1st International Conference

NEW ADVANCED GNSS AND 3D SPATIAL TECHNIQUES
APPLICATIONS to CIVIL and ENVIRONMENTAL ENGINEERING, GEOPHYSICS, ARCHITECTURE, ARCHEOLOGY and CULTURAL HERITAGE

In memory of Professor Giorgio Manzoni

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Main Conference Room - H3 Building
University of Trieste
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SPARTACUS

POSITIONING SOLUTIONS FOR CRITICAL ASSET TRACKING AND CRISIS MANAGEMENT

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Outline:

- Introduction to SPARTACUS
- Tracking applications:
  - Transport (TR)
  - Relief Goods Distribution (RGD)
  - First Responders tracking & guidance
- Two steps positioning approach (TR and RGD):
  - Low level
  - Upper level
- Numerical simulations
- Preliminary Fisrt Responders field test
- SPARTACUS answer & innovation

Introduction to SPARTACUS

Partners

Large Enterprises:

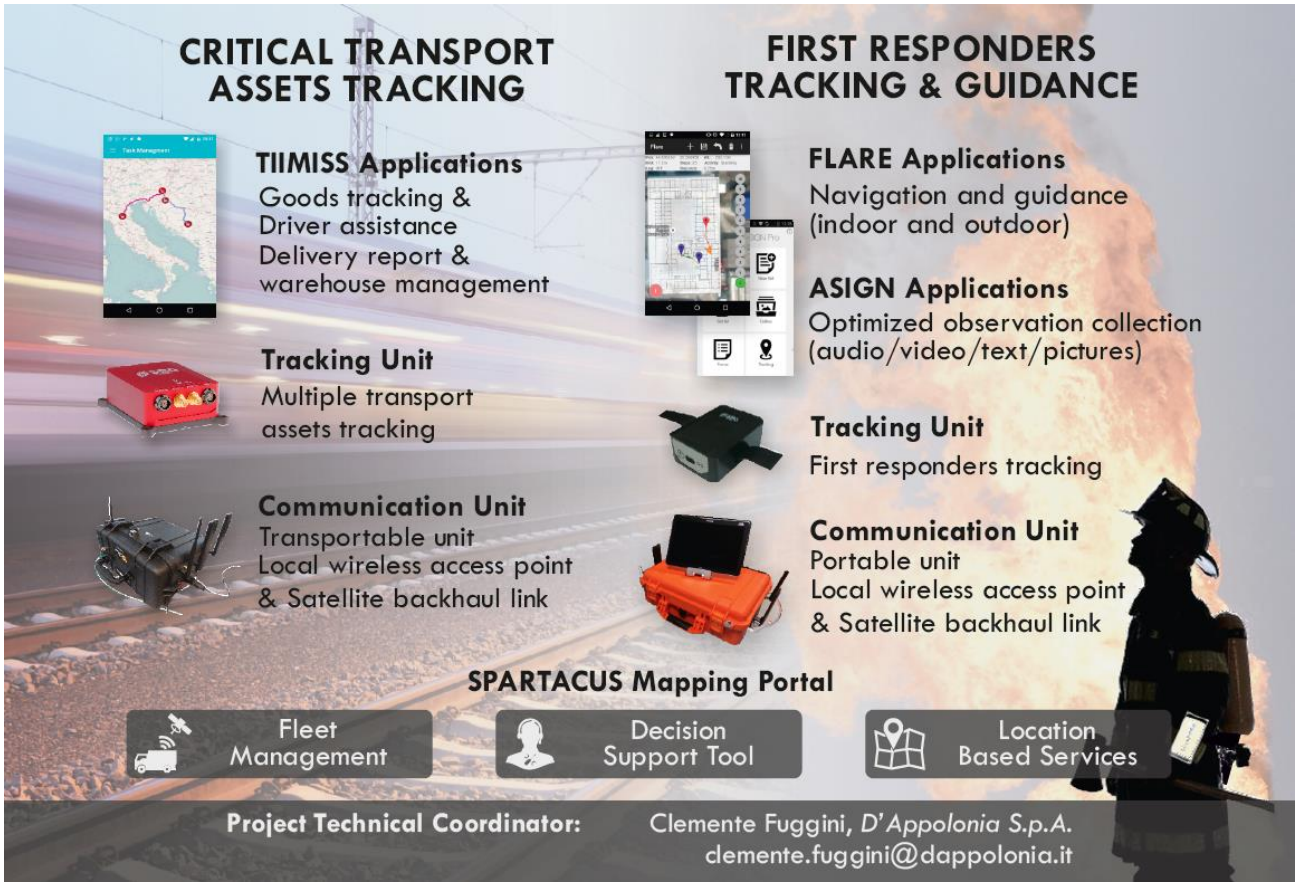
- D'Appolonia S.p.A.
- Romanian Railway Authority
- TriaGnoSys GmbH

Small to Medium Enterprises:

- DMAT Consulting KG
- AnsuR Technologies
- GlobalGPS BH
- SBG systems SAS

Research and Academic:

- University of Pavia
- University of Bologna
- Newcastle University
- Institute Mihajlo Pupin
- Johanniter-Unfall-Hilfe e.V.



Tracking applications

Three main fields of application

1. **Transport:** tracking freight trains and containers (i.e. dangerous transports);
2. **Relief Goods Distribution:** tracking of trucks and containers (i.e. during civil protection missions);
3. **First Responders:** outdoor & indoor tracking of pedestrian first responders (i.e. management of firebrigade and sanitary personell teams).

Stakeholders requirement for positioning precision:

±3m in open sky conditions; ±10m after 60s GNSS outage.

