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ASSESSMENT AND VALIDATION OF NEXT GENERATION EV HIGH POWER CHARGING PROFILES

PROJECT ID# ELT272

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"This presentation does not contain any proprietary, confidential, or otherwise restricted information"

OVERVIEW

Timeline:

- Project Start Date – 6/1/2020
- Project End Date- 3/31/2022
- Percent Complete- 75%

Budget:

- Project Funding:
  - FY20: $225k
  - FY21: $75k

Collaborations / Partners:

- *ELT266: Nex-Gen Profiles*
  - 200kW + focus
  - FY21 AMR presentation
- US DOT NHTSA
  - Supported vehicle collaboration

ASSESSING THE LIMITS AND LOADS OF MODERN ELECTRIC VEHICLE CHARGING

Relevance:

In-depth datasets of advanced EV high-power charging at varying conditions are needed to capture vehicle and grid impacts

Approach:

- **Vehicle-system focused DC charging behavior:**
  - **Charge profiles** (with varying ambient &battery temps)
  - **Power limitations** (Charge Power vs SOC vs Temp)
  - **Component operation** during the DC Charge
  - **Advanced charge conditioning** behaviors
    - Tesla 'On-route warmed' DC charging impacts
- **Project utilizes developed & available resources:**
  - Heavily instrumented, road worthy, research fleet
  - ANL equipment and facilities – Smart Energy Plaza
  - Chicagoland area DCFC network
    - Tesla Supercharger (all types) / CHAdeMO / CCS

2017 Chevrolet Bolt
MY17-MY19 : 60kwh
SAE- Combo
up to ~55kW

2020 Chevrolet Bolt
MY20: 66kWh
SAE- Combo
up to ~55kW

2020 Nissan Leaf E+
E+ (62kWh)
Chademo
up to ~100kW

2020 Tesla Model 3
Long Range / AWD (~75 kWh)
Supercharger / Chademo
250kW @ Tesla v3
150kW @ Tesla v2
72kW @ Tesla Urban
50kW w/ CHAdeMo adapter

ACCOMPLISHMENTS: INSTRUMENTATION HIGHLIGHTS

During logging, RAW vehicle communication (CAN) collected

TESTING SUMMARY

- General operator test notes
  - Environment conditions
  - Vehicle state (mileage, firmware ver., etc)
  - Surrounding vehicles notes
  - General notes during the data capture
- 'Since last charge' metrics
  - Captured data about prior discharge cycle (vehicle dependent signal)
- Pictures
  - Charging station, vehicle, dash, etc.
- Specific AC power data
  - ANL IOC data captured – multiple DCFC stations
  - Offsite metrics - as reported

KEY COMMUNICATION (CAN) MESSAGES

- Vehicle state:
  - Active systems (HVAC, screen, audio, etc)
  - Environment (ambient temp / solar load)
- BMS data:
  - Voltage, Current, SOC, Capacity, Temp, Energy
- Charger data:
  - Voltage, Current, Limits, State
- Cooling system: Temps, Flows, Set points, State
- Low voltage system metrics for power flow
- Limits- BMS power or charger

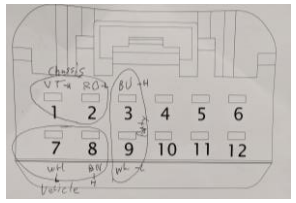
Signals are variable based on test vehicle

Note: Due to Tesla OTA updates, available CAN messages do change between updates- requiring attention/revision.

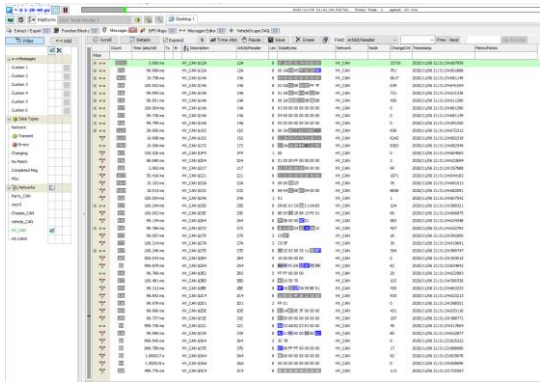
DEVELOPMENT OF A DATA MANAGEMENT PIPELINE

