Submitted by the representative of the United States of America

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NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION RESEARCH PROGRAM ON LITHIUM-ION BASED ENERGY RECHARGEABLE STORAGE SYSTEM (RESS)

WP.29 – WORLD FORUM FOR HARMONIZATION OF VEHICLE REGULATIONS NOVEMBER 17, 2011

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Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Research Objective:

To research and develop repeatable test based safety performance tests, tools, and comparison metrics for Li-ion based RESS, and provide initial data for analysis.

- These tests and metrics will provide data and enable NHTSA to generate and compare safety critical performance data from RESS equipped vehicles and component systems during all normal and abnormal use conditions and crash and post crash events.

- The results of this research could potentially be used by NHTSA and the EV-SGS GTR informal working group to support and establish minimal safety performance standards and compliance test procedures for RESS equipped passenger vehicles and light truck applications.

- The methods of research will include:
  - Failure Modes and Effects Analysis (FMEA)
  - Test Procedures Development
  - Analytical Tools Development for Control System Safety Performance

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Lithium-ion based Rechargeable Energy Storage Systems (RESS)

NHTSA Vehicle Safety Research – RESS Research Program Projects & Process Flow

Failure Modes Effects and Criticality Analysis (FMECA)

•Identify and rank all Failure modes and rank based on likelihood and severity

Test Procedures Development

•Develop performance based test procedures for failure modes identified from: FMEA, Industry Standards, Industry Experience, and DOE/NL programs

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Analytical Tools for Control System Safety Performance

•Develop safety-performance requirements and methods to measure RESS control systems

Comparable Safety Metrics with Data for Li-ion RESS

NHTSA Policy and Rulemaking & EV-SGS GTR

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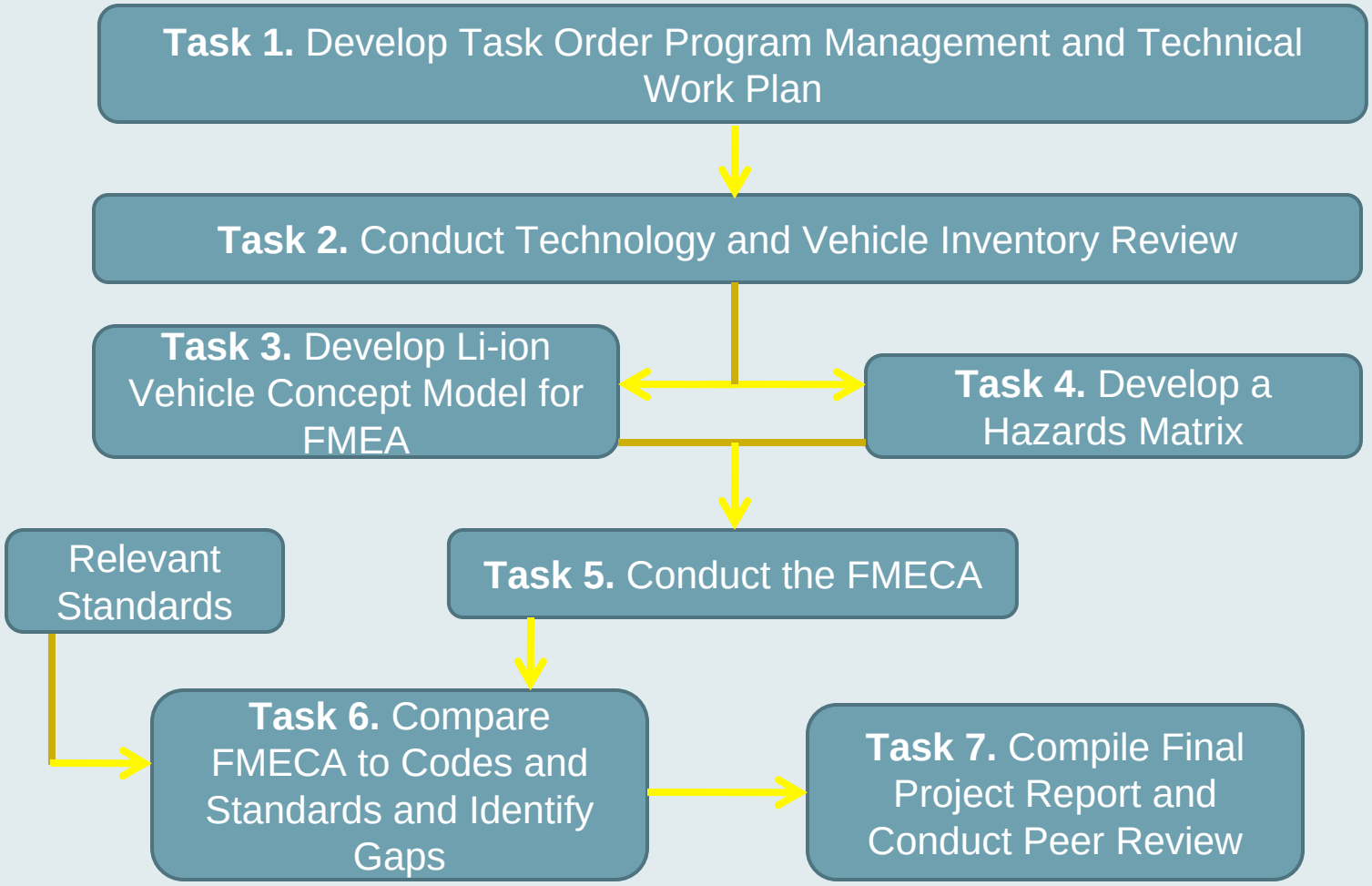
Failure Modes Effects and Criticality Analysis (FMECA)



