This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 653511

The RESOLVE Project

Technologies for Urban Light Electric Vehicles

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Agenda

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- 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

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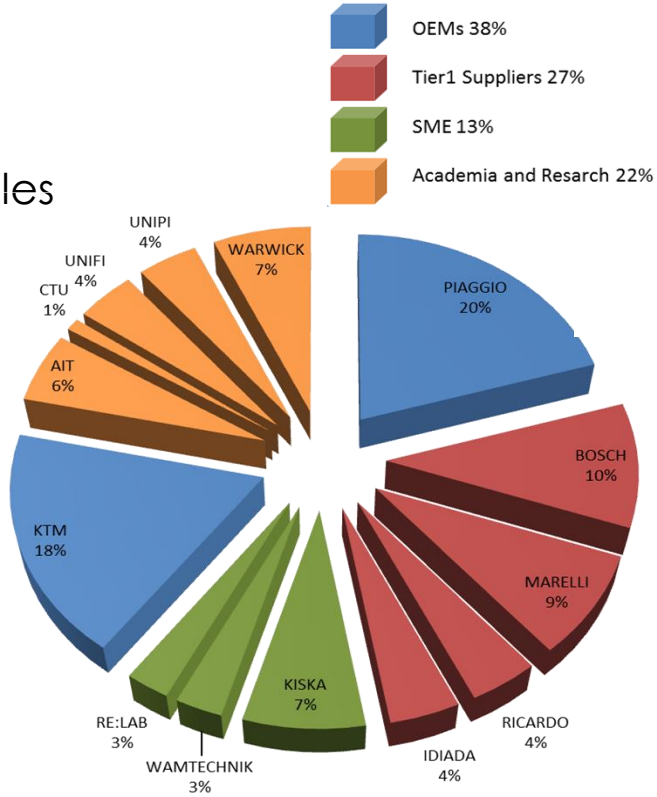
- RESOLVE Outlines
  - **R**ange of **E**lectric **SO**lutions for **L-**category **VE**hicles
  - EC Call: H2020 - GV.5-2014 – Electric two-wheelers and new light vehicle concepts
  - Contract Number: n° 653511
  - Project Start Date: 01.05.2015
  - Duration: 36 Months
  - Project costs: 6,92 M€
  - 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)

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Project Overview

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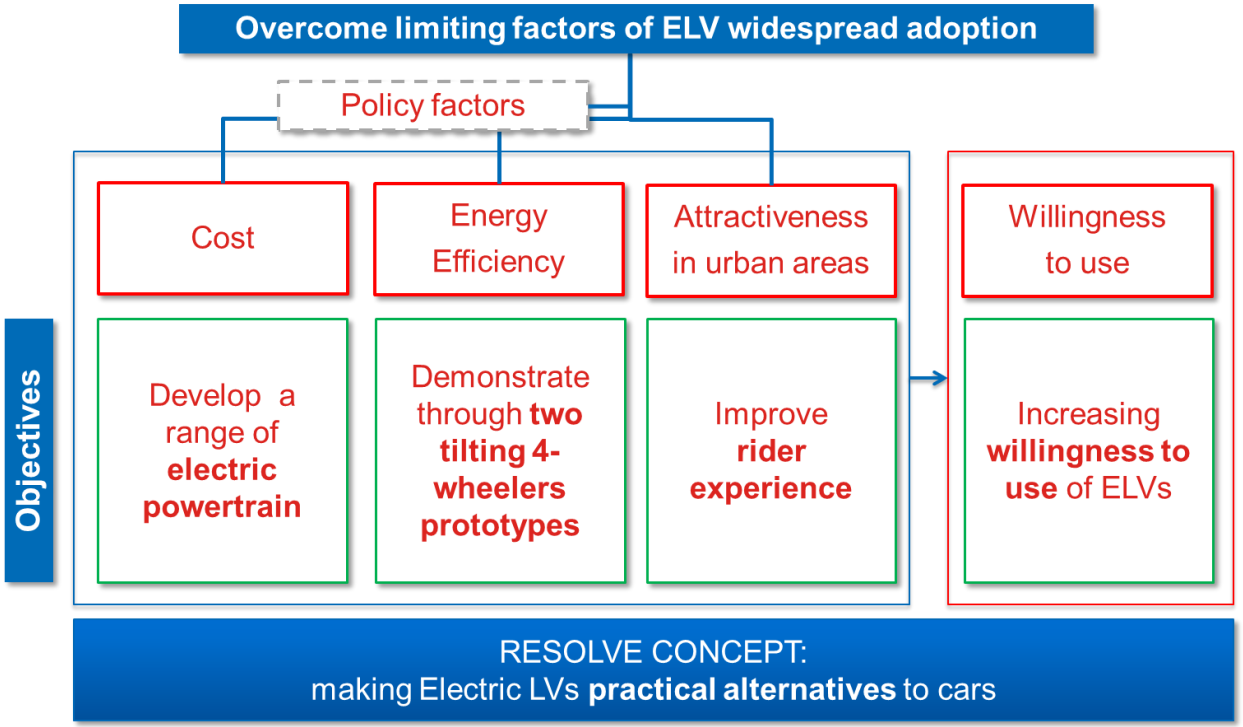
- Objective



