

ROAD VEHICLE POSITIONING AT THE LANE LEVEL BASED ON GNSS INTEGRATION WITH ENHANCED MAPS



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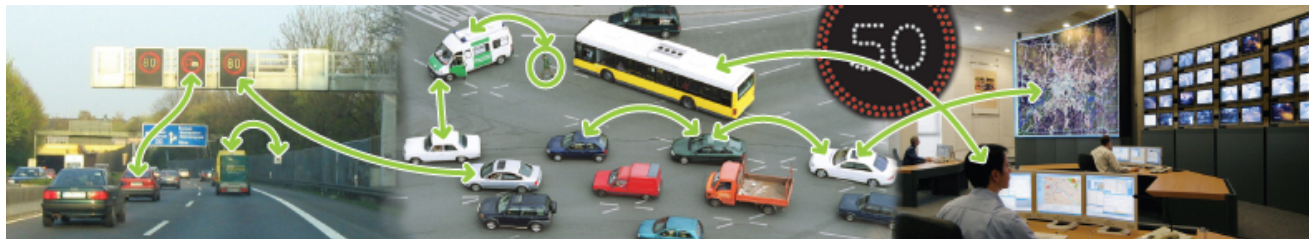
Technical University
of Cartagena



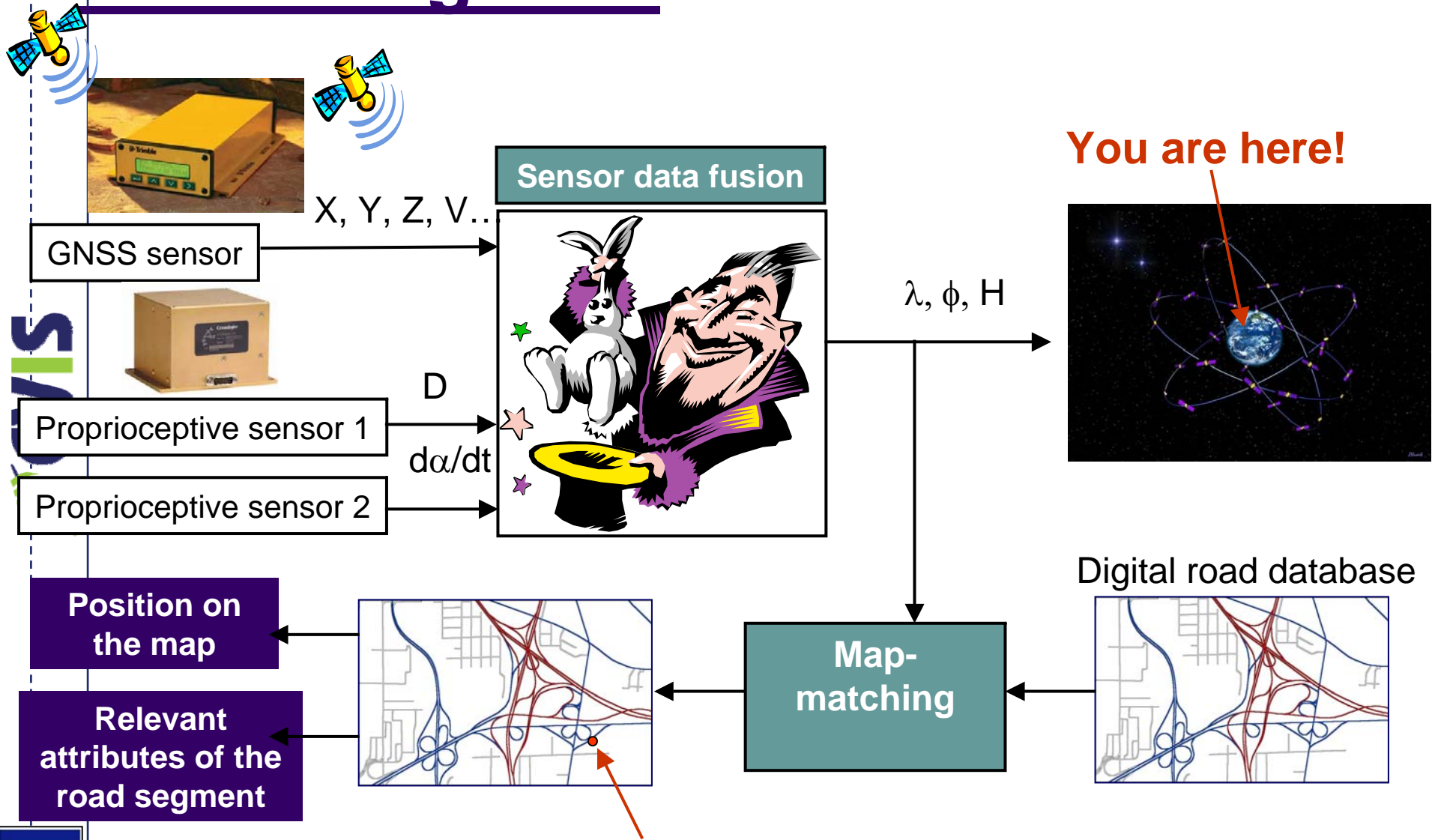
