nav4you

CHARLI Projet - NAVISP

Introduction

Problematic

No solution for accurate location of first responders in complex environments

Technical & functional

- Limited accuracy and reliability in complex environments
- Loss of operating continuity
- Integration and interpretation on a map

Economic

- Technology costs

Sovereignty & Security

- Data control

CHARLI project (Challenging Areas Localisation services) aim to protect First Responders through an innovative foot mounted location device. Our solution apply real-time intelligence that saves lives and optimizes interventions indoor and outdoor.

The Team: nav4you

nav4you is a spin-off of the Geoloc laboratory of the Gustave Eiffel University. The company, created in 2021, is supported by Atlanpole, a regional incubator approved by the Ministry of Research and Innovation and esaBIC nord France.

esa BUSINESS INCUBATION CENTRE Nord France

ATLANPOLE Land of innovation

CTO

CEO

Scientific strategy

PhD

PhD

Engineer

Engineer

Developper

ANR

EUSPA

DGA

NIST

Challenge MALIN

Galileo masters France

France Relance

connect by cnes

Challenge FRST

Space Tour 2021

The Partner: Geoloc

Geolocation for the evolution of mobility

Methods and systems for ubiquitous localization

Evaluation and definition of localization performance

Université Gustave Eiffel

Organization of an Int. conference (IPIN 2018)

