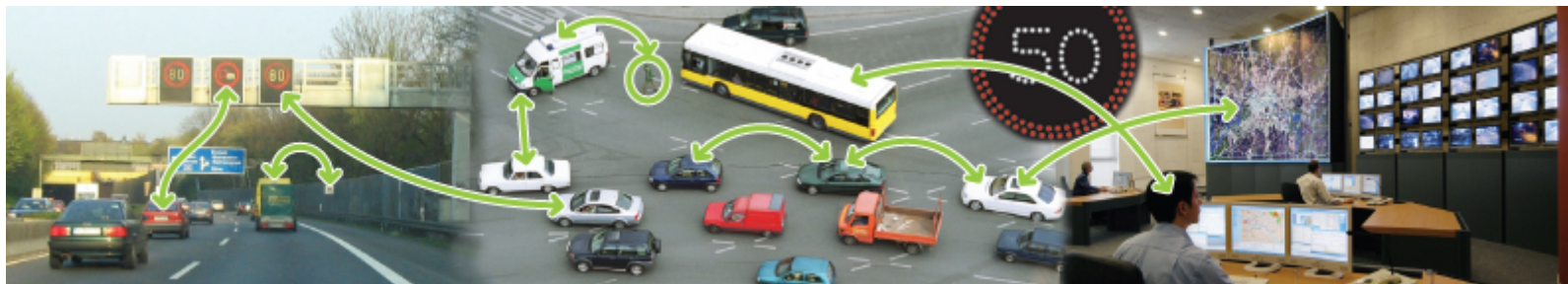




POMA

Positioning and Map-matching

Ph Bonnifait (speaker) F. Peyret
D. Bétaille, G. Dherbomez





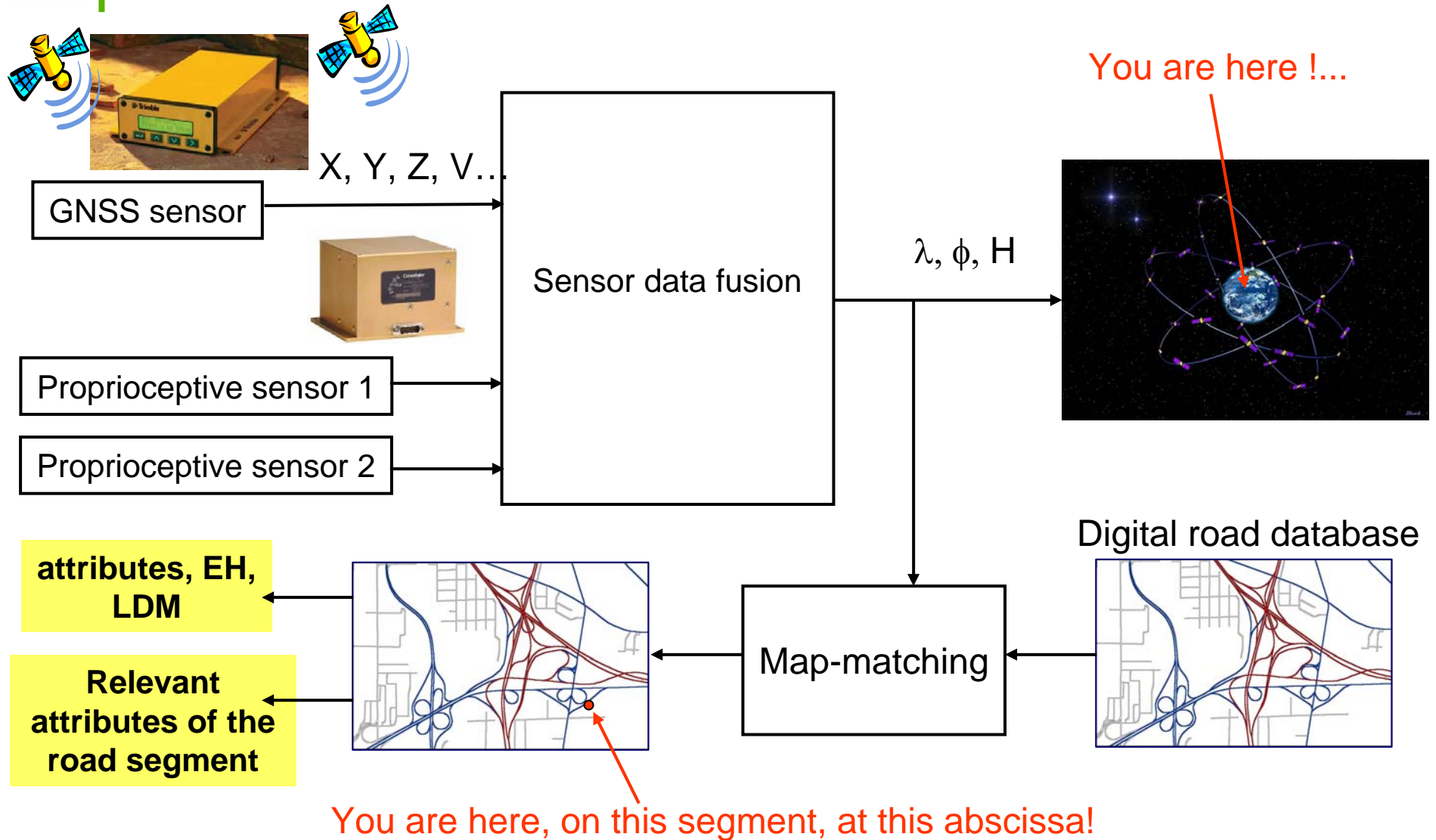
POMA – Main requirements



- Study cost-effective and reliable positioning solutions
- Use on-board sensors and road-side sensors
