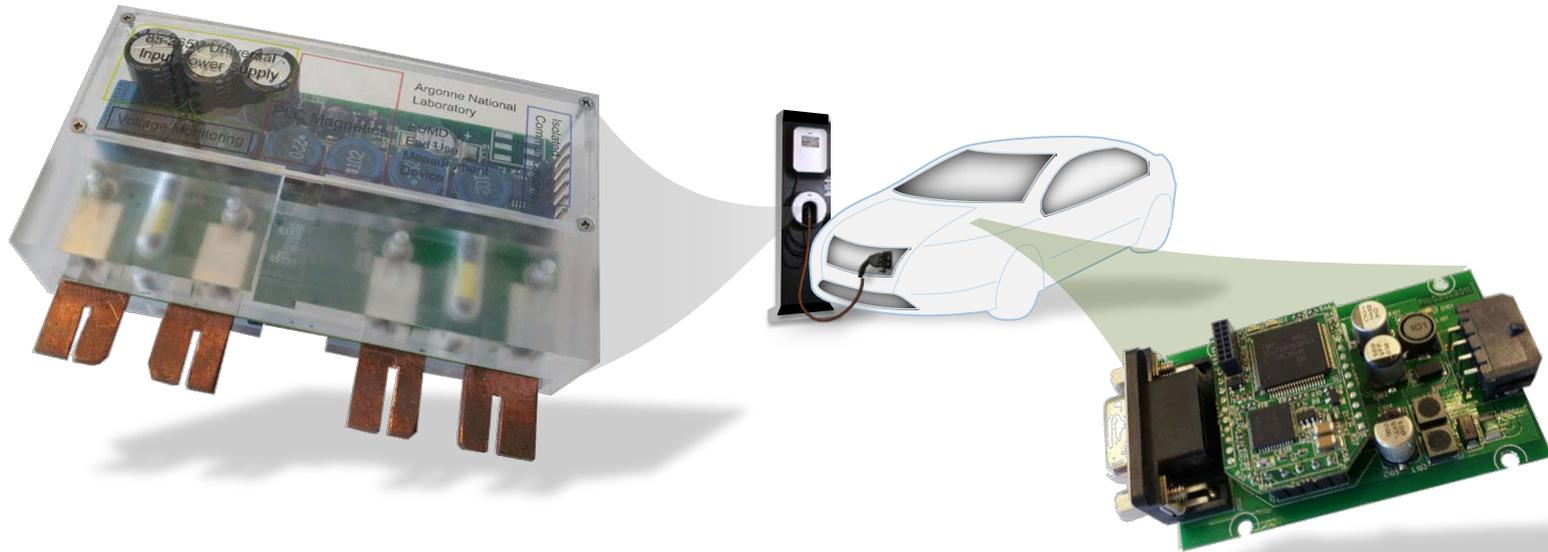
- **Vehicle-grid communication/interoperability**



- **Agreement to establish Electric Vehicle-Smart Grid Interoperability Centers in the US and Europe**

- Harmonized/compatible standards, test procedures, components

Compact Metrology/Communication



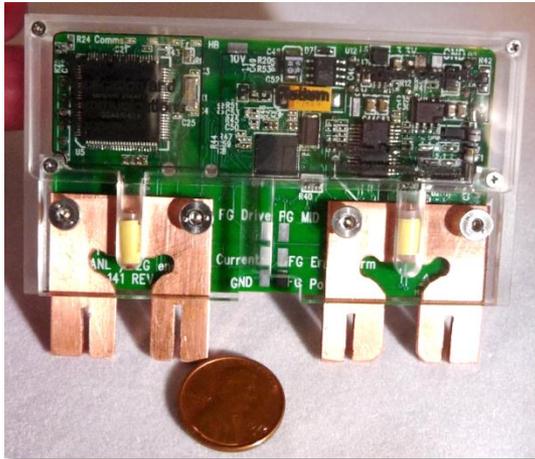
End Use Measurement Device (EUMD)

- *EVSE-to-grid messaging**
- Revenue-grade meter communicates EVSE energy use to the energy service provider (via smart meter) or Home Area Network (HAN)
- Low cost potential
- Key reference for CPUC sub-metering deliberations
- * Add'l locations /communication links possible (next slide)

'Auto-rem' Communication Module

- *Vehicle-to-EVSE messaging*
- Communicates vehicle information to EVSE for identification and charge control
- TI Octave hardware chip set with power line communication (G3-PLC) and CAN interface