University of
Murcia



LCPC, Nantes,
France



road navigation



You are here, on this segment, at this abscissa!



lane level navigation



X, Y, Z, V..

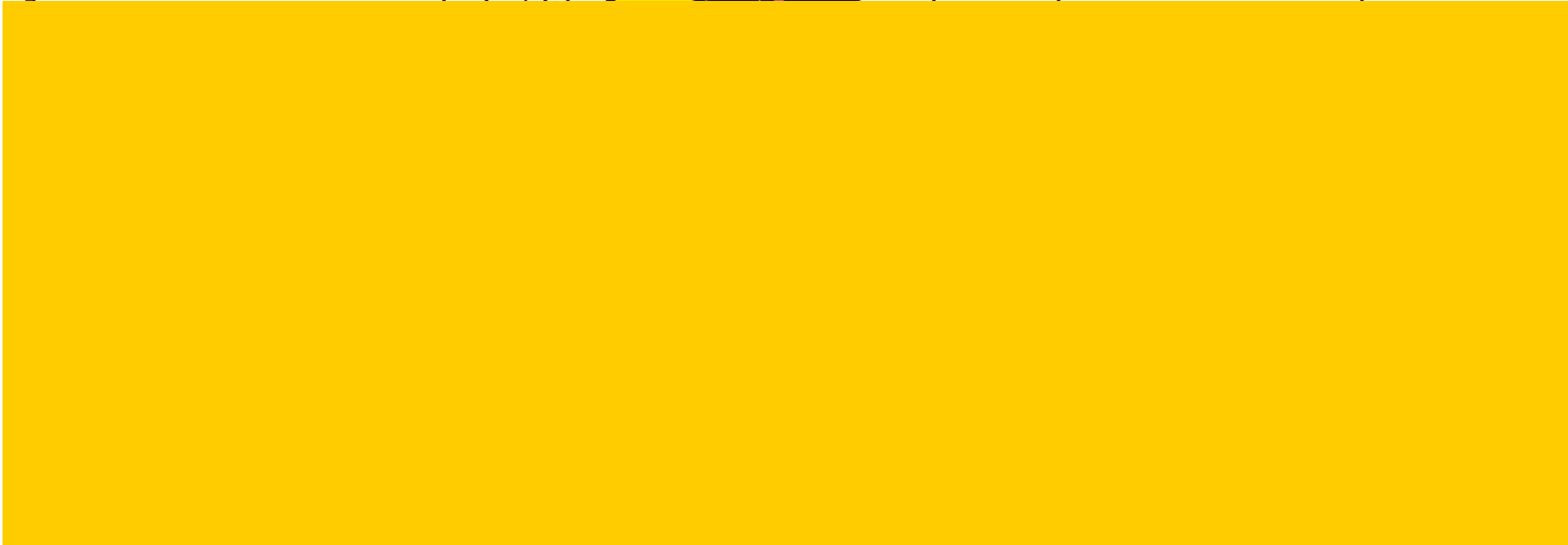
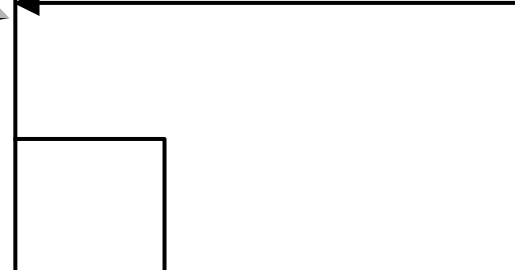
GNSS sensor