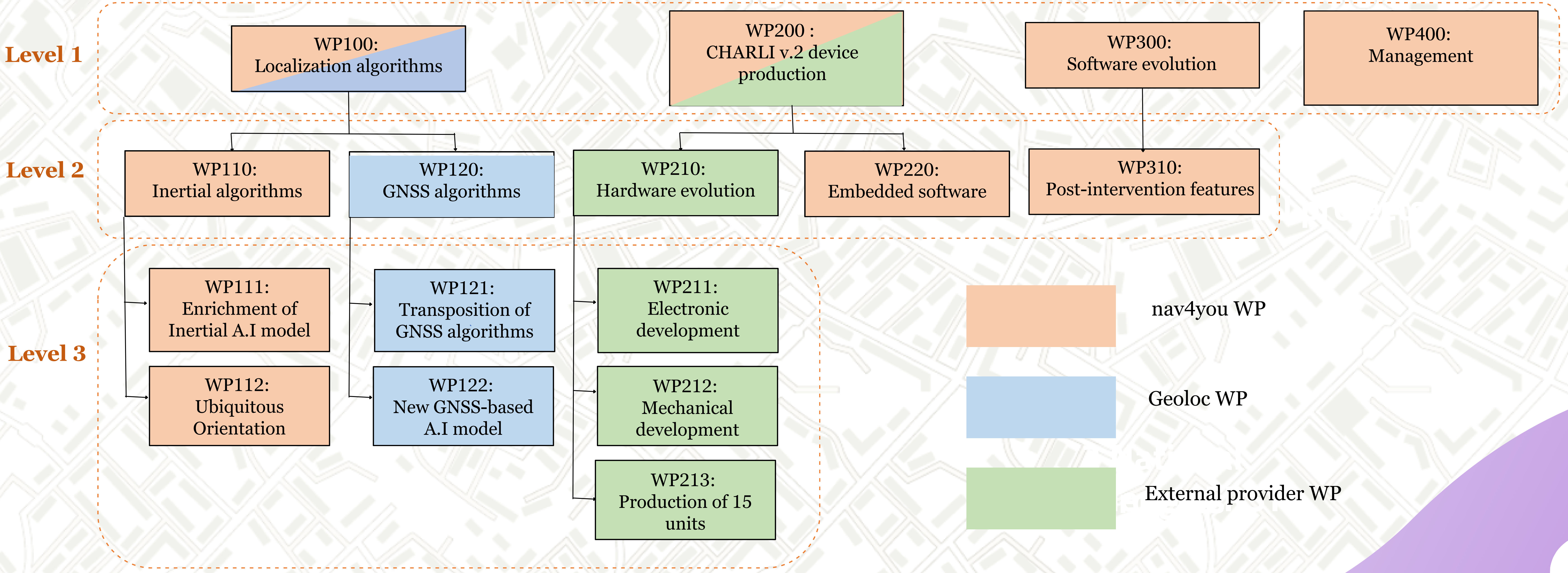
3 Regional projects

5 EU projects

2 National projects

8 international Conferences invitations

Project structure

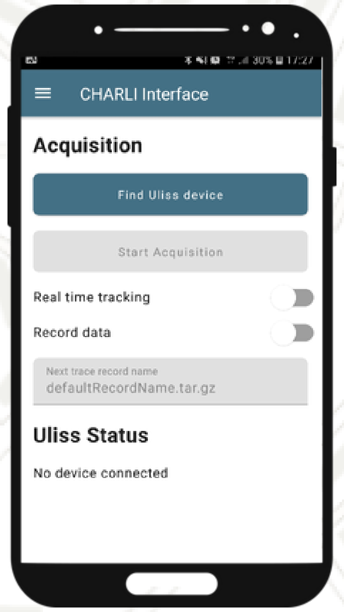


Initial state

Foot-mounted Localization device

Inertial, GNSS and magnetic sensors

Real-time processing



Android control App

Real-time display

record data

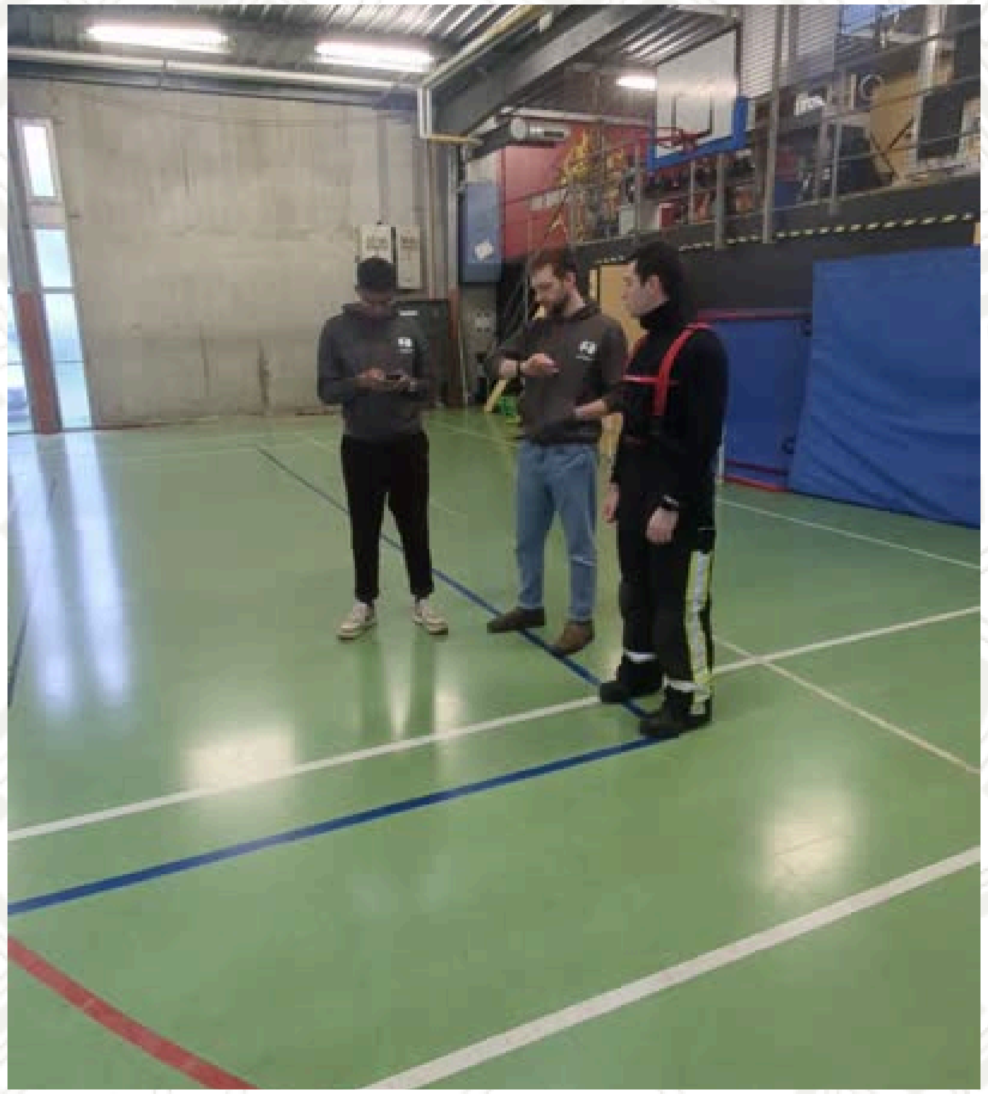
start/stop recording

Algorithms development

A.I Step detection

Objective:

GEOLOC Lab developed an HGB model to detect Zero velocity UPdaTes (ZUPT) but : too slow for realtime applications, only wlaking, and running learned.

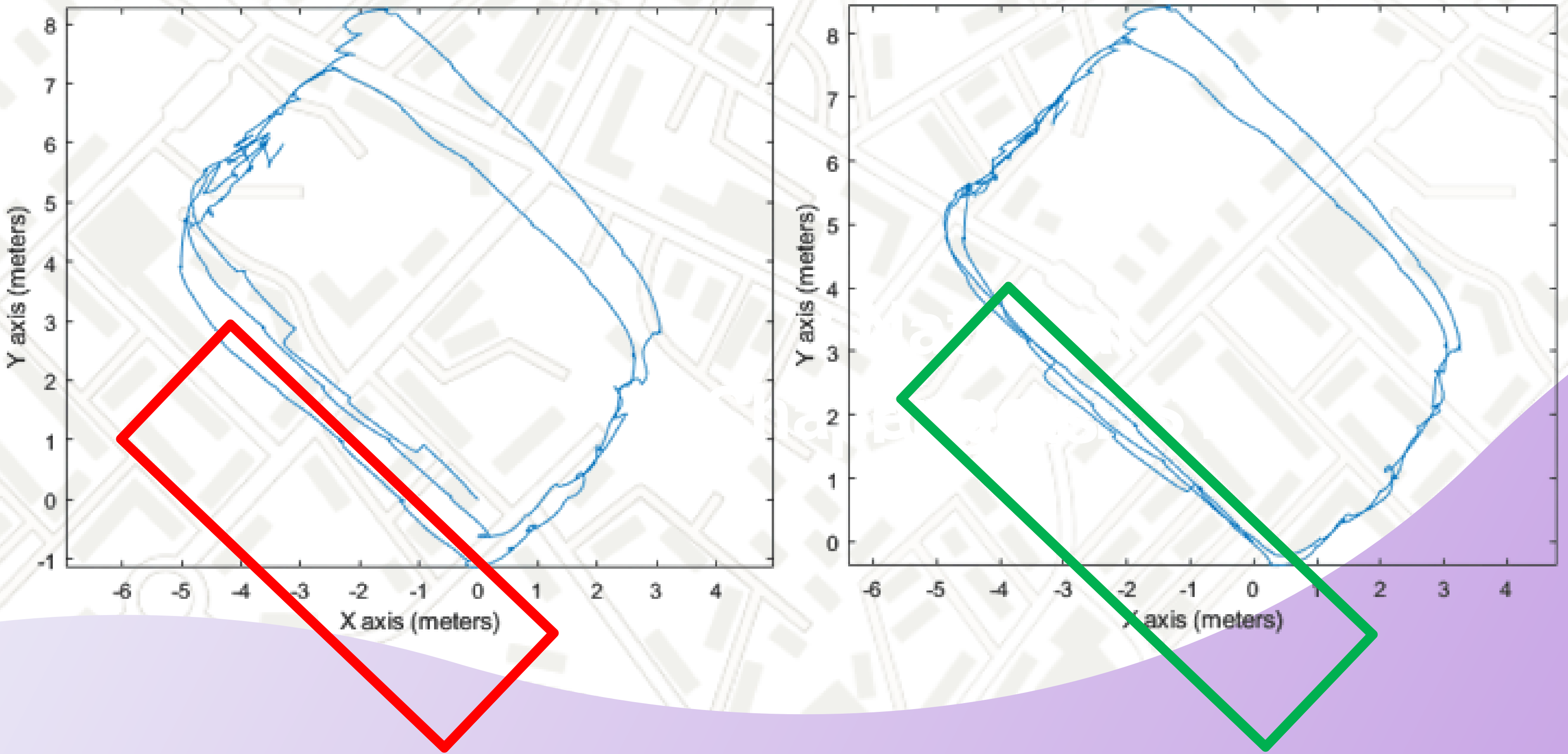


Use of Light Gradient Boosting Machine (LGBM)

Same performances but 10 times faster

Addition of new movement specific to firefighters ()

Ramp, scouting, knees...



