Cybersecurity for Grid Connected eXtreme Fast Charging (XFC) Station (CyberX)

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ELT205

Overview

Timeline

- Project start date: 01/2019
- Project end date: 12/2020
- Percent complete: 20%

Barriers

- Designing XFC station considering future extensions
- Identify/detect anomalies in the XFC station
- Integrate the prototype result into power HIL testbed

Budget

- Total project funding
  - Total: $2.1 M
  - DOE share: $1.68 M
  - Cost share: $0.42 M (20%)

Partners

INL: Power hardware-in-the-loop and EV simulator for demonstration, Don R Scoffield (lead)

APS Global: : Electric distribution system model and threat analysis, Karl Heimer (lead)

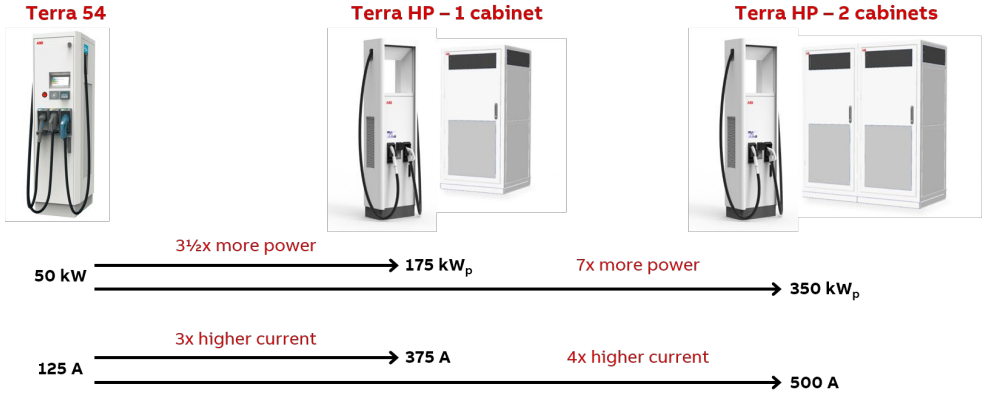
Thor Trucks: Electric vehicle for testing of demonstration, Austin Benzinger (lead)

Relevance

Objectives

- **Research, develop and demonstrate a resilient XFC (>350kW) station that reduces the risk and impact of cyber intrusions**
  - Reduce the false positive/negative ratio of anomaly detection
  - Prototype integration using commercial products in power HIL testbed

- **Design a resilient XFC station management system to safeguard EVs, EVCI (electric-vehicle charging infrastructure), customers and station operators**



Relevance

Overall Impact

Impacts

- A cyber secure extreme fast charging (XFC) station that reduces the risk and impact of cyber intrusions
- Prototype implementation with commercial products in HIL
- Implement the solutions into existing and future products

Innovations

- XFC station management system with first principle based cybersecurity features
- A state-of-the-art anomaly detection system that can identify the abnormal cyber behaviors within the XFC station

Approach

Milestones

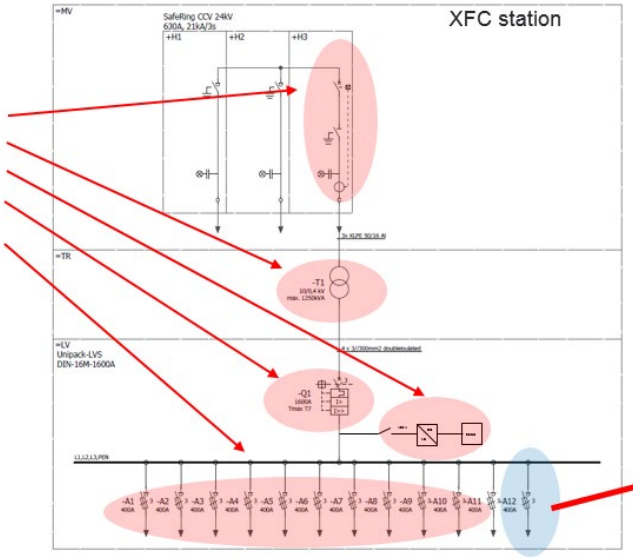
- Planned milestones and go/no-go decisions for FY 2019 and FY 2020