- **Connecting**- Determine location and directly capture vehicle network traffic
- **Decoding** of desired signals from vehicle communication networks / **validation** of signals
- **Data collection** of RAW CAN
  - Scripting for independent operation
  - Enables changes post test if updates found
  - Results in LARGE binary files (1-5 gb)
- **Post Processing** from binary
  - Signal and sample rate selection (2hz)
- **Merging**- generation of combined data set
  - Merging of test summaries
  - Development of useful key metrics
- **Analysis and Data Distribution**

Connecting

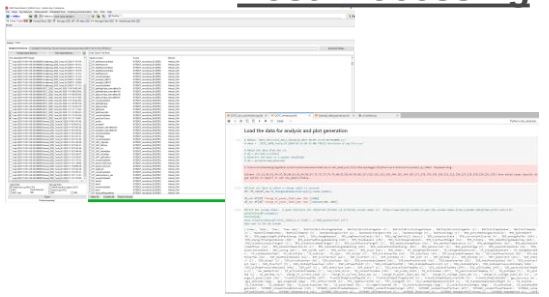


Decoding

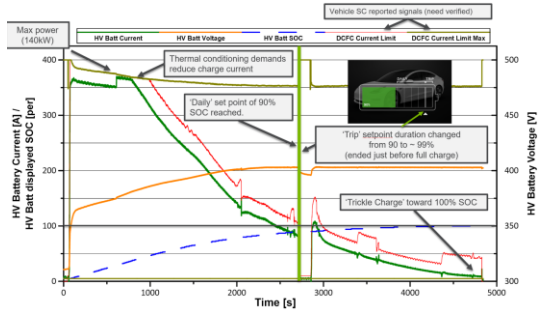


Collecting

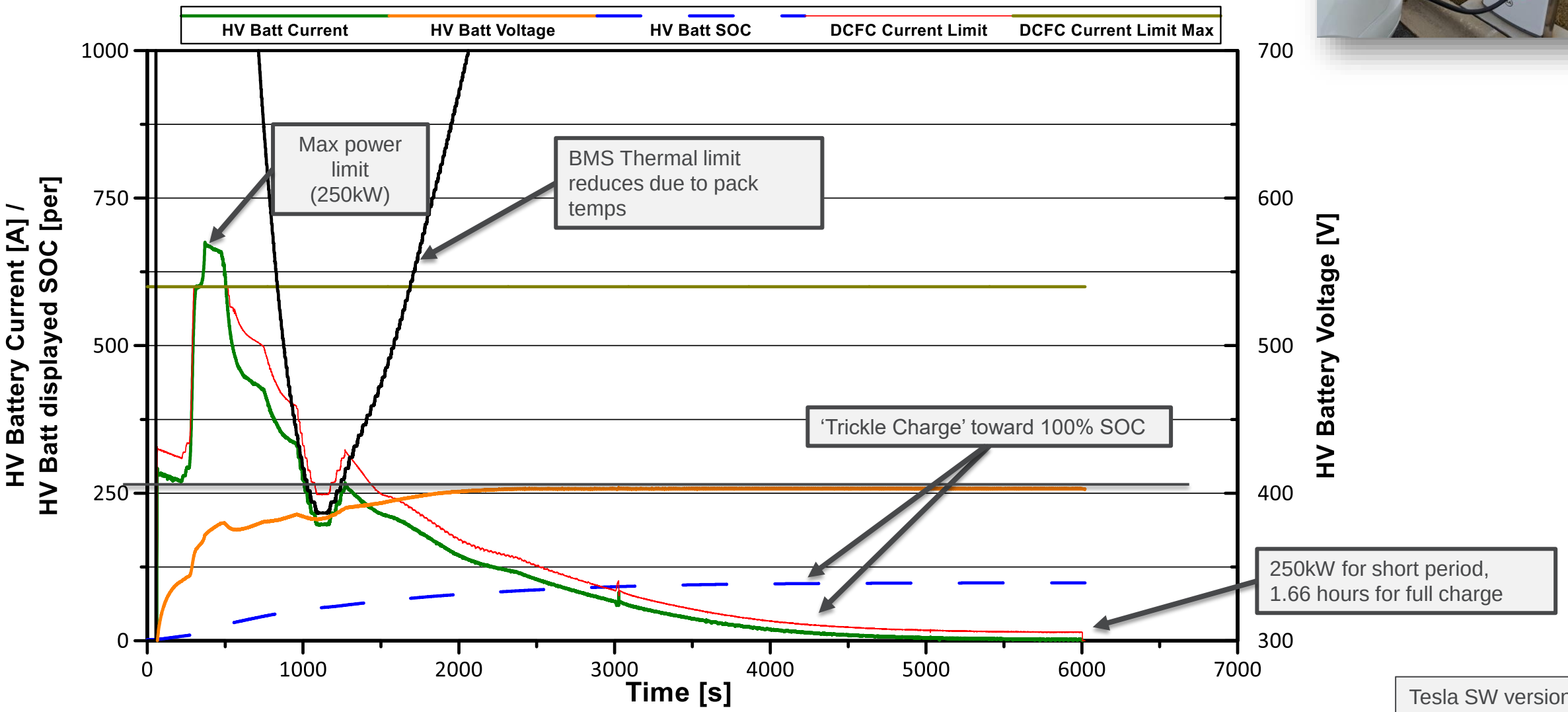
Post Processing



Analysis

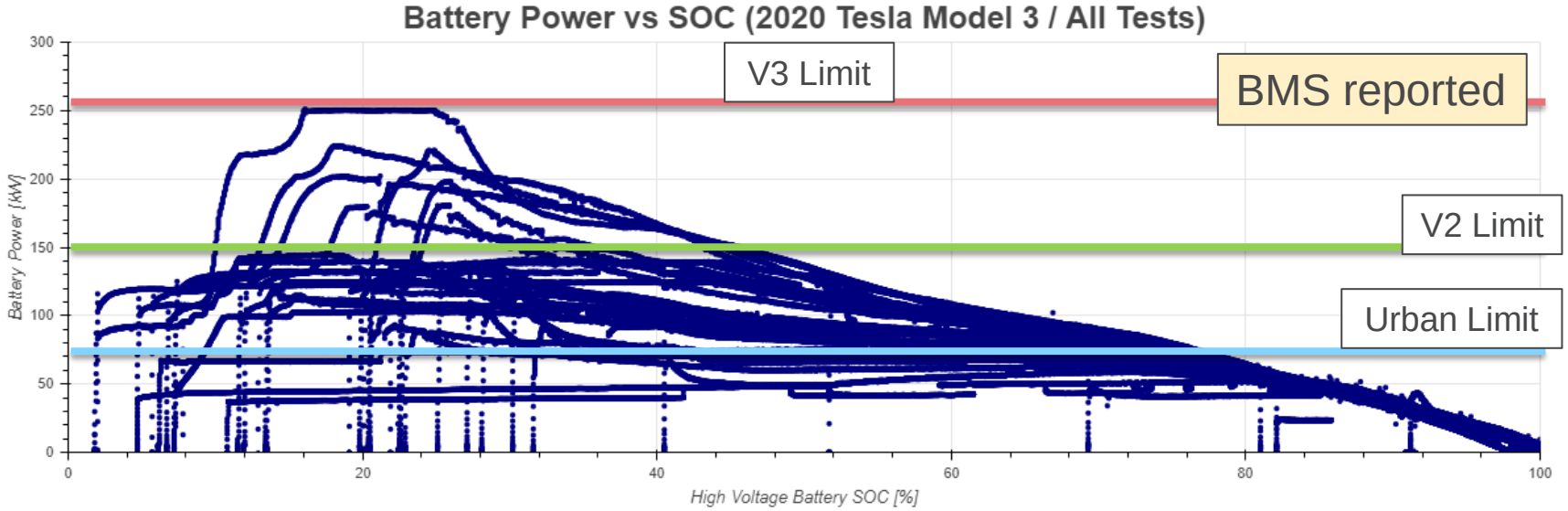


ACCOMPLISHMENT HIGHLIGHT EXAMPLE: TESLA MODEL 3 SUPERCHARGE– V3 95F



Tesla SW version: 2020.32.3

TESLA SUPERCHARGING SUMMARY (ALL TESTS)