Ubiquitous initialization

Objective:

Enable orientation to be initialised indoors. The current method is based on accelerometer data during static phase to estimate roll and pitch and earth magnetic field to estimate yaw, so it works only without magnetic disturbance

- **Gyrocompassing:** requires a high-grade gyroscope to measure earth's rotation rate
- **2 poses maytagging implemented**:
  Use of static measurements in horizontal plane taken 180° apart to eliminate gyroscope bias thanks to a dedicated attachment system with 90° rotations

Static phases duration	10s	100s	600s
Mean yaw error	21.1°	7.3°	3.2°

Insufficient performance (100s required)

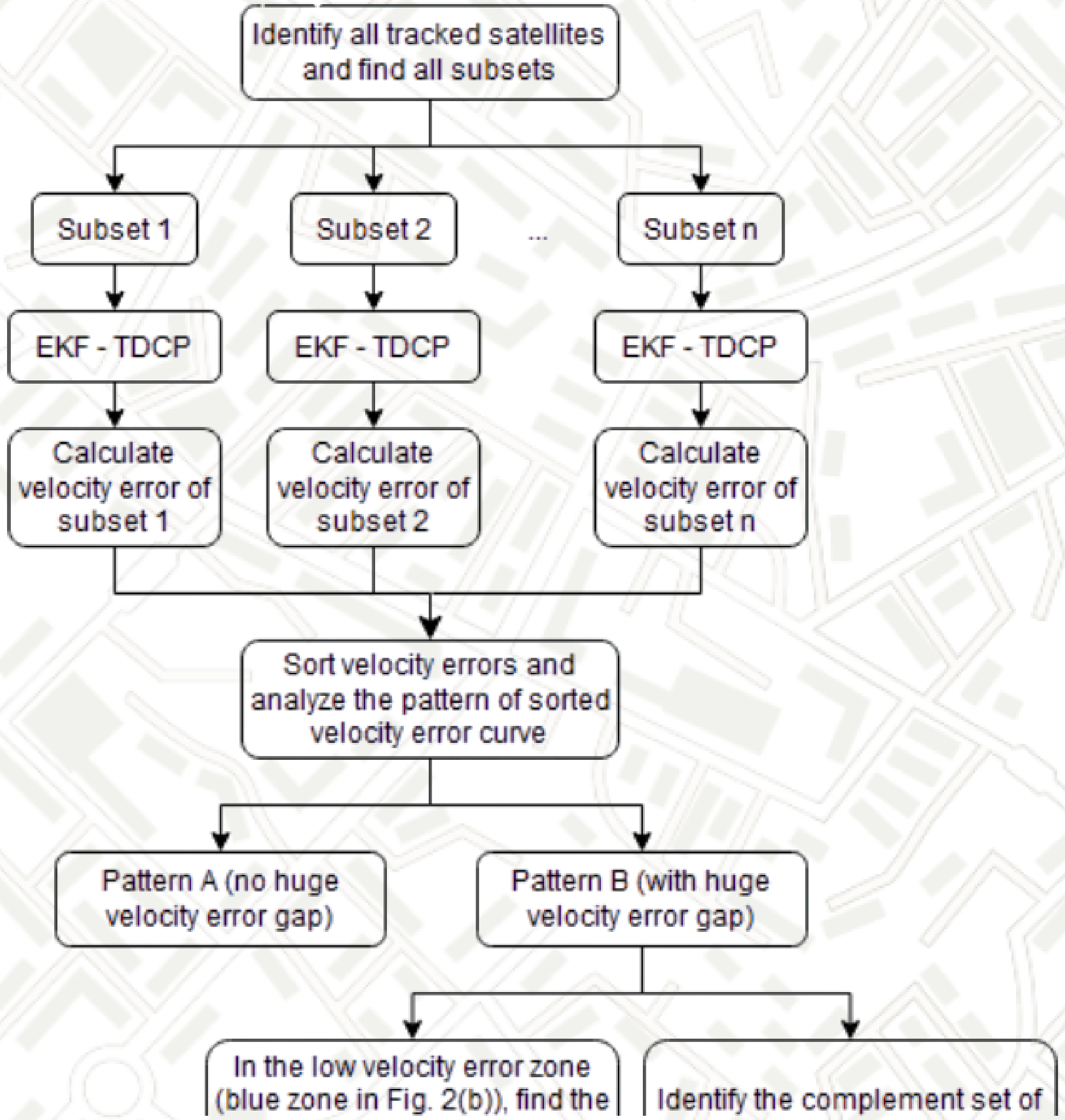
Probable causes : projection to horizontal plane and calibration

- **Manual correction**
  Allow user to adjust orientation manually and dynamically during the intervention.
  This option was tested and approved by partner Fire Department.

Transposition of GNSS algorithm

Objective:

Adapt a patented code based on estimating velocity from phase measurements, even degraded, for use in real time



Conversion from matlab post-processing to python in real time

- Adaptation of the code to run in iterations, without block calculations on all the data
- Modification of sliding windows to avoid using future data

