SAFER-LC

SAFER LEVEL CROSSING BY INTEGRATING AND OPTIMIZING ROAD-RAIL INFRASTRUCTURE MANAGEMENT AND DESIGN

Development and Integration of Technical solutions

Louahdi Khoudour, CEREMA

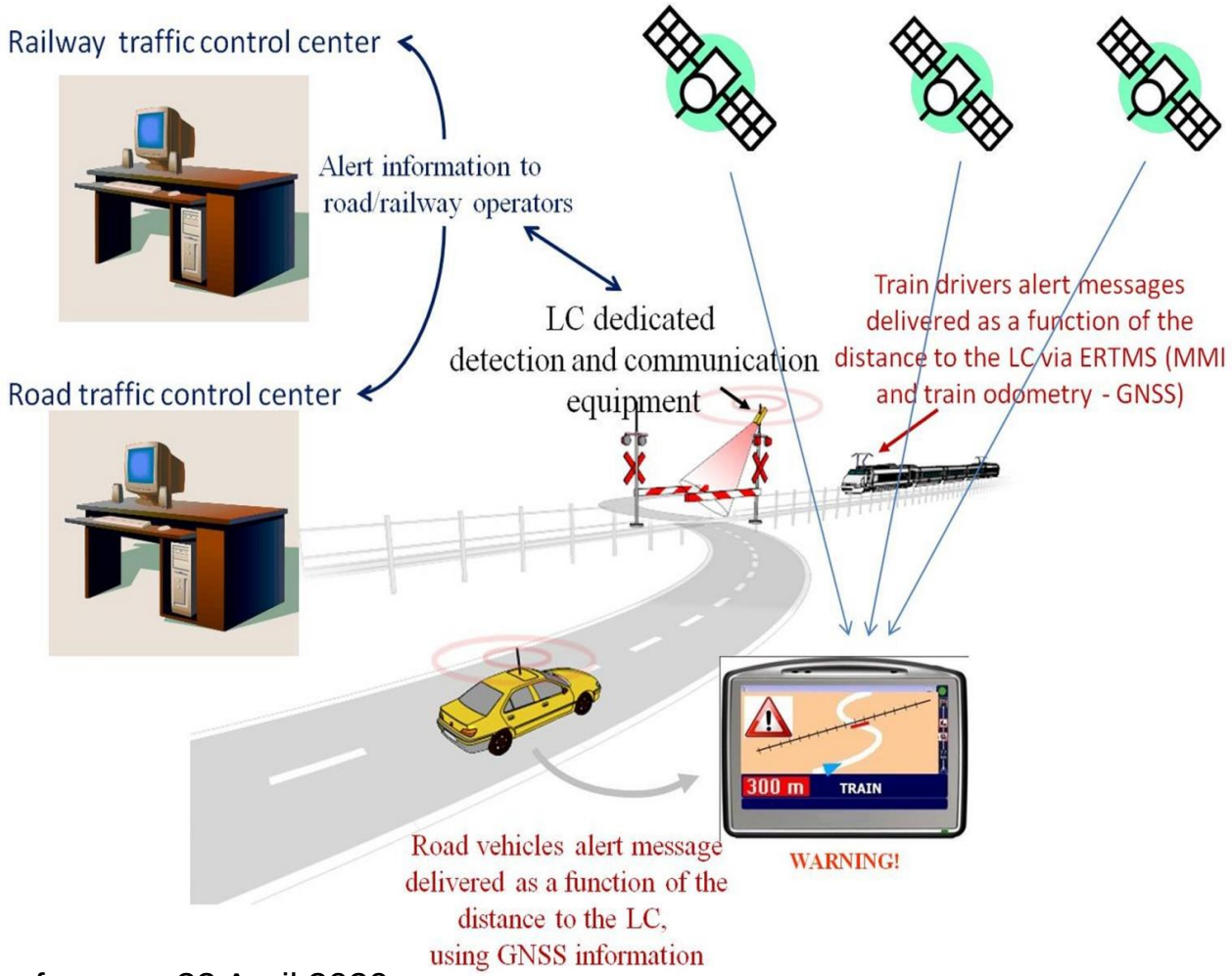
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723205

Objectives

- The aim of this work package is to develop technological solutions to improve safety at level crossings as well as at working zones through :
  - Sharing information
  - Giving warnings to trains/vehicles approaching/arriving to level crossings and to workers at or near train passing zones.