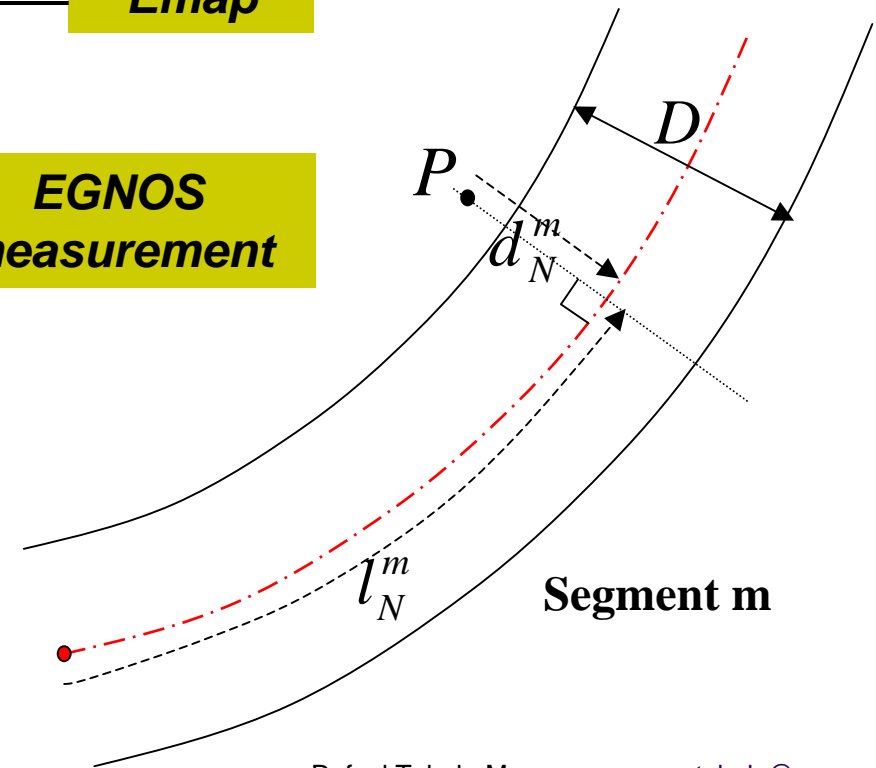
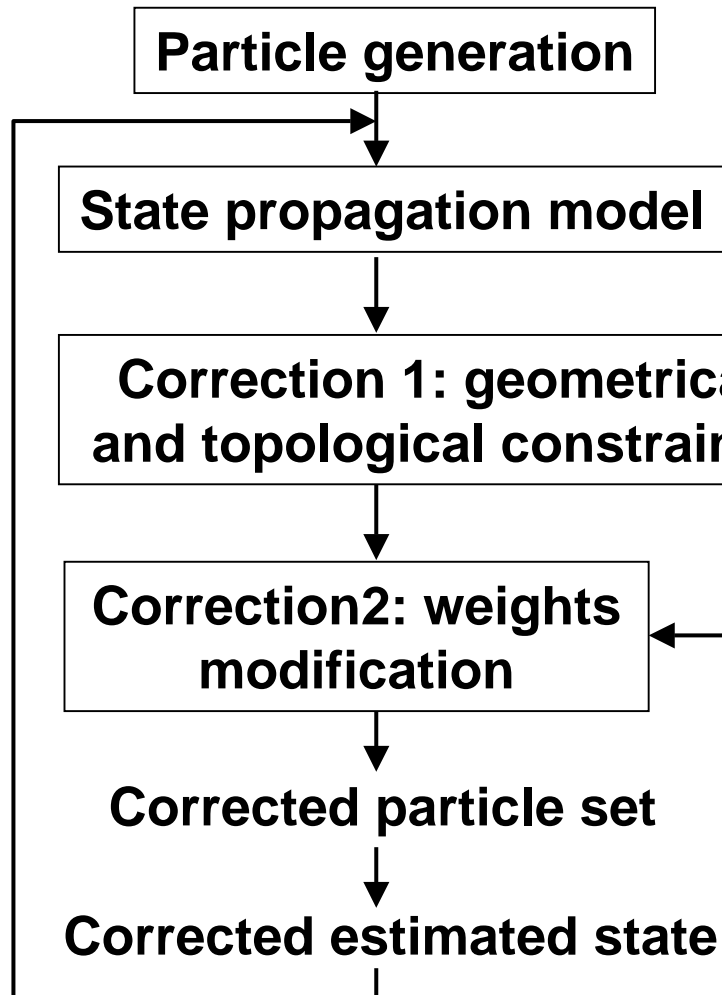
Proprioceptive sensor 1