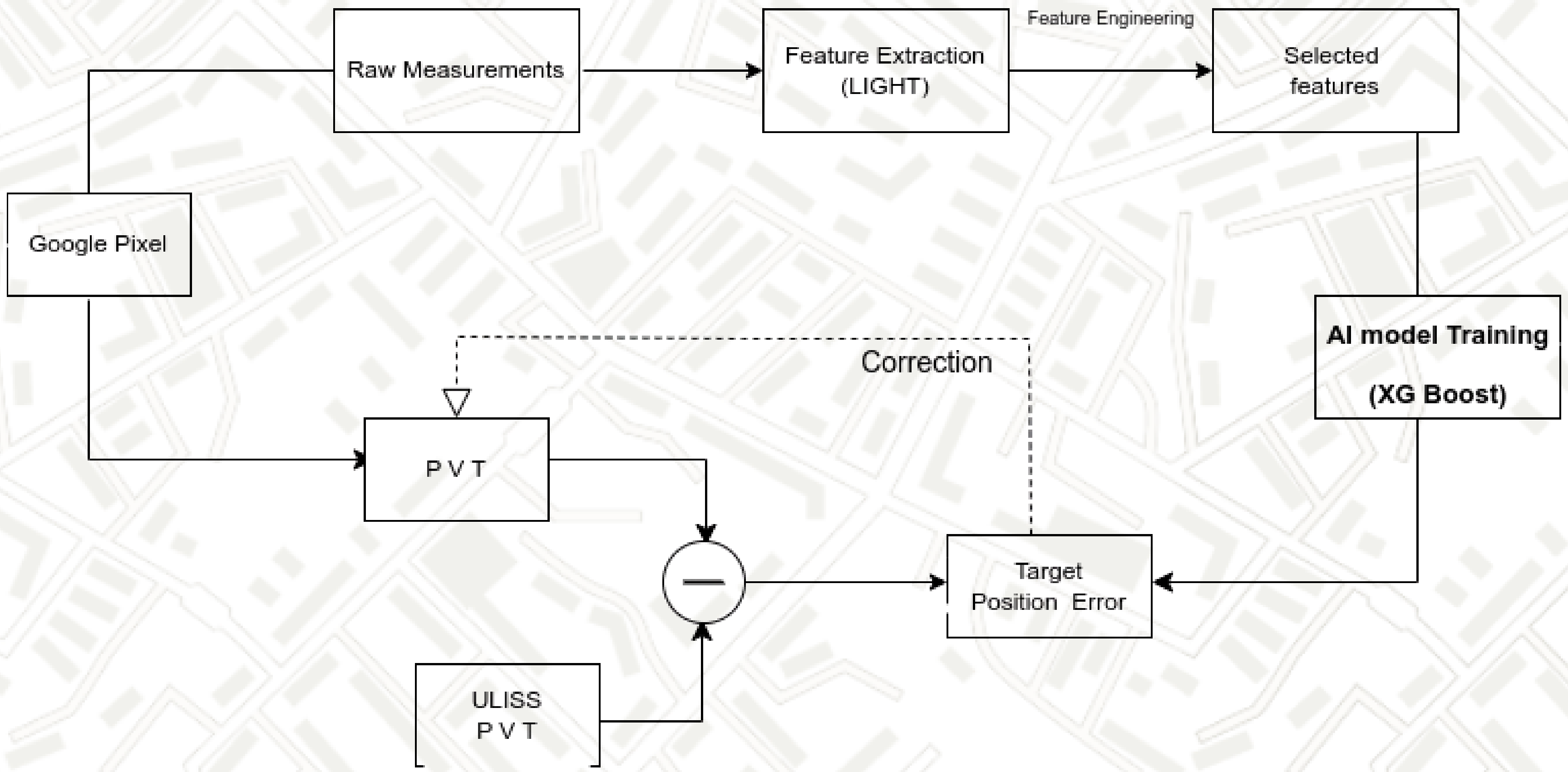
Mean for 3 DataSet	MATLAB	Python
Data retrieval	51.63s	1.67s
Maximum Time taken in TDCP update	0.035s	0.041s
Minimum Time taken in TDCP update	0.004s	0.008s
Mean Time taken in TDCP update	0.005s	0.012s
Standard deviation Time while performing TDCP update	0.002s	0.002s
Total Time taken for computation for 3804 epochs	71.31s	46.56s

Li, Z., Zhu, N., & Renaudin, V. (2023, September)

New A.I GNSS model

Objective:

develop a machine learning (ML) based model to enhance the positional accuracy of the device developed by nav4you



Development of a new GNSS based AI model to estimate position error

- Use of smartphone data and Ublox F9P as reference
- 27 dataset in urban environments
- XGBoost used with hyperparameter tuning via Optuna

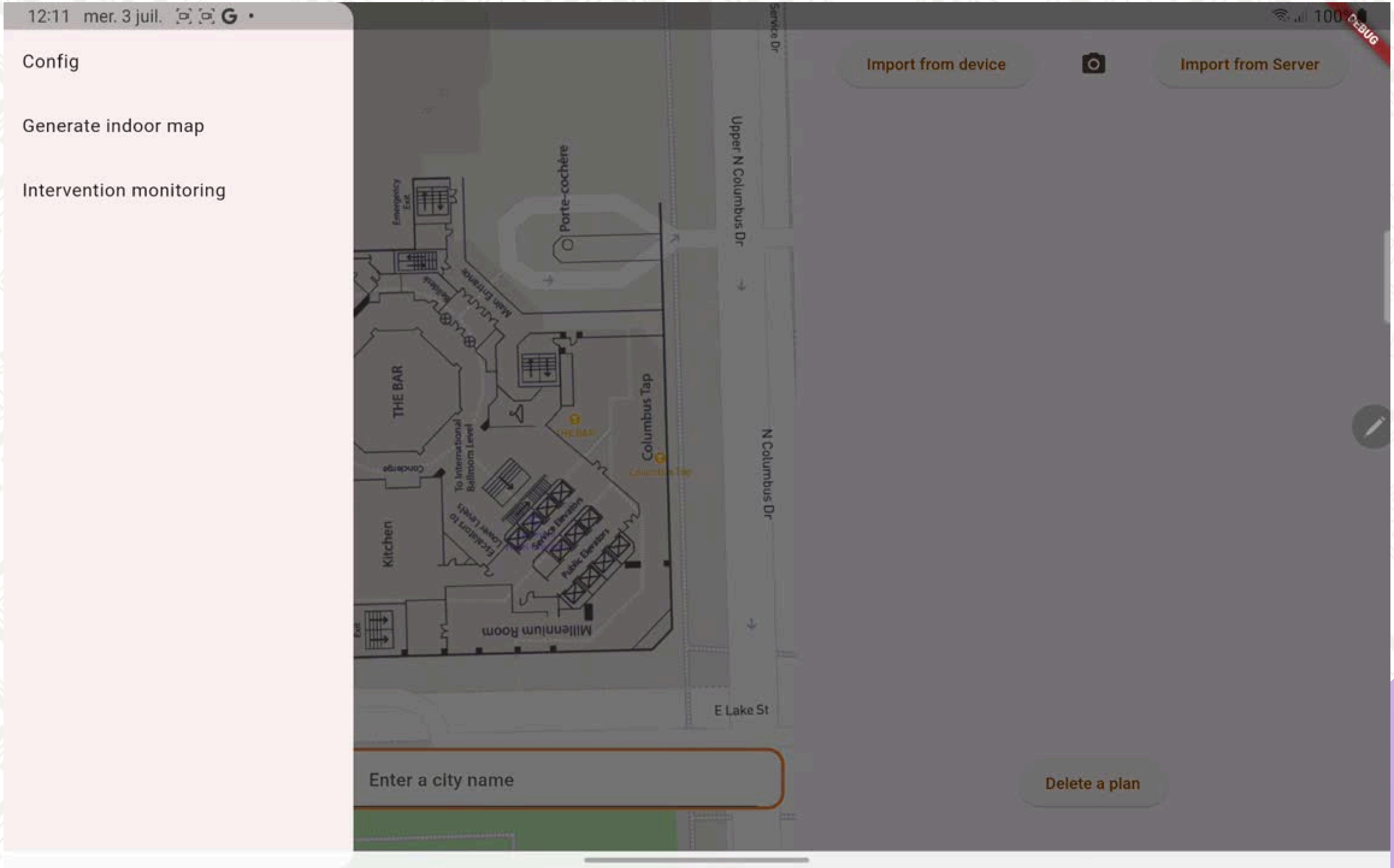
Weak correlations between variables and errors in some cases