EUMD Configurations



Modular architecture/socket for flexible mounting

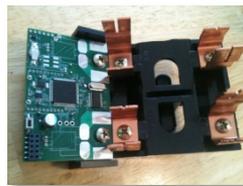
- Transformer monitoring (power, temperature)
- Fused instrumented disconnect EUMD (w/main meter)
- Un-fused instrumented disconnect - in EVSE
- Level 1 EUMD, no electrician, NEMA 5-15, multi-family
- Vehicle mounted EUMD, plugs into stock charger inlet

Applicable to global interoperability pilot projects

- Laboratory and field testing
- 3Ø version of EUMD for EU application

Communication technology options

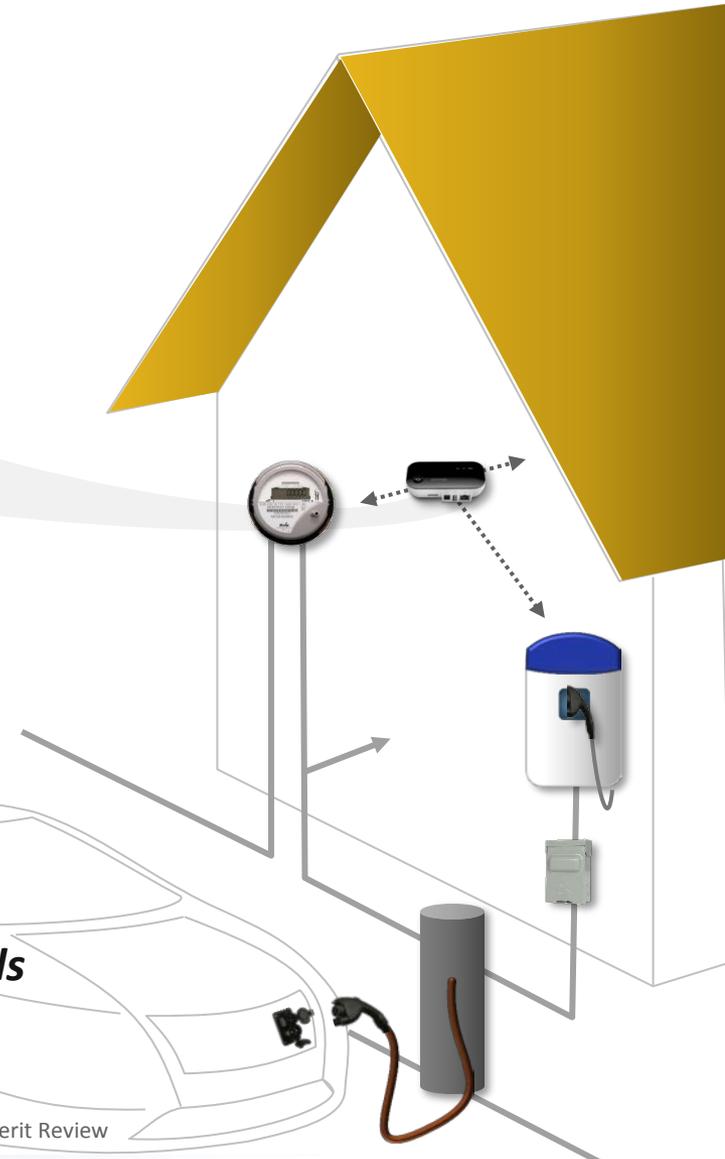
- G3-PLC, FSK or HomePlug GP (GreenPHY)



Home/Network Gateway



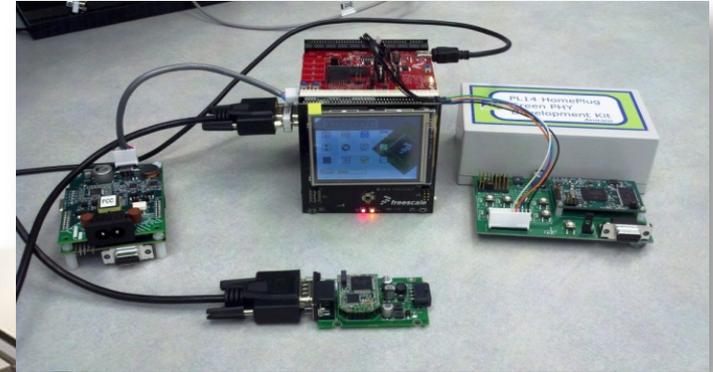
- **Home area networks (HANs)** enable communication between smart meters and appliances with communication and control capability (e.g., Zigbee) to manage/balance loads
- **PEVs/EVSEs will be compatible** with the ‘gateway’ via SAE J2847 compliant messaging
- **ANL is working with Greenwave Reality and Grid2Home** to develop a gateway to bridge from existing messaging infrastructure (SEP 1.1) to SEP2.0 (similar to OpenV2G in the EU, i.e., ISO IEC 15118) ...
Adapting off-the-shelf hardware for use in field trials to encourage commercial development