- Enhance current real-time map-matching solutions
- Formulate confidence levels of the estimates
- Implement POMA interface within CVIS applications



Positioning and Map-Matching





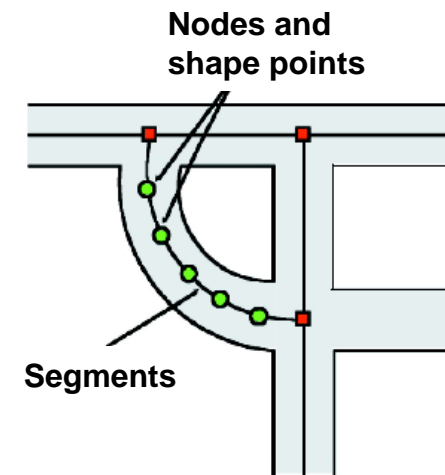
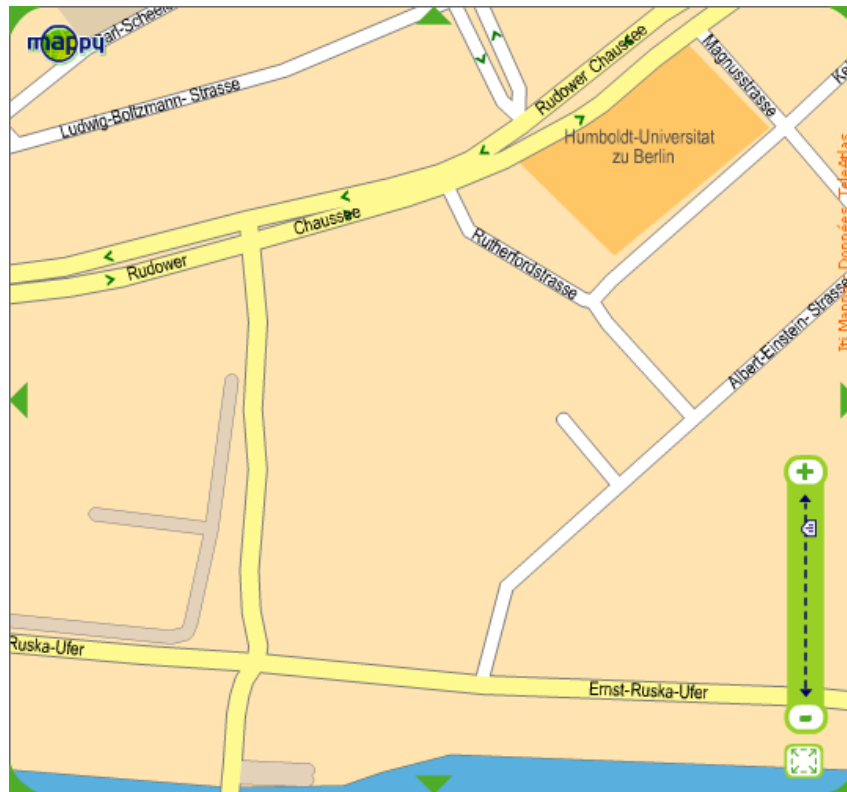
POMA Maps



Standard map (macro-scale)