Trajectories not significantly improved by the model

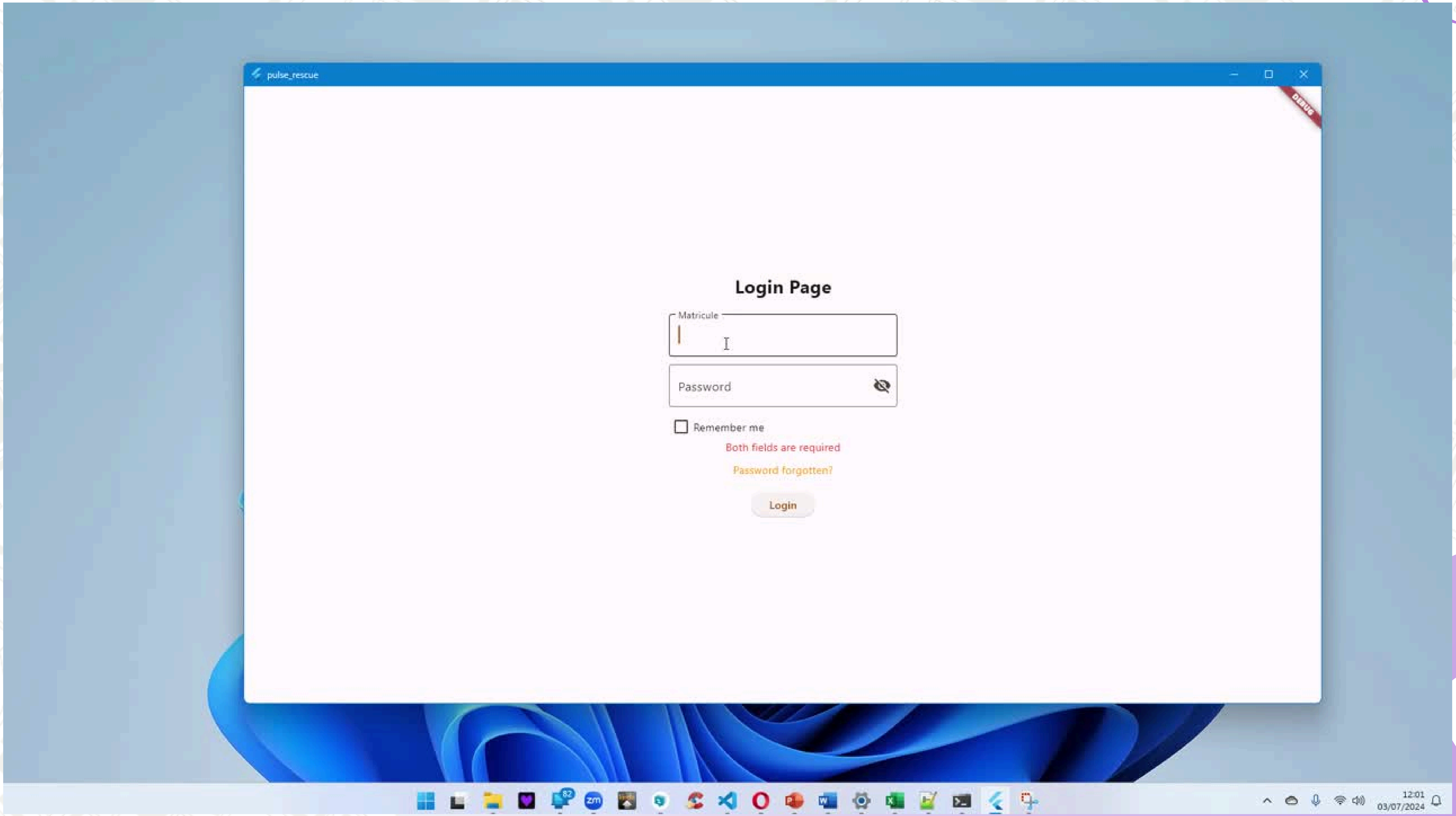
Li, Z., Zhu, N., & Renaudin, V. (2023, September)

