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ASSETS4RAIL

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Student Workshop
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WP8 – Sensor System to support track geometry monitoring

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Background

This WP focuses on the development of a sensor system to support track geometry monitoring performed by the master system under development in other Shift2Rail projects. The aim is to develop a sensor system alternative to the inertial platform for the detection of the transversal relative position between the wheelset and the rail, suitable for the use on commercial vehicles.

In fact, in the field of track geometry inspection, are commonly applied many sensors suitable for detecting the track geometrical characteristics, applicable to vehicles in normal commercial service. While, for the location of the measured measurements, inertial platforms are used, which are generally quite expensive. Therefore, these systems lend themselves to use on special diagnostic trains, rather than to extensive use on a commercial fleet. For this reason, this project intends to focus on systems which allow the detection of the wheelset transversal position on the track that can avoid the inertial platforms.

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Aim of WP8

Development of an on-board sensor system able to measure the transversal position of the wheel in relation to the rail in order to support track geometry measurements, including the following specific objectives:

- proof that the selected sensor could be operated under a large set of weather and environmental conditions (dust, rain, snow, etc.) and be active on in-service trains at 60-200 km/h;
- setup of a data acquisition system with easy and safe installation process on different typologies of bogies;
- setup of energy supply system for the equipment;
- process data into a specific format that is compliant with the track geometry monitoring system developed in the complementary project.

Expected results

Setup and configurations of the required sensor system and results of preliminary testing.

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Experimental investigation

During the experimental investigation, two technologies were under review:
i) based on **stereo camera**; ii) based on **thermal imaging camera**.

i) The Zed stereo camera developed by STEREOLABS (ZED, 2019) was used. It uses the technology of real-time depth-based visual odometry and SLAM. Main parameters: Max resolution 4416x1242; Max frames per second 100; 6-axis pose accuracy ± 1 *mm*. Field of View: 90° (H) x 60° (V) x 110° (D) max; ƒ/2.0 aperture.

ii) The T420 thermal imaging camera developed by Flir was used (Flir, 2019). Main parameters: resolution 320x240 with UltraMax technology, as a result, thermal images can be converted to 640 x 480 pixels. Temperature range -20°C to 1000°C, Max frames per second 60; Field of View: 25° (H) x 19°(V)/ (0.4 m). Thermal sensitivity (N.E.T.D) <0.045°C at 30°C.

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Developing of the test platform for real-time testing of sensing solutions

1. Stereovision camera; 2. AI computer Nvidia Jetson TX2 with SSD; 3. Laptop used to control the Nvidia Jetson remotely; 4. is 12V DC to 220V AC inverter; 5. 12V battery.