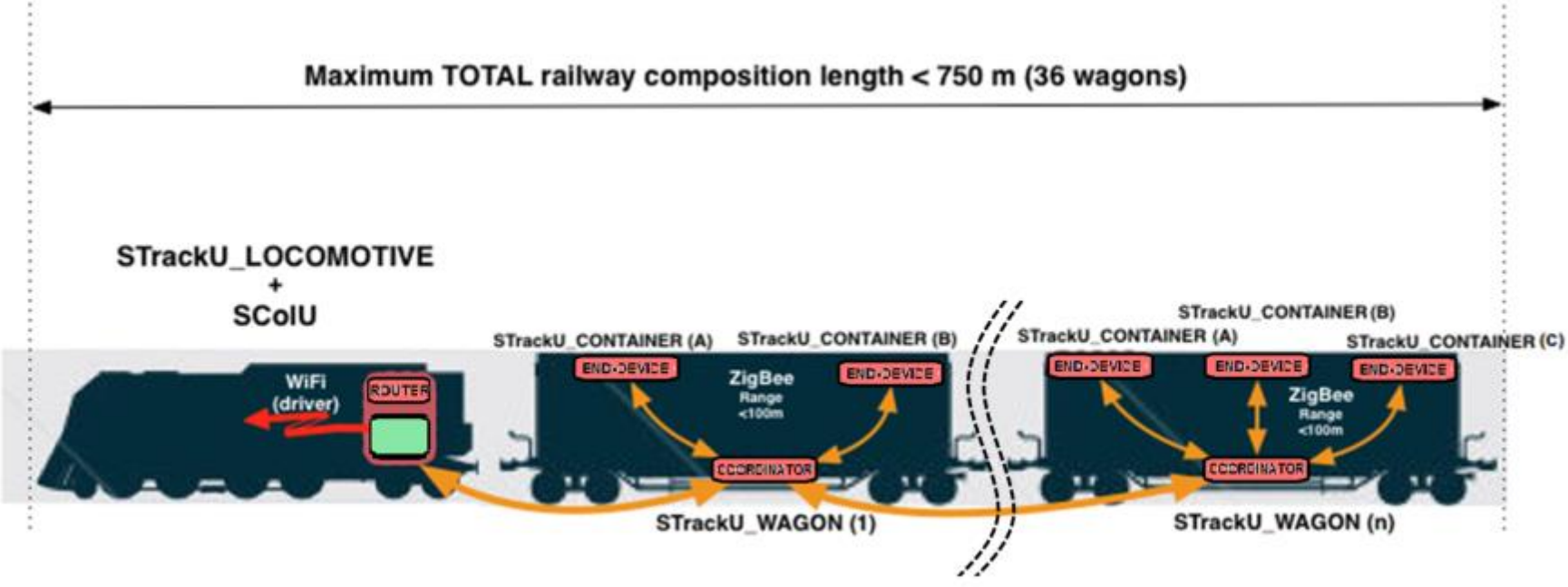
Tracking applications

Main HW devices shared by all the applications

- **STrackU:** Spartacus Tracking Unit (GNSS/INS Sensor&data)
- **SColU/SFU:** Spartacus Collecting Unit or Smart Field Unit (data fusion)
- **SComU:** Spartacus Communication Unit (radio link)