Software development

Importation of indoor map



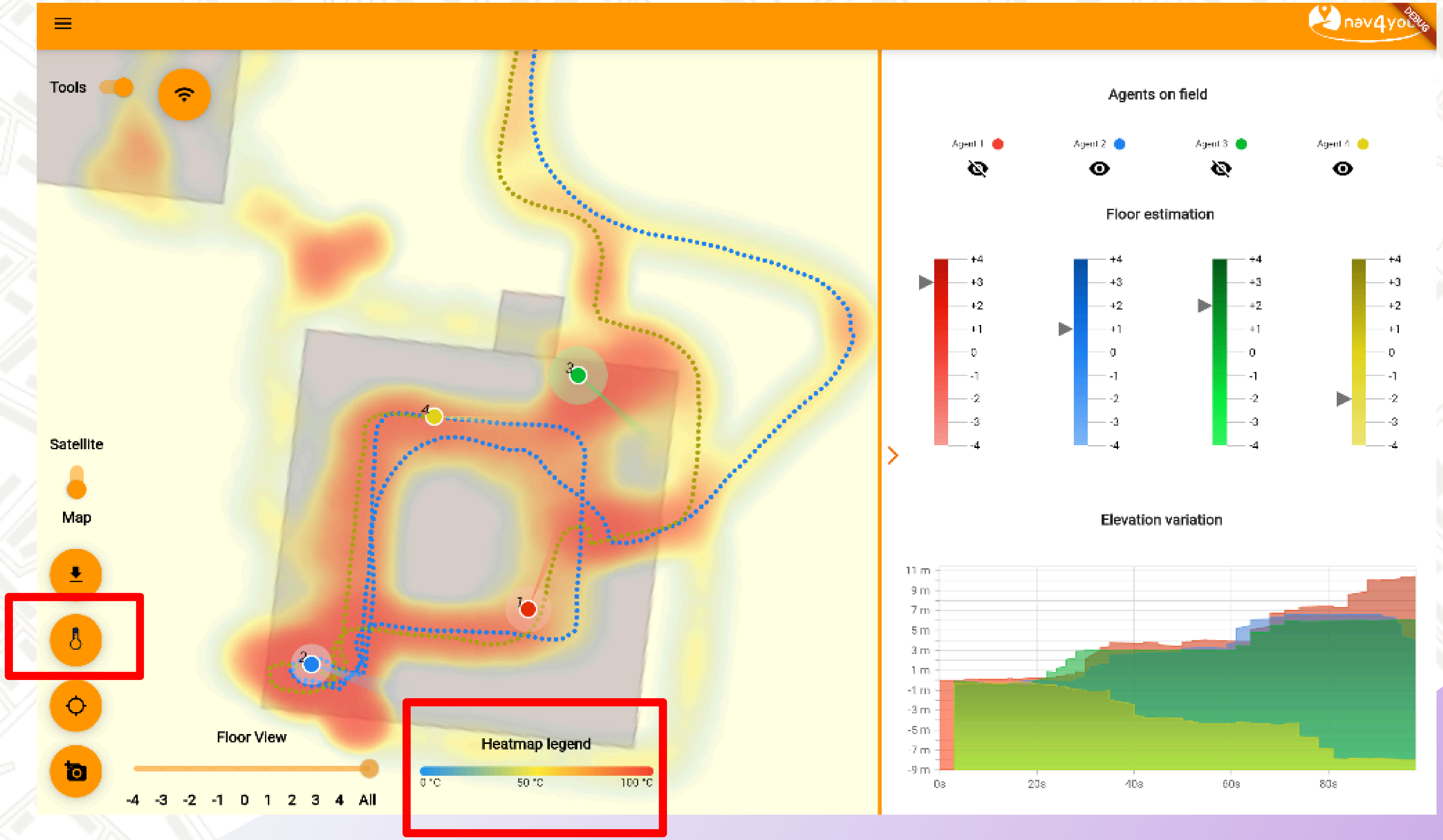
Post intervention software



Integration of temperature heatmap

Objective:

Take advantage of temperature measurement by our device to draw up a heat map in real time and identify the hottest areas and accessible passages



Hardware development

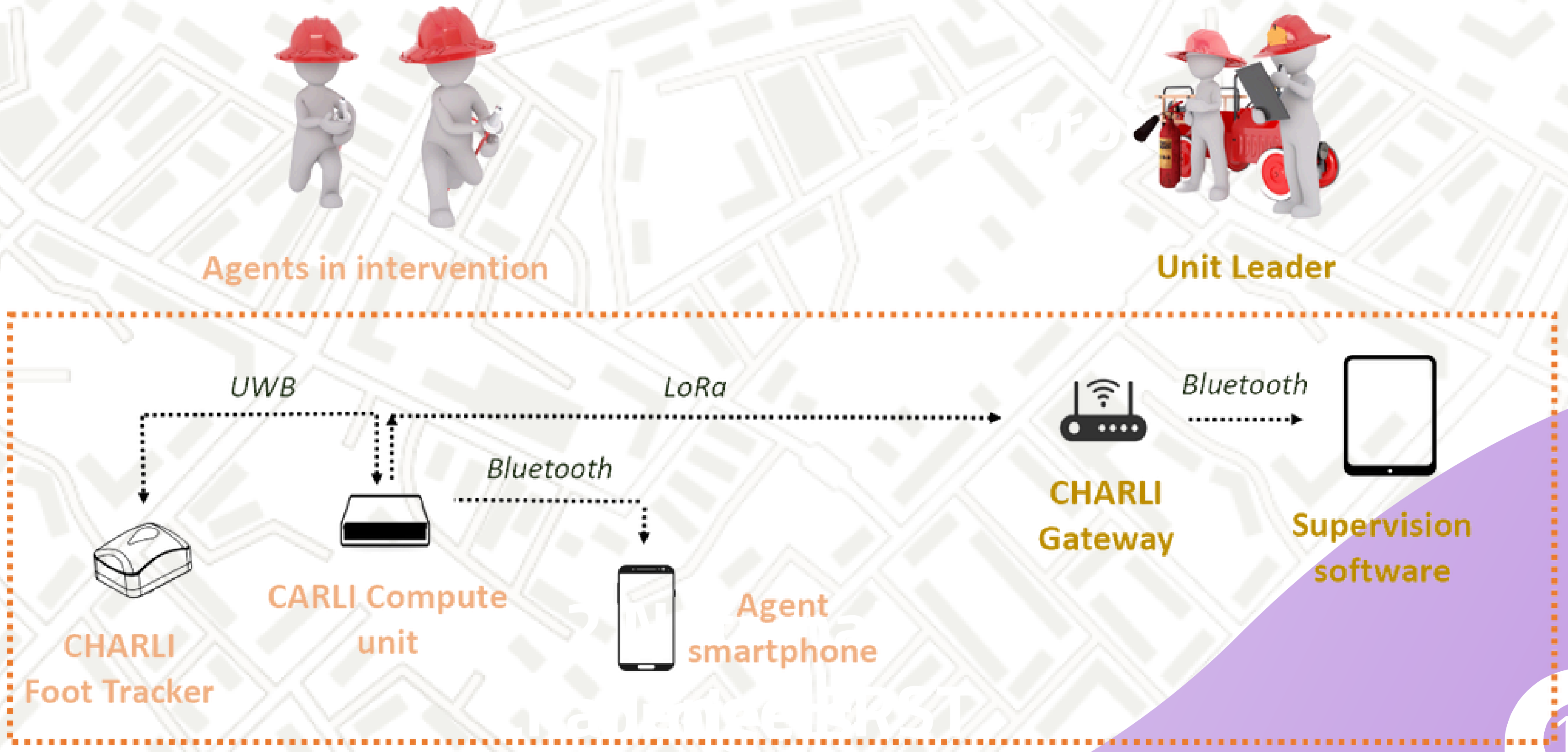
Initial objectives

Objective:

New design with smaller foot mounted device and remote management

First prototype

Targeted architecture



First solution

CHARLI Foot Device

- IMU
- Barometer
- Magnetometer
- 70% volume reduction
- 10h autonomy

CHARLI Compute Device

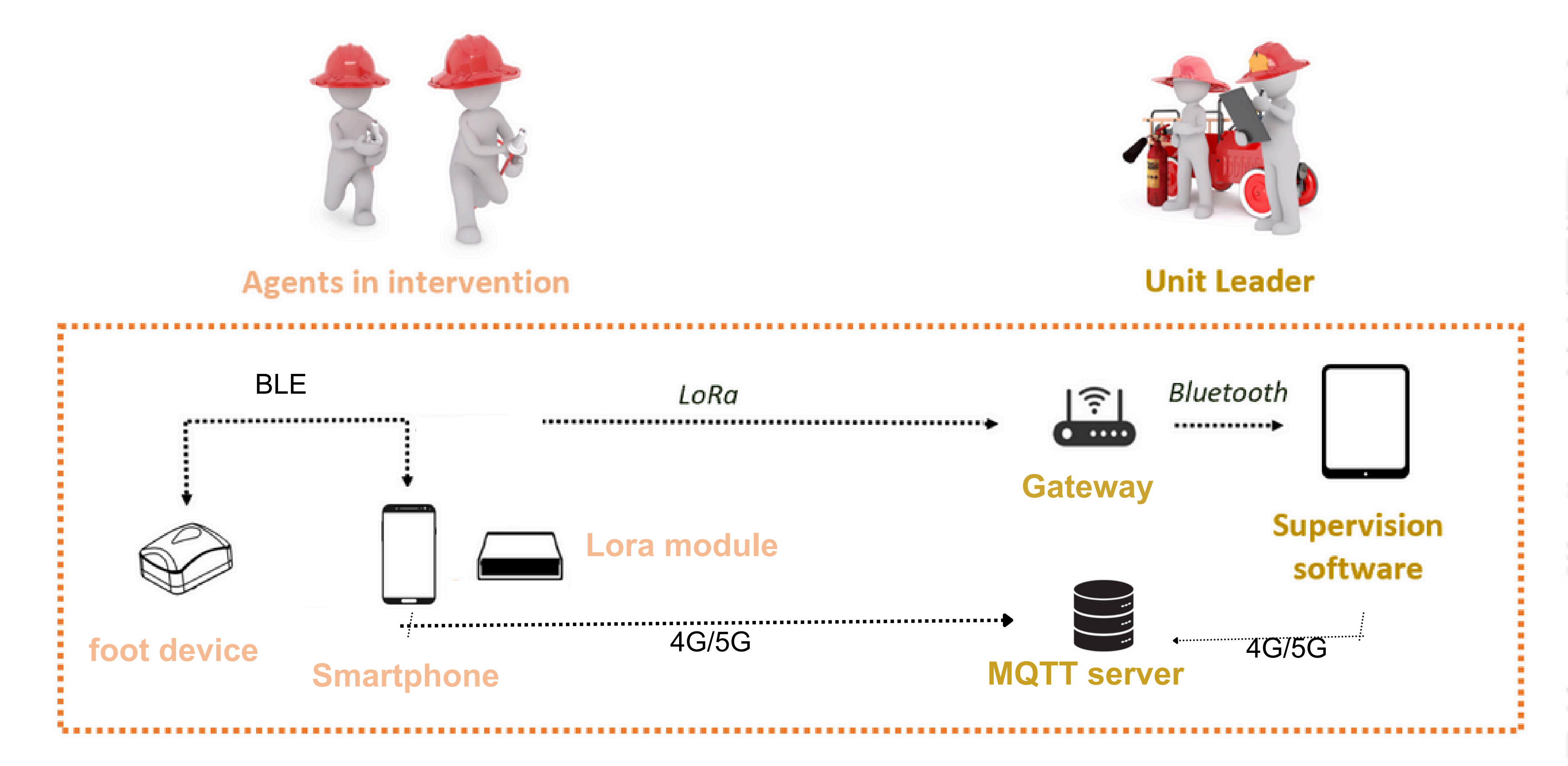
- GNSS receiver
- Lora/Bluetooth/Wi-Fi
- Off-the-shelf USB docking station