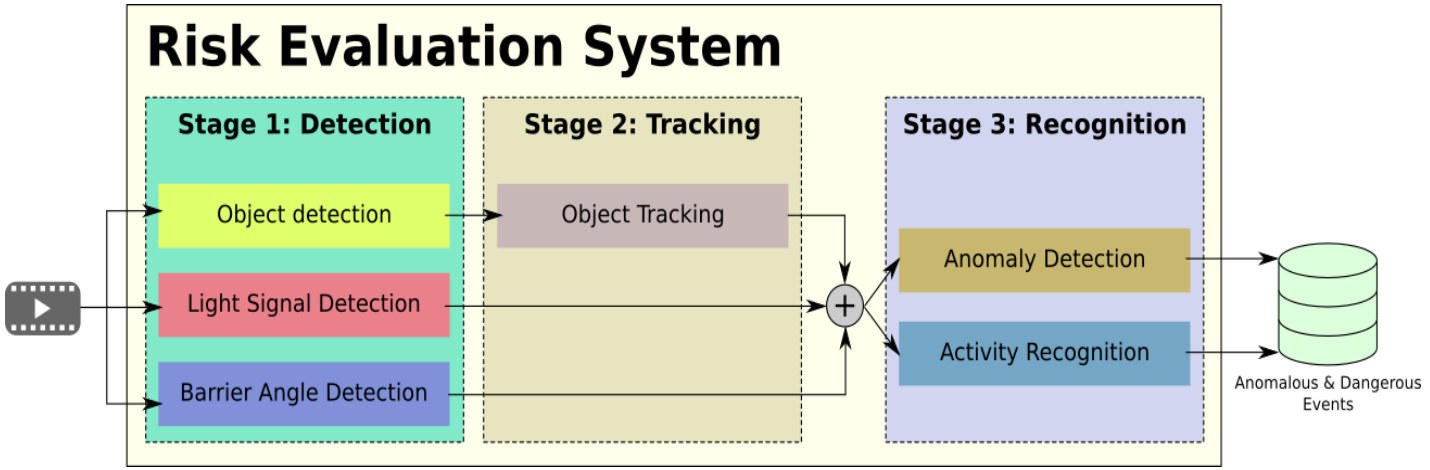
Architecture

To develop **technological solutions** to **improve safety** at level crossings as well as at working zones through ***sharing information*** and ***giving warnings*** to trains/vehicles approaching/arriving to level crossings and *to workers at or near train passing zones*



Risk Evaluation

- **Objectives**
  - Analyzing video recordings of level crossings and their surroundings
  - Extracting data about the occurrence of dangerous and/or anomalous behaviors
  - Allowing a human operator to evaluate the dangerousness of the monitored level crossing
- **Three stages architecture:**
  - Stage 1: deep learning based user and level crossing state detection
  - Stage 2: user tracking
  - Stage 3: dangerous activity recognition and anomalous behaviour detection