One carriageway = one polyline

Longitudinal topology only

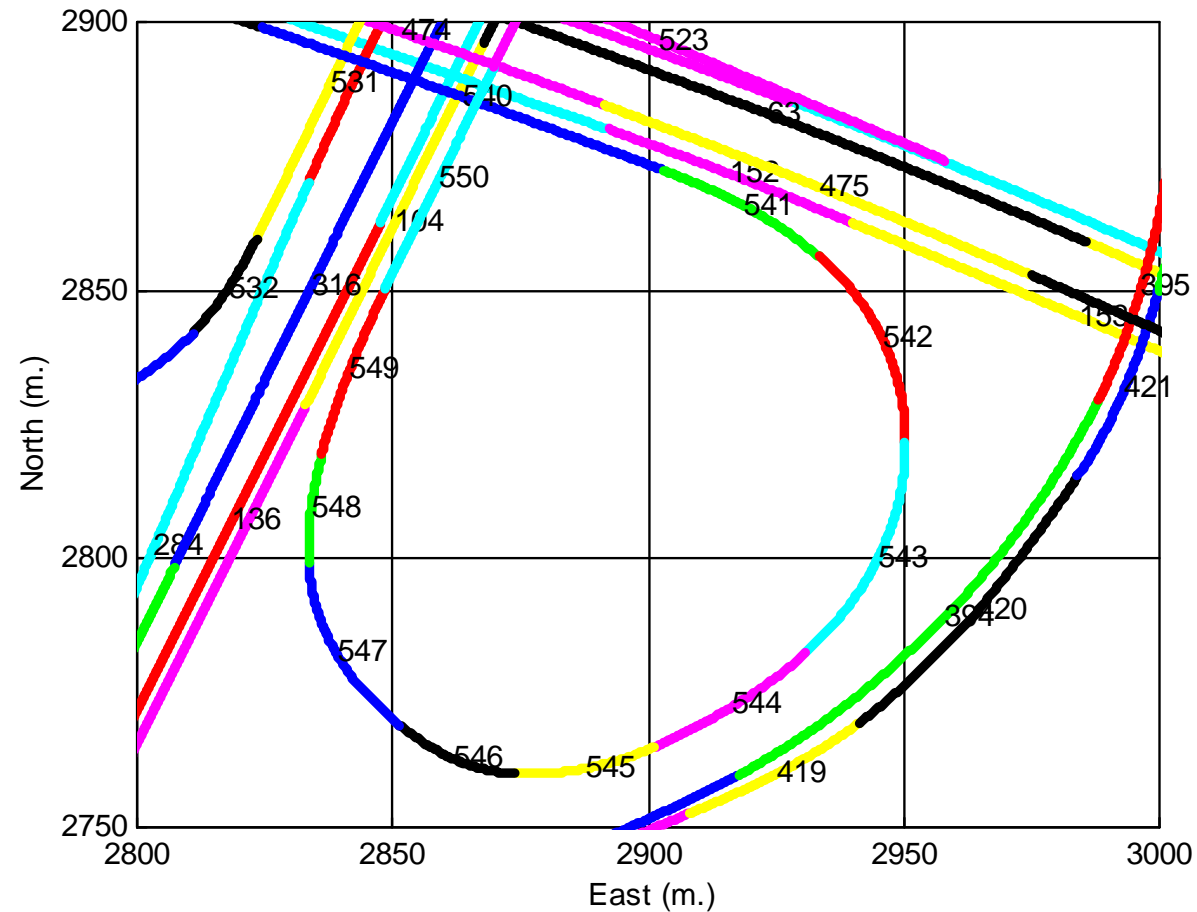




Enhanced Maps (meso-scale)

