SAFE STRIP has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 723211.

SAFE STRIP

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**

Coordinator

Technical & Innovation Manager

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).

for ALL road users
(cars, trucks, VRU, ...)

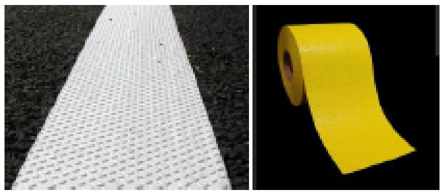
for ALL types of vehicles
(equipped, non-equipped, autonomous)

How

By integrating micro/nano sensors, communication & energy harvesting modules in low-cost, integrated strips road pavement tapes/ markers on the road.

polyurethane, glass and ceramic particles.

Product Dimensions	
The typical dimensions of the Series 290 marker are:	
Height:	0.625 ± 0.050 in. (15.88 ± 1.27 mm)
Width:	4.00 ± 0.50 in. (101.6 ± 12.7 mm)
Length:	3.50 ± 0.50 in. (89.2 ± 12.7 mm)



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

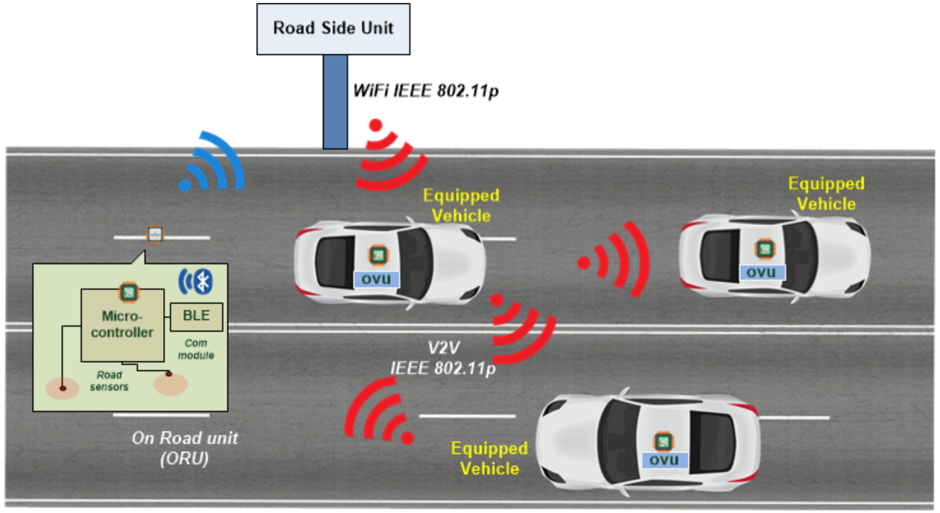
Background

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***



"Strip-to-vehicle" **solution 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 I**EEE802.11p** enabled microcontroller &communication module.

- **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***

Equipped car utilising info provided by the system to enhance its on-board systems reliability

"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).

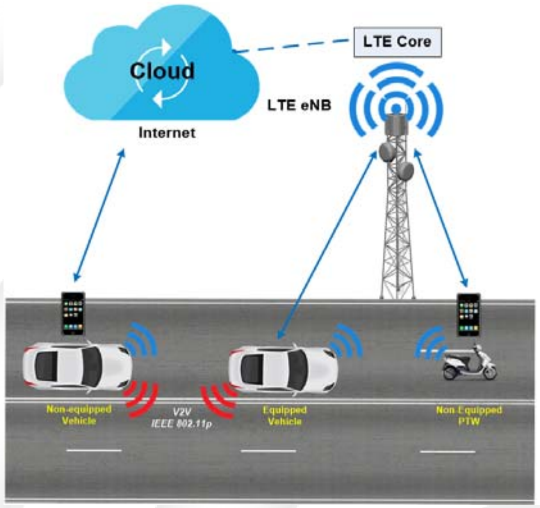
TMC floating cars act as service providers by exhibiting their ability to connect to the TMC network and send coded messages to the appropriate FM radio broadcaster for transmission as a RDS signal within ordinary FM radio transmitters.

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.



"Strip-to-RSU-to-vehicle" **solution for non-equipped vehicles & PTW's**

- 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).