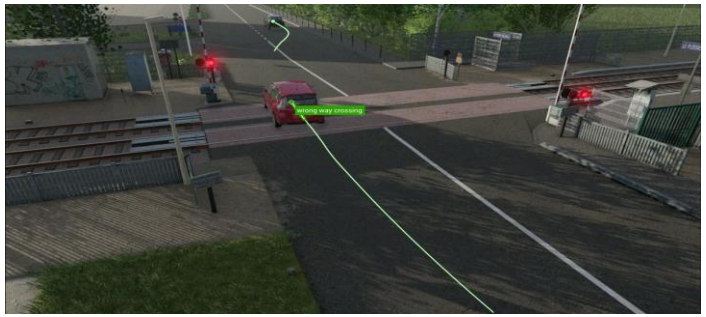


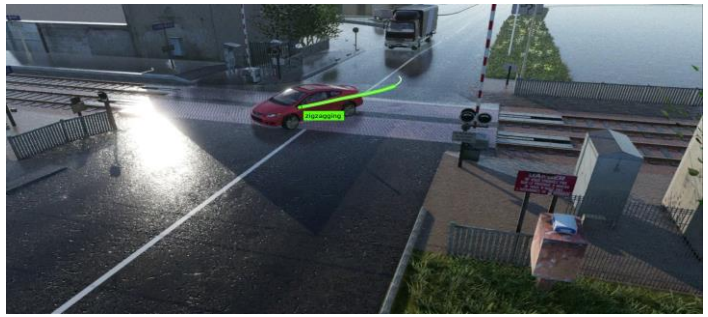
Use cases

- **System evaluated in simulation with Virtual reality:**
  - Under varying weather and lighting conditions
  - Including trucks and cars
  - With two 3D models of existing level crossing
  - With six dangerous activities:
    - Illegal crossing
    - Queuing
    - Vehicle stopped on the tracks
    - Wrong-way crossing
    - Zig-zagging
    - Speeding

- **Results:**
  - User detection precision: ≈69%
  - Light signal detection: Pearson's correlation ≈0.98
  - Barrier angle detection: mean error ≈0.6° , standard deviation ≈11°
  - Tracking precision: ≈83%
  - Activity recognition precision: ≈98%

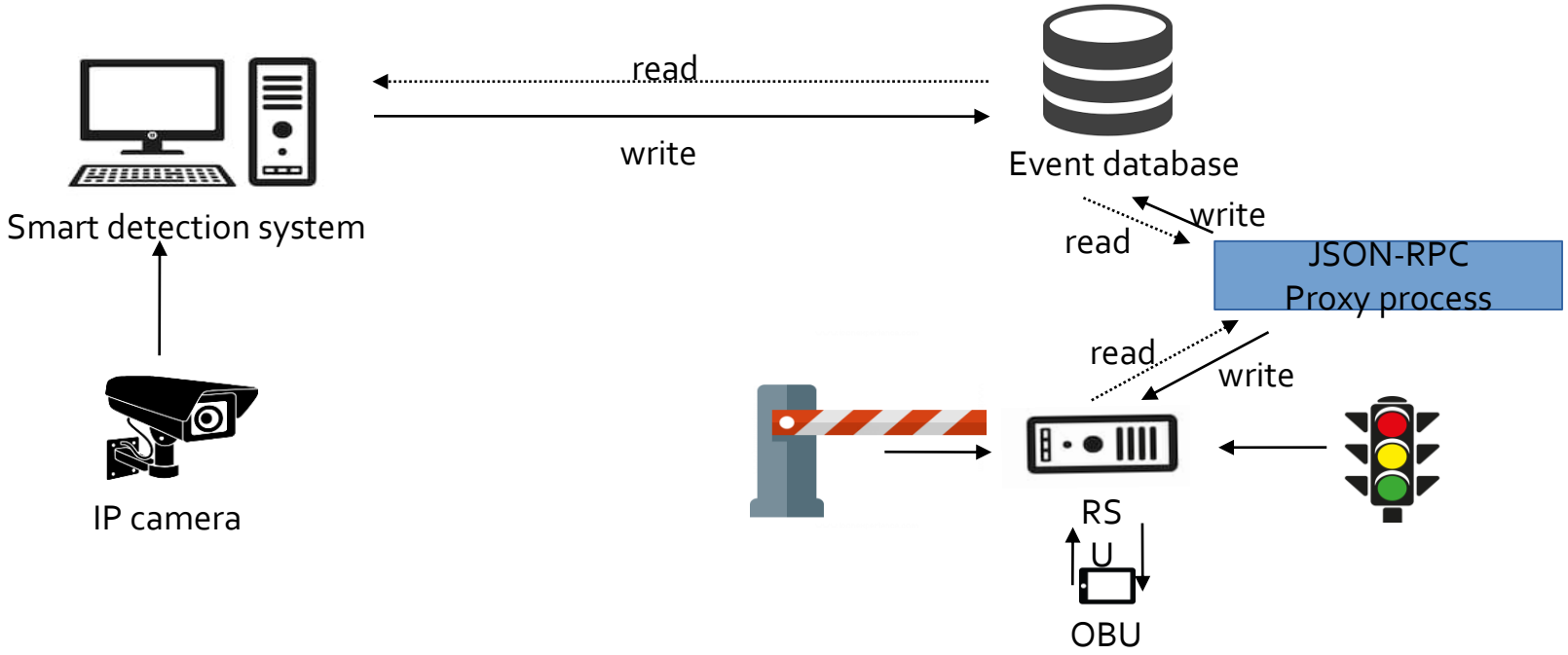
- **Perspectives**
  - A fully automated simulation tool able to create hundreds of LC scenarios and data processing