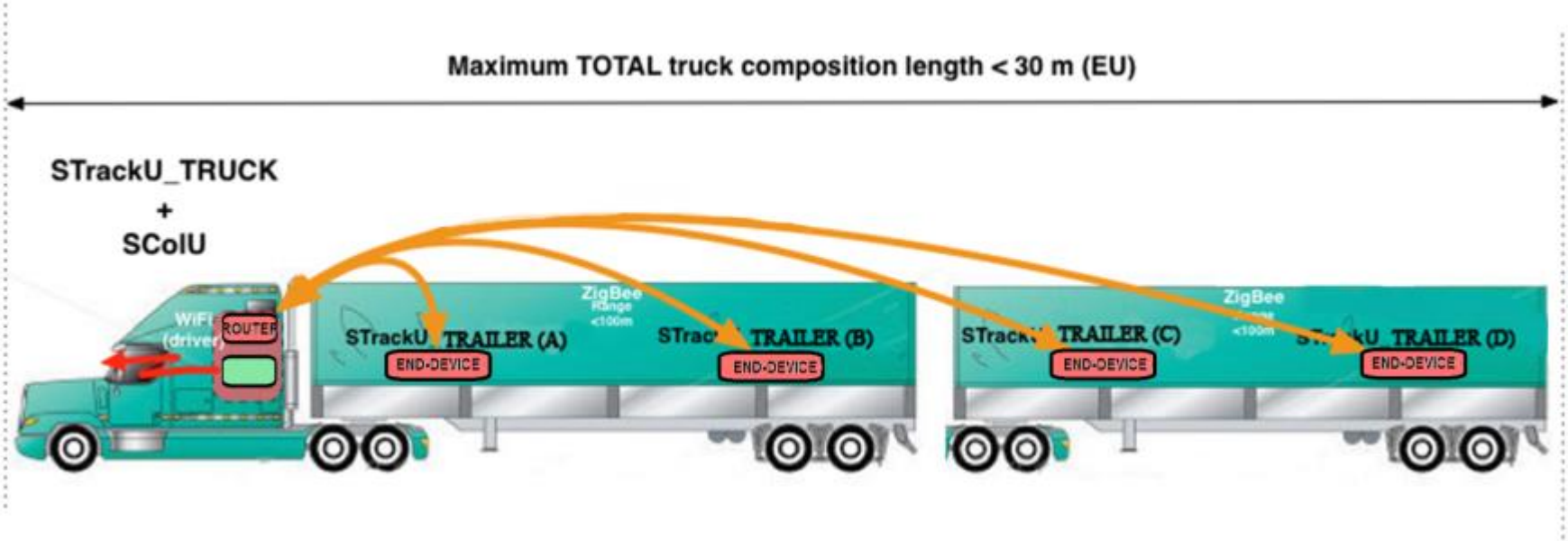
Transport

- RED = STrackU
- GREEN = SColU



Relief Goods Distribution

- RED = STrackU
- GREEN = SColU

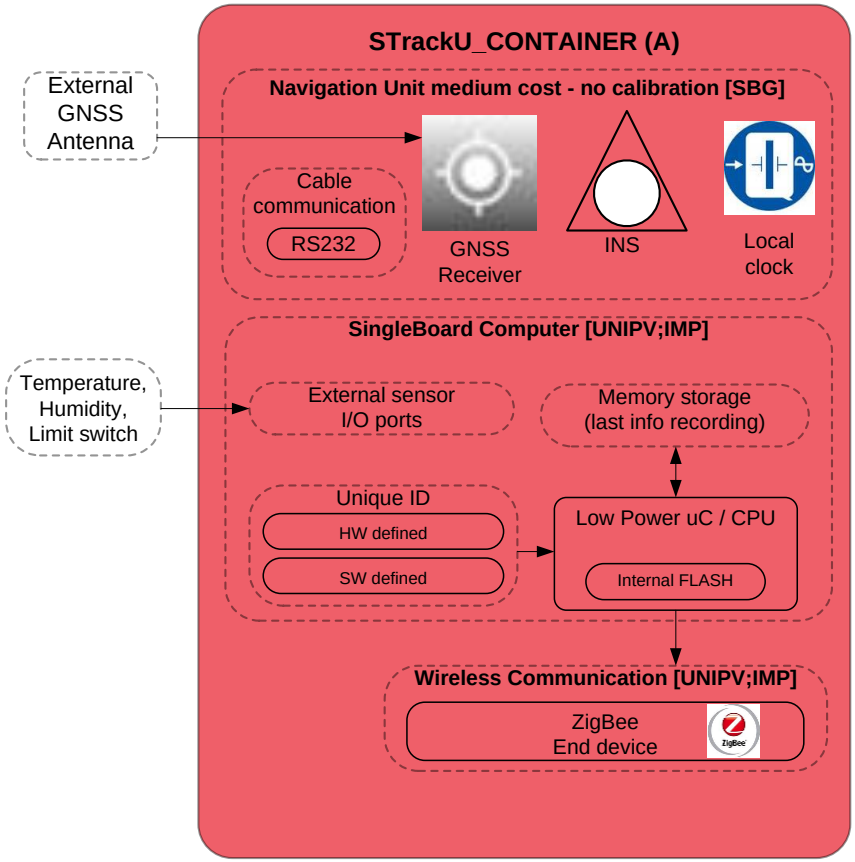


First Responders

- RED = STrackU
- GREEN = SFU

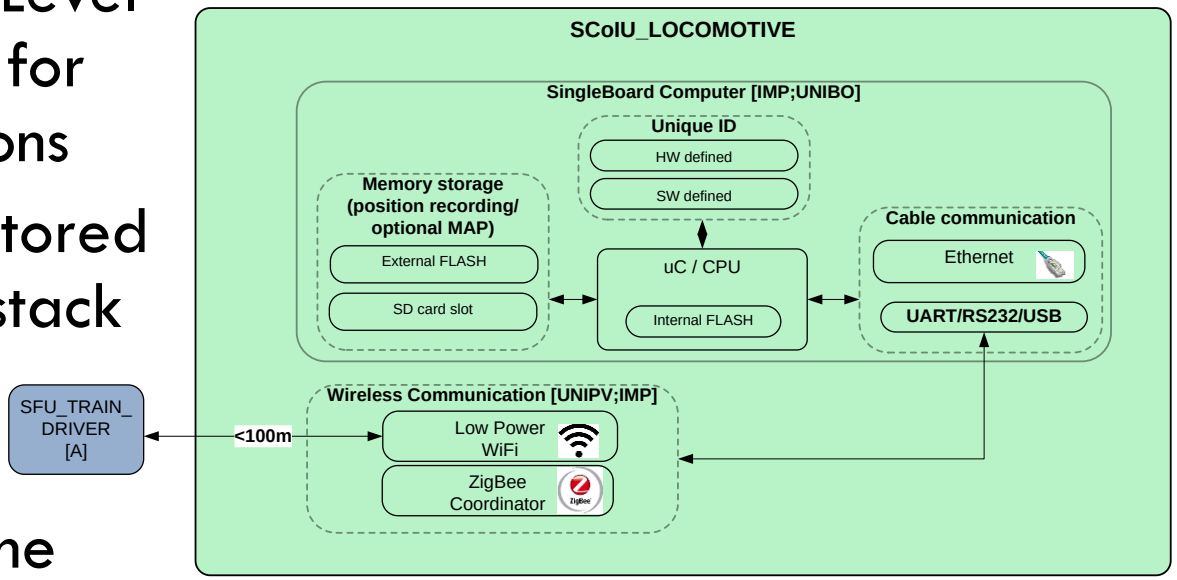
STrackU HW

- Performs Low-Level positioning functions for containers, wagons and locomotive
- All information are stored internally in a LIFO stack together with ID
- Temperature, humidity sensors and limit switch are foreseen as future option

