Hybrid Fusion Module with IMM approach for Cooperative Vehicle Infrastructure Systems

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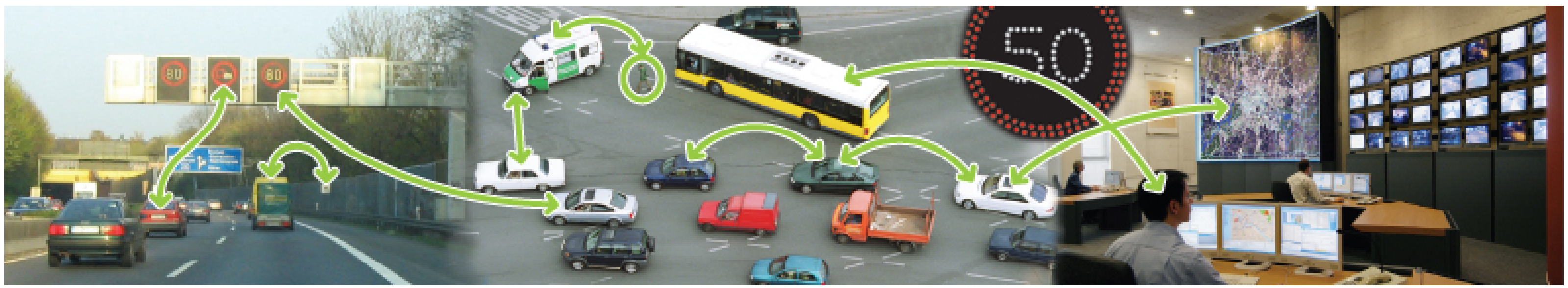

Outline of the presentation

1. **Presentation of the team members**
2. **CVIS & its positioning facility**
   - Focus on POMA
   - Positioning subsystem overview
   - POMA requirements
3. **About hybrid fusion positioning**
   - What? How? Why?
   - Probabilistic approaches
   - Focus on IMM concept
4. **POMA IMM prototype**
   - Overview
   - Testing & data analysis
   - Refinements
5. **Next steps (on-going work) & conclusion**