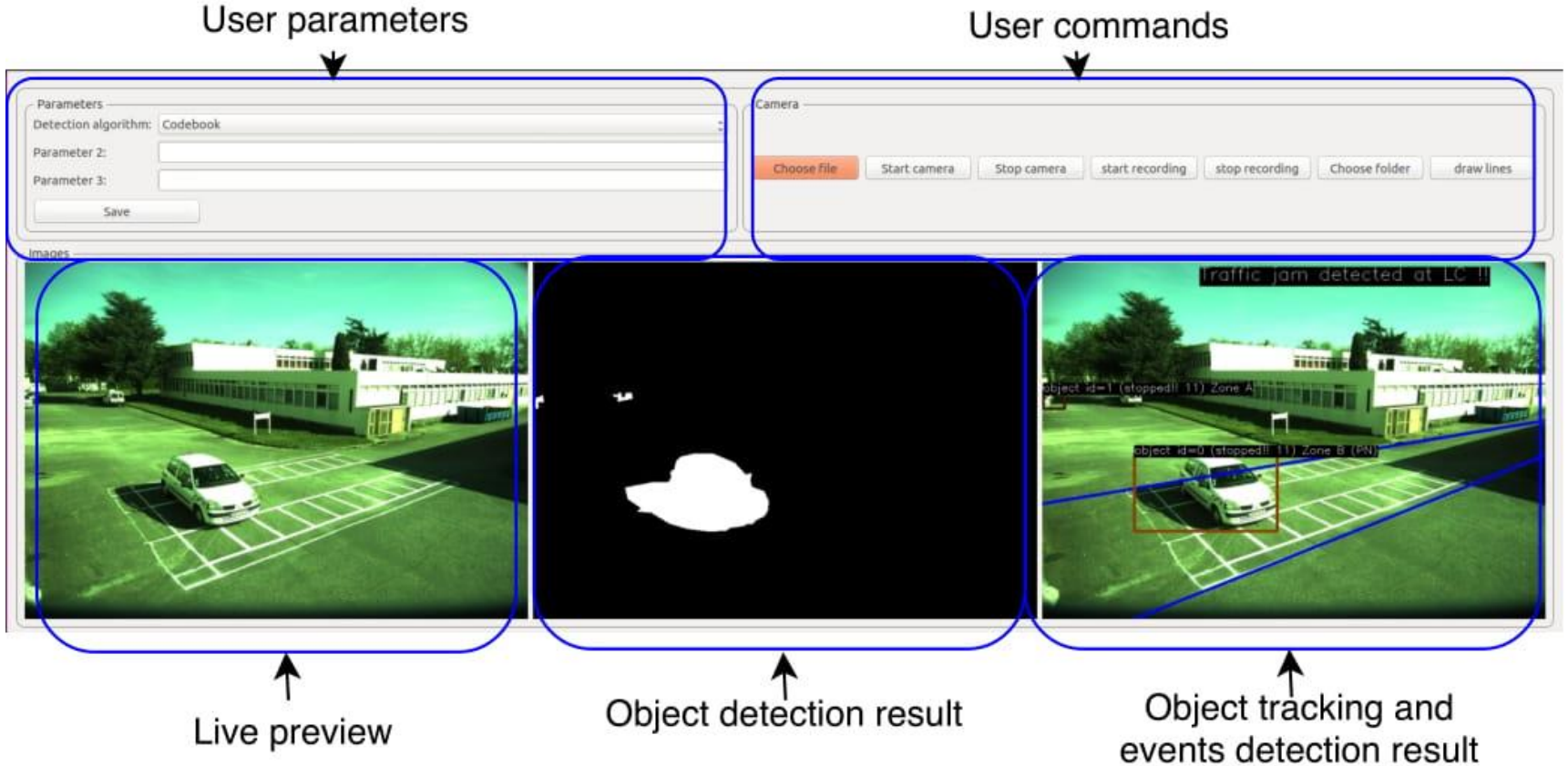
Smart detection system (SDS)