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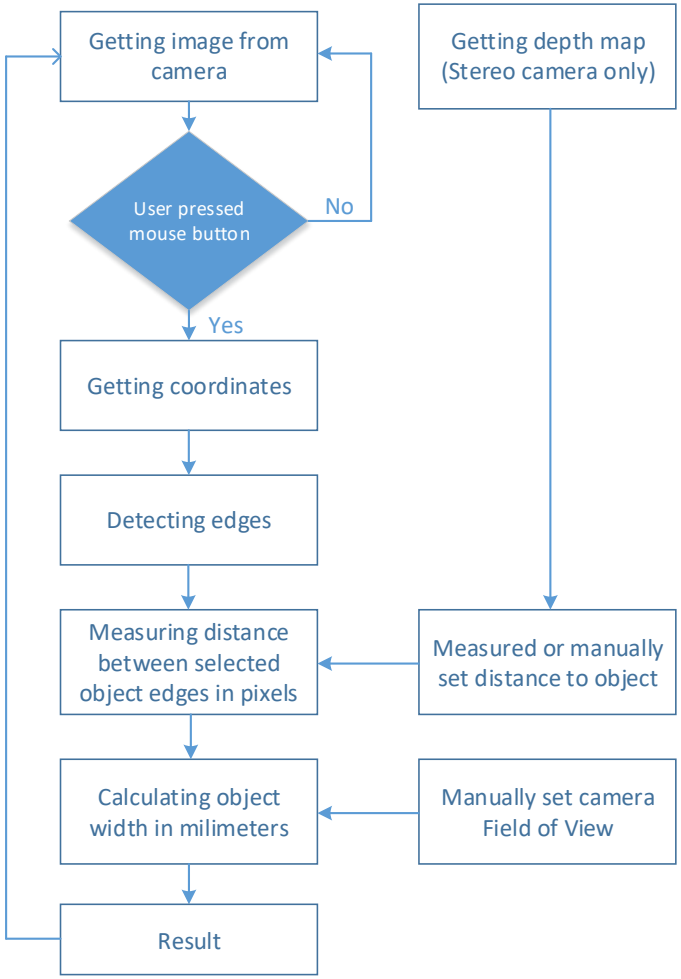
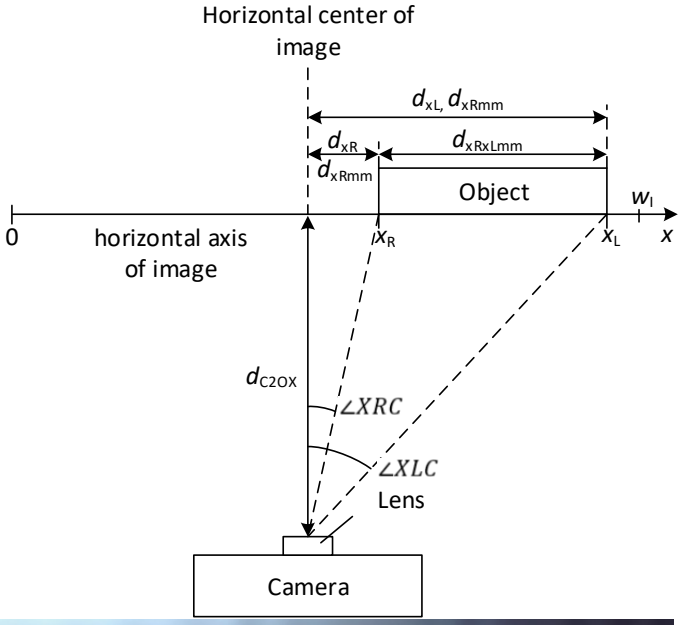
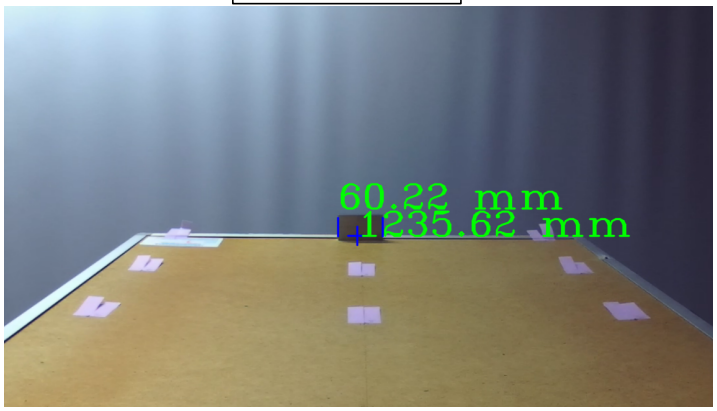
Initial measurement algorithm







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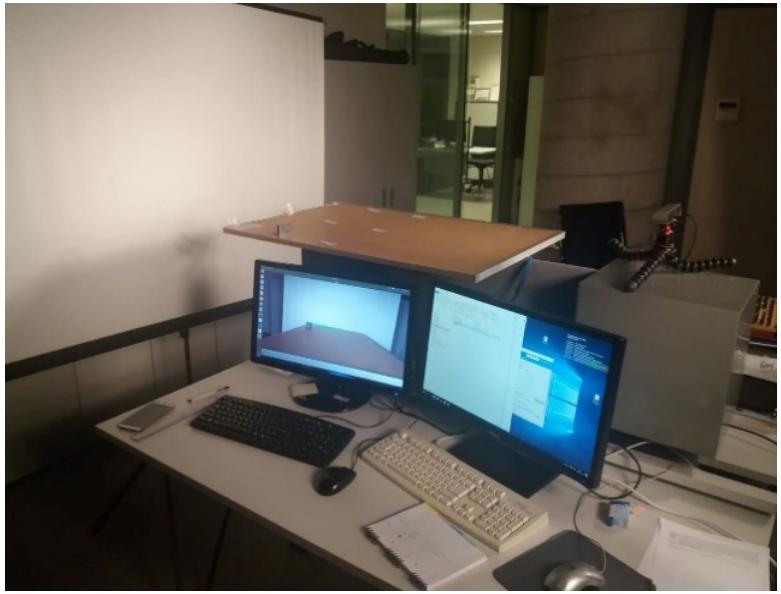
Development of the test platform for real-time testing of sensing solutions