D

Sensor data fusion and map-matching



emap-matching: particle filter



navigation results



Horizontal Positioning Error

Test	Mean	Std	Max.
S1	0.309	0.296	2.468
S1M	0.580	0.795	4.049
S1E	0.289	0.287	2.277
S1ME	0.389	0.405	2.317
S2	0.660	0.698	2.002
S2M	0.800	0.619	2.007
S2E	0.691	0.709	2.088
S2ME	0.876	0.658	2.028
S3	0.261	0.274	1.915
S3M	4.849	6.635	20.048
S3E	0.296	0.324	2.289
S3ME	0.279	0.426	2.944

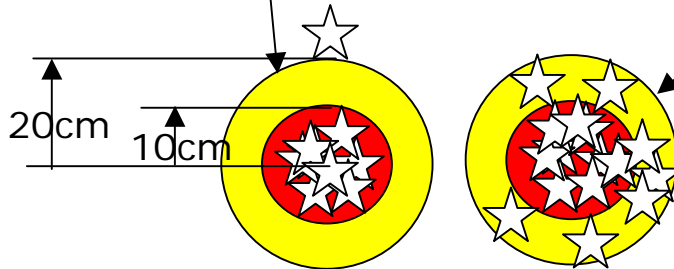
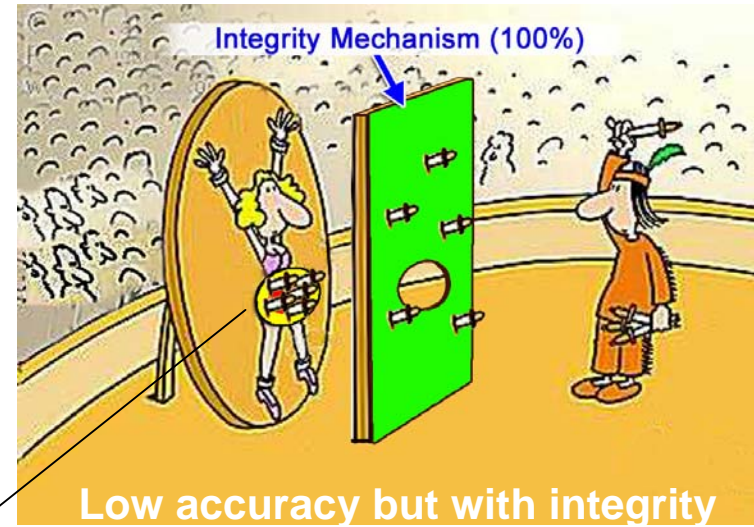
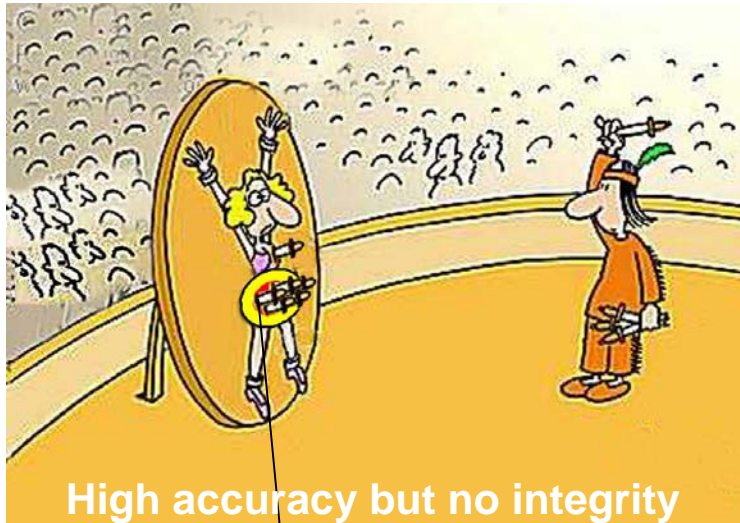
We also want to provide integrity:
Indicators of the reliability of the navigation system