- Dynamically detect any abnormal behaviour of road/vulnerable users and
- Detect/identify obstacles (e.g. stopping vehicles) that may be the potential source of an incident at a LC, by monitoring the LC environment and its surroundings,
  - to reduce the risk of collisions and near misses at LCs.



Use cases

- Cars stopped, Pedestrians, Atypical behaviour, Traffic jam
- Indicators : detection performance, recognition performance, processing time



A fully smart detection system based on video sensing and image processing

Telecommunication

The aim

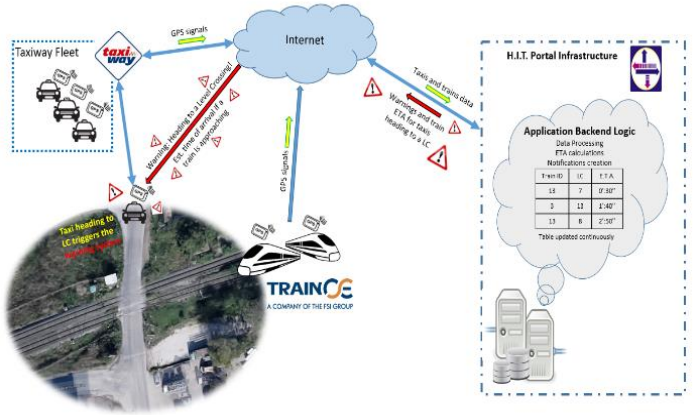
- to share information of an LC status, in relation with a smart detection system (SDS), with road drivers, train driver and to control room operator.

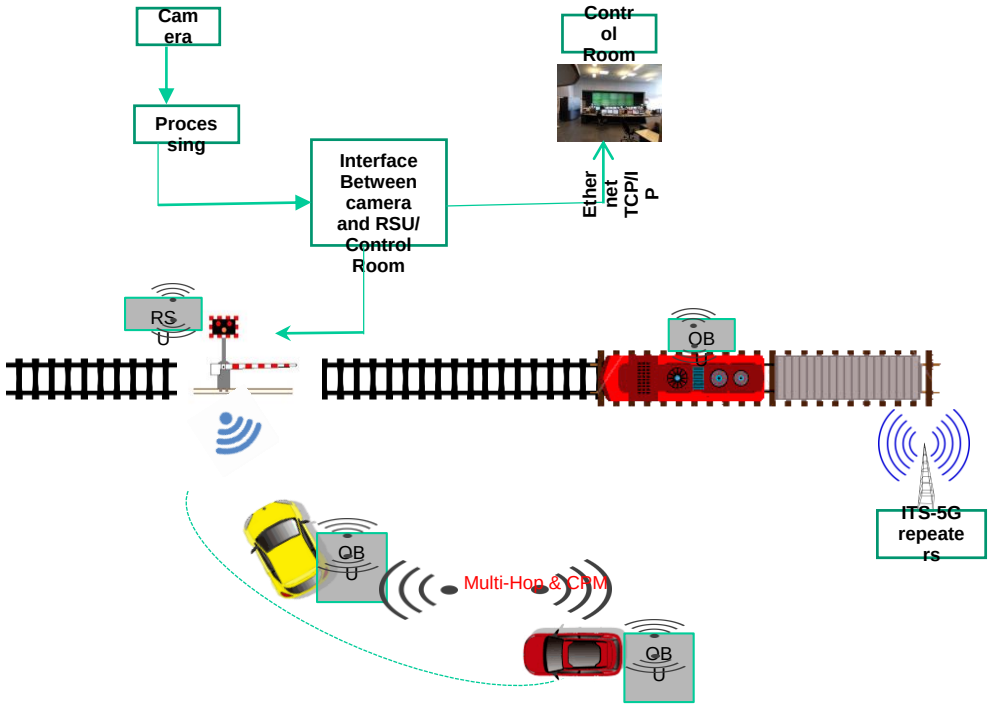
Objectives:

- Definition of the scenarios
- Implementation and test the existing communication technologies (LTE, ITS G5) in LC context.
- Definition of methodology and key performance indicators (KPI) of the communication systems.
- Evaluation of all proposed solutions in real environment (Aachen and Thessaloniki pilot sites)

Two configurations of architectures

The architecture based on LTE (Thessaloniki pilot site)





The architecture based on ITS-G5 (Aachen pilot site)

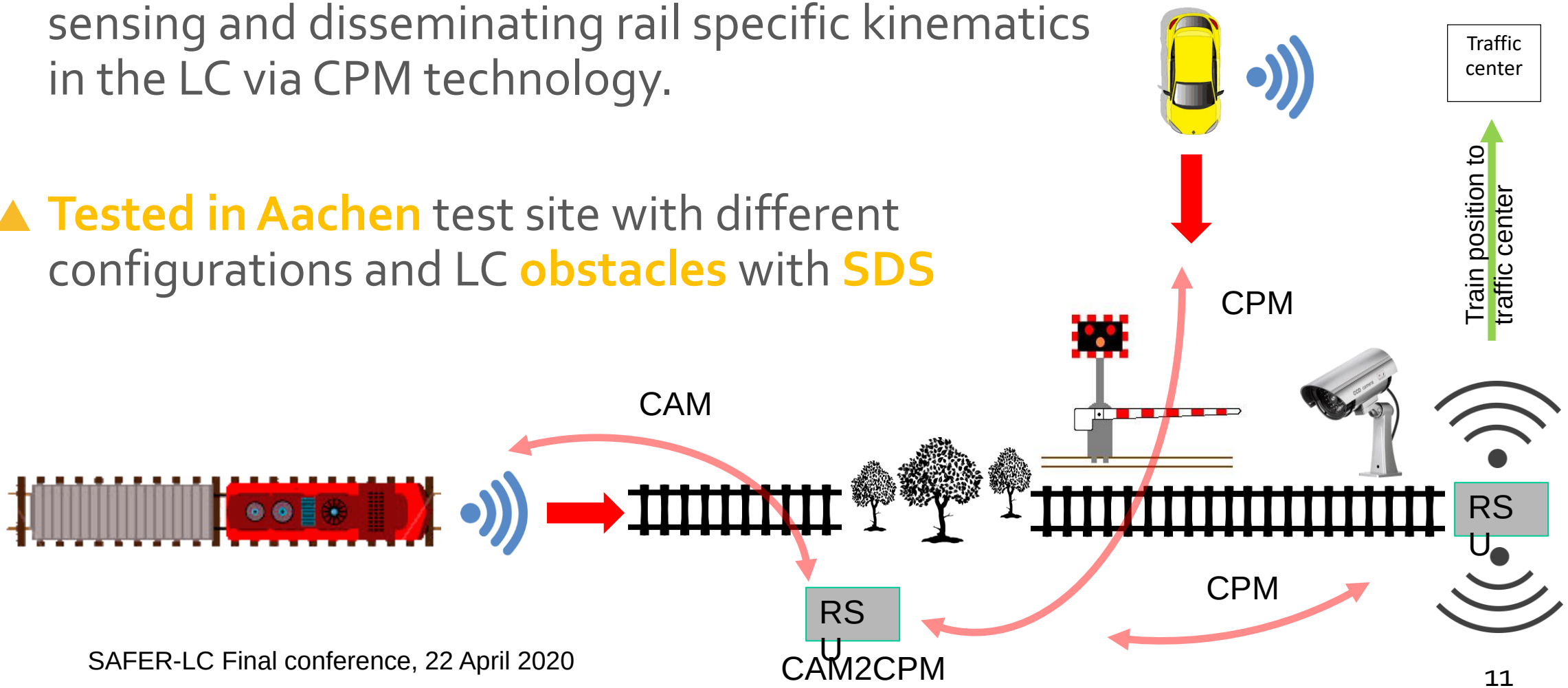
LC Clearance

- **Performed by the LC Intersection Management Safety Application** (LIMA)
- It is an LC specifically modified version of the standard Intersection Movement Assist Safety Application based on V2X CAM processing and sensor data fusion.
- **LIMA** provides collision warning and hazard mitigation for car drivers and clearance assurance for train.
- It helps car drivers **to avoid front-to-train** and side-to-train collision situations and mitigate the severity of collision hazards for trains.

Enhancement in LC environments

- **A detection range extension** to advertise the status and position of the approaching train by sensing and disseminating rail specific kinematics in the LC via CPM technology.

- **Tested in Aachen** test site with different configurations and LC **obstacles** with **SDS**



In-vehicle train and LC proximity warning

- **In-vehicle train** and LC proximity alert
- **Mobile application** aiming to enhance road user safety around level crossings.
- **Use of any common mobile device** such as a smartphone or tablet, and it warns road users about the presence of a LC and a short audio alert, whenever they approach a LC.