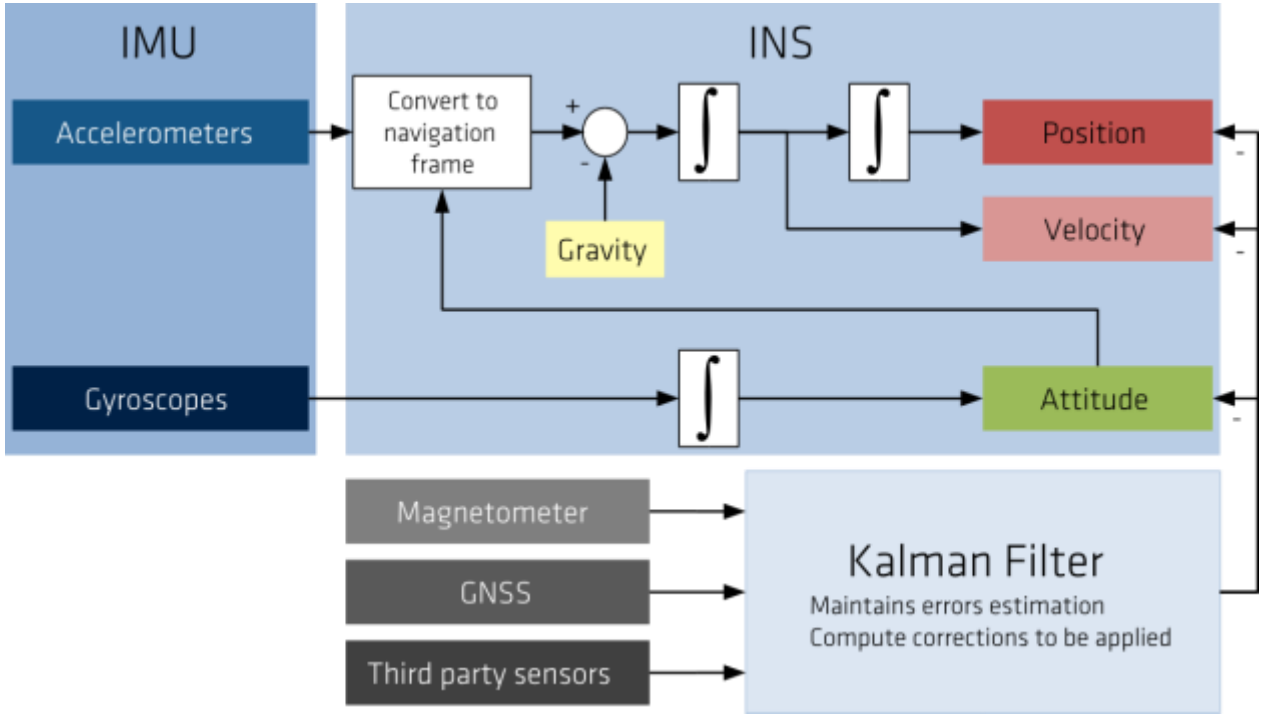


SCoIU HW

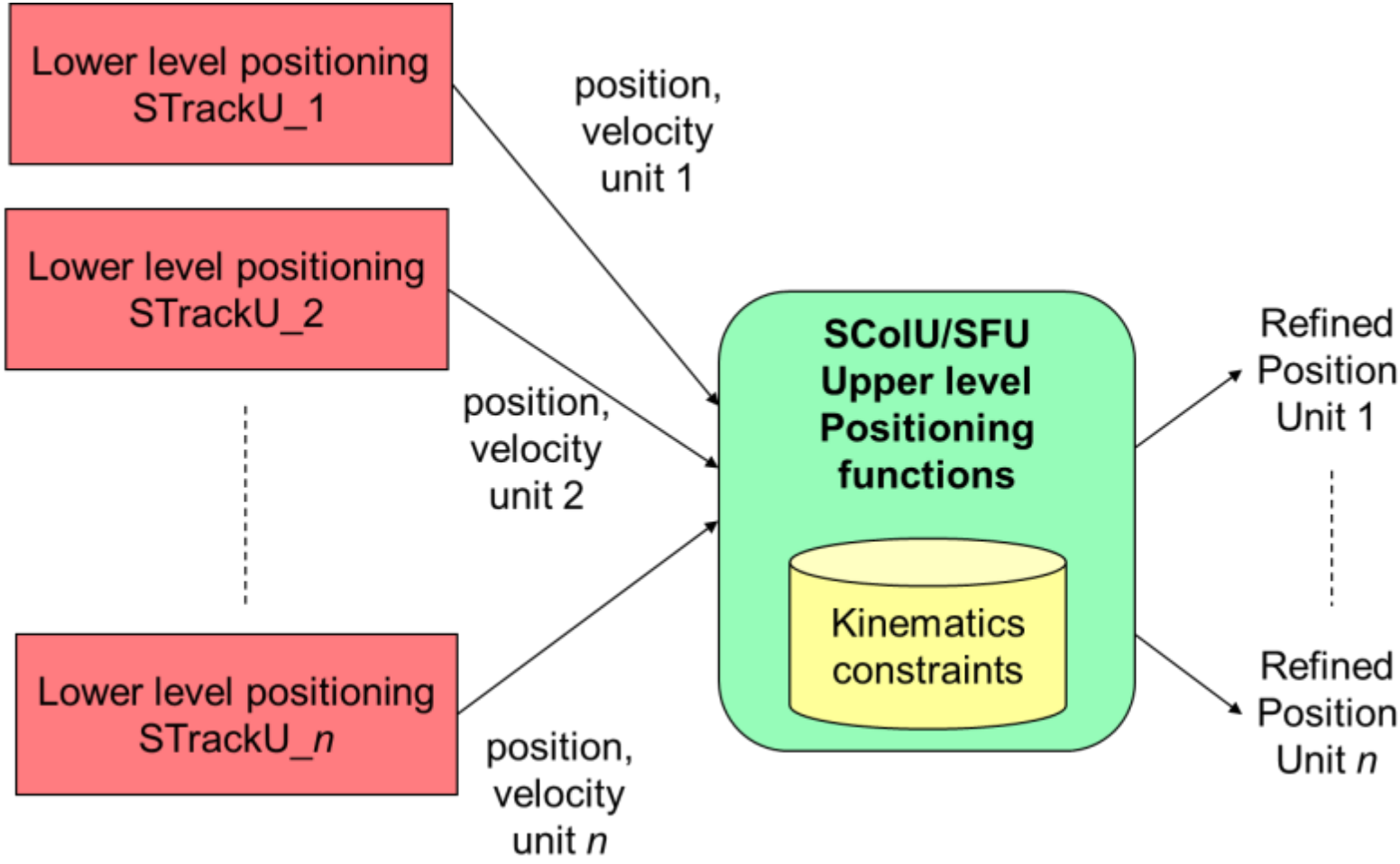
- Performs the Upper-Level positioning functions for containers and wagons
- All information are stored internally in a LIFO stack together with ID
- Gives a real time monitoring data to the SComU and the train driver