Project Overview

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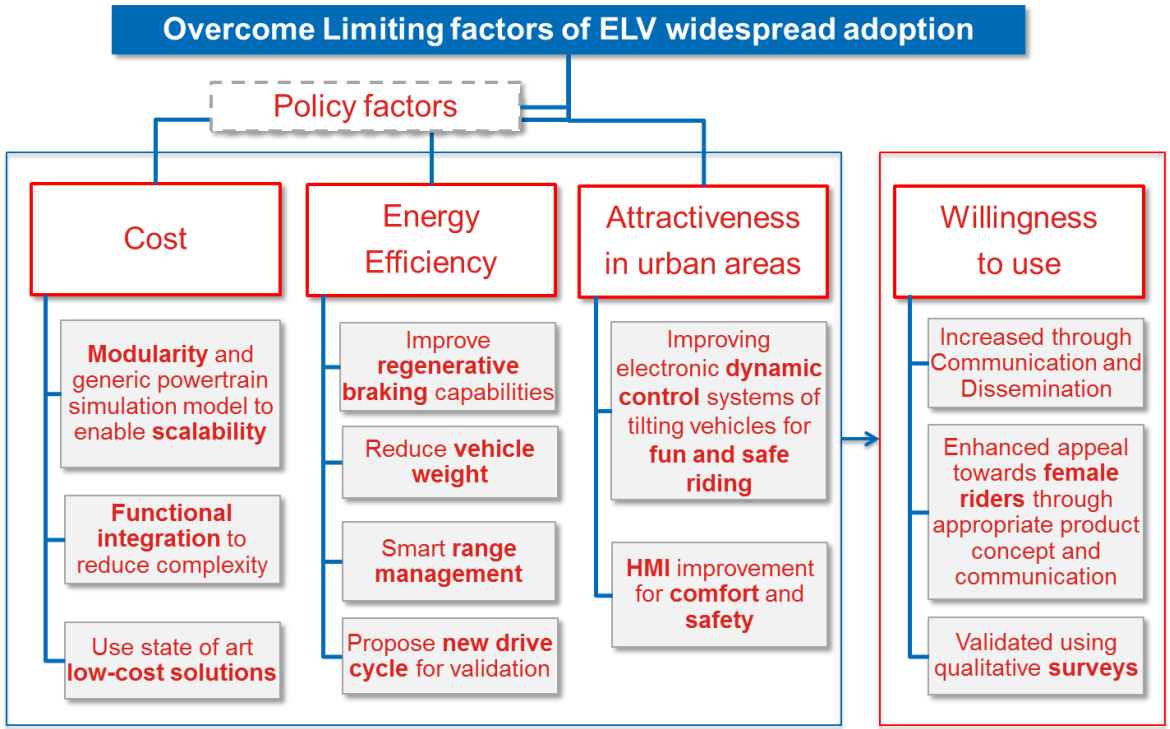
- Strategy