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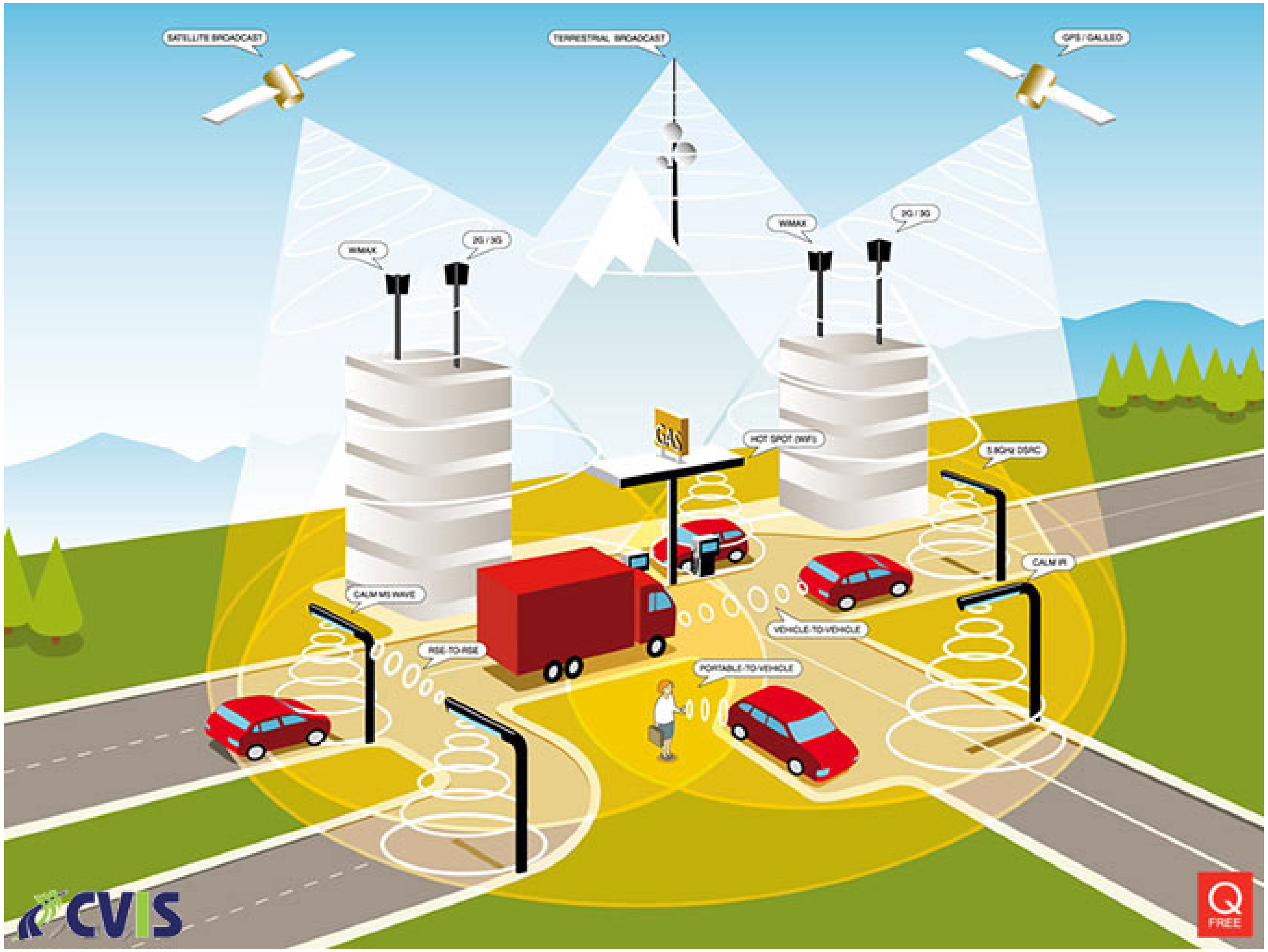