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Results of the measurements

Real value	5.12	10.24	15.36	21.50	25.00	30.12	35.24
Measured value	5.33	10.37	15.43	21.26	25.00	30.14	34.93
Error	-0.21	-0.13	-0.07	0.24	0.00	-0.02	0.31
Standard deviation	0.33	0.32	0.35	0.36	0.28	0.28	0.35
Min value	4.77	9.80	14.79	20.74	24.36	29.77	34.36
Max value	5.70	10.86	15.95	21.74	25.74	30.79	35.73
Real value	40.36	46.5	50.00	55.12	60.24	65.36	
Measured Value	40.16	46.55	49.73	55.38	60.46	65.37	
Error	0.20	-0.05	0.27	-0.26	-0.22	-0.01	
Standard deviation	0.39	0.32	0.43	0.35	0.4.	0.38	
Min value	39.44	45.96	49.32	54.79	59.67	64.62	
Max value	40.74	47.19	50.35	55.8	61.05	66.16	

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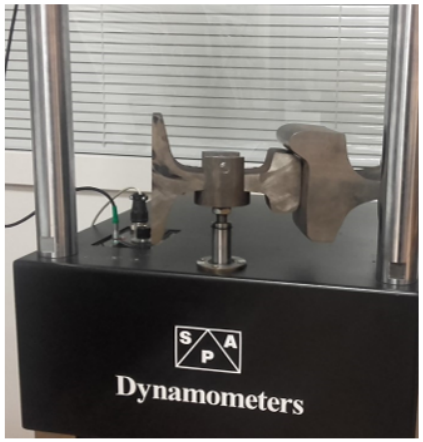
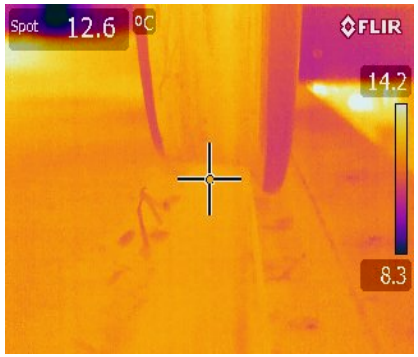
First problems and solution





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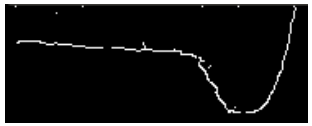
New algorithm

Calibration

a) Create image edge template of wheel flange area, by capturing one photo and performing small corrections on it



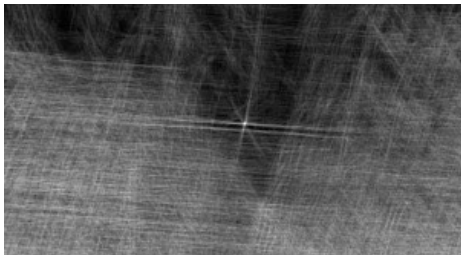
b) Create image edge template of rail near the interface point by capturing one photo and performing small corrections on it

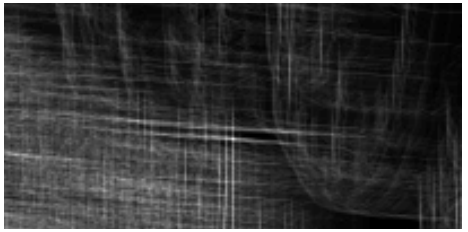
Measurement

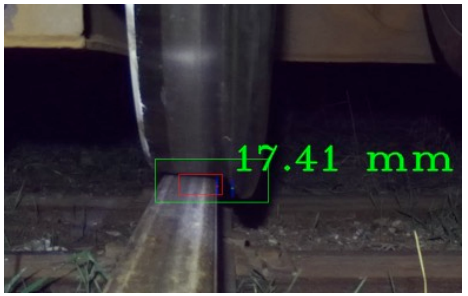
c) Find wheel flange coordinates, using selected template matching with edge image

d) Find rail coordinates, using selected template matching with edge image

e) Calculate the distance between video pixels and convert to milimeters using trigonometry