One lane = one poly-clothoid

Longitudinal and lateral topology





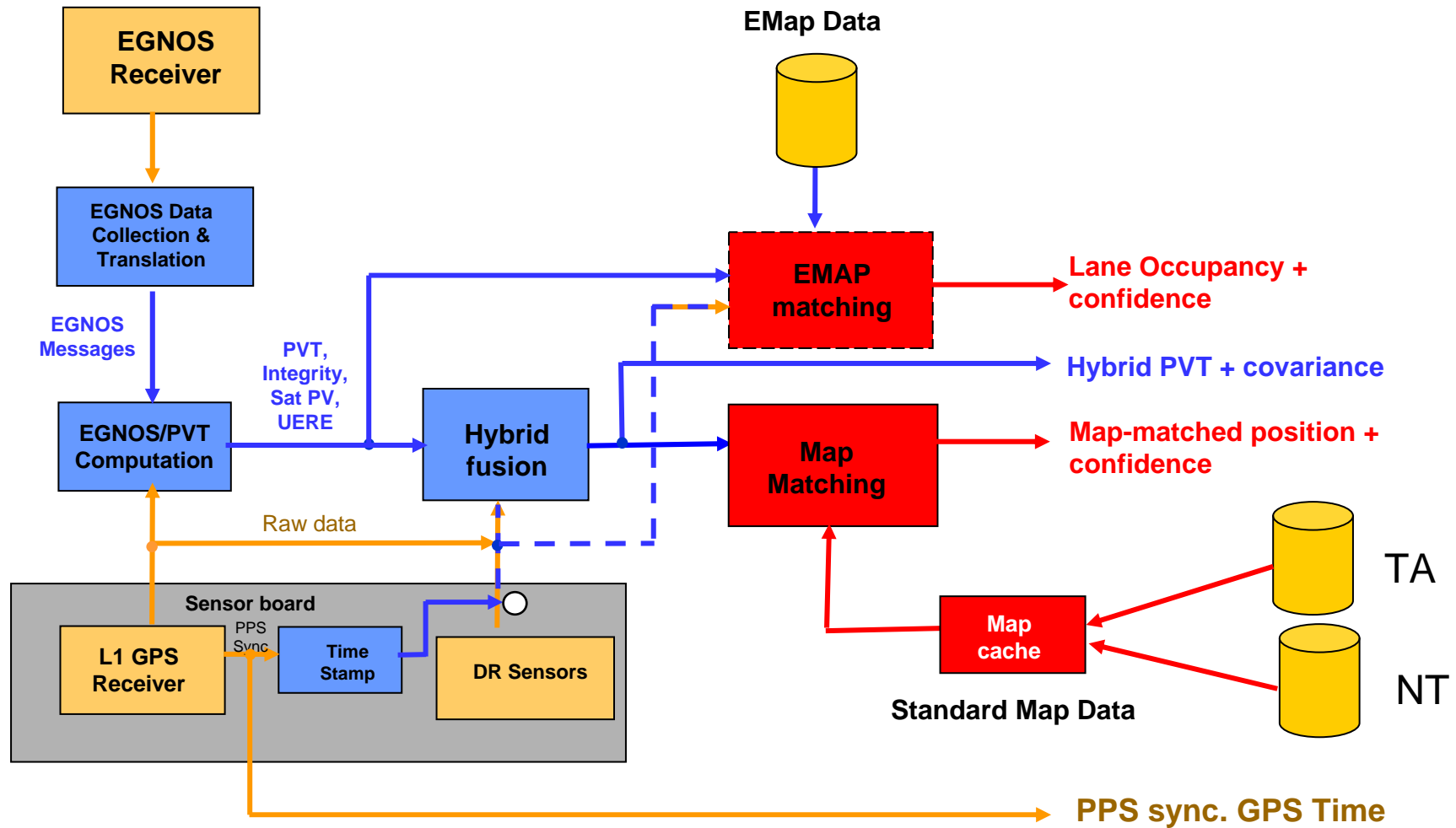
POMA specifications



- Map-Matching Module (up to 10 candidates)
 - Segment ID
 - Longitudinal and lateral position on the segment
 - Confidence indicator
 - Consistency indicator
 - Longitudinal error bound
- Emap module (for the most-likely candidate)
 - Lane ID
 - 1, 2, etc... from right to left vs. total number of lanes
 - Longitudinal and lateral position on the lane
 - Confidence indicator of the lane occupancy
 - Error bound of the position



