Electric Vehicle Alert for Detection and Emergency Response (eVADER)
An EARPA Project Initiative for FP7

**Introduction**

- Recent studies suggest that vehicles, driven in electric mode, either hybrid or pure electric vehicles, are considerably quiet and, thus, they constitute a safety hazard for pedestrians and bicyclists in traffic. It is claimed that such vehicles are not acoustically perceived due to the power unit being exchanged from a combustion engine to electric motors; something that essentially cuts away all power unit noise and leaves tire-road noise, the latter of which is the same as for similar-sized vehicles with combustion engines. Actions have been taken by the US and Japanese governments as well as within international bodies such as UN/ECE and ISO, with the expected outcome that “minimum noise” of vehicles shall be measured with a standard method and legal limit values for such “minimum noise” shall be established.
- Recent findings reported in NHTSA Technical Report (September 2009) suggest that pedestrians and cyclists crossing involves both electric vehicles (EV) and Internal Combustion Engine (ICE) driven vehicles commonly occurred on roadways, in zones with low speed, with higher incidence rates for EV than Hybrid EV (HEV) or EV when compared with internal combustion driven vehicles (ICE). The study showed that for vehicles moving slowly or stopping, backing up or entering or leaving a parking place the HEV was about two times more likely to be involved in a pedestrian accident than ICE vehicles. Similar trend was also found for cyclists, particularly at intersections. Accordingly, special emphasis is given to noise at speeds below 20 km/h for which the problem is expected to be the worst and where not enough data is available.

**Current European research situation**

- eVADER will investigate the interior and exterior sound scape of electric vehicle for safe operation, considering driver’s feedback, feasible pedestrian reactions, driver and pedestrian warning systems and pedestrian safety. The project will also analyze innovative methods to improve the acoustic detectability of electric vehicles in urban scenarios. The project will define solutions to warn vulnerable users of a nearby moving vehicle while providing means for heightening the awareness of drivers in critical situations.

Among other’s some of the most important areas covered by eVADER will be:
- Optimum warning signals definition to induce correct driver reaction for safe operation
- Adaptation of the warning signals to the real in-service vibro-acoustic environment
- Integration of the generation of acoustic warning signals with in-vehicle intelligent systems data such as external microphones, vehicle speed (CAN) or ADAS (Advance Driver Assistance) systems.
- Use of in-vehicle complementary information to improve directivity, timing, intensity, modulation and frequency characteristics of the warning signal, depending on real close-to-accident scenario
- Optimum warning signals maintaining the quietness of residents

**Project Objectives**

- To get a comprehensive knowledge of the sound criteria for interior and exterior noise of EV with special emphasis on driver’s feedback and pedestrian safety:
  - Jury tests (end users)
  - Diversity (the benefits of the project will be addressed to all population groups (children, elderly, blind, ...)
  - Real noise measurements on market EV
- Research and development of new active sound actuator
- To achieve a high level of pedestrian safety in terms of the additional risk associated to the low exterior noise of EV:
  - Optimum warning signals definition to induce correct driver reaction for safe operation
  - Adaptation of the warning signals to the real in-vehicle vibro-acoustic environment
  - None negative influence in the noise pollution. Use of available in-vehicle complementary information to improve directly, timing, intensity, modulation and frequency characteristics of the warning signal,
  - depending on the real close-to-accident scenario

- Integration of IVSS data with warning signals for close-to-accident pedestrian safety:
  - Intelligent active safety systems for both actors (driver and pedestrian): Optimum warning signals definition for pedestrian and drivers in close-to-accident situations
  - Increased the potential benefit of on-coming Intelligent Vehicle Safety Systems through the integration with the new generation of warning signals

- The knowledge gained to be used for future applications on real traffic conditions:
  - All chain value covered by the consortium members (DEM, TIIPTA, Research centers, Universities, End users)
  - Results available for future standards (basis for the European Guidelines)
  - Validation and demonstration activities are included in the project (in controlled environment (proving grounds) and in real traffic conditions (guarantee for the further massive implementation))

**Project Innovations**

- **Jury tests and IVSS testing**
  - Example: IVSS Pedestrian manikin instrumentation for acoustic detection
  - Recording of warning activation in real close-to-accident conditions (Driver B pedestrian)

- **Optimal warning signal**
  - Directivity patterns around the vehicle (interior and exterior spatial distribution)
  - Detection thresholds in real driving conditions (drivers) and urban noise environment (pedestrians)
  - Time structure of warning signals
  - Frequency characteristics of warning signals
  - Psychological effects of warning signals on drivers and pedestrians
  - Physical device for warning signal generation (electrodynamic, piezoelectric, etc)

- **Integration between IVSS, environment information and acoustic warning signal**
  - The development of an noise signal generator with high spatial directivity will allow the development of integration of warning early warning signals for pedestrian detection in any close-to-accident situation
  - The thresholds for warning signal detection will be determined as a function of background noise perceived by the pedestrian

- **Warning signal performance vs. acoustic landscape**
  - The development of an noise signal generator with high spatial directivity will allow the development of integrating control algorithms that will integrate in-vehicle intelligent systems data with the exterior warning signal for pedestrian selection in any close-to-accident situation
  - Thus, increase of unwanted noise effects on pedestrians not involved in the danger situation will be avoided