EVERSAFE

# Everyday Safety for Electric Vehicles

## Developing Safety Requirements for Electric Vehicles

Bruno Augusto

ERA-NET Electromobility + Final Event

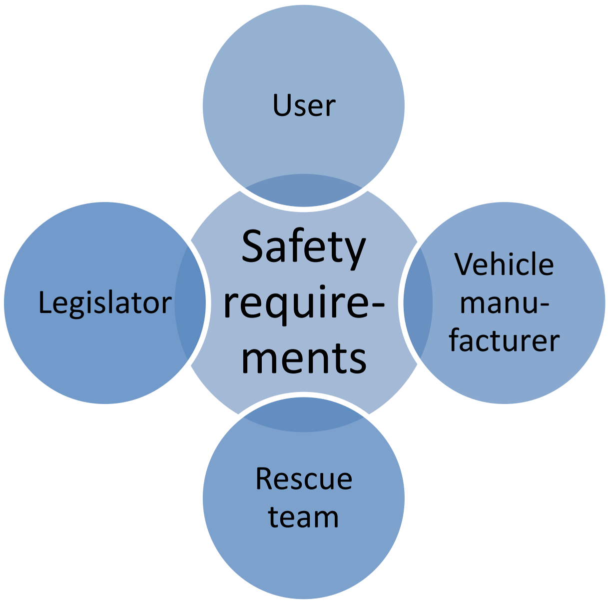
Berlin, 20th of May, 2015

SEVENTH FRAMEWORK PROGRAMME

# 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**

vti

VOLVO

KTH VETENSKAP OCH KONST

bast

TECHNISCHE UNIVERSITÄT CHEMNITZ

Fraunhofer

**Germany**

# Contributions to Key Dimensions

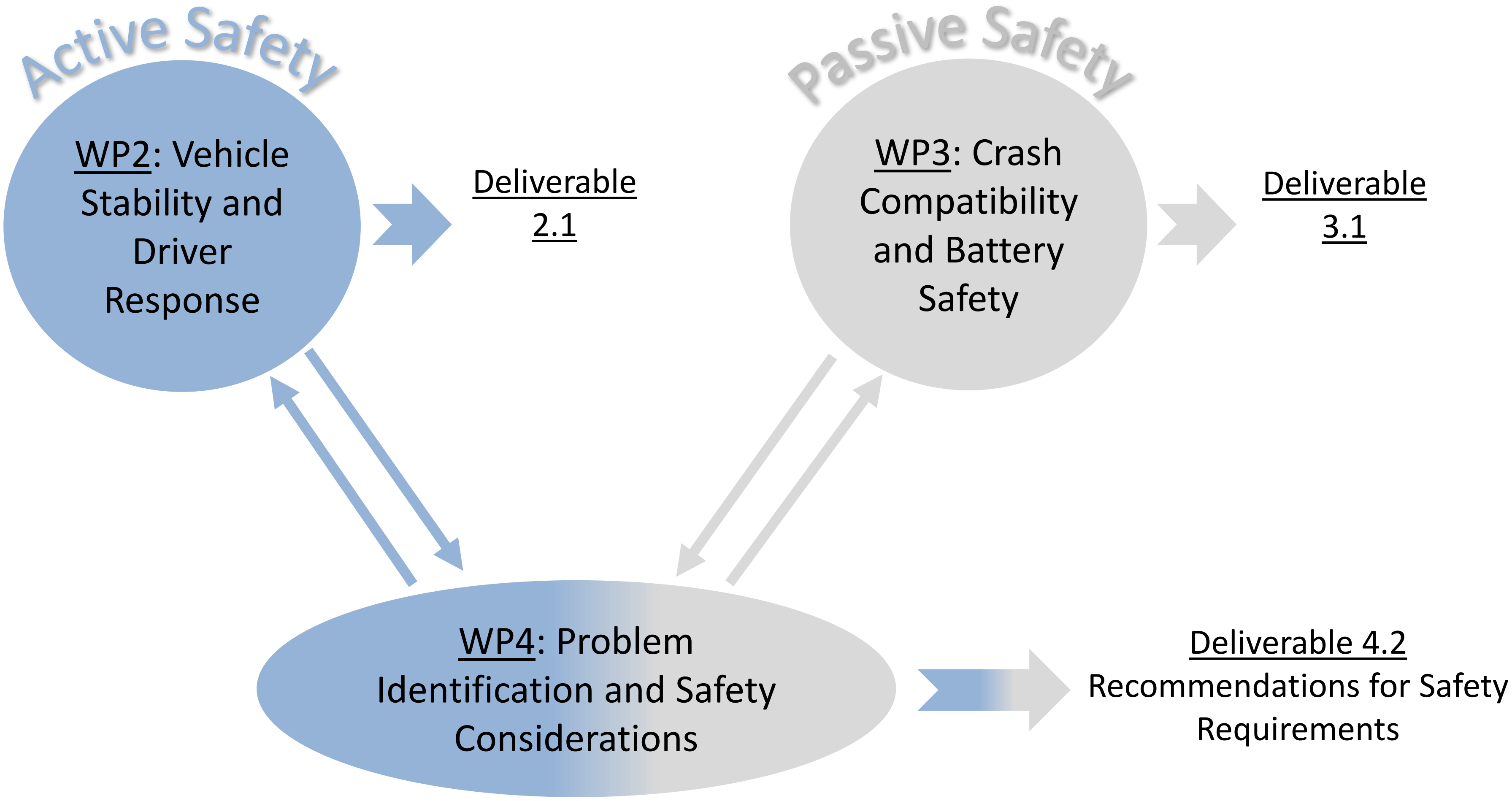
a) **Technological Strategies :**

- 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



# Problem Identification and Safety Considerations

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

# Vehicle Stability and Driver Response : Field Experiments

- Real car feedback.
- Failures simulated with actuators.
- Low speed tests.