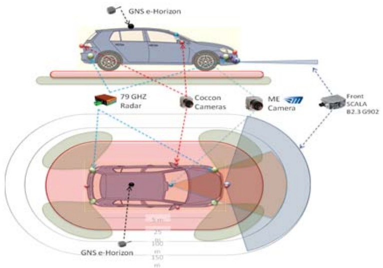
Safer Rail Crossings Use Case

- 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

CRF, FIAT 500L

CERTH, Lancia Thesis



VALEO demo car Cruise4U

Piaggio (Beverly)

CERTH, Piaggio MP3 Hybrid

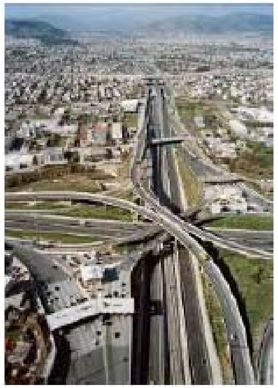
CONTI test vehicle with laser sensor

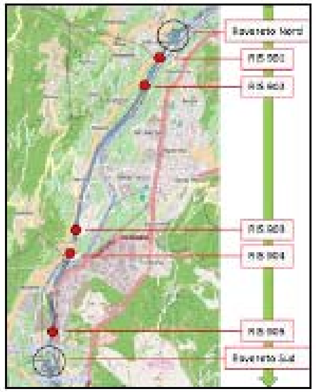
7 demonstrators

5 test sites

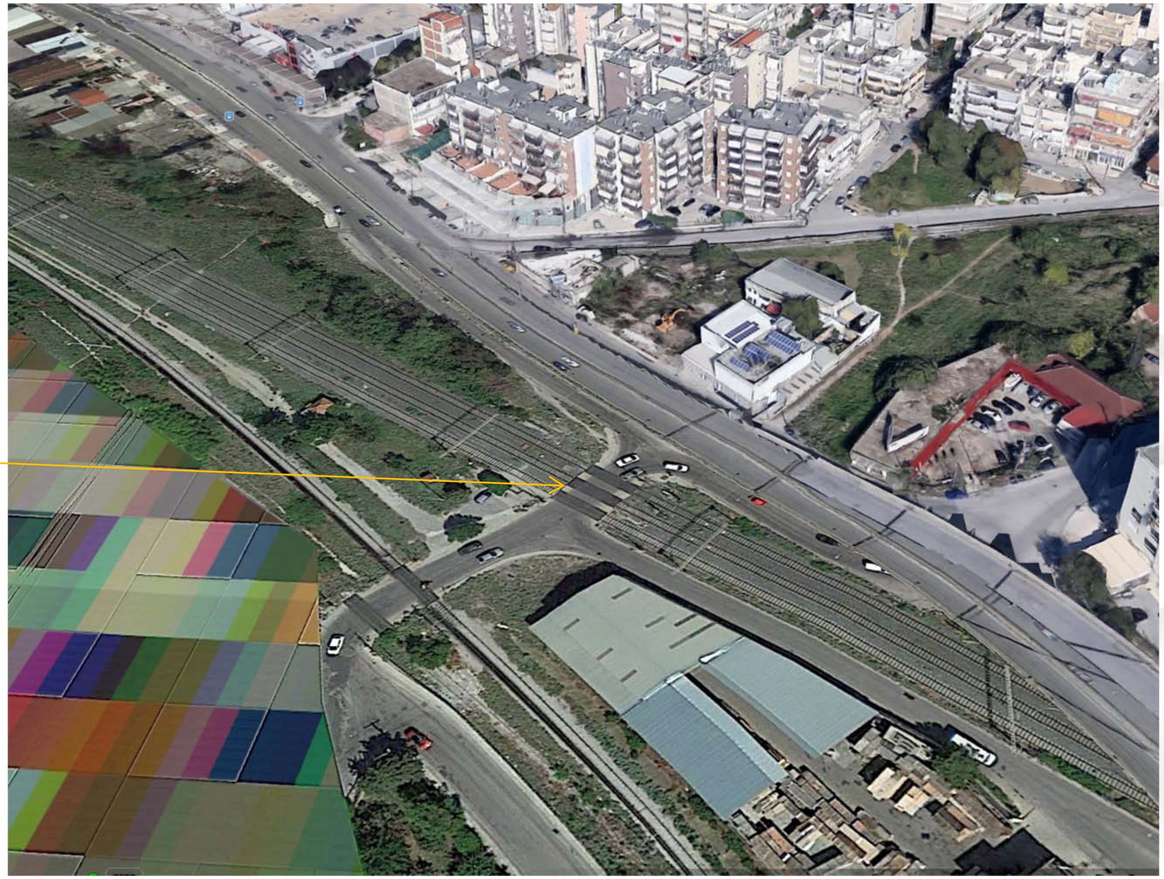
2 highways

(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 ≈ 5% - 8%**
- ✓ **Reduction of fatal accidents at specific traffic scenarios (i.e. merging/intersections) ≈ 15% - 30%**
- ✓ **Cost saving for infrastructure ≈ 50%-95%**
- ✓ **Cost saving for driver/rider ≈ 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)

Contact

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