Extended Kalman Filter implementation



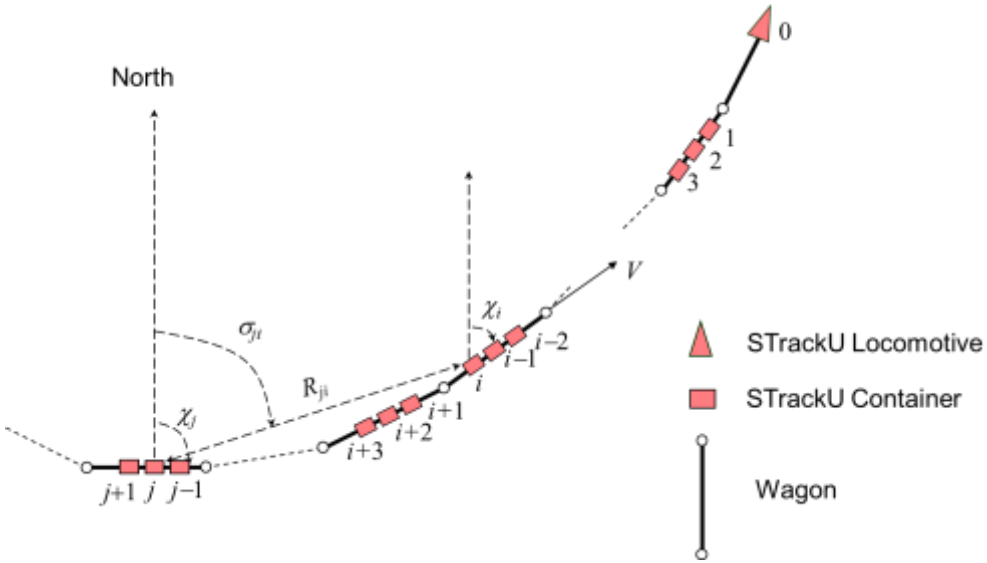
SCoIU SW Upper-Level algorithms



SColU data fusion filter model

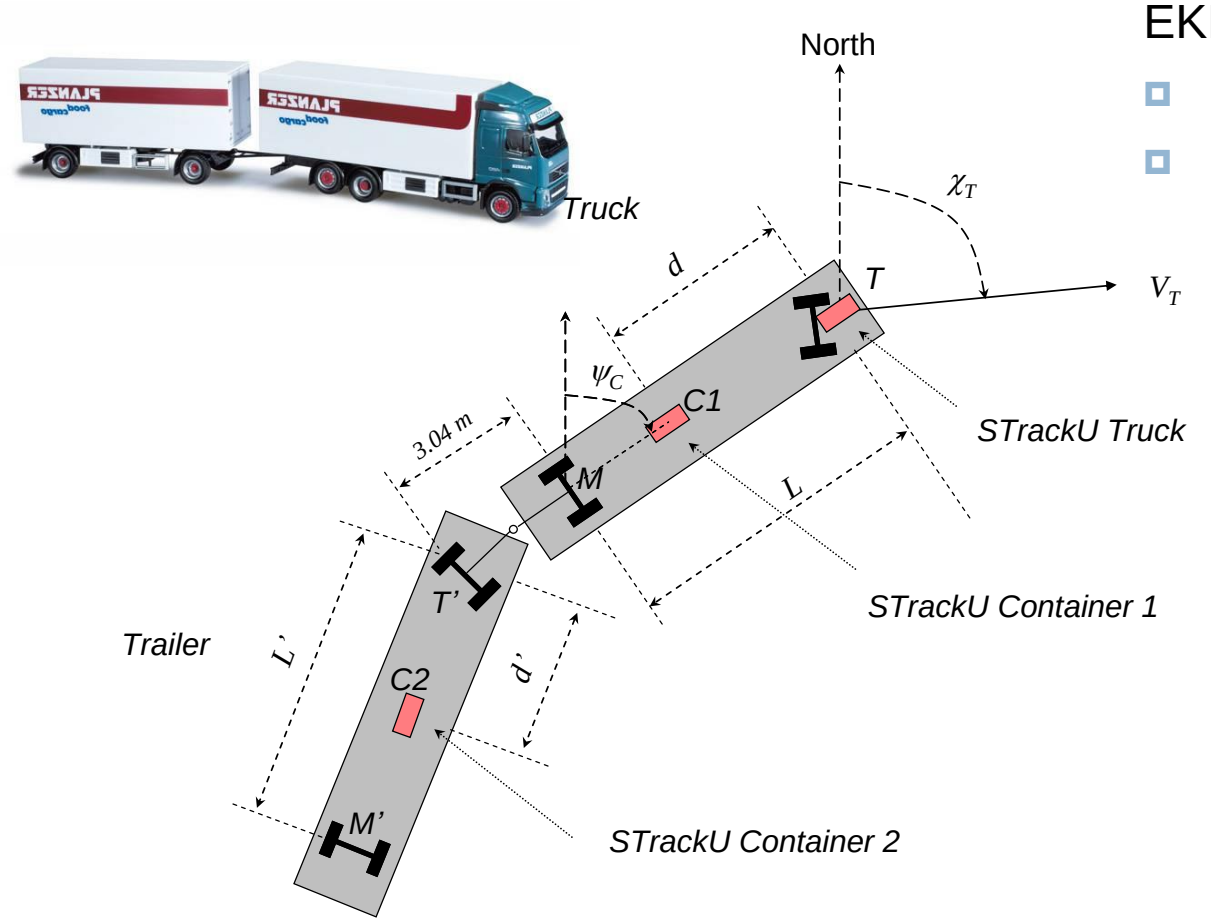
EKF filter kinematic constraints:

- relative distance
- relative velocity
- aligned velocity and heading
- radius of curvature of railway



$$
\begin{cases}
\dot{N}_i = V\cos(\chi_i) \\
\dot{E}_i = V\sin(\chi_i) \\
\dot{V} = a_{il} \\
\dot{\chi}_i = \Omega_i \\
\dot{R}_{ji} = 0 \\
\dot{\sigma}_{ji} = \dfrac{2V\sin(\chi_i - \sigma_{ji})}{R_{ji}}
\end{cases}
$$

SColU data fusion filter model



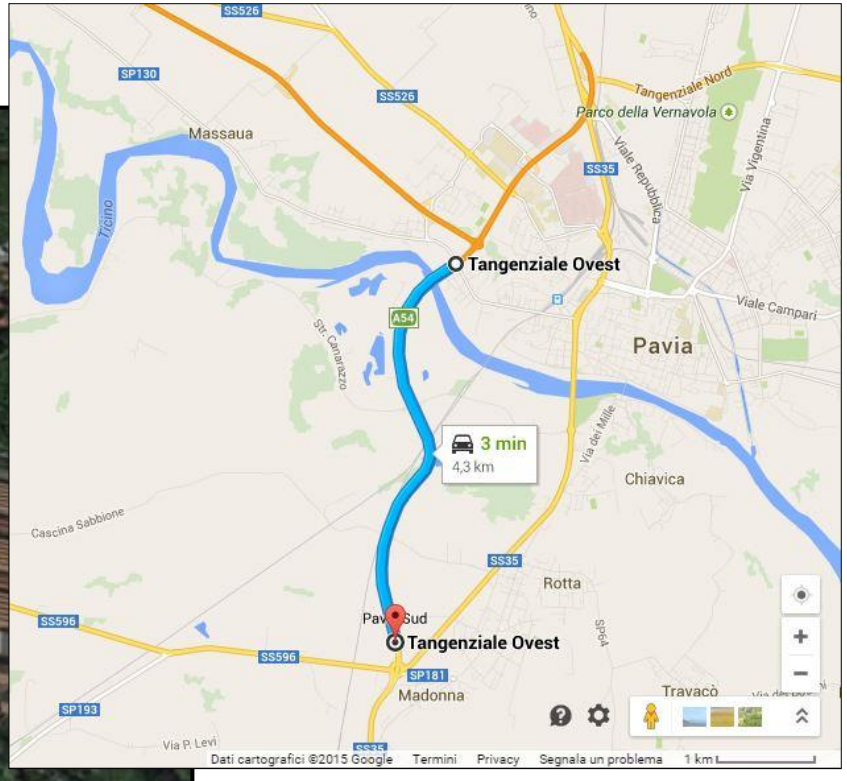
EKF filter kinematic constraints:

- relative distance
- relative velocity

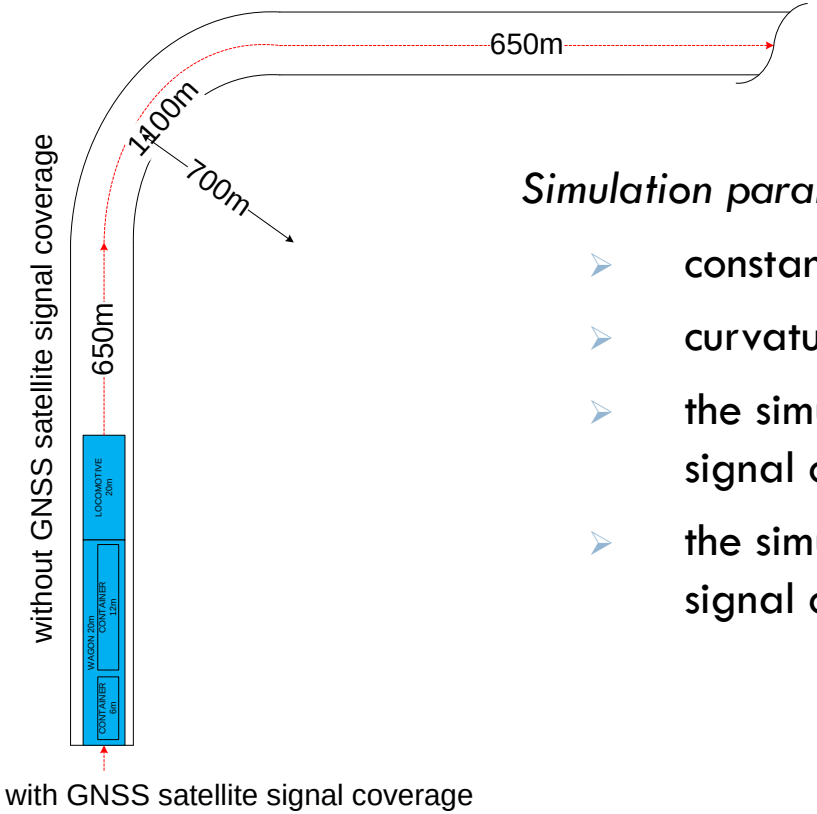
$$
\begin{cases}
\dot{N}_T = V_T \cos(\chi_T) \\
\dot{E}_T = V_T \sin(\chi_T) \\
\dot{\psi} = \dfrac{V_T}{L} \sin(\chi_T - \psi) \\
\dot{L} = 0 \\
\dot{d} = 0
\end{cases}
$$