LANE LEVEL matching

Test Scenario	Mismatch percentage	Mismatch time	GNSS blockage duration
S1E	0.6 %	3.5 s	13 s
S1ME	1.8 %	10.9 s	141 s
S2E	0.0 %	0.0 s	0 s
S2ME	1.8 %	1.8 s	22 s
S3E	1.3 %	2.9 s	9 s
S3ME	1.9 %	4.43 s	45 s



integrity mechanism



8 cm	18 cm
99 %	100 %

Accuracy (error RMS)

Integrity (probability to remain inside the yellow circle)



current integrity indicators on road

Classical methods imported from the aerial navigation

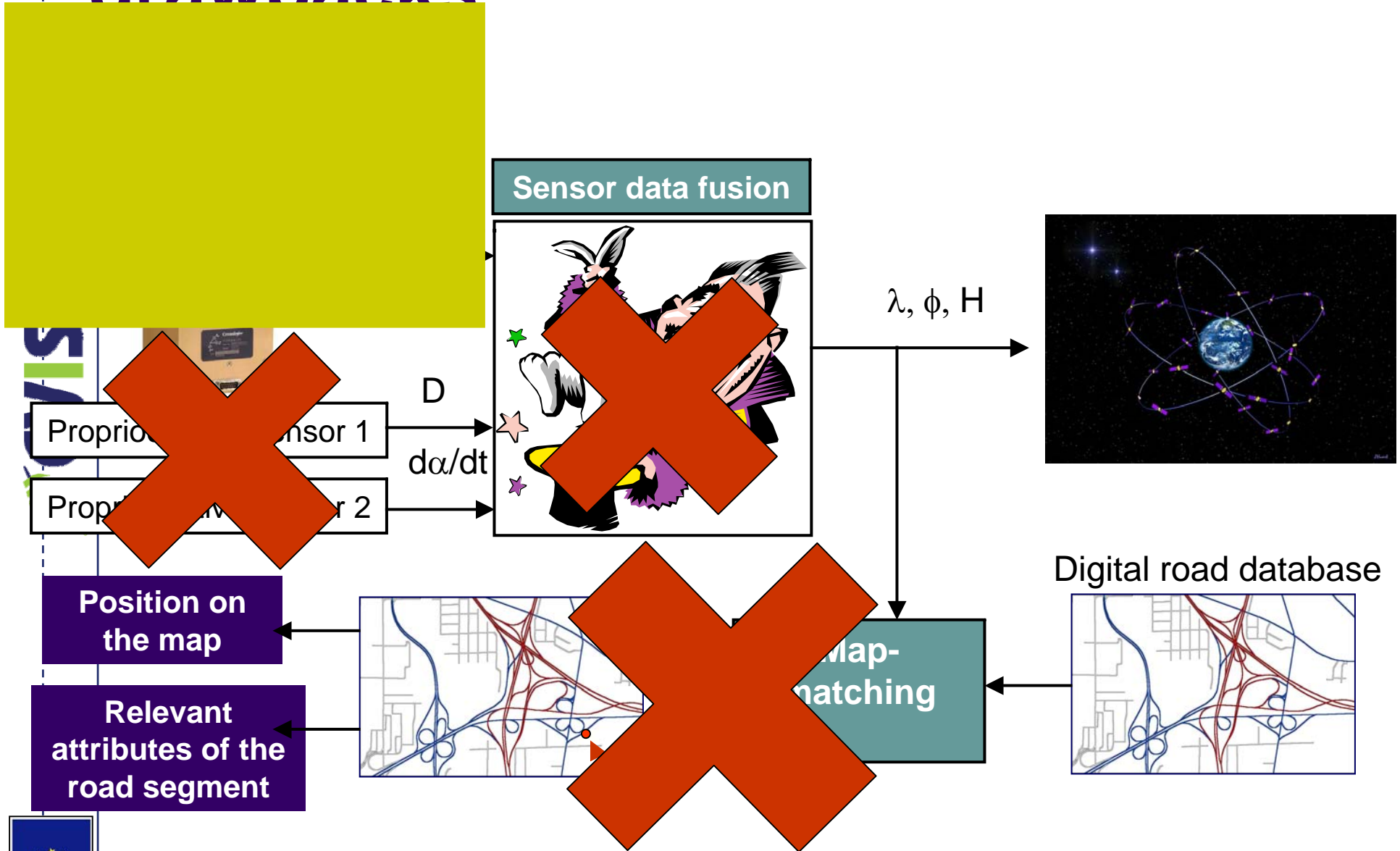
RAIM

HPL_SBAS

- Assumption of one fault at one time
- In navigation systems integrated by several sensors, they don't model the whole system solution