SAE J2953 Interoperability



All Tech Team Display with Gridtest PEV Emulator (right)



Communication module testing at ANL



Photo courtesy of Gridtest systems

- **SAE J2953 specifies connectivity and communication standards** between a plug-in vehicle, EVSE, network gateway/HAN and utility messages
- **Display at the All Tech Team Meeting (Oct. 11) demonstrated interoperability** between emulated PEV, production EVSE with EUMD, production home gateway and SEP 1.0 AMI (advanced metering infrastructure) development system
- **ANL/PNNL focuses on evaluating tools and verifying test procedures** to support SAE committees (in as realistic operating environments as possible)

SAE Standards Committees Support

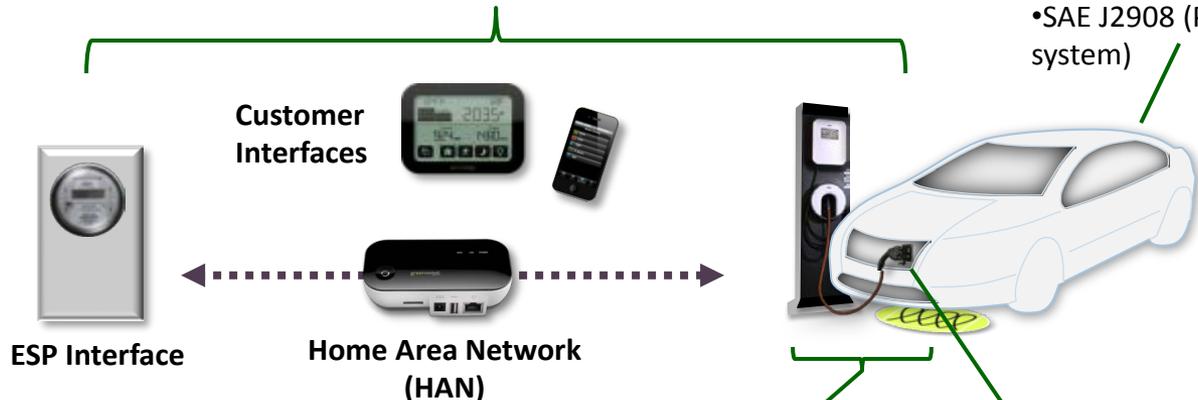
Compatibility/Interoperability

- SAE J2931 (Communication, telematics, security)
- SAE J2953 (EVSE-PEV compatibility)

Power Ratings

- SAE J2907 (Motor and power electronics)
- SAE J2908 (Propulsion system)

Energy Service Provider



Electric Vehicle Supply Equipment (EVSE)

- SAE J2894 (Power Quality for charger – test methods)
- SAE J2954 (Wireless charging)

Support ranges from supplying reference materials to chairing committees, supplying hardware/test fixtures and testing

Charge Coupler

- SAE J1772 (DC)
- SAE J2836 (Use cases for communication)
- SAE J2847 (Communication protocols and messaging)