On-Board Positioning and Map-matching





Solver used for the computations



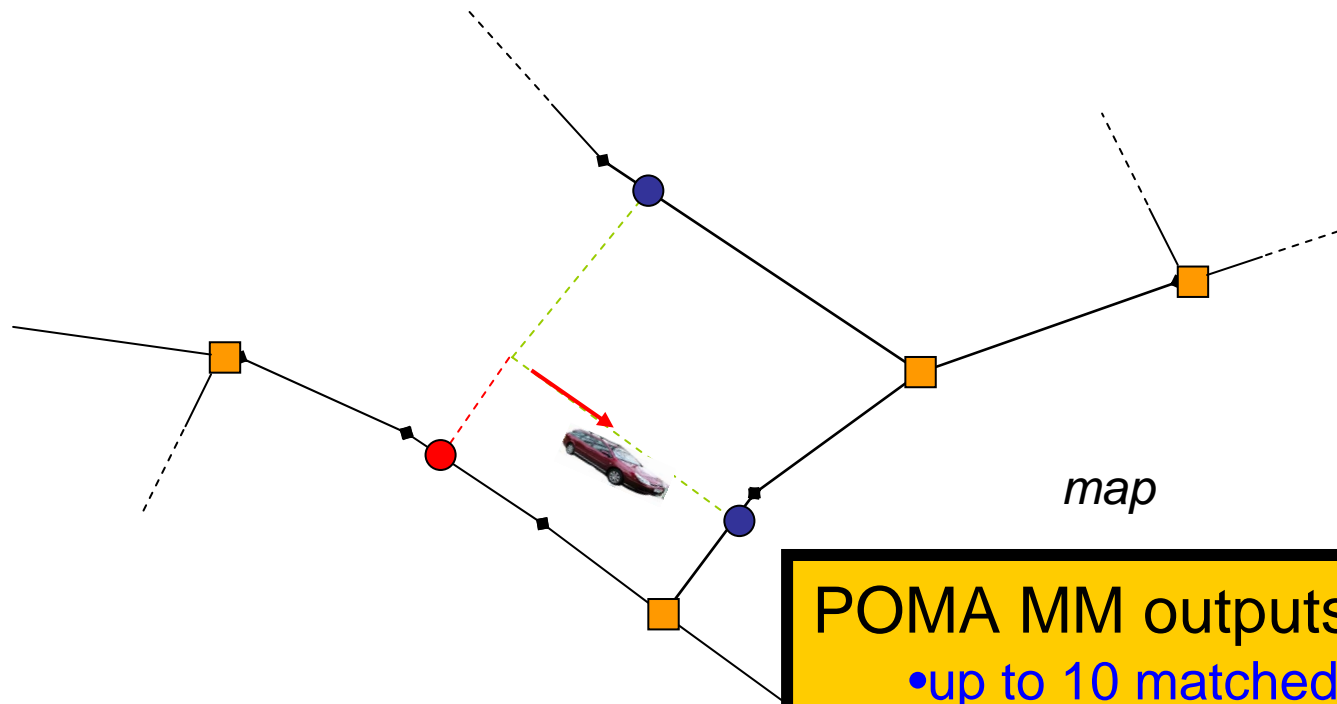
- Particle filtering
- Sequential Bayesian state estimation technique that generalize the Kalman filtering
- Advantages
 - Can cope with non-linear systems and non Gaussian noises
 - Solve efficiently data association problems



Map-Matching



Map Matching - Definition



POMA MM outputs :

- up to 10 matched candidates
- with confidence indicators

« *map-matching* » : determining the vehicle's position % a digital road database