User's mobility needs and expectations

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- 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

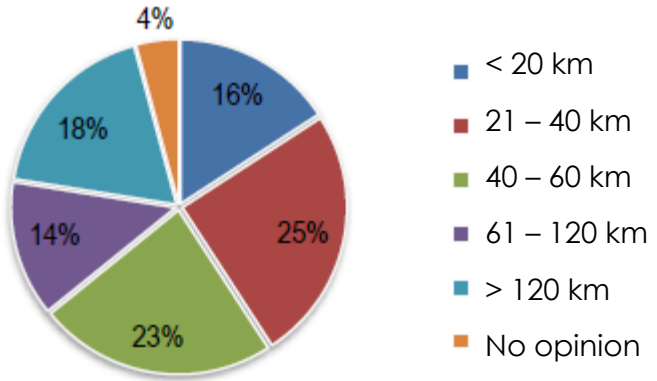
Drawbacks current EV

- 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

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- 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)

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

Comparison of RESOLVE vehicles with competitors

Vehicle layout and architecture – D1

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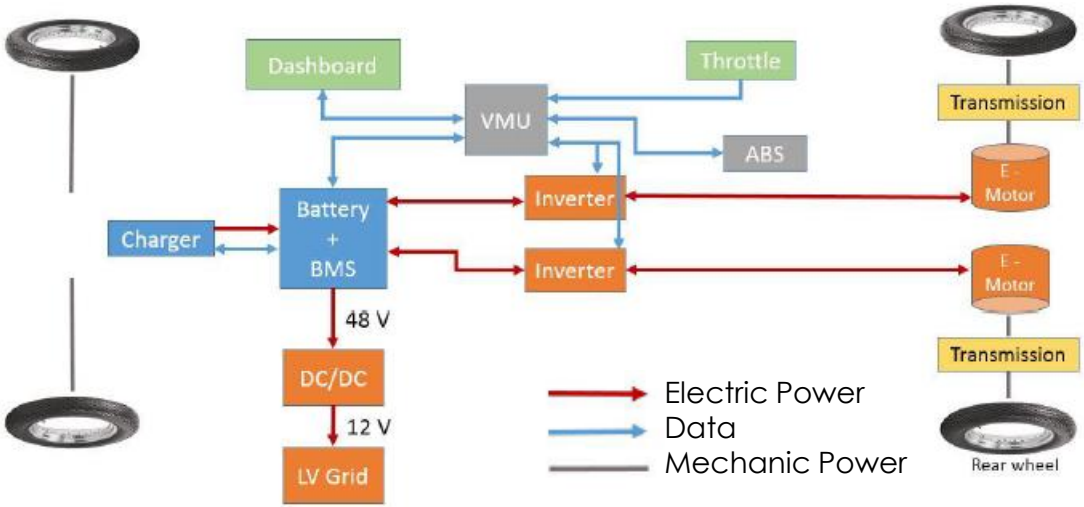
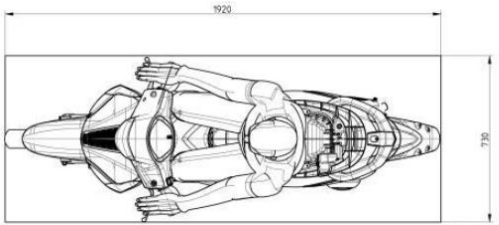
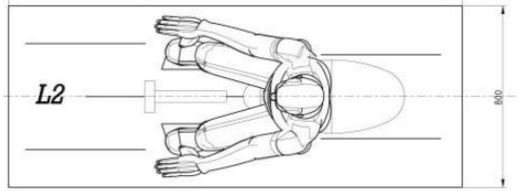
- Preliminary layout
  - Ergonomic models : 2 passengers + Luggage
  - Powertrain: electric + torque vectoring

