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An introduction
About SAFE STRIP

- **SAFE STRIP** - “Safe and green Sensor Technologies for self-explaining and forgiving Road Interactive aPplications”
- H2020 project, started on 1st of May 2017 to last 36 months
- [www.safestrip.eu](http://www.safestrip.eu)
The need

- Despite the apparent benefits of C-ITS, the high cost on infrastructure end is prohibiting.
  - Especially when it needs to support automated driving functions.

- 35% of the root causes for road injury accidents in EU are due to **night, bad weather conditions and absence of information for road surface condition** (TRACE 2015).

- In 8% of PTW accidents, **road condition** was described as “wet” (MAIDS).
  - In 2.5% of the, ice, snow and mud were reported.

- In 26% of all roadways there was **surface deterioration or damaged bitumen** (i.e. broken or separated asphalt) detected.

- 30% - 40% **accident reduction cost** due to **application of VSL** at intersections/merging links (Lind 2009).

- **Benefits** in terms of safety, traffic efficiency and time gains from **VMS application**; still they are quite costly (~ 24-90 K€ each).
The need

1. We need info about the road, the environment & the traffic conditions in order to save lives

2. It can’t be expensive
The proposed solution

- A disruptive technology that will achieve to embed C-ITS applications in existing road infrastructure, including novel I2V and V2I, as well as VMS/VSL functions.

- In order:
  - to make roads self-explanatory & forgiving
  - to reduce operational & maintenance cost and achieve full recyclability
  - to provide added value services (i.e. real-time predictive road maintenance functions).
By integrating micro/nano sensors, communication & energy harvesting modules in low-cost, integrated strips road pavement tapes/markers on the road.
**How**

- **Embed static info** (i.e. enhanced map data, speed limit, curvature, asphalt characteristics, etc.) **to be transmitted to the vehicle**, that are programmed after deployment and reprogrammed when the use of the road changes or during road works.

- **Receive dynamic info** (i.e. TMC messages), **process and transmit them to the passing vehicles**, to be offered to the driver/rider in a personalised manner.

- **Measure dynamic environmental parameters** (like temperature, humidity, water, ice, oil, smoke) and **accurately estimate each vehicle’s friction coefficient** (through road sensors data fusion with vehicles’ intelligent tyres’ info).

- **Sense passing vehicles**, including non-equipped ones, measure the transit time, speed and lateral position in the lane, provide basic classification of the vehicle type and, thus, offer key road load & circulation data to the TMC.

- **Sense pedestrian crossings, work zones, railway crossings** and other critical areas and warn the driver/rider well ahead of them.

- Enable **high accuracy and low cost automatic parking/tolling/insurance policies**.

- **Define and manage lane-level virtual corridors for automated driving**.
Background

Sensors

• Nano & Micro sensors
  – Commercial: ultrasound proximity sensors, force and vibration sensors, embedded and/or surface strain gages, etc.
  – Prototypes: basically nano-sensors based upon existing, carbon nano-tubes based nano-immobilizing biomolecules, plastic micro-spheres and silicon micro structure wafers technology for sensing humidity and temperature change, smoke, oil and ice.

• Electrical Resistance Strain Gages & Embedded Strainmeters for road wear (cracks, deformations, collapses) measurement

• On complementary basis, visual markers (QR codes) - “virtual” sensors for providing road static info
  – Data received to be combined with data retrieved from intelligent tyres’ sensors about friction coefficient and mounted ADAS sensorial systems – when existing.
Background

Sensors – Data

√ Useful for road users & TMC

**Passive info** (i.e. speed limit, critical asphalt characteristics pedestrian/railway crossings and work zones)

**Active info** (i.e. friction level that will be fused with vehicles’ intelligent tyres’ data, info about passing vehicles (type, transit time, speed and lane position) that will be transmitted to the TMC

**Dynamic environmental road attributes** (i.e. temperature, humidity, ice, ambient light, water, etc.)
Background

Friction Coefficient

- Actual use of preview of potential friction has not been used yet in ADAS systems, except some preliminary use in APALACI & SAFESPOT projects

- SAFE STRIP will go one step further, dynamically estimating friction coefficient and making forecast

- Potential future friction will be used for the HMI (e.g., to provide explanation of the cautious maneuvers recommended by ADAS)

- Fusion architecture, combining existing friction information from on-board sensors and respective road-based info & smart tyre info – benchmarking study
Background

Hybrid Energy Harvesting, Communication, Encapsulation & Integration

• Hybrid energy harvesting approaches
  – Collection of energy from more than one energy sources like PV cells and piezoelectric and/or electromagnetic vibration devices, RFID, Wireless Power Transfer techniques, selection of an ultralow-power architecture, using low-power radio protocols.