- Redundant information coming from more satellites than for positioning (quite unusual in cities), or
- a base station nearby or solution degrades
- When map matching is needed, what represents the most of the cases, no integrity of the final map-matched solution is provided, but only of the associated navigation solution

7

drawbacks



You are here, on this segment, at this abscissa!





our approach

EVERYTHING COUNTS!

- The GNSS sensor
- The rest of sensors
 - The map
- The vehicle model
- The data fusion & map-matching



our approach

Apply integrity concept onto map-matched position, with 2 indicators. Both are derived directly from the PF

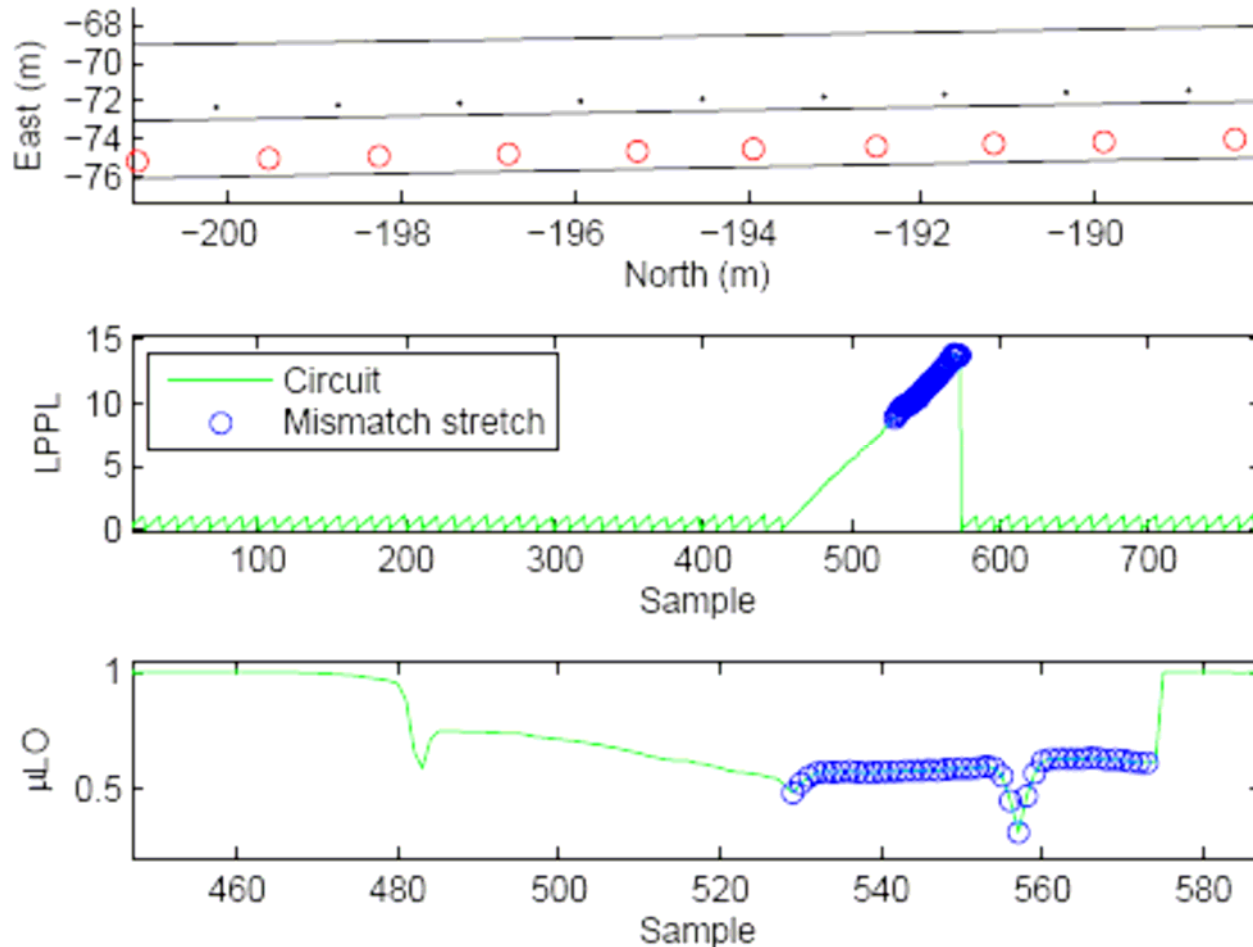
- Correct lane assignment:

Probability of lane occupancy (μLO)

- Confidence on the position of the vehicle on the assigned lane:

Lane Positioning Protection Level (LPPL)
(in meters)

integrity example

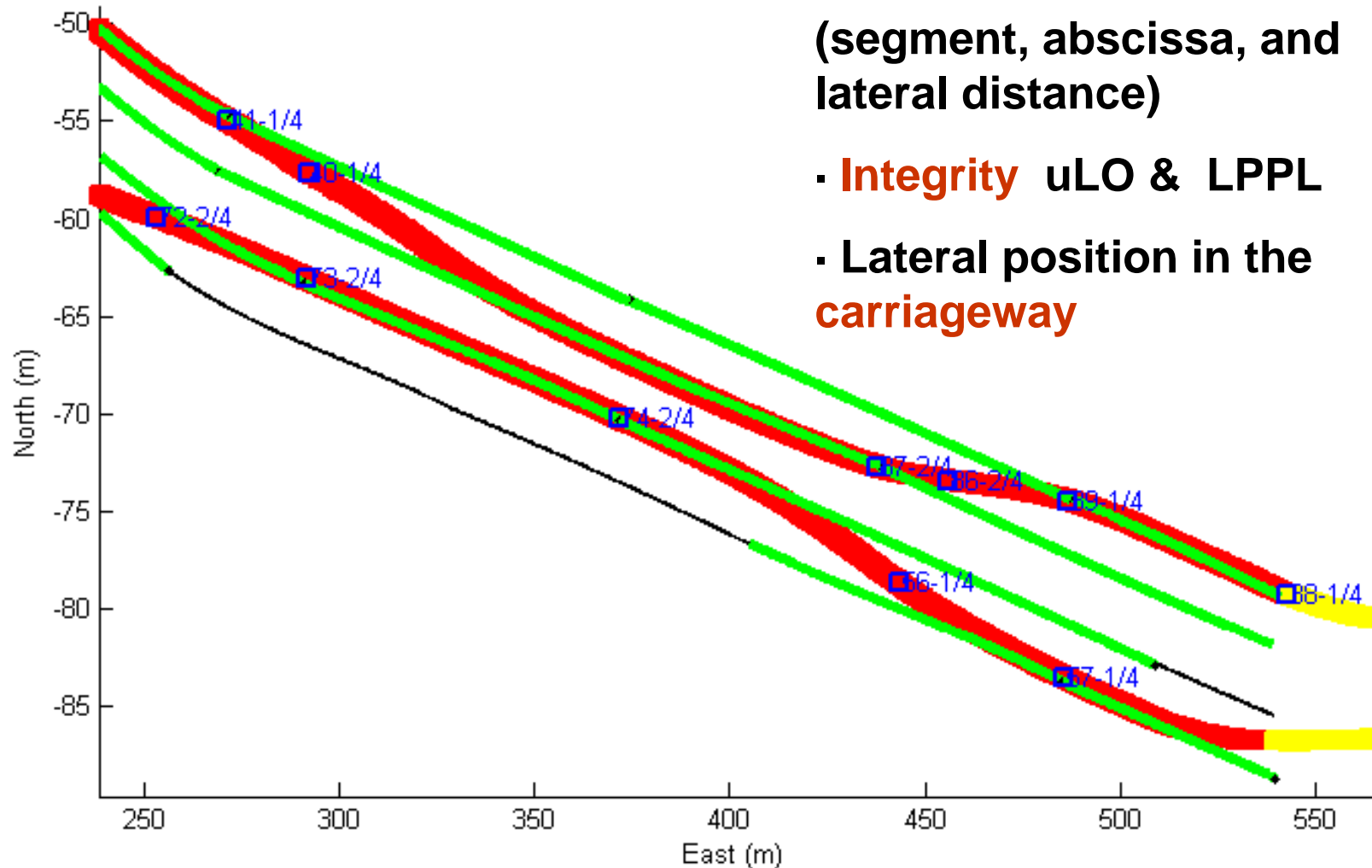


A bad value of uLO and good of LPPL can appear when changing a lane, and still our confidence in positioning can be good.

A good value of uLO and bad of LPPL can appear when visibility is bad, and matching is clear.

navigation information

- Position **E,N**