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Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Status: Failure Modes Effects and Criticality Analysis (FMECA)

- Draft Final Report - December 2011
- Independent FMEA application variants:
  - Hybrid Electric Vehicles (HEV)
  - Plug-in Hybrid Electric Vehicles (PHEV)
  - Battery Electric Vehicles (BEV)
- RESS designs representing current model and near term production intent
- RESS operating conditions:
  - Charging
  - Storage
  - Normal Use
  - Crash (and Post-Crash) event
- FMECA – criticality where applicable

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Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Test Procedures Development

Complete single and dual point/level failure modes including loss of the control system

- Develop repeatable test procedures
- Develop test boundary conditions and limits
- System level scope including RESS Enclosure performance and propagation characterization
- Develop comparable safety performance-metrics
- Perform test for data and repeatability validation

RESS operating conditions:

- Charging
- Storage
- Normal Use
- Crash (and Post-Crash) event

(Continued)

Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Fault mechanisms in which the Vehicle Level Test Procedures will be premised and expanded upon to further system level performance

Mechanical

- Mechanical Shock (Crash Pulse)
- Vibration
- Drop Test (Service Remove or Install)
- Immersion
- Penetration (rapid rate "road hazard", or crash)
- Crush (crash event and post crash performance)
- Humidity/Moisture Exposure
- Chemical Exposure

Electrical

- Short Circuit (hard and soft)
- Overcharge
- Over-discharge/ cell reversal

Thermal

- Fire Resistance
- Propagation Resistance
- Control
- Shock

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Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Status: Test Procedures Development

• Contract(s) awards in September, 2011 and Draft Final Report(s)is scheduled for September 2013