• Communication will be addressed on complementary basis with IEEE 802.11p & infrastructure-based LTE cellular network architecture

• Development and iterative evaluation of test protocol for different encapsulation materials - dust & water immersion requirements, mechanical loading, environmental aging

• Integration in custom pavement marking tapes or road markers
Technological Approach

Approach for **Equipped Vehicles**

“Road Strip to Vehicle”

Through the communication of the **On Road Unit (ORU)** and the **On Vehicle Unit (OVU)** by means of a **IEEE802.11p** enabled microcontroller & communication module.

“Strip-to-vehicle” solution for equipped vehicles

- **ORU** embeds the **on-road sensors** (e.g. humidity, ambient light detector, temperature, etc.), which are wired on a **IEEE 802.11p enabled micro-controller and communication module** capable for interfacing with the road sensors (e.g. through a GPIO h/w interface).
- One ORU is installed per lane of the road.
Technological Approach

Approach for **Equipped Vehicles**

“Road Strip to Vehicle”

• Data fusion is processing incoming data from the **road**, the **tyres/friction coefficient estimation module** & the **CAN Bus**.

• Decision making is running in the OVU & notifications /warnings /recommendations are sent to the on-board HMI (or the smartphone).

**TM applications** are enabled through **V2V communication between the equipped cars and the TMC floating cars** (by use of the IEEE 802.11p standard).

*TMC floating cars act as service providers by exhibiting their ability to connect to the TMC network and send coded messages to the appropriate FM radio broadcaster for transmission as a RDS signal within ordinary FM radio transmitters.*
Technological Approach

Approach for Non-Equipped Vehicles & PTW’s

“Road Strip to RSU to Vehicle”

• Relies on an infrastructure-based Long Term Evolution (LTE) cellular network architecture.
• OVU or smartphone samples and gathers the relevant information and **periodically exchanges beacon messages with other vehicles via the base station node** (eNB in LTE) of the cellular network.

• Transmission of the ORU captured data over the infrastructure-based TMC network **through the base station node (RSU) wirelessly**.
• OR by exploiting the V2V communication capabilities between appropriately equipped cars, and through the TMC network, by involving TMC floating cars.

Communication between the ORU and the RSU is handled through a micro-controller with wireless communication capabilities (e.g. through IEEE 802.11b/g/n).
Safer Rail Crossings Use Case

• Issue a safety warning if the driver does not react in time when nearing a rail crossing.

• For this UC, SAFE STRIP collaborates with SAFER LC

• CERTH is participating in both projects

• SAFER LC provides information about approaching trains

• A test site will be setup in Tessaloniki, Greece
4 testing rounds

7 demonstrators
5 test sites
2 highways
(A22 in Italy & Attiki Odos in Greece)
Tessaloniki SAFER-LC Demo Site
Intended innovation

- To improve existing “intelligence” in vehicles through more accurate, reliable and personalised information and offer somehow equal “intelligence” to drivers/riders of unequipped vehicles, bringing in this way a significant increase in safety and promoting equity on the road.

- To open a new carrier for introducing micro and nano sensors in road applications, transforming pavement and other roadside markings and elements into a smart miniaturised integrated platform.

- To explore new I2V and V2V communication possibilities through the deployment of ad hoc IEEE 802.11p standard.

- To contribute to a hybrid estimation of actual road friction, that is much more accurate that anything achieved so far and without the need for additional on-board sensors, bringing great benefits to ADAS applications through the continuous prediction of actual friction (and not only during a few driving manoeuvres) and future friction before arriving on the surface.

- To offer a low-cost efficient solution reducing the infrastructure manufacturing and installation cost about 50% - 95%.
Overall Impact

- Reduction of highway fatal accidents $\approx 5\% - 8\%$
- Reduction of fatal accidents at specific traffic scenarios (i.e. merging/intersections) $\approx 15\% - 30\%$
- Cost saving for infrastructure $\approx 50\%-95\%$
- Cost saving for driver/rider $\approx 95\% - 100\%$

***Depending on the business model***
Extensions

• In other modes
• For other C-ITS applications
• For other conceptual contexts (i.e. SAFE STRIP in pavements)
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