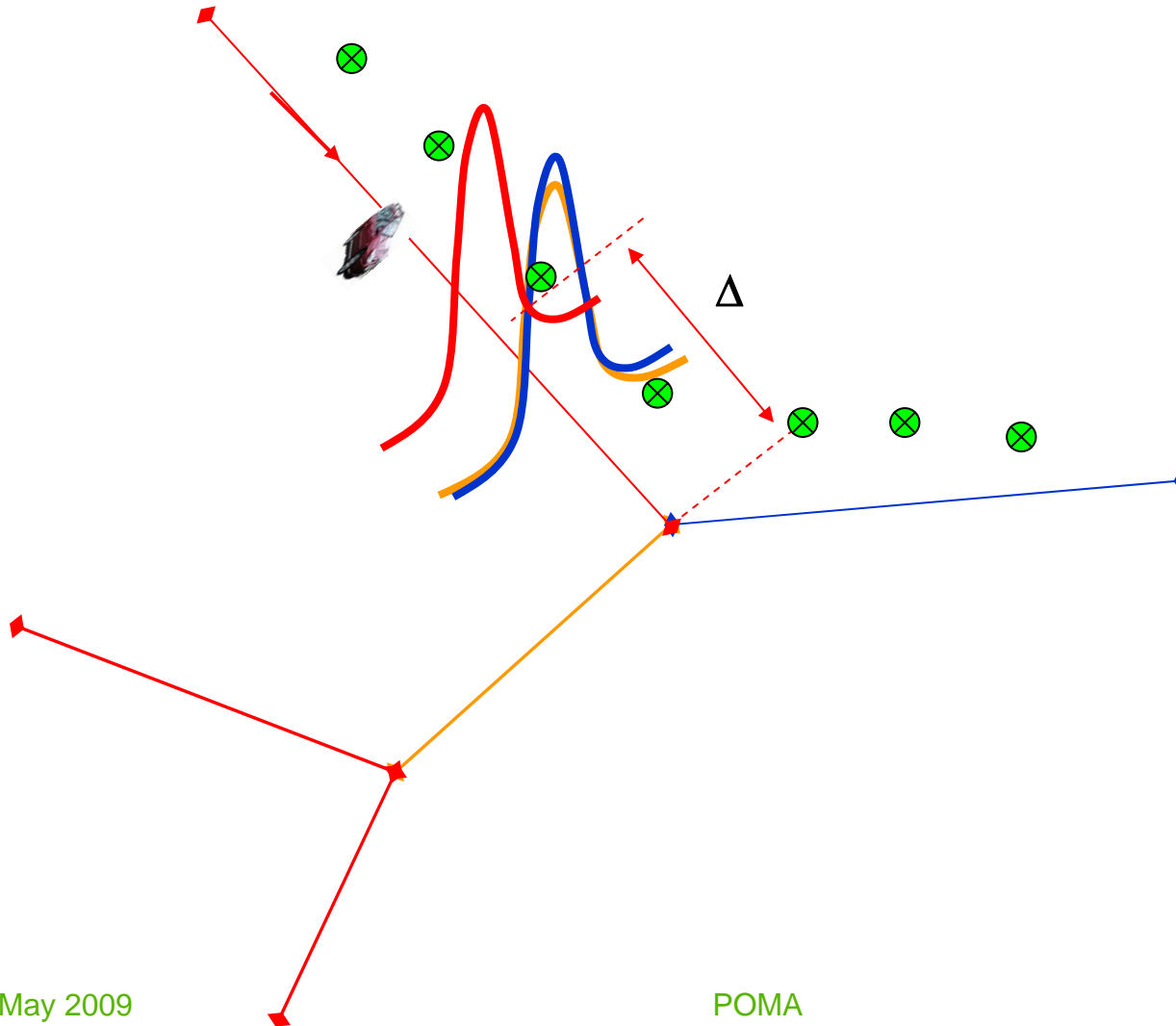
POMA MM in real-time



- Multi-Hypothesis Map-Matching (MHMM)
- Estimate the probability of each hypothesis with respect to the others
- Compute Normalized Residuals for each hypothesis
- Apply a decision rule for integrity monitoring
 - the risk depending on the application



Road tracking



Helmond May 2009

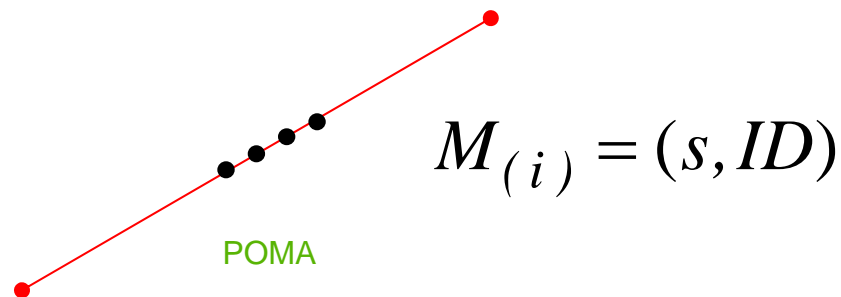
POMA



Particle Filter with Multiple Evolution Models



- Road tracking method
- Particles are constraint to follow the poly-lines representing the roads
- Noise is added at each prediction step in order to explore randomly the different hypotheses.
- A map matched position is a hybrid state