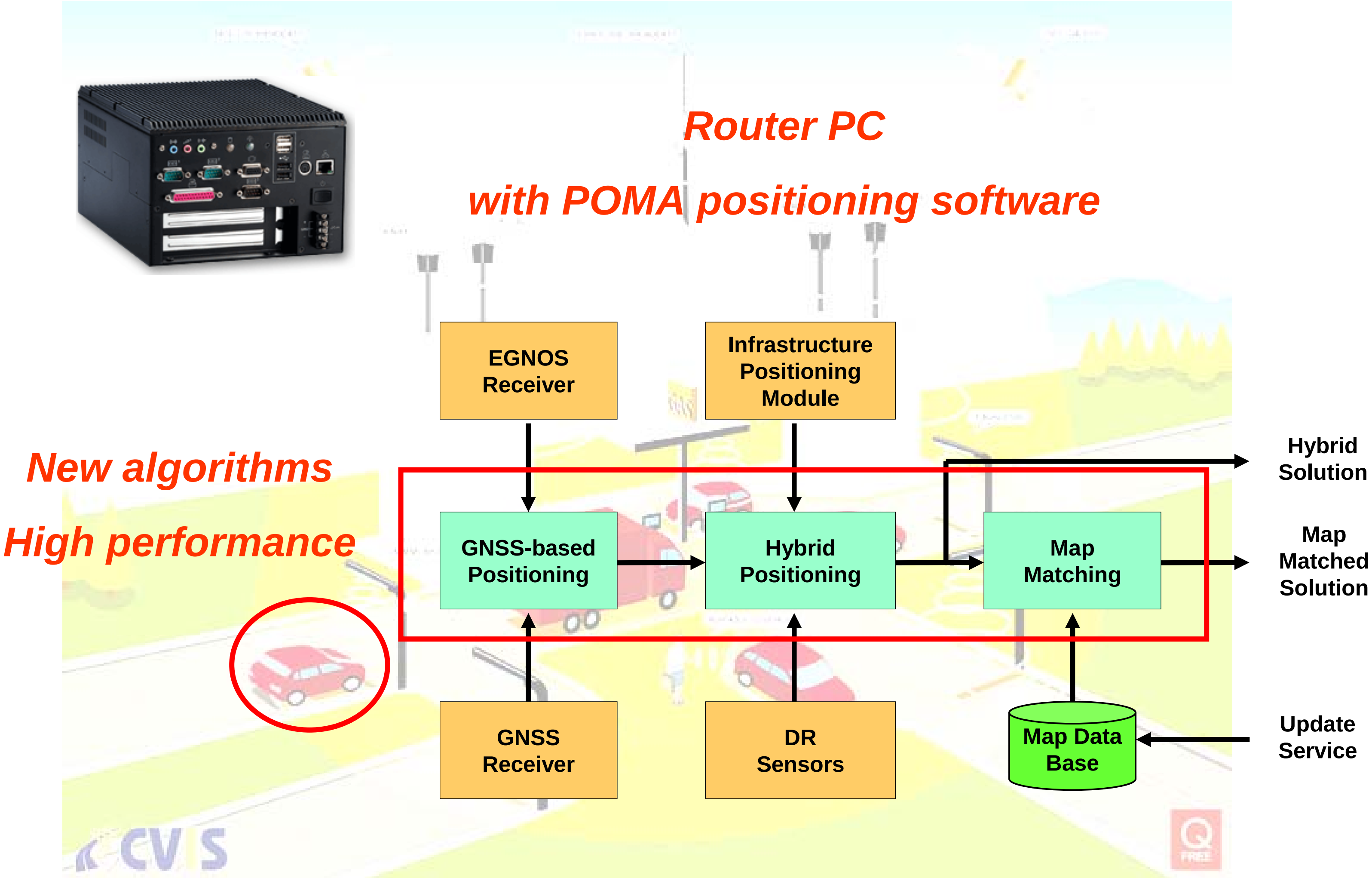
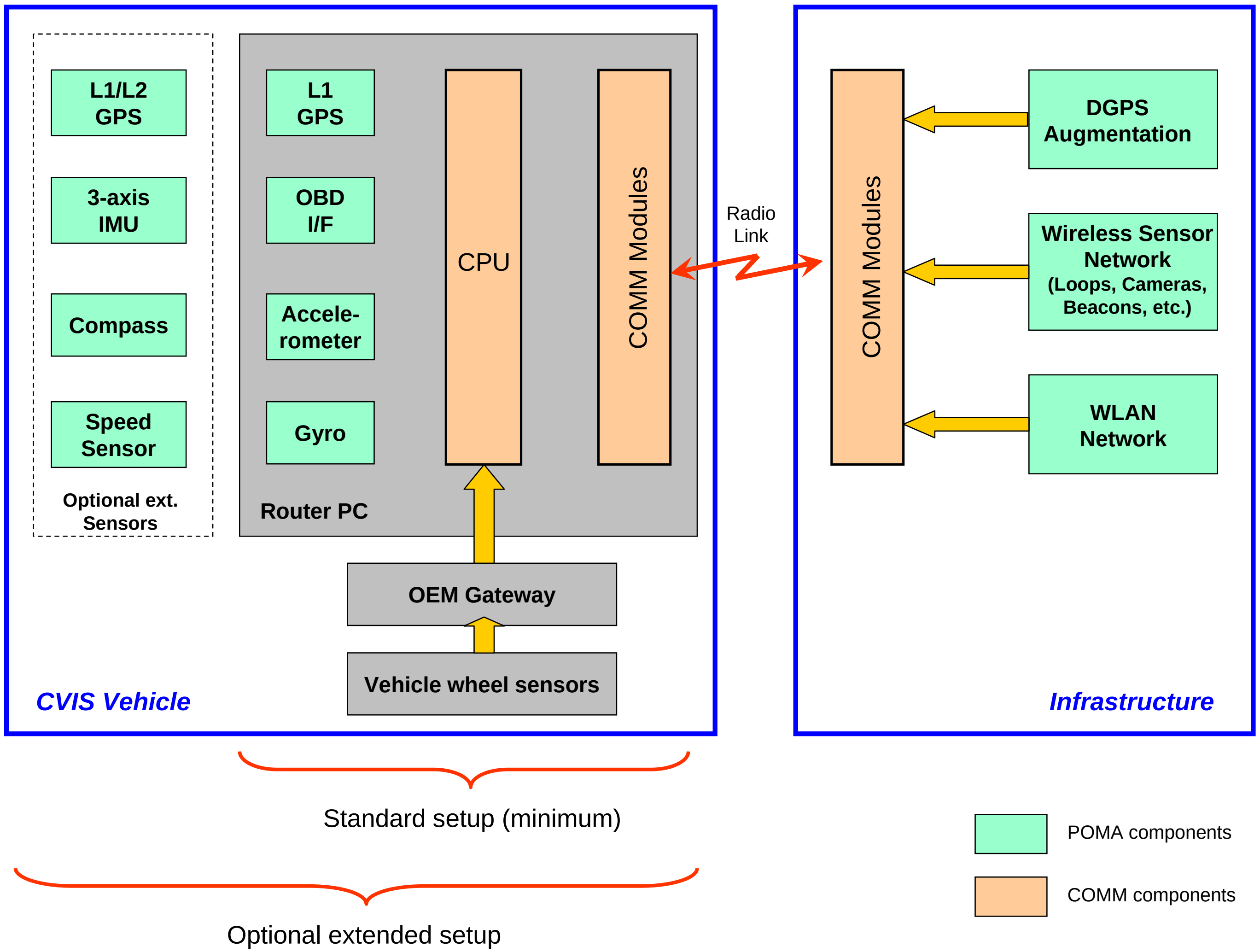
The CVIS world