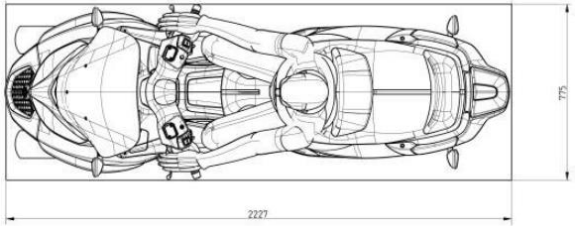




50cc Piaggio Scooter (L1 Category)



Demonstrator 1 (L2 Category)



Piaggio MP3 (L5 Category)

Vehicle layout and architecture – D2

AMAA 2016

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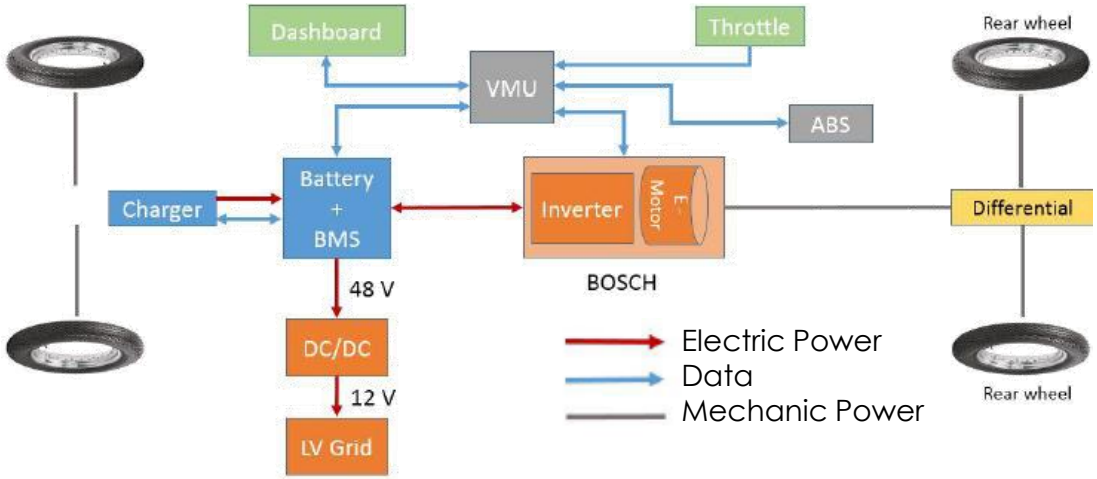
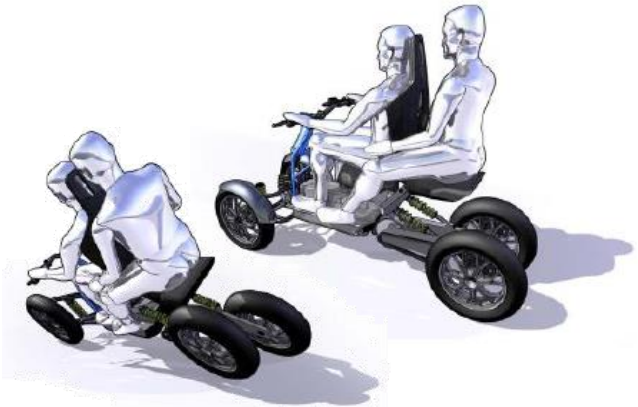
- Preliminary layout
  - Ergonomic models : 2 passengers + Luggage
  - Powertrain: electric + differential