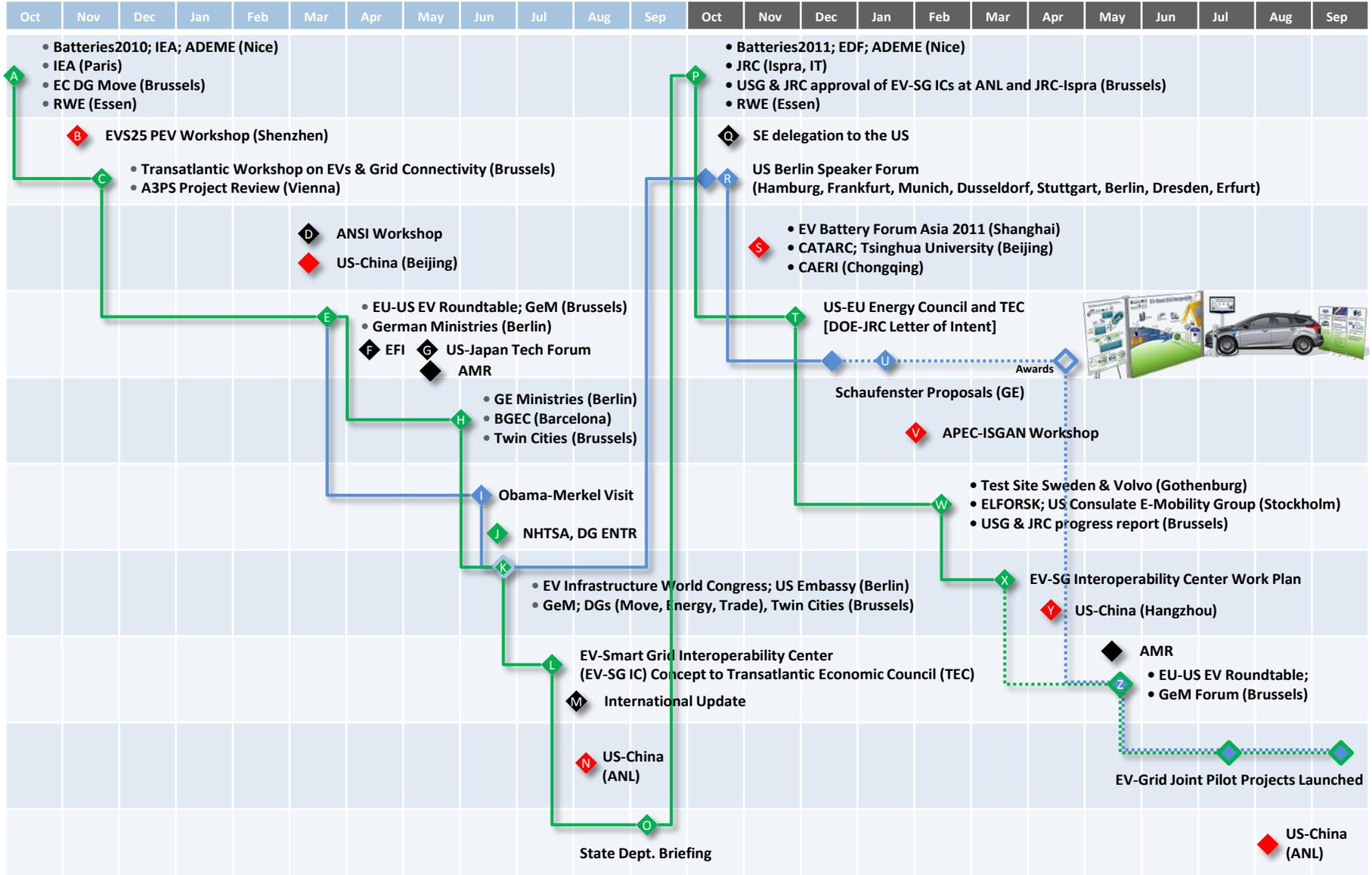
GITT Milestones

Month/Year	Milestones
SAE standards support (examples) May '11 Jun. '12 Oct. '12 TBD	J2954 Committee objectives and structure Wireless charging test fixture specification and design Wireless charging test fixture fabrication and de-bug at ANL Coordination with UL and TUV SUD
Sub-metering/communication modules Oct. '11 June '12 July '12 July '12-Jan. '13 Sep. '12	EUMD rev 3 Auto-rem Multi-port router EUMD rev 4 Interoperability hardware set/EUMD use cases (CPUC) Network gateway/flexible interface
Interoperability Oct. '11 June-Oct. '12 Mar. '13	Demonstrated vehicle-EVSE-network-meter-transformer monitor communication Define general interoperability test bench specifications (US and EU) Assembly/fabrication of J2953/IEC 15118 interoperability test bench (ANL and JRC-Ispra)
Global harmonization/cooperation Nov. '11 May '12 June '12 May '12-March '13 July '12-Jan. '13 TBD	EU-US E-Mobility Work Plan approved DOE-JRC Letter of Intent – EV-SG Interoperability Centers EV-SG IC Work Plans 3Ø EUMD Technology transfer/best practices coordination (ANL and JRC-Ispra) Interoperability hardware sets/US and EU joint pilot projects EV, Battery and IC test facility coordination/commissioning
	Completed Milestones

International Program Development

FY 2011

FY 2012



Key Milestone for US-EU Cooperation



Photo courtesy of US Department of State

DOE and European Commission Agree on Cooperative Activities to Support Harmonization (November 2011)

- **Agreed to a joint Work Plan for Advancing E-Mobility Cooperation**
 - **Established Electric Vehicle-Smart Grid Interoperability Centers**
 - Common test procedures and protocols (vehicles, batteries, interoperability)
 - Data-driven, joint refinement of standards
- to promote harmonization of standards and component compatibility***