POMA: focus on positioning



POMA positioning subsystem overview



INS/GNSS vehicle positioning requirements

- 27 (on 178) requirements for the POMA positioning facility like:
  - Data input: at least GNSS, Inertial sensor, RF power, AGNSS data
  - Data output: latitude, longitude, height, time in WGS84 format, heading, speed
  - Output frequency: ***1 Hz*** (up to 10 Hz) or on request (maximum latency 100 ms)
  - Accuracy: ***sub-meter accuracy*** level (i.e. lane level) locally (crossroads, bus lanes…)

- The position shall be available with a degraded accuracy in places ***where no external GPS signals are available***

About hybrid fusion positioning

- **What is this?**

  It is an algorithm able to

  1. Predict how a dynamic system is evolving
  2. Correct the prediction done so far

- **How is it working?**

  By fusing all available sensors data

  exteroceptive (**GPS**) & proprioceptive (**odometer, gyrometer**, **IMU**, etc.)

- **Why do we need it?**

  Precise position is required

  for advanced navigation applications

  (like ghost driver, flexible bus lane allocation,…)

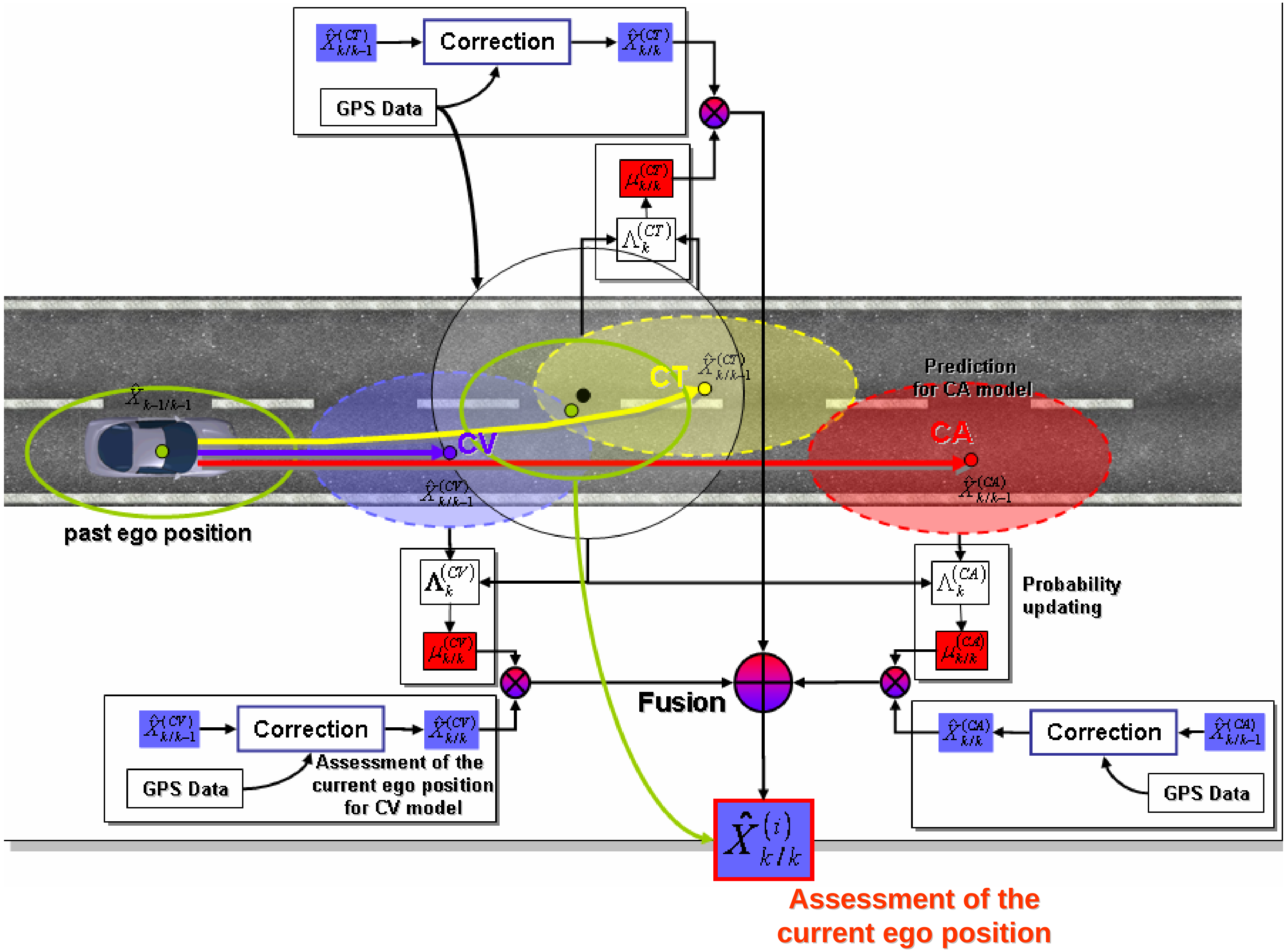
Hybrid fusion positioning: probabilistic methods

- **Kalman Filter**
  – Nonlinear system may diverge in case of strong nonlinearities
- **Unscented Kalman Filter**
  – Based on scaled unscented transformation for updating random data
- **DD1 & DD2**
  – Nonlinear filter approximated by polynomials
- **Monté Carlo Localization**
  – Based on random generation of data sets