STrackU tests

- Field Test for Transport Application



SColU simulation implemented

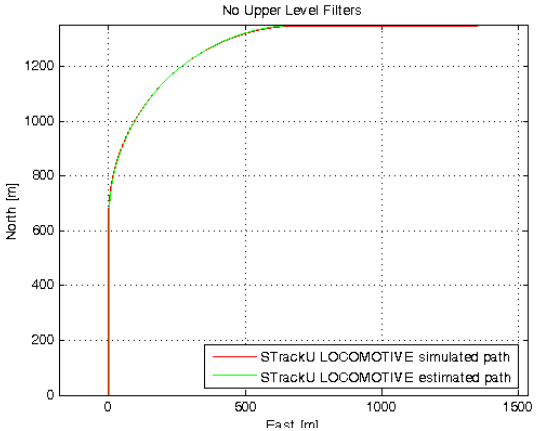
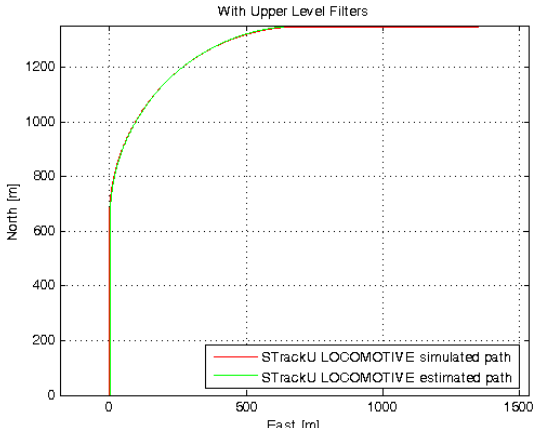
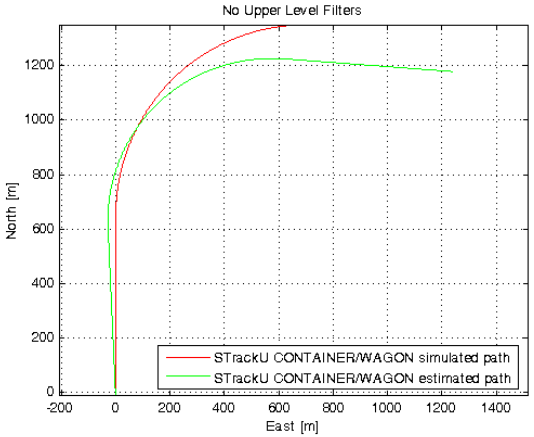
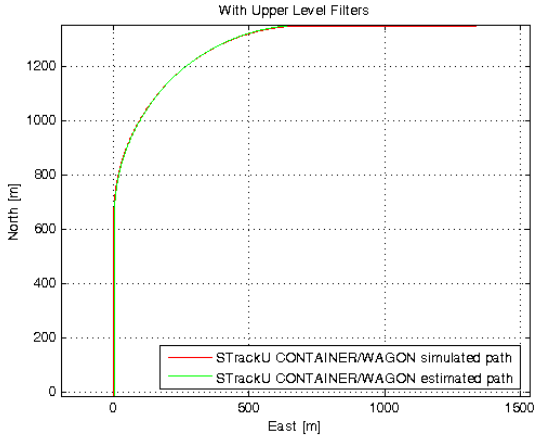


Simulation parameters:

- constant speed = 20 [m/s]
- curvature radius = r = 700 [m]
- the simulation begins without GNSS satellite signal coverage
- the simulation continues without GNSS satellite signal coverage for 120 seconds

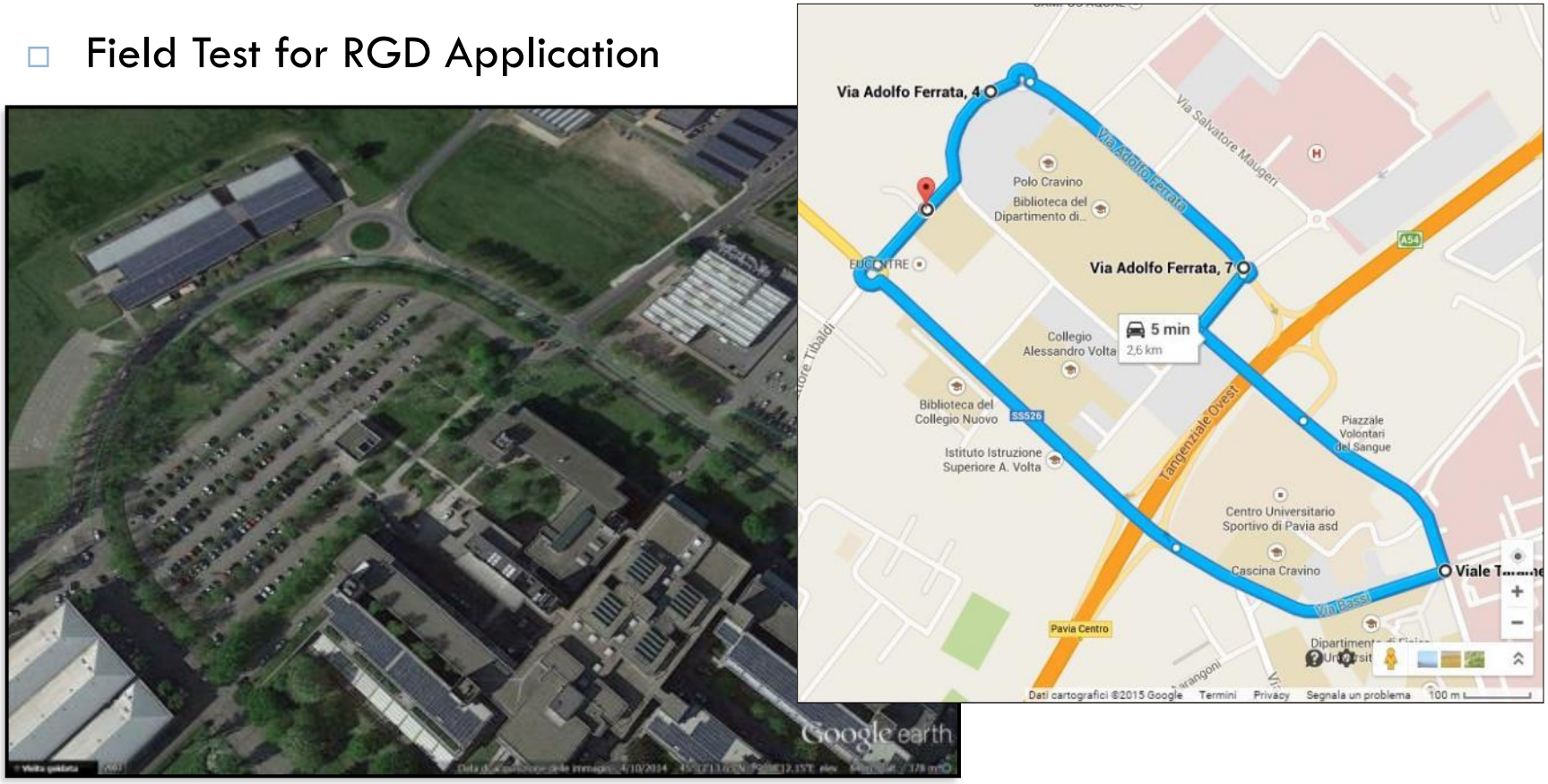
Motion profile for Transport application