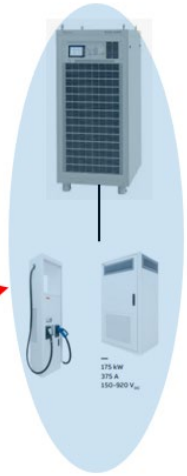
Milestone	Date	Type
Complete design documentation of XFC station and control system	6/31/2019	QPM*
Complete threat analysis report	12/31/2019	Annual Milestone
Complete report of resilient control architecture	12/31/2019	Annual Milestone
Threat analysis report, and design documentation for XFC station	12/31/2019	Go/No Go
Prototype implementation for steady state validation	6/31/2020	QPM
Hardware integrated with HIL co-simulation platform and demonstration	12/31/2020	QPM
Complete report of CyberX performance analysis	12/31/2020	Annual Milestone
Knowledge dissemination to ABB's EV charger business unit	12/31/2020	Annual Milestone

* Quarterly Progress Measure

Approach

Strategy





- **Overall approach for CyberX**
  - Tasks for CyberX
    - Task1.1: XFC station and control system
    - Task1.2: Threat analysis
    - Task1.3: Secure XFC station control methodology development
    - Task2.1 ~ 2.2: Methodology validation
    - Task2.3: Performance analysis
    - Task3: Knowledge dissemination
  - Unique aspects
    - XFC station management system (XMS) with cybersecurity features
    - Prototype implementation using HIL testbed
  - Use knowledge from previous/on-going DOE (CEDS) funded cybersecurity projects
    - Substation, microgrids, HVDC, FACTS and IEEE1547 and etc

Technical Accomplishment to Date

- Build XFC station system layout and design (off-line simulation platform) – Milestone #1
- Build base XFC station model and use cases - Milestone #1

Responses to Previous Year Reviewers' Comments

- The project was not reviewed last year

Collaboration and Coordination

- **Project collaborators**
  - ABB (prime), industry
  - INL (sub), national lab
  - APS Global (sub), industry
  - Thor Trucks (sub): industry

- **Communications**
  - Weekly meeting, ABB internal
  - Monthly meeting, Project partners
  - As needed meeting with DOE and partners

Collaboration and Coordination (cont.)

Expertise

- **ABB: Cyber attack detection and mitigation architecture and practices, algorithm development and validation with HIL testbed**
  - Anomaly detection, machine learning, communications, and system modeling
- **INL: Power hardware-in-the-loop simulator for demonstration**
  - EV/EVSE communication, HIL testbed and power systems
- **APS Global: Electric distribution system model and threat analysis**
  - EV/EVSE cybersecurity and threat analysis
- **Thor Trucks: Electric vehicle for testing of demonstration**
  - EV engineer

Remaining Challenges and Barriers

- Designing XFC station considering future extensions
- Identify/detect anomalies in the XFC station
- Integrate the prototype result into power HIL testbed