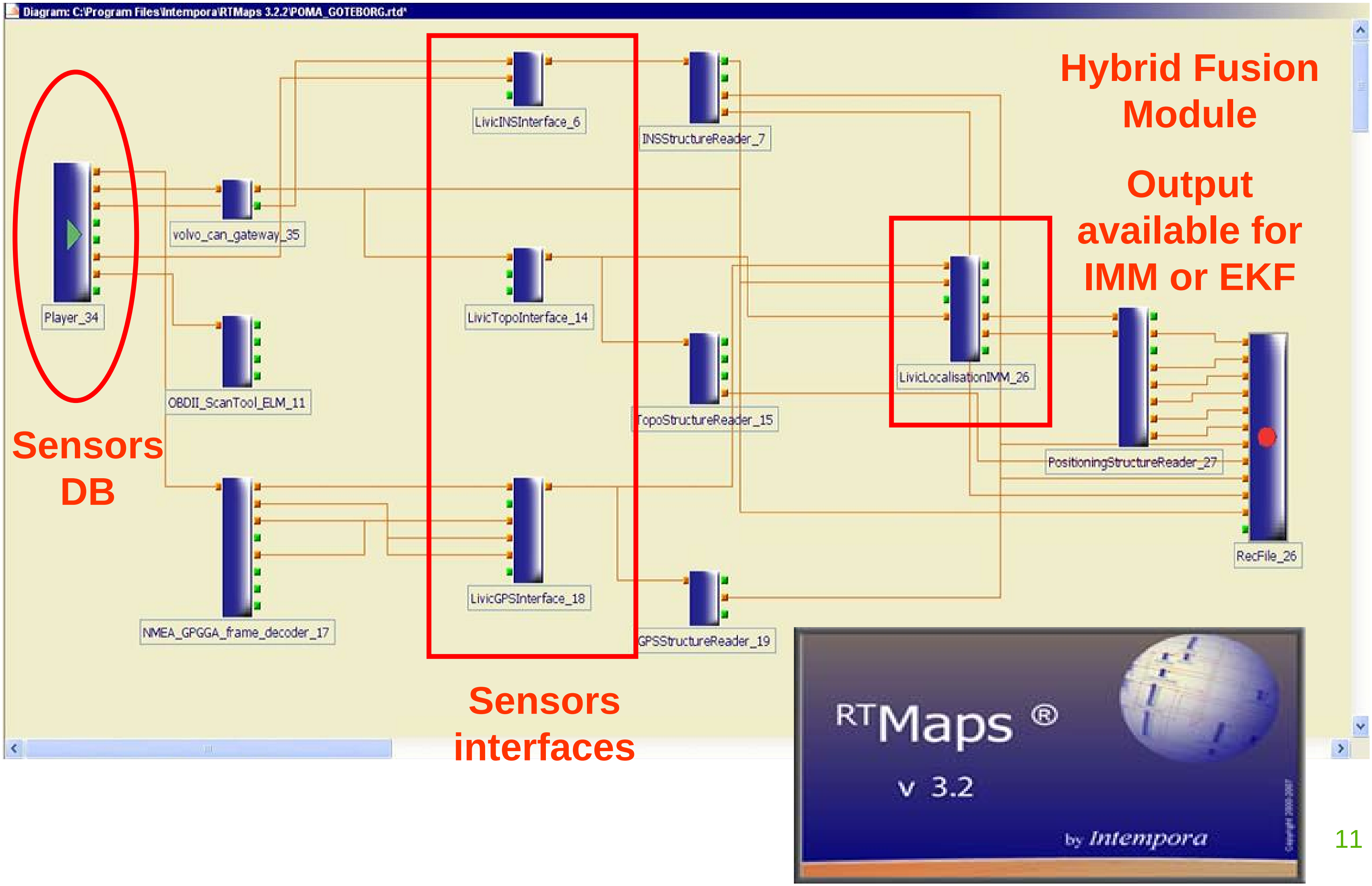
Our choice for CVIS

- **Interacting Multiple Model**
  – A complex model is subdivided into simpler sub-models with associated probabilities
  – Advantage: robustness
- **Extended Kalman Filter**
  – Kalman Filter extended to nonlinear case