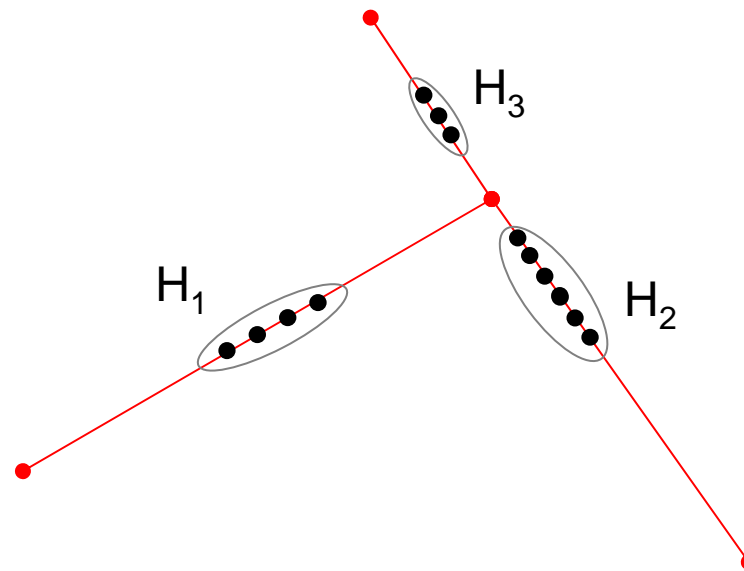




MEMPF estimation stage

Hypothesis H_i : approximated by sub-particle sets

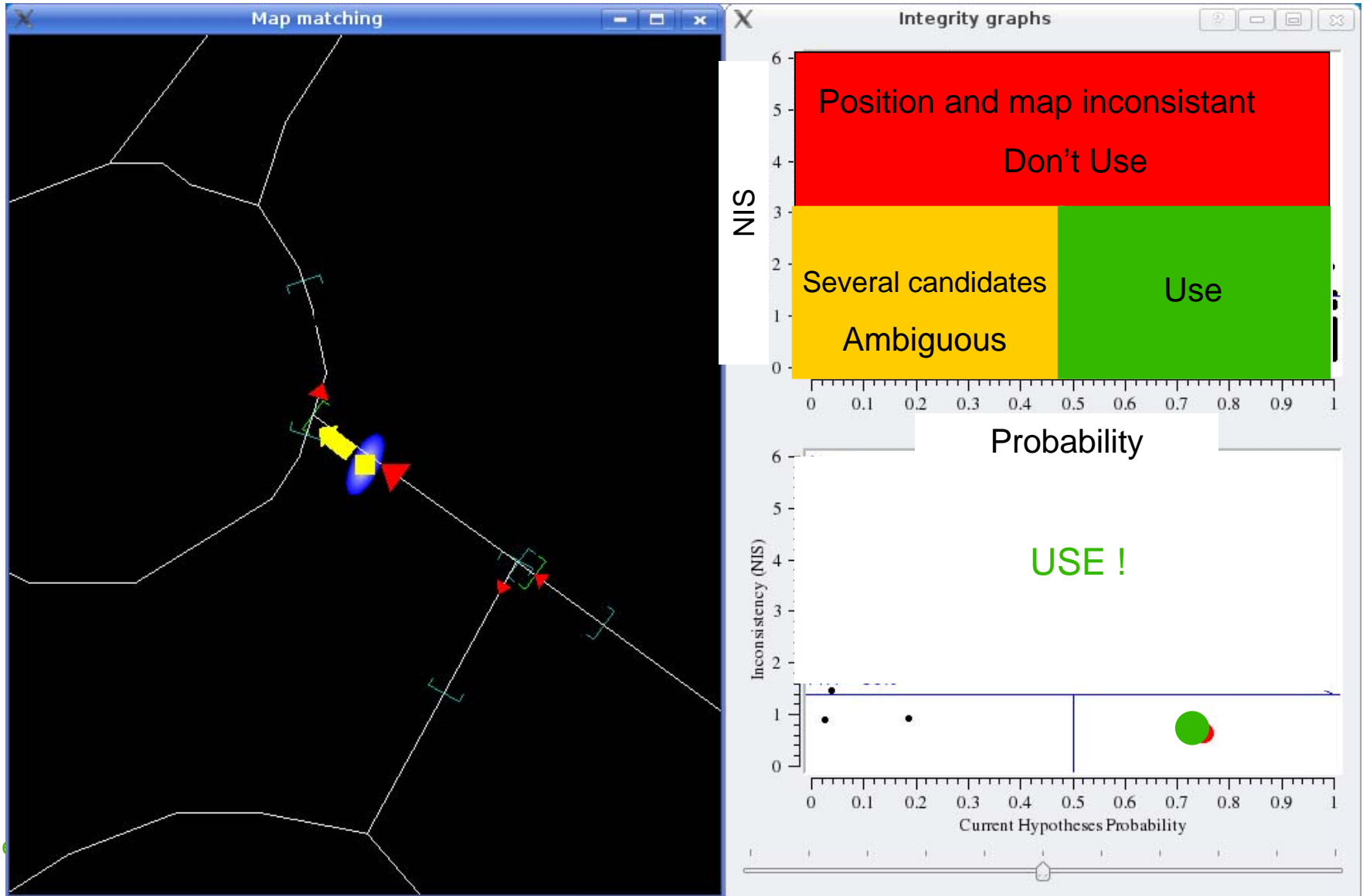
$$\chi_{h,t} = \{ \langle (s, ID)_t^n, w_t^n \rangle / ID = h \}_{n=1:N}$$