- The warning also includes **the estimated time of train arrival**, whenever an incoming train is expected to reach the LC within one minute

Key performance indicators

- **Driving behavior** based on trajectories of taxis when approaching a LC including driver speed profiles with respect to temporal and spatial distance to the rail, number of stops for safety checking, temporal duration of stops, and distance of stops from LC.

- **Kinematic** indicators including vehicle speed and acceleration-deceleration functions around LCs.

- **Questionnaires** for drivers

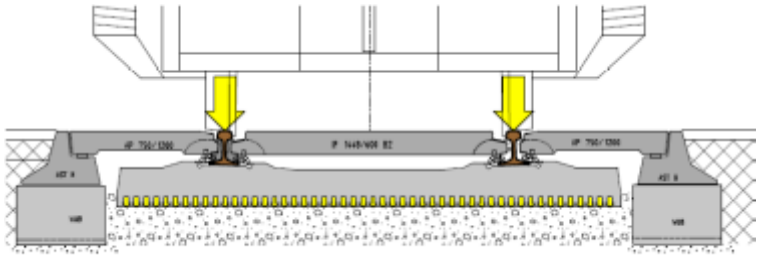
Global results

- **70% of subjects reacted when receiving a notification sound** (beep) providing information of LC status (LC closed, road works at LC or LC in xx meters),
- allow them to anticipate their speed on approach to the LC and to better prepare for the stop.
- The majority of subjects understood **that message was sent to anticipate situations demanding attention on approach to the LC.**

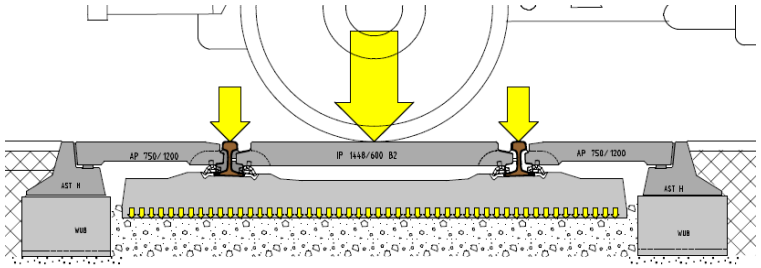
Infrastructure Monitoring and remote maintenance

- **To develop a real-time monitoring system of LCs using vibration sensors**
  - To monitor the vibration on track/road components due to dynamic loading
  - To set an alert threshold to assess the status of the LC components
  - To send alerts to LC owners and maintainers of possible safety risks

- **To monitor and assess the condition of LC infrastructure to ensure the safety performance of the LC**
  - To identify and predict the potential failures at LC boom barrier
  - To send alerts of possible safety risks due to LC infrastructure faulty operations