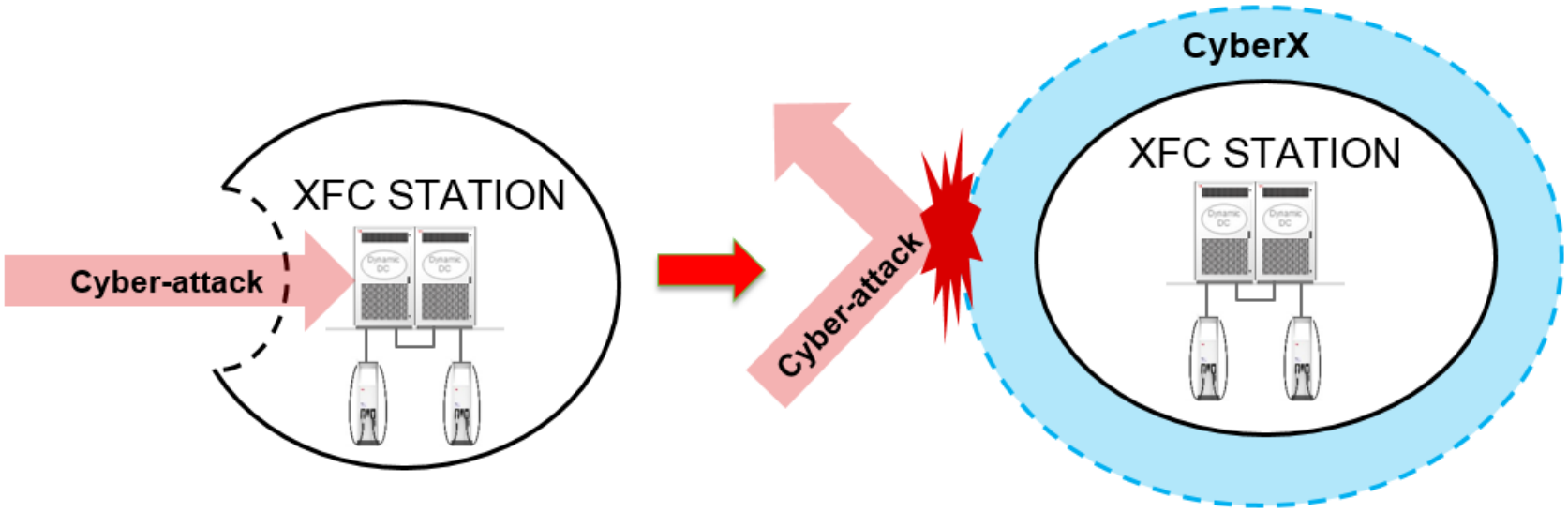
Proposed Future Works

- **Ongoing FY-19**
  - Finish the real-time system modeling in power HIL testbed, and perform functional testing and use case scenarios
  - Integrate the High fidelity XFC charging models (INL)
  - Complete a threat analysis report of the grid connected XFC station
  - Develop cyber attack detection and mitigation algorithms

- **FY-20**
  - Prototype implementation
  - Power HIL testing using EV truck
  - Performance analysis
  - Dissemination

Summary

- Secure grid connected XFC (>350kW) station
- CyberX layer for cyber attack detection and mitigation
- Prototype implementation
- Power HIL testbed and demonstration



Technical Back-Up Slides

existing capabilities

will be developed

Resources and Capabilities

- What charging equipment or facility capabilities does your project have available?
  - ABB EV charger (350 kW)
  - XFC station management system (XMS)

- INL has installed and commissioned the ABB Terra HP Fast charger in its lab
- XFC charging models will be based on and validated against this charger

existing capabilities

will be developed

Resources and Capabilities (cont.)

- What software/hardware tools will your team be using during the project?
  - MATLAB (system modeling), Python (ADS), C/C++ (XMS)
  - Embedded system for the prototype of XMS
  - Power HIL testbed (Opal-RT, Chroma grid simulator, EV simulator, EV truck and EV charger)
  - High fidelity XFC charging models (INL)