SColU simulations results

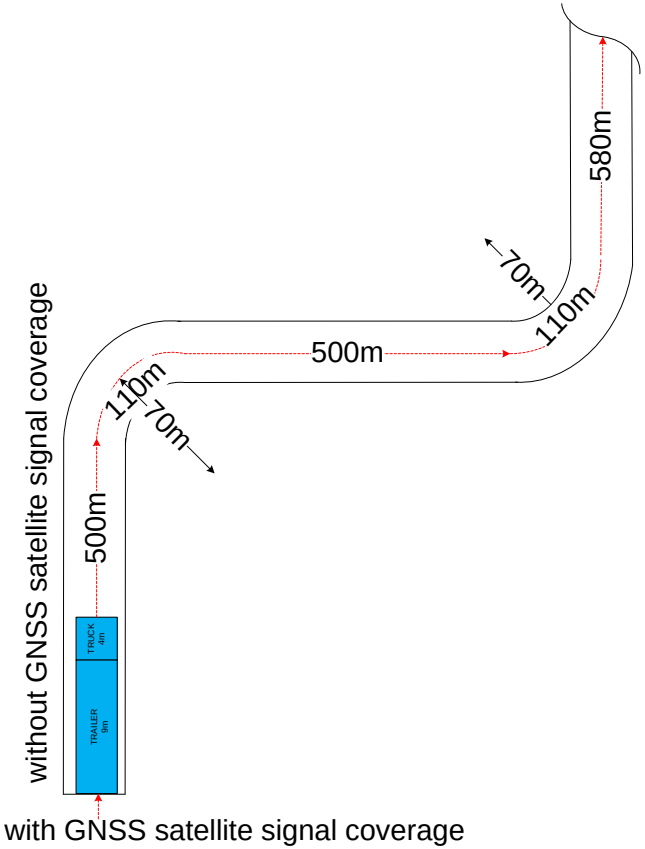
UNIT			60' of GNSS signal outage accuracy
LOCOMOTIVE			Before 5m **After 5m**
CONTAINER or WAGON			Before 100m **After 5m**

STrackU tests

- Field Test for RGD Application



SCoIU simulations implemented



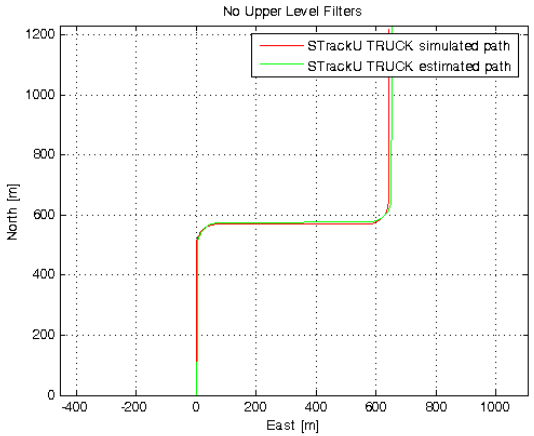
Simulation parameters:

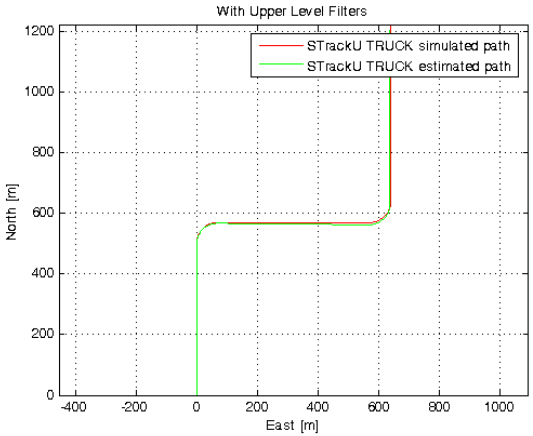
- constant speed=15[m/s]
- the simulation begins without GNSS satellite signal coverage
- the simulation continues without GNSS satellite signal coverage for t=120[s]

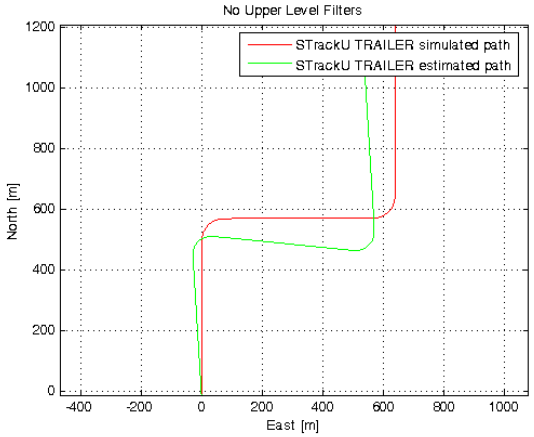
Motion profile for RGD application

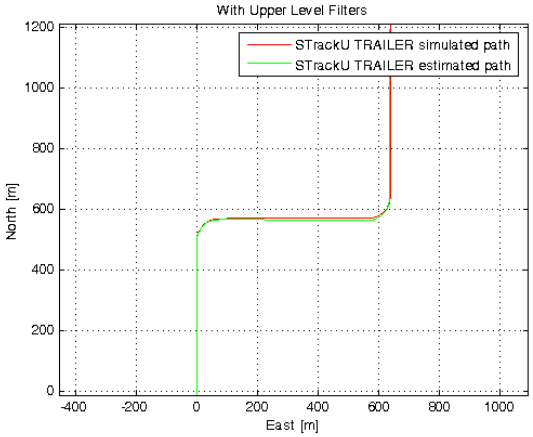
SColU simulations results

UNIT	60' of GNSS signal outage accuracy
TRUCK	Before 10m **After 6m**
TRAILER	Before 100m **After 6m**