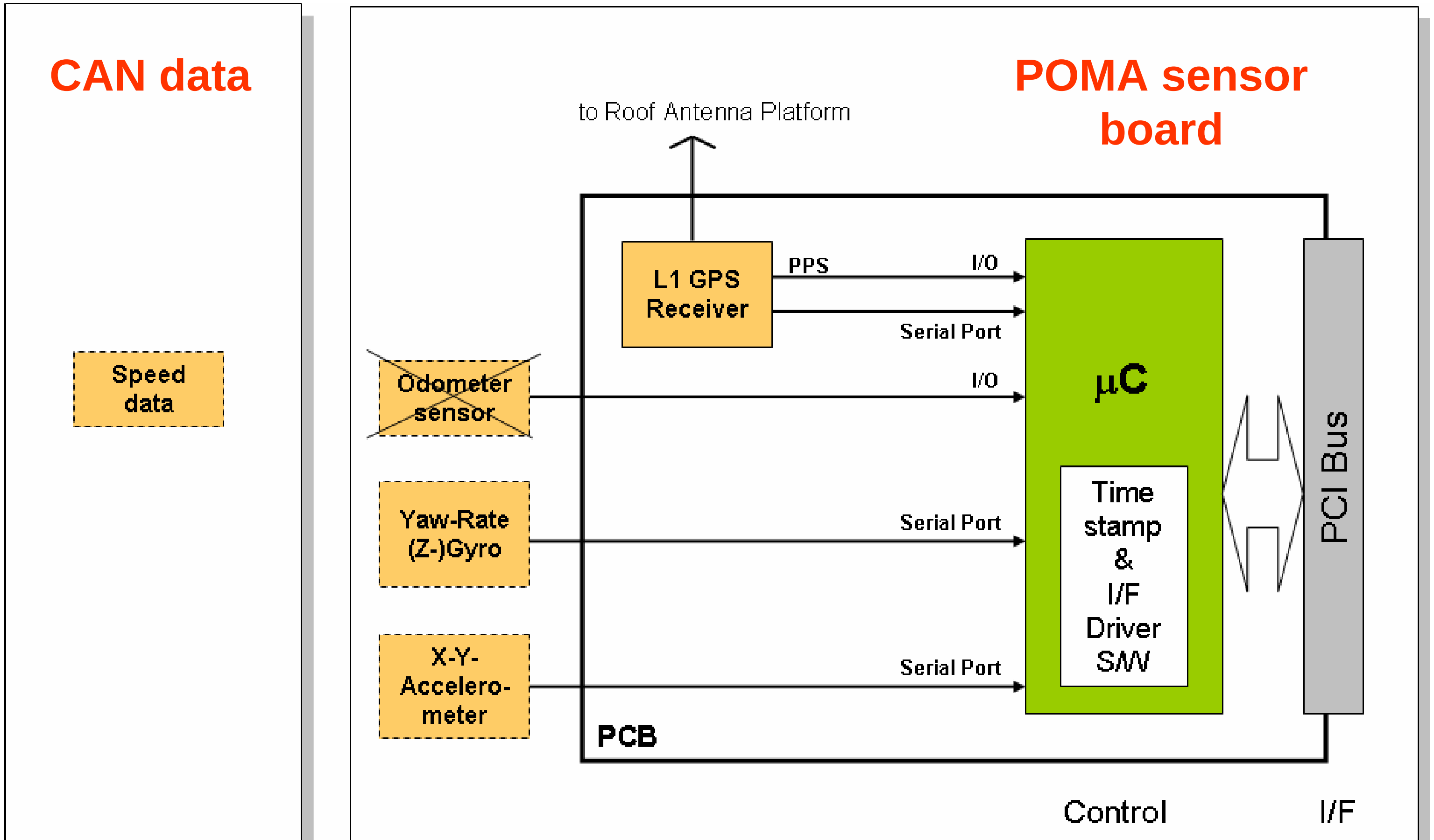
Focus on IMM concept



How IMM is prototyped with POMA



Our tests in Gothenburg with *available sensors*



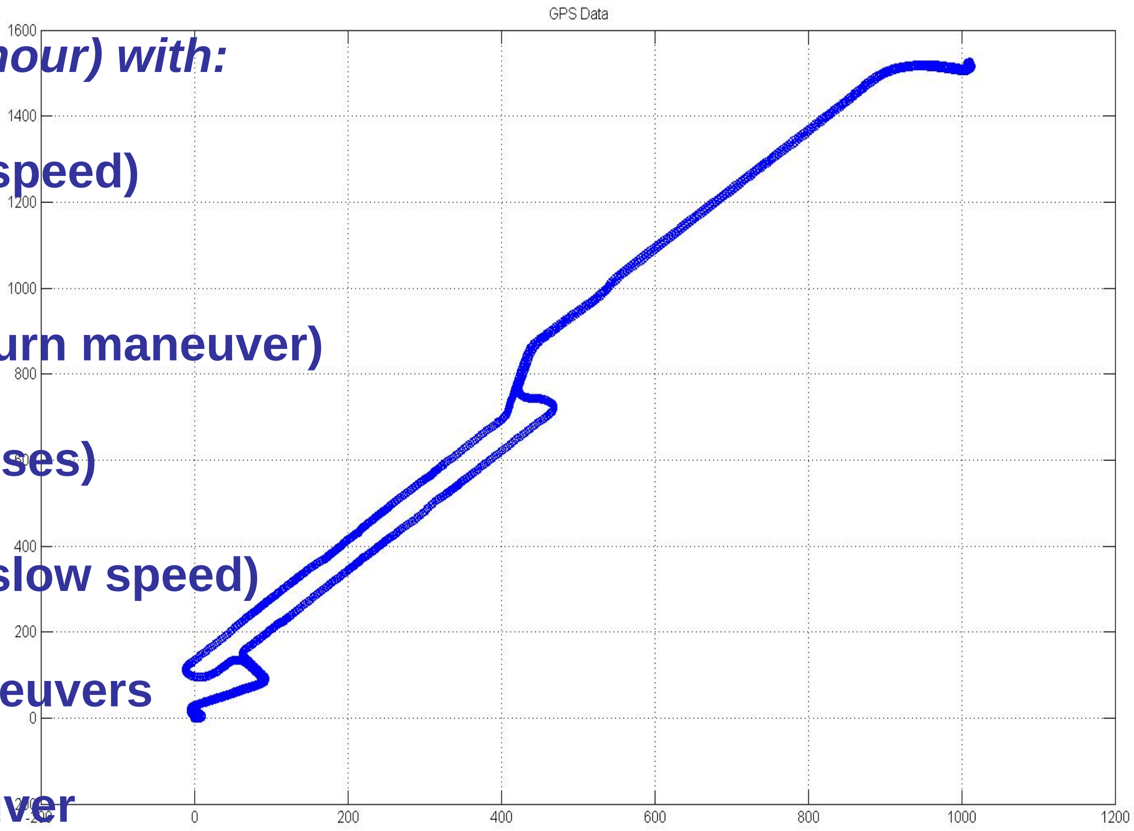
Tests done without any reference sensors like EGNOS, VG700 and no map-matching