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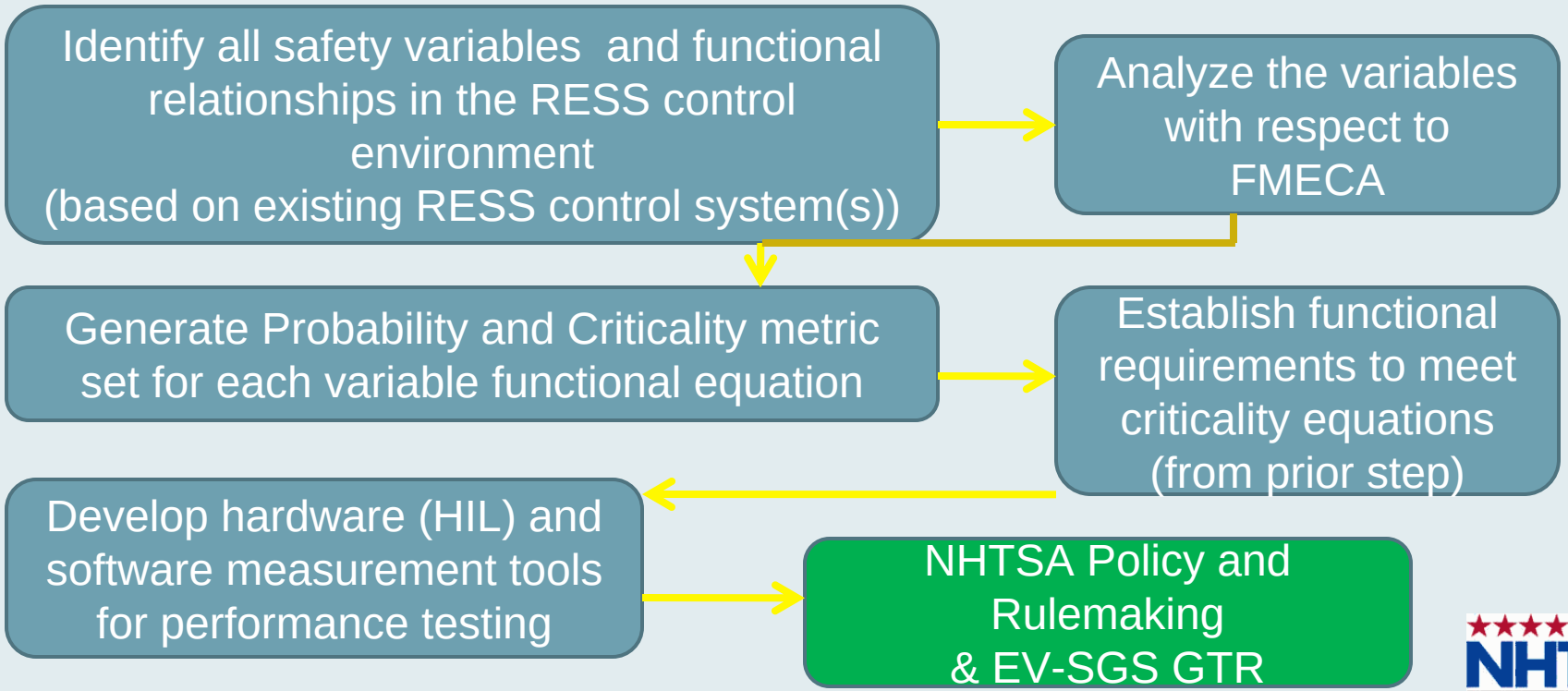
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Analytical Tools Development for Control System Safety Performance

Develop a high-level analytical tool set to define and/or evaluate potential minimal control system performance requirements. Use these analytical tools, conceptually based on probability or criticality functions, to measure active control, redundancy, and passive protection performance for each of the control critical sequences which may result in a failure mode identified in the FMEA.



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Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Status: Analytical Tools Development for Control System Safety Performance

- Development partnership – Unidentified
  - Timing – coincidence with test procedures (24 months)
- Conceptual Scope:
  - Based upon probability and/or criticality functions derived from: FMEA, fault tree analysis (FTA), and control logic flow diagrams
  - Separate tools for HEV, PHEV, and BEV applications
  - Potential for adaptation to HIL analyzer for testing/comparing OEM systems

Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Other NHTSA Safety Activities

- Work with the first/second/third responders to provide safety guidance on issues of fire rescue, towing and storage EVs as well as disposal and recertify of RESS.

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