Future Plans

Maintain focus on near-term needs with long-term impact, direct support of SAE standards committees and global cooperation/harmonization

- **Update EUMD and communication modules with latest/recommended technology**
 - Support CPUC sub-metering deliberations, field testing and harmonization initiatives
 - Develop apps for displaying data/billing information
- **Fabricate/assemble connectivity/communication hardware sets for the US and EU**
 - Vehicle-to-EVSE-to-network gateway-to-smart meter/energy service provider
- **Demonstrate communication and control of DC charging**
 - Communication between DC fast charger controller, chargers, J1772 coupler, power supply and programmable load using standard message protocols, dual-phy gateway and EUMD
- **Development to support wireless charging**
 - Prototype wireless charging test fixture for standards verification; future implementation by UL/INL/TUV for benchmarking and standards refinement/verification
 - Dedicated Short Range Communication (DSRC) hardware for communication and control of off-board wireless charging electronics
- **Verify/validate cyber-security standards**
 - Distributed generation resource and reverse power flow standards.
 - Evaluation of impact of DC charging/decoupled local storage, dispatch on the grid

(Remaining) FY 2012 Activities

- **SAE standards committee support**
 - Wireless charging test fixture specification and design
 - Wireless charging test fixture fabrication and de-bug at ANL
- **Sub-metering/communication modules**
 - Refine designs of the EUMD, multi-port router and network gateway to support the build-up of interoperability hardware sets
 - Assemble preliminary Interoperability hardware sets for US and EU
- **Interoperability**
 - Define general interoperability test bench specifications
 - Acquisition/fabrication and build-up of J2953/IEC 15118 test bench
- **Global harmonization**
 - Final EV-SG IC Work Plans (ANL and JRC-Ispra)
 - 3Ø EUMD for EU version of interoperability hardware set (ANL)
 - Technology transfer/best practices coordination (ANL and JRC-Ispra)

FY 2013 Activities

- **SAE standards committee support**
 - DC charging (SAE J1772 v5, commercial L2 field trial)
 - Wireless charging (SAE J2954; collaborate with OEMs, UL, TÜV Sud)
- **Sub-metering/communication modules**
 - Fabricate and test multiple units of the EUMD, multi-port router and network gateway to support interoperability hardware sets
 - Open data exchange to support sub-metering protocol (CPUC, etc.)
- **Interoperability**
 - Deploy and implement interoperability hardware sets to national labs and selected locations in the US and EU (lab and field pilot projects)
- **Global harmonization**
 - Joint projects using interoperability hardware sets/local components to verify SAE/ISO connectivity and communication standards; JRC-Ispra, German cities (TBD) and (potential) Twin Cities locations

Collaborations

SAE standards committee support

- EPA, EPRI, NFPA, NHTSA, NIST, REMA USA, SAE, UL

Sub-metering/communication modules and Interoperability

- 2G Engineering, Greenwave Reality, Grid2Home, UMich-Dearborn

Global harmonization/cooperation

- USG: DOE (OE and PI), DOC (NIST and ITA), DOS (US Mission to the EU), Transatlantic Economic Council (TEC)
- Transatlantic Business Dialogue (TABD) – US and EU
- European Commission: Directorates-General for Energy, Trade and Mobility & Transport (GeM program includes 42 partners in the EU)
- Germany: Federal Ministries (Economics & Technology, Transport and Environment, States (Hamburg, Berlin, Baden-Württemberg, Bavaria)
OEMs/Suppliers: Audi, BMW, Daimler, Bosch, Siemens
Utilities: EnBW, RWE, Vattenfall
- Sweden: ELFORSK, Swedish Energy Agency, Test Site Sweden, Vattenfall

Summary

- **Relevance** – The GITT is responding to urgent technical needs of the electric vehicle-grid interface and directly supporting the connectivity and communications committees of SAE.
- **Approach/strategy for deployment** – Joint development and implementation with industry assure relevance, beneficial cooperation and direct impact. Development teams of national labs and SMEs produce rapid prototypes with a commercialization perspective. International deployment supports USG initiatives and harmonization.
- **Technical accomplishments and progress** – Unique developments (e.g., compact metrology/communication modules) are recognized as practical innovations. Technical demonstrations have contributed to the practical understanding of technical issues (State, Federal and Intl.) and the opportunities for cooperation between governments and with industry.
- **Collaborations and Coordination** – GITT activities are well-connected with industry and government agencies (domestic and international).
- **Future Work** – Maintains focus on near-term needs with long-term impact.