Our data analysis

What we get

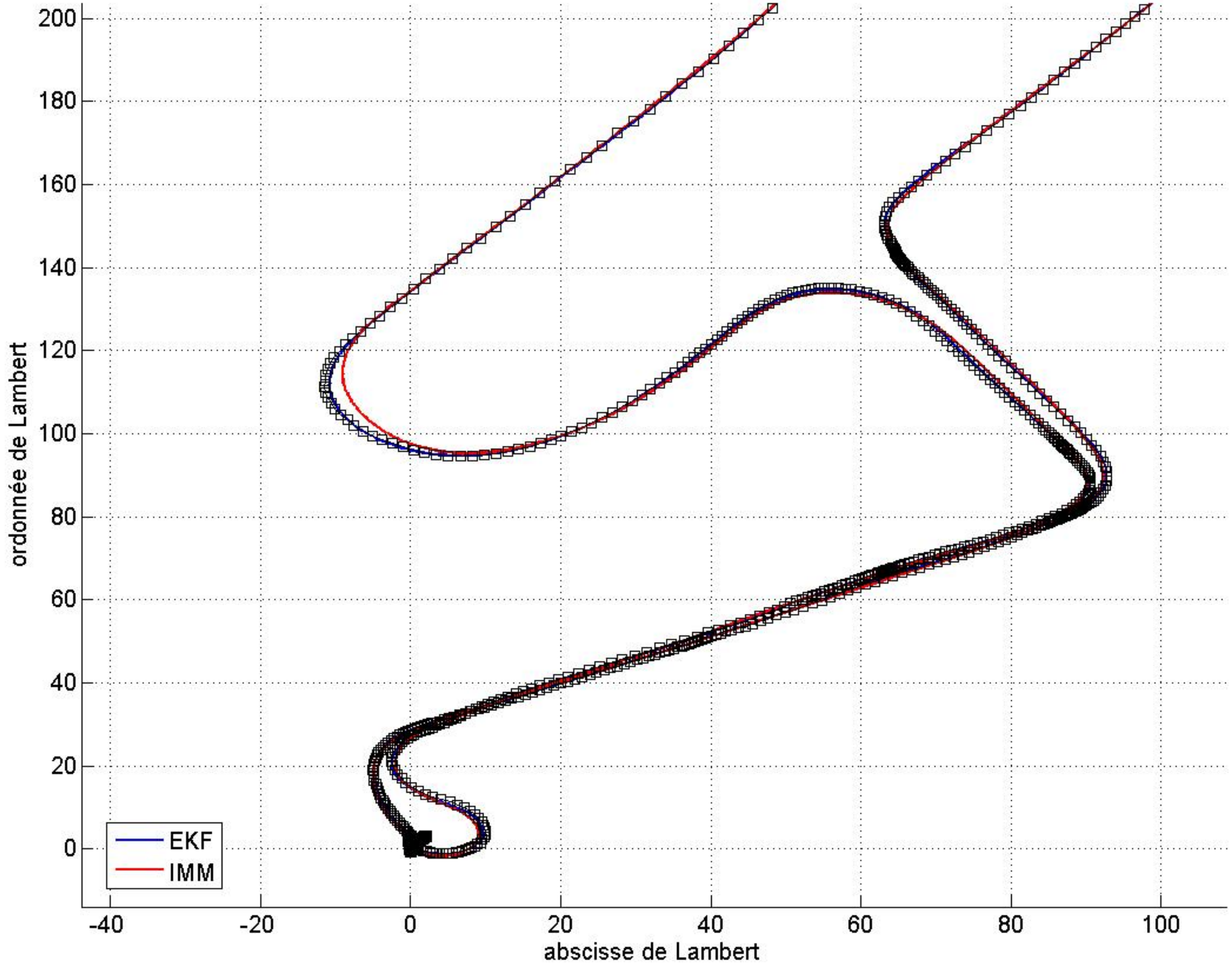
a data base (1 hour) with:

- **motorway (high speed)**
- **downtown**
  (low speed and turn maneuver)
- **tunnels (GPS looses)**
- **traffic jam (very slow speed)**
- **stop and go maneuvers**
- **backward maneuver**