## 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.

# 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.
- <u>Further research needed:</u> What is the influence of road and traffic conditions on the observations above?

# Crash Compatibility and Battery Safety : Crash Simulation

- Full scale car crash compatibility simulations.
- Crash analyses of REESS and protective structure.


## What was done :

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

# Crash Compatibility and Battery Safety : Crash Tests

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

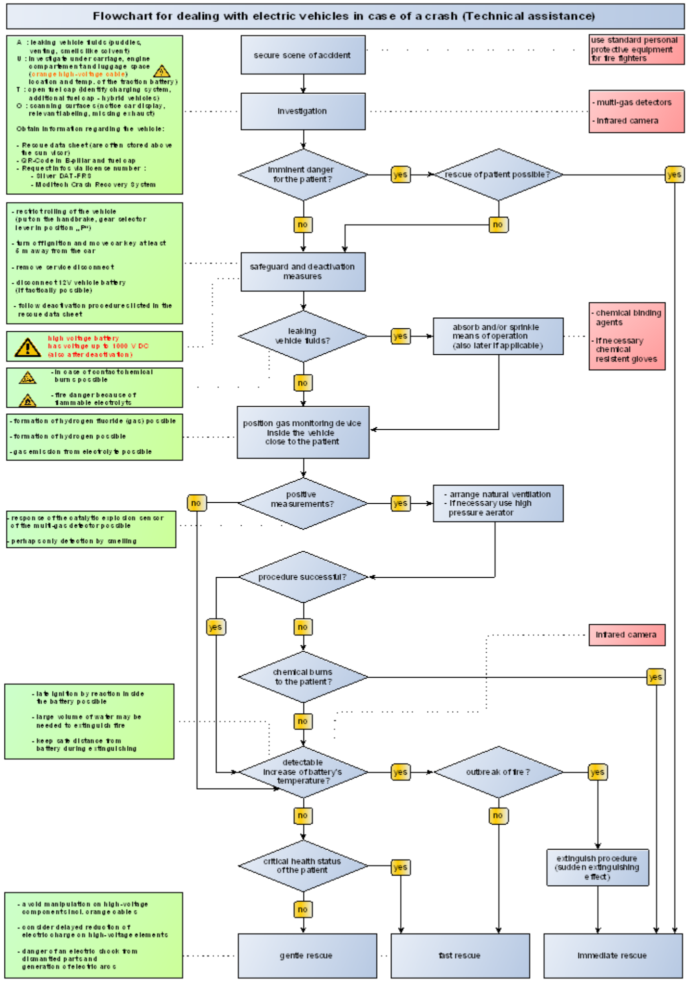

Picture by Fraunhofer EMI.

## 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*

# EVERSAFE

Electromobility+ - Final Event, Berlin, 2015

## Thank you for your attention

Project Deliverables and Dissemination list available at:
www.eversafe.project.eu

**Contact:**

**Bruno Augusto**
Swedish National Road and Transport Research Institute (VTI)
Mail: bruno.augusto@vti.se