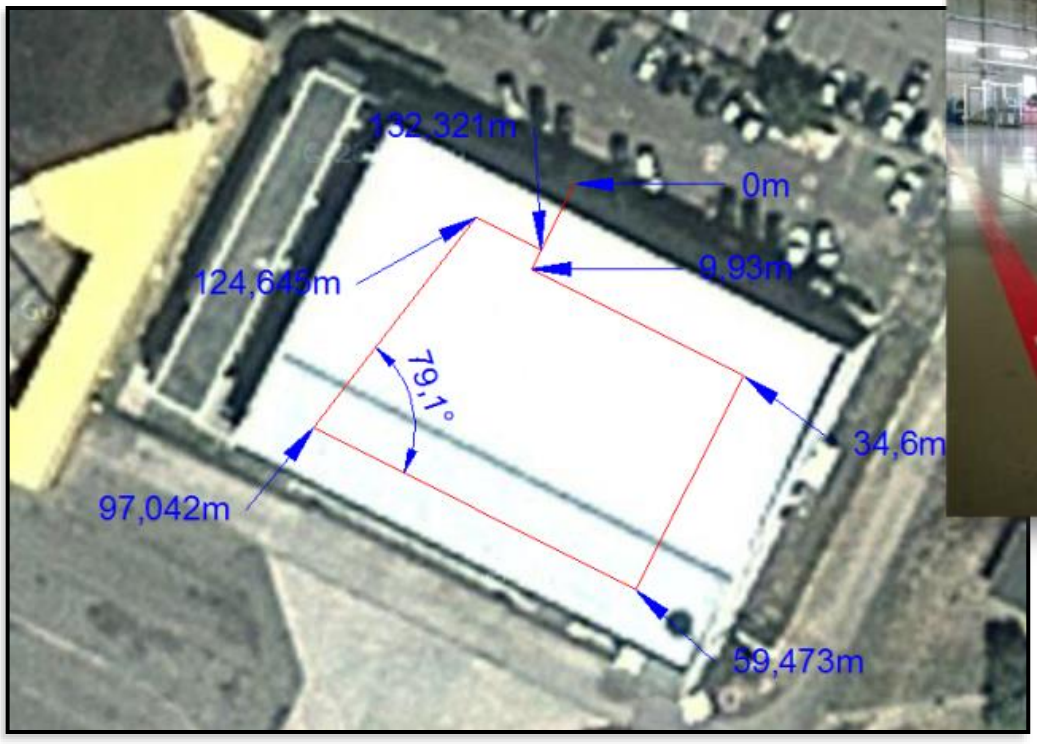


First Responders application

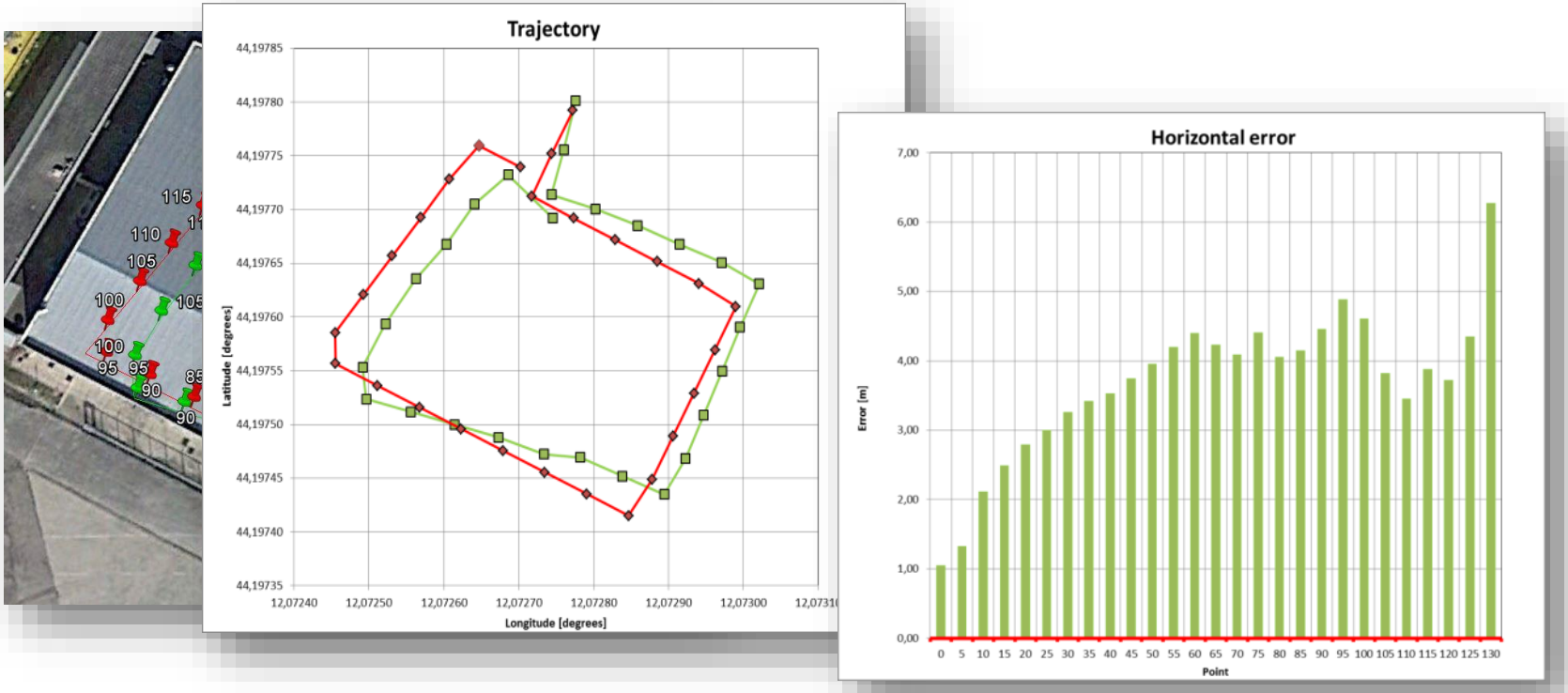
The evolution of STRACKU_PERSON FR tests

FR STrackU path tests

- Field Test for FR Application



Preliminary FR STrackU test results



The horizontal error after 60s of dead reckoning (point 60) is under 5m

SPARTACUS *Tracking solutions*

SPARTACUS Answer & Innovation

- For all three targeted applications, SPARTACUS offers a system able to:
  - Determine the position independently from external infrastructure (STrackU = GNSS + INS)
  - Have a low/medium cost for dead reckoning capabilities according to the application (Transport, RGD, FR)
  - Black box information capabilities for each module (STrackU/SColU/SFU)
  - An infrastructure less Broadband Global Area Network radio interface
  - Have a power consumption, weight and size dependent on the application (Transport, RGD, FR)

Thank you for your attentoin

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