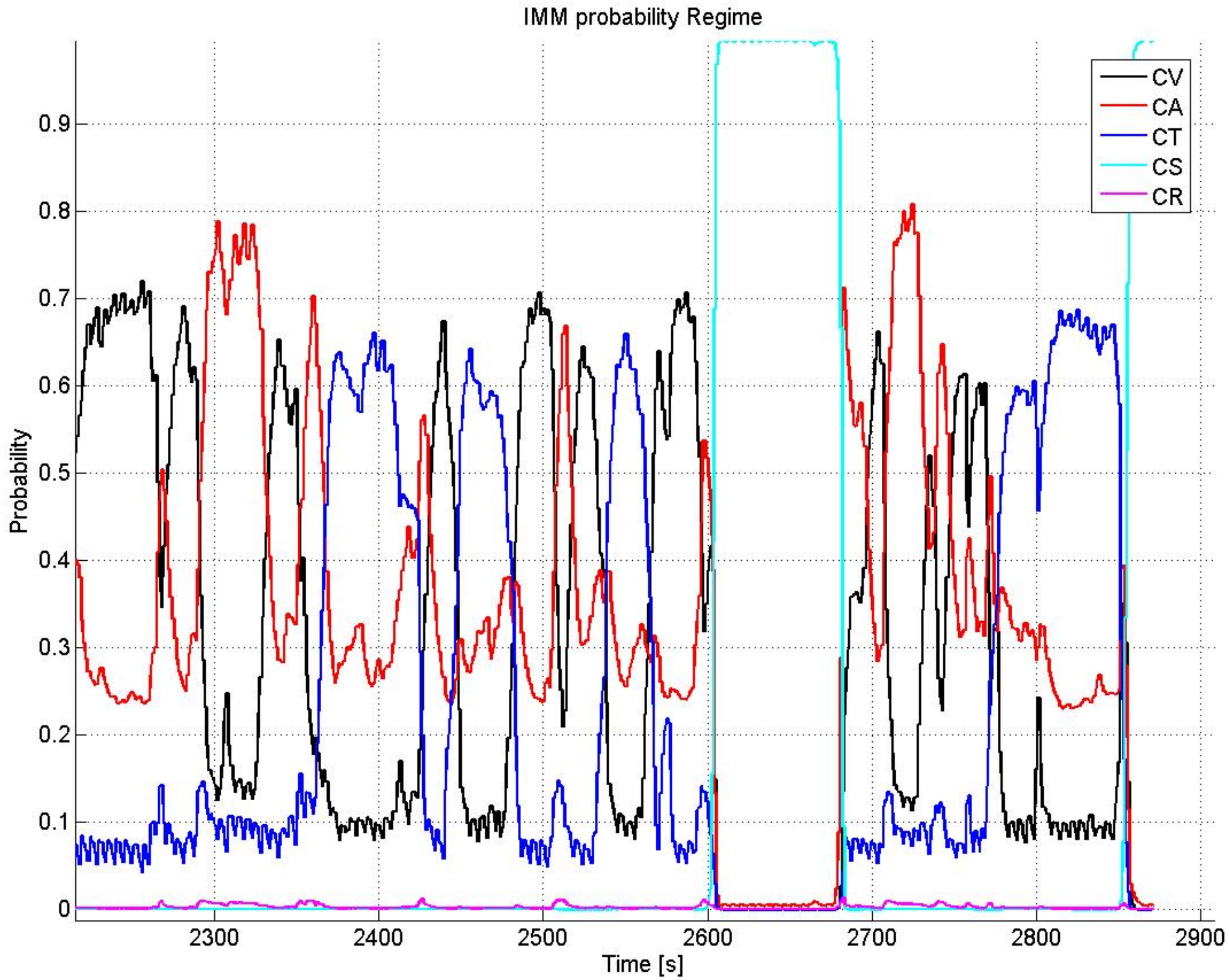


How the output (EKF, IMM, GPS) looks like?

At the end of the track



How the IMM with probabilities output looks like

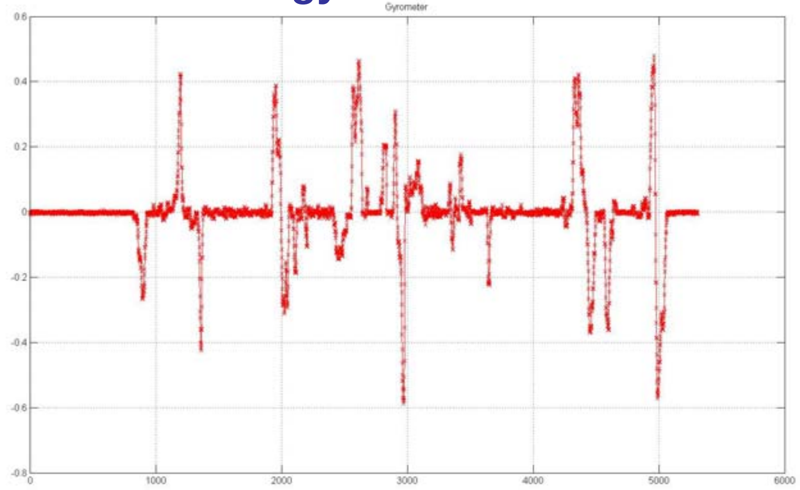


Further data analysis

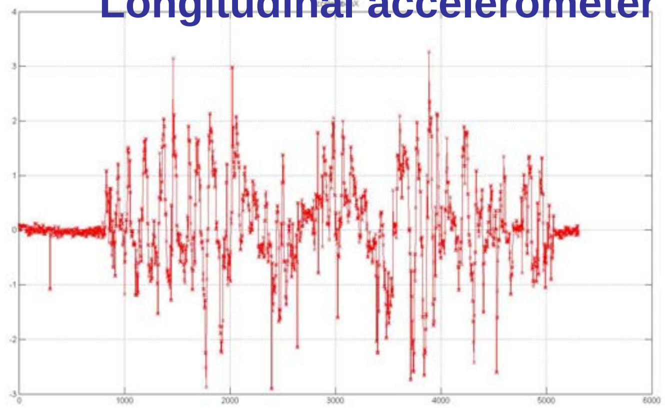
What we have observed

- Identification of the sensors configurations and noises
- Problem of synchronisation detected
- Problem of CAN data → only positive speed → trouble with backward manoeuver
- we need to add 2 new models to the IMM approach: CS and CR
- With the current sensor (< 10hz) we need to provide positioning with a 10 hz frequency

gyrometer



Longitudinal accelerometer



Our refinements

What we have observed

- Identification of the sensors configurations and noises
- Problem of synchronisation detected
- Problem of CAN data
  → only positive speed
  → trouble with backward manoeuver
- With the current sensors (< 10hz) we need to provide positioning with a 10 hz frequency

What we need to do

- **Filters to be added & denoising**

Tuning of parameters requires experience with sensors

- **Clock synchronization with POMA sensors board**
- **Adding 2 new models to the IMM approach: CS and CR**
- **Adding a new filter for signed speed**
- **Extrapolation to be set up**

Next steps: ongoing work

- **Some tests still need to be done:**
  - with EGNOS data
  - with “POMA ultimate equipment”
  - adding the map-matching module

- **Validation of the IMM positioning:**
  - Additional (expensive) sensors (RTK VG700, INS IXEA, Applanix,…)?
  - Post-processing data denoising (for new calibration of the algorithm, towards auto-calibration, …)?
  - Very very very precise digital map?

Conclusion

What did you learn today?

IMM positioning requires:

– A good knowledge of used sensors
– A refined data analysis for algorithm robustness
– Referenced tools/equipment for validating such approach

Thank you for your attention…

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