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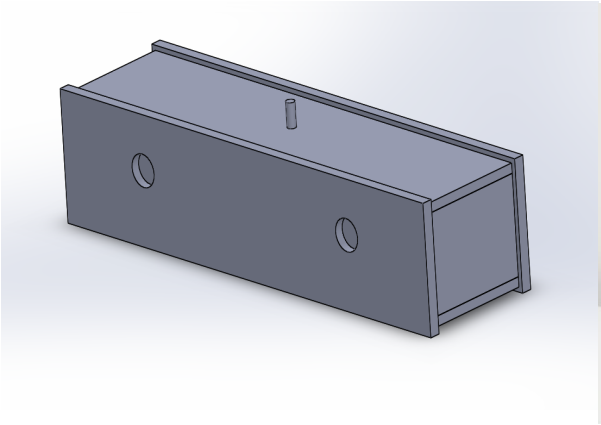
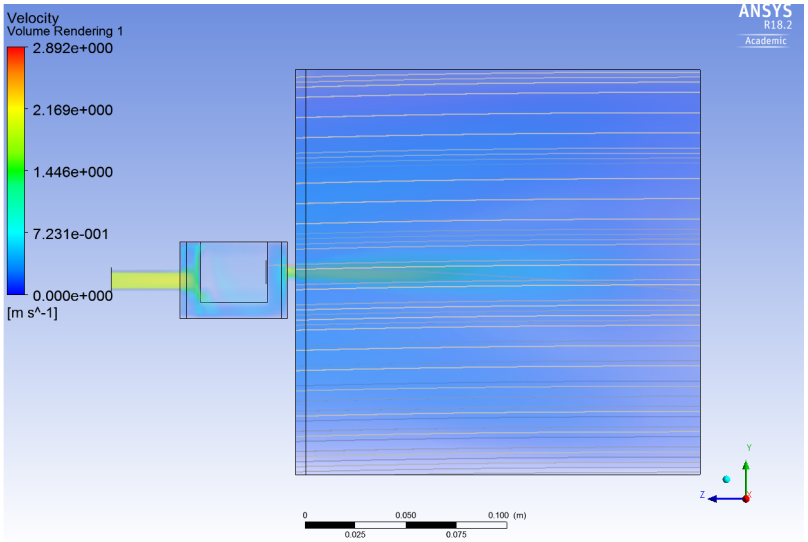
Development of the camera housing for stereo camera





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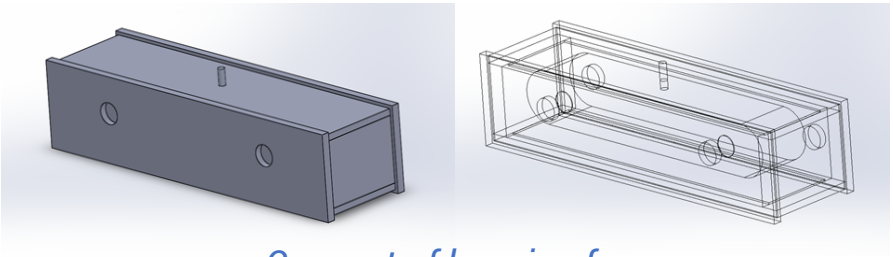
Sub-Task 8.2.1 Conceptual Design

Two concepts of housing will be developed for the two technologies identified in Task 8.1 (stereo cameras and thermal cameras). A concept of housing has been already developed by VGTU within Task 8.1 for the ZED stereo camera and can be suitably modified to accommodate the FLIR thermal camera.

ZED stereo camera



Concept of housing for the ZED stereo camera

FLIR thermal camera

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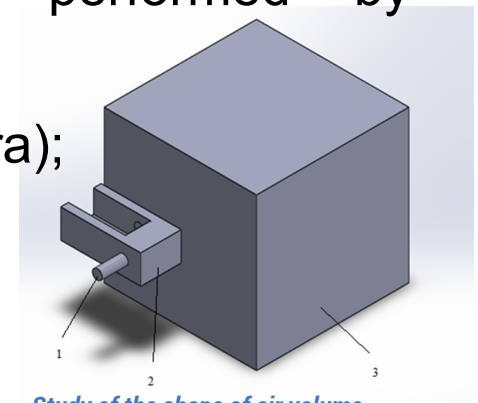
Sub-Task 8.2.1 Conceptual Design

In addition, the two housing concepts will be provided with the following devices:

- a pneumatic system to introduce an airflow into the housing in order to prevent cameras from weather and environmental conditions (dust, rain, snow, etc.) and decrease temperature of the device during summer period (a study of the air volume inside the housing concept for the stereo camera has been already performed by VGTU within Task 8.1);
- probably a lighting system (only for the stereo camera);
- a shock and vibration absorption system.