Study of different structural concepts





Ergonomic and kinematic analysis

Modular Battery Pack

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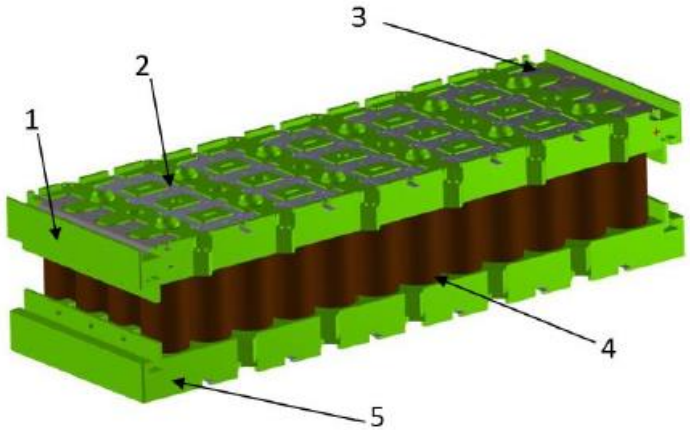
- Architecture
  - 12S4P (48 cells)
  - Weight: approx. 2.5 kg
- Li-ion, LG18650HG2 Cells
- Concept D1
  - 2 battery packs with 3 modules and one BMS each
  - Each Battery pack: 1554Wh
- Concept D2
  - 1 battery pack with 8 modules and one BMS
  - Battery pack: 4147Wh



(1) Top cell holder
(2) connectors
(3) connectors
(4) 48 18650HG2 battery cells
(5) Bottom cell holder

Energy efficiency and active safety

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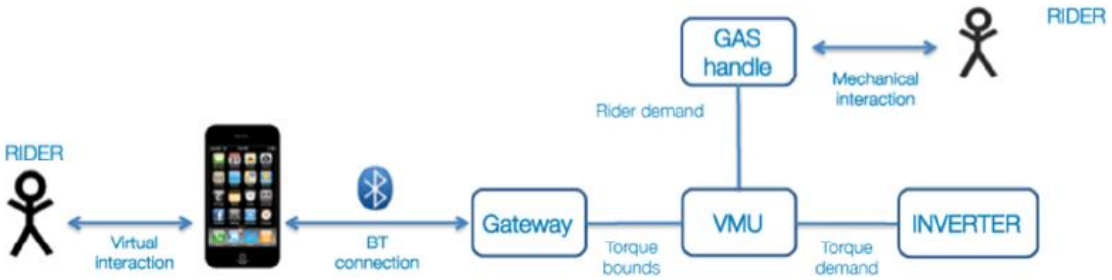
- Advanced vehicle management functions
  - Intelligent Range Management
    - ✓ Overcome range anxiety
    - ✓ Closed loop SOC control algorithm
      - Definition of desired battery discharge according to the route to be covered
      - Energy controller determines speed and acceleration bounds that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



Energy efficiency and active safety

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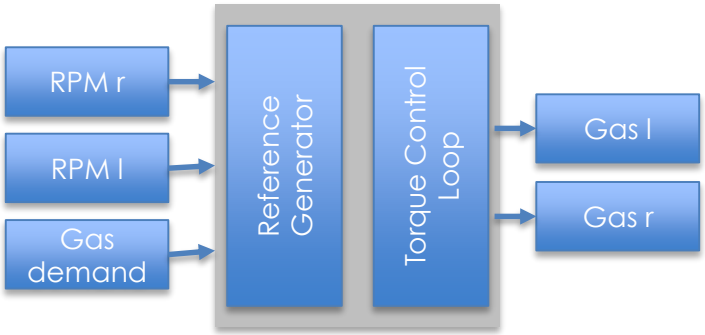
- Advanced vehicle management functions
  - Regenerative braking
  - Stability control & torque vectoring
    - ✓ Lean dependent slip control
      - Lean angle estimation block
      - slip ratio calculation block
      - reference generator for optimal lean angle
      - slip controller based on a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



Active differential scheme

HMI Concept

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- 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

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Summary and Outlook

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- 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


Rendering D2: L6e