Train loading



Car tyre loading

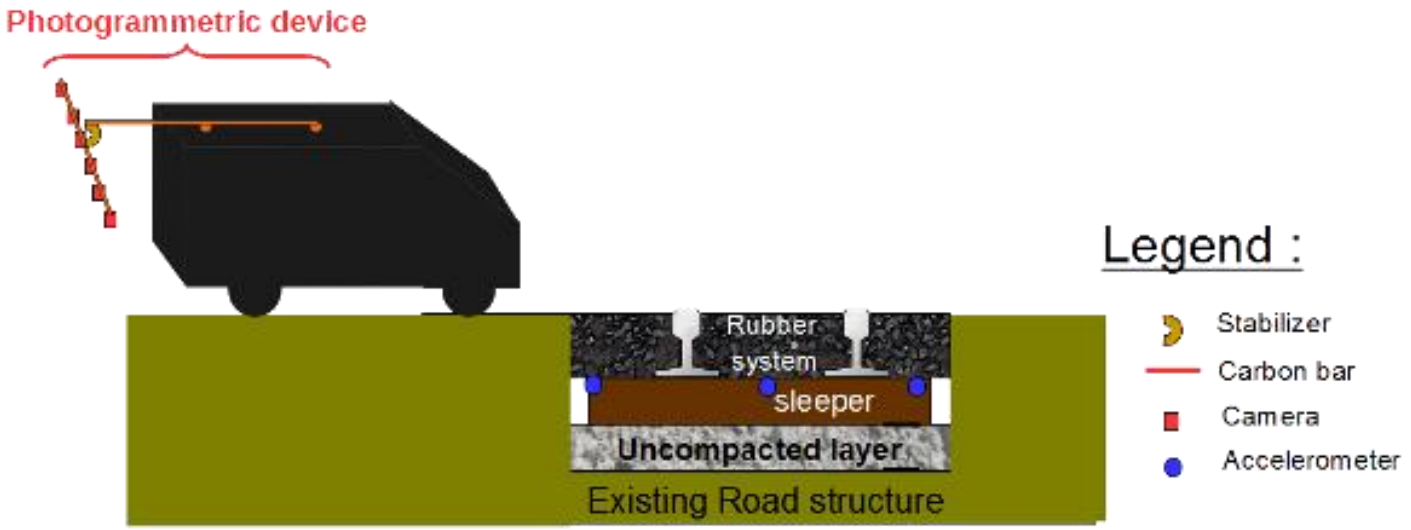
Methodology

Two approaches are followed for the real time monitoring :

- Photogrammetric method : measure the displacements to monitor infrastructure surface condition : complemented with thermal-infrared measure to detect road fissures
- Vibration method : Measure accelerations to assess the LC components status and set alert thresholds

Work done and results achieved

- A test site and test configuration is developed
- Mock tests of the photogrammetric method is conducted to to detect the movement and displacement of elements



Final developments

- **WP3**
  - is a technical workpackage
  - Demonstrators are proof of concept
  - The evaluations are carried out with real datasets
- **Results on the different demonstrators are quite promising**
  - Risk evaluation is a very good tool to generate many use cases
  - Smart detection system shows the technical feasability of a video-based sytem
  - Communication tools show also the complementarity between detection and communication
  - Infra monitoring and remote maintenance is a good predictive system for failures

Main reports

- Reports are online at https://safer-lc.eu/
  - **D3.1:** Proof-of-concept on data acquisition platform for risk evaluation and AID systems
  - **D3.2:** Report on communication and warning system
  - **D3.4:** Report on risk evaluation system and use cases for pilot test
  - **D3.5 :** Report on smart detection system

Main contacts

- Jocelyn Buisson, FFE : Jocelyn.Buisson@utbm.fr for risk evaluation
- Louahdi Khoudour, CEREMA : louahdi.khoudour@cerema.fr for smart detection system
- Fouzia Boukour, IFSTTAR : Fouzia.boukour@ifsttar.fr for Telecommunication
- Delphine Jacqueline, CEREMA : delphine.jacqueline@cerema.fr for infrastructure monitoring

Thank you for your attention!