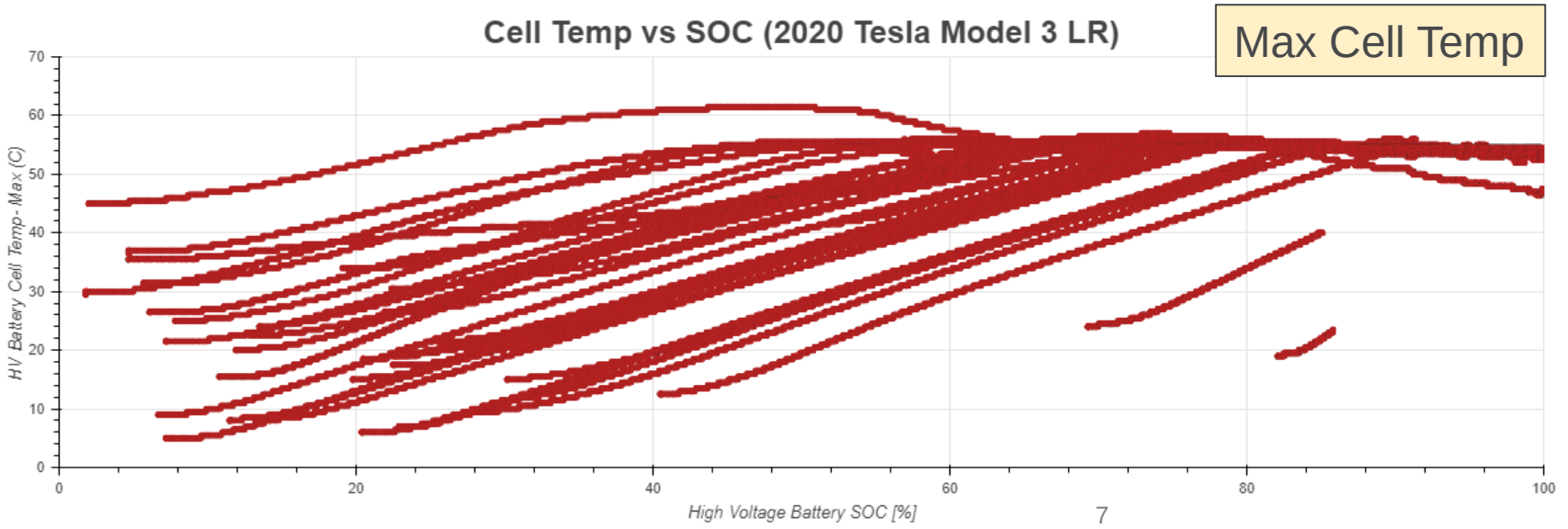


Image overview:

- Overlay of charge events displayed from variety of Tesla Supercharger stations
- Wide range of ambient and vehicle states

Technical Highlights:

- **Even on V3 stations 200kW charging rare and short**
- **High variability of power delivered from V2 stations**
- **(80-150kW)**
- **Charging profiles converge above 70% (BMS limits)**
- **HV Batt coolant & cell temps generally converge at 52C at EOT**

SUMMARY:
CURRENT STATUS AND HIGHLIGHTS

COVID-19 presented challenges, but progress strong
- Limited equipment and opportunities for depletion

- **Instrumentation completed for all test vehicles**
  - CAN based data collection w/ supplemental summary data
  - Facilities data for ANL- based DCFC
- **Charge sessions captured:**
  - **100+ total sessions captured** (Goal:120 charge events)
    - 40+ sessions with Tesla Model 3
      - Multiple vehicle firmware updates during process
    - 30+ sessions with 2020 Chevrolet Bolt
    - 20+ sessions with 2020 Nissan Leaf
  - Charges at all desired station types (focus on below 200kW)
  - Wide range of ambient temps (0-100F)
  - Variable starting and ending SOC (0%-100%)
- Data collection throughout 2021
  - Further capture high ambient temperature and start/end SOC variations
  - Datasets to be made available for DOE collaborative research efforts FY2021

80% of Charges Captured

QUESTIONS?