Everyday Safety for Electric Vehicles

Developing Safety Requirements for Electric Vehicles

Bruno Augusto
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EVERSAFE - Overview

- **Scope**: Safety of Electric Vehicles (EV).
- **Aim**: Recommendations for new safety requirements.
- **Timing**: 2012/05 – 2014/09
- **Budget**: 1.6 M€
- **Nr. Person Months**: 153
Partners:

Sweden

Germany
Contributions to Key Dimensions

a) **Technological Strategies:**
   - Development of safety requirements.
   - **Active Safety:**
     - Powertrain failures and driver reaction.
   - **Passive Safety:**
     - Behavior of Energy Storage Systems (ESS) under crash.
     - Handling of ESS after crash.

b) **Socio Economic Issues:**
   - Investigation of EV acceptance among users.
   - Assessment of safety concerns.
Project Structure

**Active Safety**

- **WP2**: Vehicle Stability and Driver Response

**Passive Safety**

- **WP3**: Crash Compatibility and Battery Safety

**WP4**: Problem Identification and Safety Considerations

- **Deliverable 2.1**

- **Deliverable 3.1**

- **Deliverable 4.2** Recommendations for Safety Requirements

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Problem Identification and Safety Considerations

- **User Expectations**
  - 23 distinct safety concerns identified.
  - Concerns not only dedicated to system failures.

- **Test Scenario Definition**

  **Active Safety**
  - Wheel Hub Motors
  - Regenerative Braking

  **Passive Safety**
  - Side Impacts
  - Rear Impacts
Vehicle Stability and Driver Response: Field Experiments

What was done:
- Two studies conducted on test track:
  - Reaction to wheel hub motor (WHM) failure.
  - Reaction to failing regenerative braking (RB).
- Complete analysis of subjective and objective data.

- Real car feedback.
- Failures simulated with actuators.
- Low speed tests.
Vehicle Stability and Driver Response: Simulator Experiments

- Simulated car feedback.
- Repeatability.
- High speed tests.

What was done:
- One failure type evaluated in the simulator.
  - Reaction to WHM failure.
  - Complete analysis of subjective and objective data.
Vehicle Stability and Driver Response: Observations and Outcomes

• For the studied circumstances, drivers appear to be able to compensate for the consequences of a WHM failure.
  • Drivers maintained control in all tests conditions.
  • Steering is most common compensatory reaction.
  • Participants rarely braked.
  • Accelerator pedal commonly used to override failure.
• Compensation efforts were manageable for RB failures.
  • Noticed by only half of drivers.
  • No extra workload or induced stress, as reported by the drivers.
• Further research needed: What is the influence of road and traffic conditions on the observations above?
Crash Compatibility and Battery Safety: Crash Simulation

What was done:

- Finite element first generation EV built.
  - Modelling of battery and protective structures.
  - Simulated 12 accident scenarios.
  - Standardized and non-standardized.

- Full scale car crash compatibility simulations.
- Crash analyses of REESS and protective structure.
Crash Compatibility and Battery Safety: Crash Tests

- Component tests.
- Cell abuse tests.
- Mechanical, dynamic, chemical and electro-chemical issues.

What was done:

- Shear, nail penetration, external shortcut and overcharge tests performed on battery cells.
- Two crash tests with EV:
  - Side pole.
  - Front and rear end crash.
- Analysis of electrical hazards, chemical reactions and thermal events for all tests.
Crash Compatibility and Battery Safety: Recommendations for improved rescue guidelines

- Existing post-crash rescue procedures reviewed and the main conclusions are:
  - Vehicle information and ID need to be clearly available once at the scene.
  - Rescue datasheets should contain more info on the chemical contents of the battery.
  - Guidelines should contain:
    - Basic info on Chemical Hazards
    - Indicators for risks (electrical, chemical etc.).
  - A set of improved rescue guidelines to better fit EV was developed.
Crash Compatibility and Battery Safety: Observations and Outcomes

- **Simulations revealed:**
  - No significant damage or intrusion in battery pack.
  - Non-standard undercarriage impact simulations indicate severe loading on the high voltage battery.
  - The worst case was identified as the front pole impact.

- **Experimental tests showed:**
  - Cells reacted safely under standard tests. More severe reactions in case of derivations from standardized tests.
  - After shear and nail penetration tests, no cell degradation was observed. Small quantities of electrolyte as well as traces of toxic compounds were detected.
  - Tested EV show high level of protection, comparable to conventional vehicles.
  - Now new or unexpected risks seen in crash tests with EVs.
EVERSAFE – Impacts and Contributions

- Insight into the consequences of electric powertrain failure on traffic safety and vehicle stability.
- Improved understanding of the behavior of EV, its ESS and protective structures under crash conditions.
- Updated set of rescue guidelines for vehicles in post-crash situations better suited for EV.
- Increased awareness of safety concerns among experienced and inexperienced EV users.

Recommendations for new safety requirements and research
Thank you for your attention

Project Deliverables and Dissemination list available at:

www.eversafe.project.eu

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