Study of the shape of air volume
1. air volume in input pipe
2. air volume inside the housing
3. air volume in front of the camera housing

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Sub-Task 8.2.2 Energy supply system

The energy supply system will be constituted by dedicated batteries powered both by means of sustainable and permanent technologies (e.g. harvesting systems using the vibration of bogies) and/or by the low-voltage power supply system of the wagon.

Sub-Task 8.2.3 Data collection, processing and communication

This activity significantly relates to the developments achieved by the other Shift2Rail projects IN2RAIL and IN2SMART.

The data sampling rate, data format and communication interface of the sensor system to be developed in Task 8.2 shall be compliant with the master system being developed in the mentioned projects.

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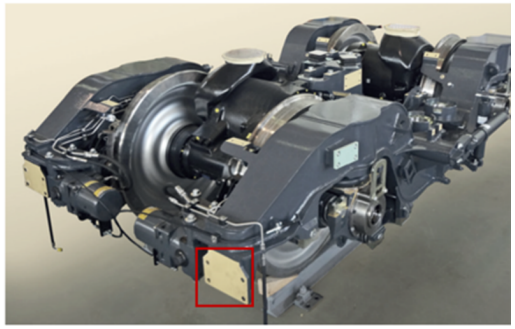
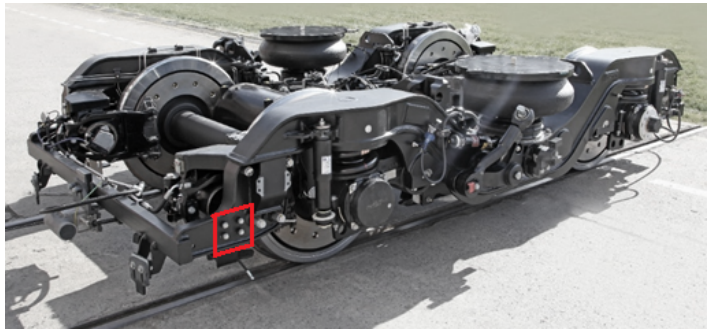
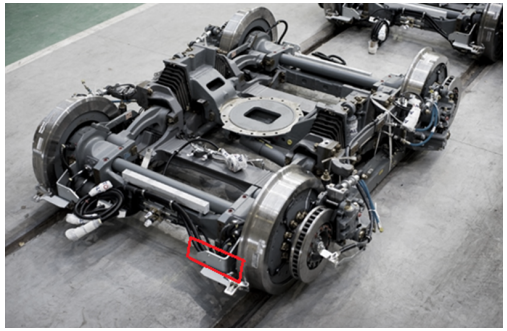
Sub-Task 8.2.4 Montage solution

The montage solution will include a connecting system between the main module (including the image monitoring system, the housing and the shock-vibration absorber) and the fixing point on the bogie and will be developed with the contribution of Trenitalia (FSI Railway Undertaking) especially regarding safety and interoperability issues.

This connecting system will consist of flanges, so that only changing their dimensions and shapes it will be possible to adapt the whole sensor system to different types of bogies.







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Challanges

1. How the resistance of the sensor system to environmental conditions can be assured? Do you think the pneumatic system (introducing an airflow into the housing) is adequate or can you suggest other systems?

2. Do you think that the sampling rate of 60 Hz is adequate for the sensor system or should be higher in order to be equal to that of the main track geometry monitoring system? *(e.g. at 200 km/h with a sampling rate of 60 Hz the distance between the measuring points is about 1 meter)*

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Challanges

3. Could you suggest technical solutions for shock and vibration adsorption?
4. Do you think that it could be useful to integrate the measurement performed by the sensor system with axle box acceleration (ABA) measurements? *(considering that measurement systems based only on accelerometers allow the detection of almost all the track geometric parameters except the lateral alignment)*

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Thank you for your attention!

For further questions please do not hesitate to contact the coordinator:

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