CHARLI Gateway

- Off-the-shelf Lora Gateway

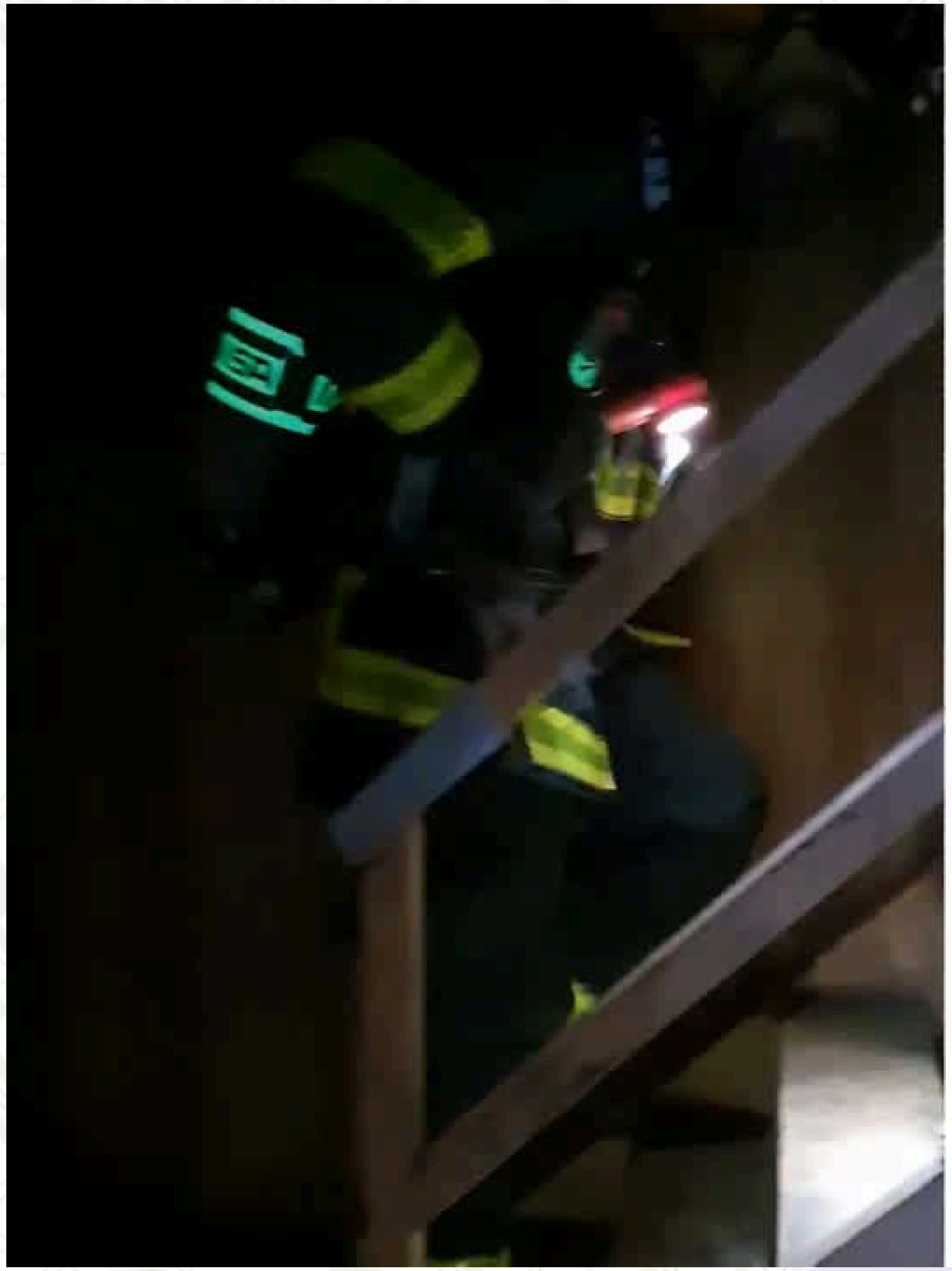
Final solution

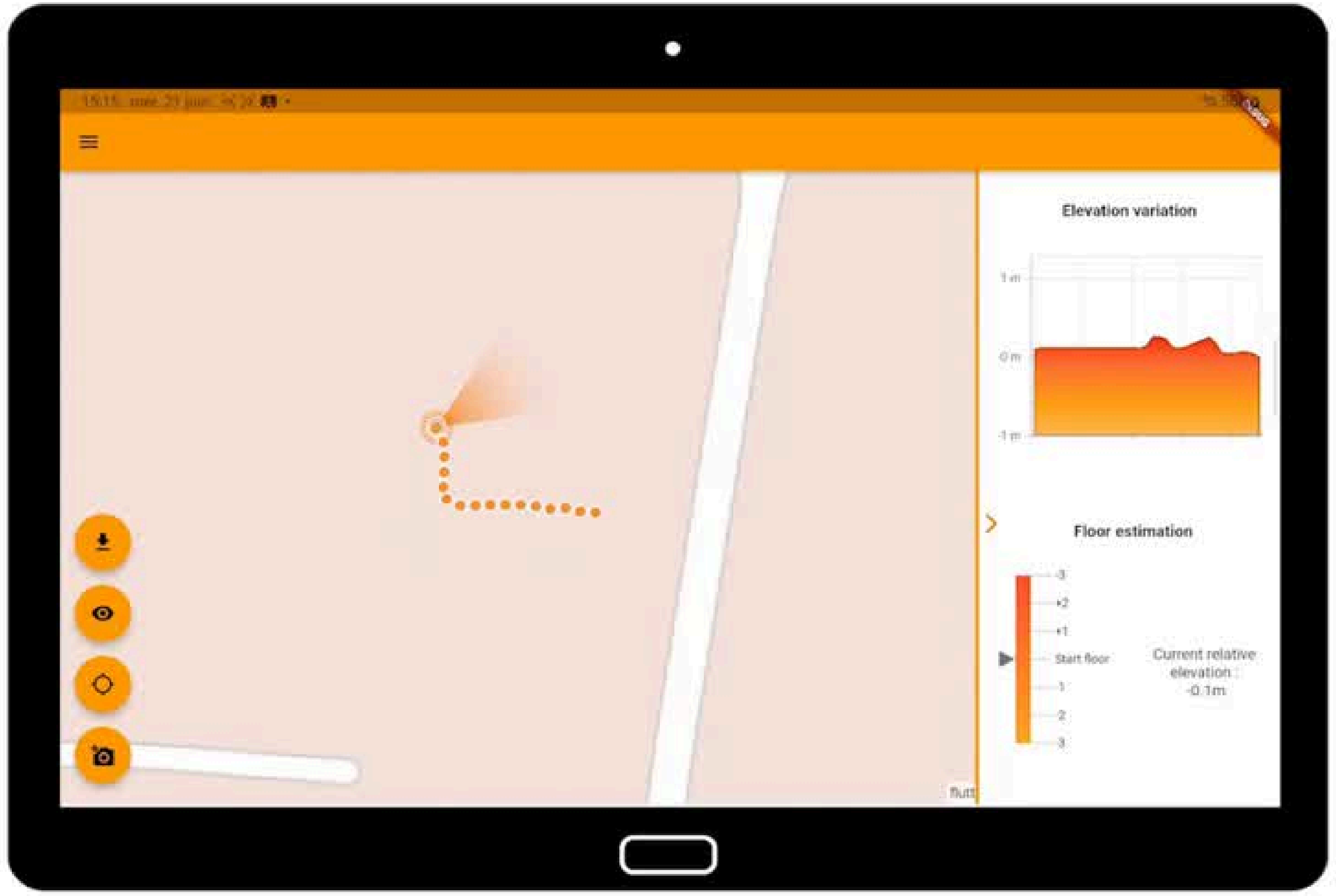
Final architecture



Experimentations and validation

Experimentations





Experimentations

Performances

Objective:

Confirm the functioning of the new hardware under realistic conditions and validate the algorithmic performance

Methodology

- Real-time experiments were conducted on a 2 km path combining indoor and outdoor sections
- The test included realistic firefighter movements: lateral steps, U-turns, crawling, duck walking, window crossing, etc.
- Results were compared with those from the initial project algorithms (T0) to measure improvements

Conclusions

- T0 algorithms results (1,7%) below targeted performance (1%)
- Final algorithms reduce error from 26m to 10m / from 1,7 to 0,8%
- Endpoint error dropped significantly from 90 m to 25 m, thanks to GNSS updates during outdoor segments.
- Plot consistency greatly improved, due to magnetometer new update.
- Better handling of complex field movements thanks to new AI model

Conclusion

Conclusion

Bilan

- **Main objective achieved:** Design and validation of a complete real-time location system, without infrastructure, for first responders in challenging environments.
- **Successful integration of technologies:** Inertial, magnetic, and GNSS, coupled with advanced filters and contextual maps, for accuracy and robustness in real-world conditions.
- **Modular approach**: Flexible hardware and software architecture, designed for a variety of use cases

Key Takeaways & Outlook

- **Adaptability and resilience:** Proactive management of material difficulties, GNSS algorithm delays, and production contingencies Strategic transition to a smartphone computer to reduce costs and simplify the software ecosystem
- **Performance despite delays:** Overall delay of 8 months, but all critical components delivered and validated
- **Next steps:** Transition to the commercialization phase, Preparation for production ramp-up and large-scale deployment.

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Thank you!

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