The RESOLVE Project

Technologies for Urban Light Electric Vehicles

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Agenda

- Project Overview
- User’s mobility needs and expectations
- Preliminary vehicle specifications
- Vehicle layout and architecture
  - Demonstrator 1: L2e
  - Demonstrator 2: L6e
- Modular battery pack
- Energy efficiency and active safety
- HMI Concept
- Summary and Outlook
Project Overview

• RESOLVE Outlines
  - Range of Electric SOLutions for L-category VEhicles
  - EC Call: H2020 - GV.5-2014 – Electric two-wheelers and new light vehicle concepts
  - Contract Number: n° 653511
  - Project Start Date: 01.05.2015
  - Duration: 36 Months
  - Project costs: 6,92 M€
  - Total effort: 606 PM
  - Project Coordinator: Piaggio & C. S.p.A.
  - Project Officer: Georgios Charalampous
Project Overview

• Consortium

- AIT (A)
- IDIADA (SP)
- KTM (A)
- Piaggio (IT): coordinator
- Ricardo (D)
- University of Pisa (IT)
- University of Warwick (UK)

- Bosch (D)
- KISKA (A)
- Marelli (IT)
- RE:Lab (IT)
- University of Firenze (IT)
- University of Prague (CZ)
- Wamtechnik (PL)
Project Overview

• Objective

Overcome limiting factors of ELV widespread adoption

Policy factors

Cost
Develop a range of electric powertrain

Energy Efficiency
Demonstrate through two tilting 4-wheeler prototypes

Attractiveness in urban areas
Improve rider experience

Willingness to use
Increasing willingness to use of ELVs

RESOLVE CONCEPT:
making Electric LVs practical alternatives to cars

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Project Overview

- Strategy

Overcome Limiting factors of ELV widespread adoption

Policy factors

Cost
- Modularity and generic powertrain simulation model to enable scalability
- Functional integration to reduce complexity
- Use state of art low-cost solutions

Energy Efficiency
- Improve regenerative braking capabilities
- Reduce vehicle weight
- Smart range management
- Propose new drive cycle for validation

Attractiveness in urban areas
- Improving electronic dynamic control systems of tilting vehicles for fun and safe riding
- HMI improvement for comfort and safety

Willingness to use
- Increased through Communication and Dissemination
- Enhanced appeal towards female riders through appropriate product concept and communication
- Validated using qualitative surveys

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User’s mobility needs and expectations

- **Online User Survey**
  - 791 people from 13 countries
  - 83% male 17% female

- **Key factors to decide for EV**
  - Driving distance
  - 2 people + Luggage space
  - Comfort
  - Weather protection
  - Agility in traffic
  - HMI
    - Integration future Mobility
    - Connectivity
    - Charging infrastructure

**Drawbacks current EV**
- vehicle range too short
- Recharging time too long
- Cost of ownership

**Reasons for EV**
+ Efficiency
+ Cost of Ownership
+ Driving pleasure
+ Possibility to access restricted/pedestrian traffic areas

**Required range***

*according to users with daily driving distance below 30km
Preliminary vehicle specifications

- **Modular battery architecture**
  - Standard Lithium-ion cells
  - single pack below 60V

- **Energy efficiency**
  - affordable lightweight concept
  - Target range: 60-80 km

- **HMI**
  - Connectivity

- **Attractiveness**
  - price
  - Comparable driving behavior to motorcycle (tilting)

<table>
<thead>
<tr>
<th>vehicle</th>
<th>wheels</th>
<th>Weight incl. Driver</th>
<th>Engine power</th>
<th>Target energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESOLVE D1</td>
<td>4</td>
<td>225 kg</td>
<td>4 kW</td>
<td>35 Wh/km</td>
</tr>
<tr>
<td>Piaggio Liberty Email</td>
<td>2</td>
<td>200 kg</td>
<td>2.6 kW</td>
<td>40 Wh/km</td>
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<tr>
<td>RESOLVE D2</td>
<td>4</td>
<td>325 kg</td>
<td>6 kW</td>
<td>41 Wh/km</td>
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<tr>
<td>BMW C evolution</td>
<td>2</td>
<td>340 kg</td>
<td>11 kW</td>
<td>56 Wh/km</td>
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<tr>
<td>Renault Twizy 45</td>
<td>4</td>
<td>545 kg</td>
<td>4 kW</td>
<td>86 Wh/km</td>
</tr>
</tbody>
</table>

Comparison of RESOLVE vehicles with competitors
Vehicle layout and architecture – D1

- Preliminary layout
  - Ergonomic models: 2 passengers + Luggage
  - Powertrain: electric + torque vectoring

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Vehicle layout and architecture – D2

- Preliminary layout
  - Ergonomic models: 2 passengers + Luggage
  - Powertrain: electric + differential

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Modular Battery Pack

- **Architecture**
  - 12S4P (48 cells)
  - Weight: approx. 2.5 kg
- **Li-ion, LG18650HG2 Cells**
- **Concept D1**
  - 2 battery packs with 3 modules and one BMS each
  - Each Battery pack: 1554Wh
- **Concept D2**
  - 1 battery pack with 8 modules and one BMS
  - Battery pack: 4147Wh

(1) Top cell holder
(2) connectors
(3) connectors
(4) 48 18650HG2 battery cells
(5) Bottom cell holder
Energy efficiency and active safety

- Advanced vehicle management functions
  - Intelligent Range Management
    - Overcome range anxiety
    - Closed loop SOC control algorithm
      - Definition of desired battery discharge according to the route to be covered
      - Energy controller determines speed and acceleration bounds that must not be exceeded
      - Low-level motion controllers ensure to stay within these bounds
Energy efficiency and active safety

- Advanced vehicle management functions
  - Regenerative braking
  - Stability control & torque vectoring
    - Lean dependent slip control
      - Lean angle estimation block
      - slip ratio calculation block
      - reference generator for optimal lean angle
      - slip controller based on a PID control loop
    - Active electronic differential
      - Torque vectoring

Active differential scheme
HMI Concept

• HMI principles for ELV
  • Principle 1: safety-critical and vehicle-status info always accessible
  • Principle 2: let users set goals in the most straightforward way possible
  • Principle 3: deliver tips and suggestions according to priority levels
  • Principle 4: allow users take action quickly
  • Principle 5: define situation dependent use cases
    ✓ pre-route (including off-vehicle)
    ✓ post-route (statistics / learning)
    ✓ on-route (diagnostic vs. critical events) uses cases
  • Principle 6: define and separate route-levels
    ✓ Long term (strategic)
    ✓ 4-5 Kms range (tactic)
    ✓ imminent (contingent)
HMI Concept

• Scalable HMI architecture
• Main functions
  • Energy efficient and safe driving
    ✓ regenerative braking
    ✓ stability control)
  • Smart range management
  • Maintenance
  • Personal settings
  • Basic vehicle info
• Concepts
  • All-in-one Solution
  • Distributed solution

Distributed HMI solution scheme
Summary and Outlook

• Project Goals
  • Overcome shortcomings of ELVs
    ✓ Costs
    ✓ Efficiency
    ✓ Attractiveness
  • Provide scalable and modular solutions for L-category vehicles

• Project outcome
  • Mobility concepts for the future
  • 2 Demonstrators
    ✓ L2e
    ✓ L6e