- Position in the **lane reference** (segment, abscissa, and lateral distance)
- **Integrity** uLO & LPPL
- Lateral position in the **carriageway**

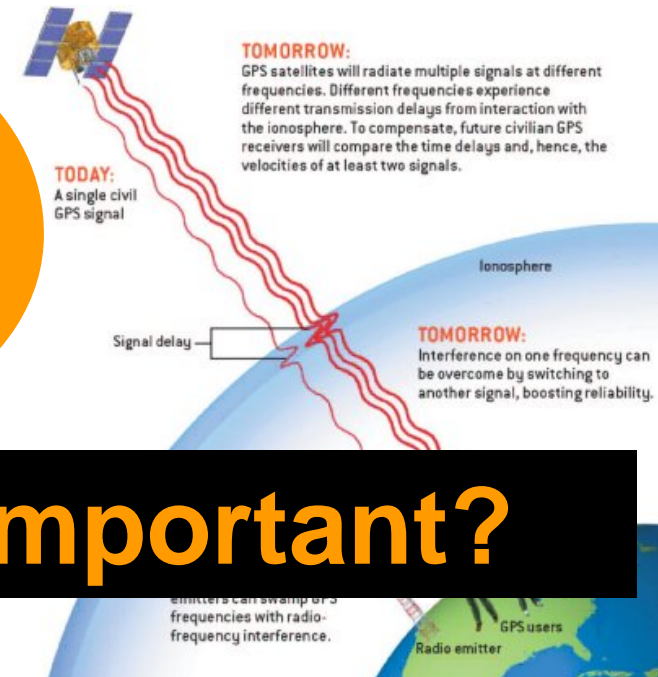


future of integrity in navigation?

- 3 fully operational GNSS systems (GPS+GLONASS+GALILEO)
- NIO-RAIM (Novel Integrity Optimized RAIM): More than one satellite at once
- Civil oriented multiple frequencies

What will be more important?

- Improvements in MEMS technology
- Maps with more contents and higher accuracy
- 3D maps



<http://scpnt.stanford.edu/>