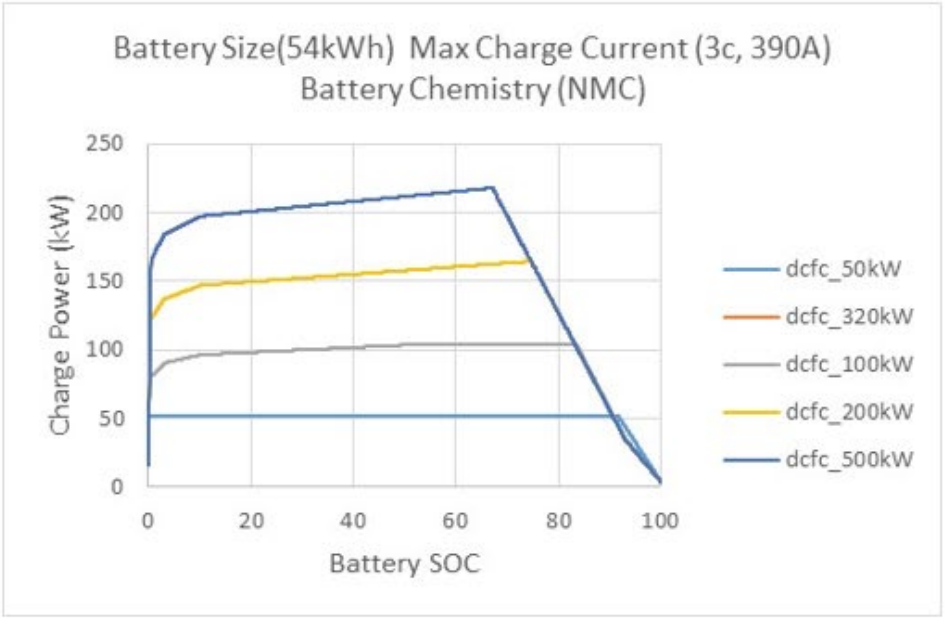
existing capabilities

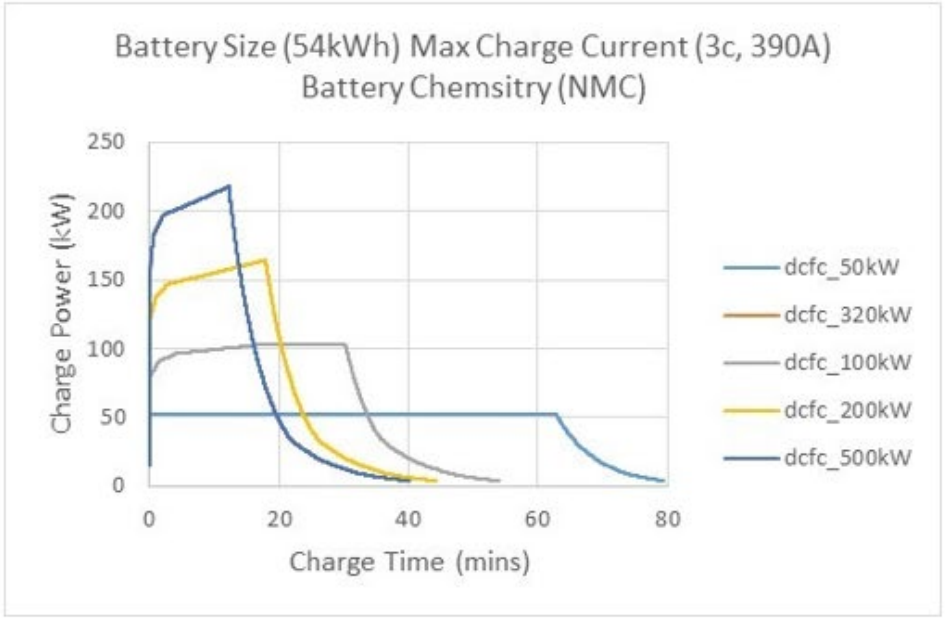
will be developed

Resources and Capabilities (cont.)

High fidelity XFC charging models (INL)

- INL has done extensive battery testing for various battery chemistries
- Using test data able to generate high-fidelity charge profiles for PEVs that are not commercially available





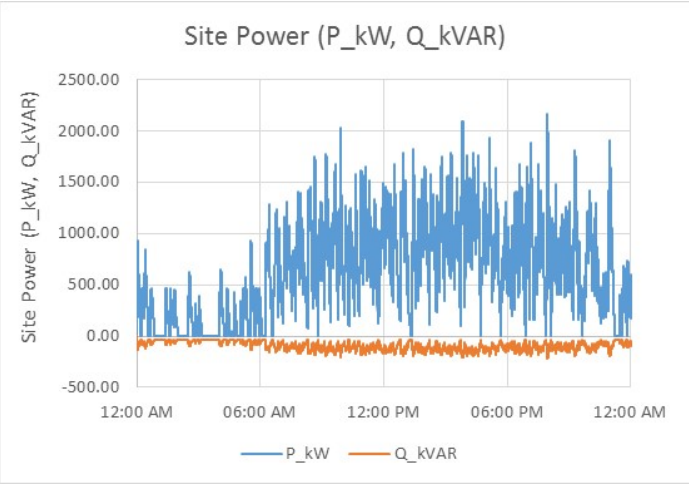
existing capabilities

will be developed

Resources and Capabilities (cont.)

High fidelity XFC charging models (INL)

- XFC site load profiles can be very volatile
- Volatile behavior may cause False Positives in anomaly detection systems
- Accurate charging models needed when designing system to avoid False Positives



- XFC site charge profile generated from charging models
- XFC site with 6 chargers
- All PEVs charged at site able to charge at 350 kW