→ the system provides several candidates with confidence indicators

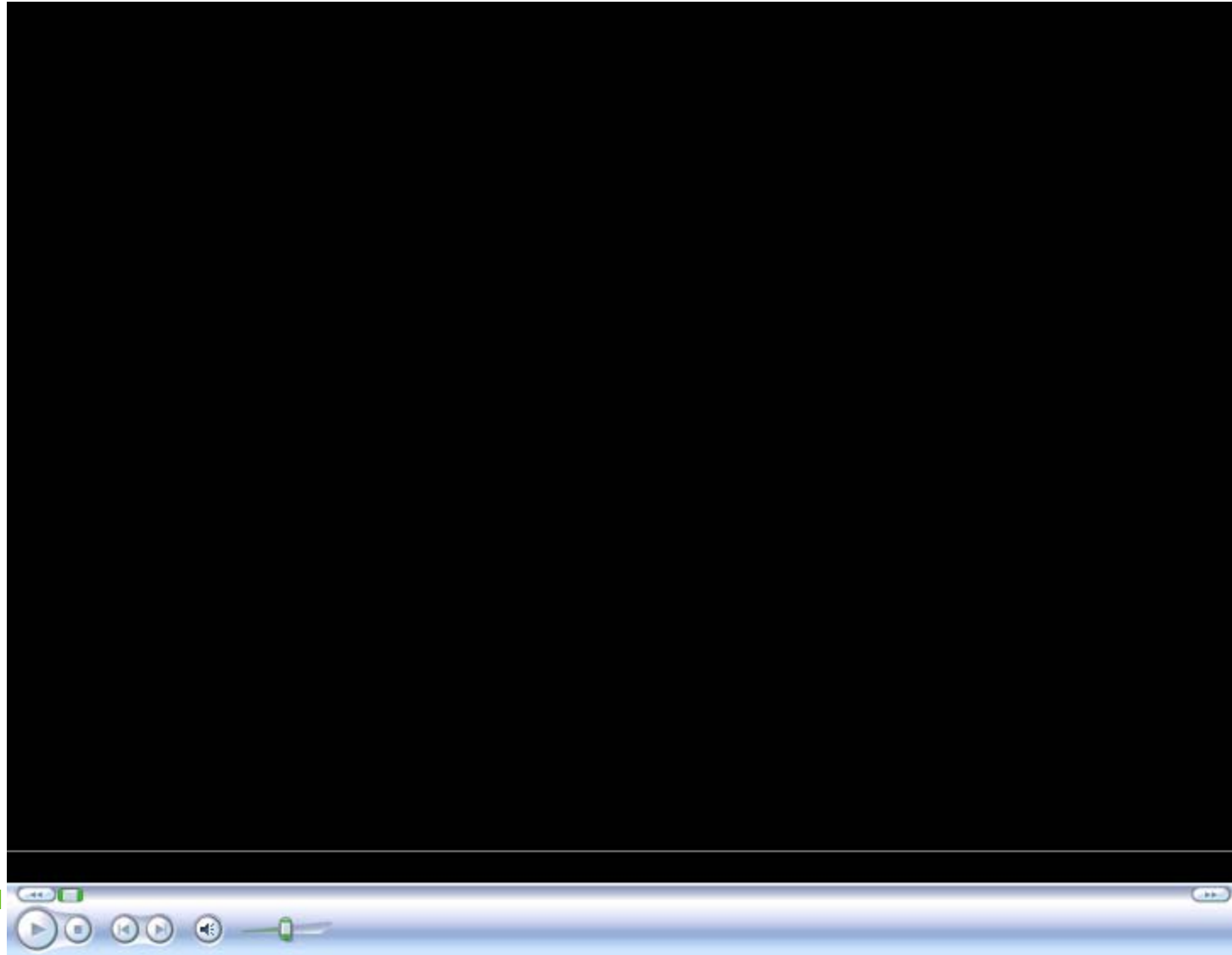


Map-Matching Integrity Monitoring





MM real-time Implementation



Helmond



Performance Analysis

Experimental results, Göteborg test track

<i>Map</i>	FAR (%)	MDR (%)	OCDR (%)
Map <i>i</i>	0.66	0.57	98.77
Map <i>j</i>	1.33	0.91	97.76

~3000 Map-Matched positions

OCDR (overall correct detection rate)



EMAP Matching



Emap example (Berlin test site)



H

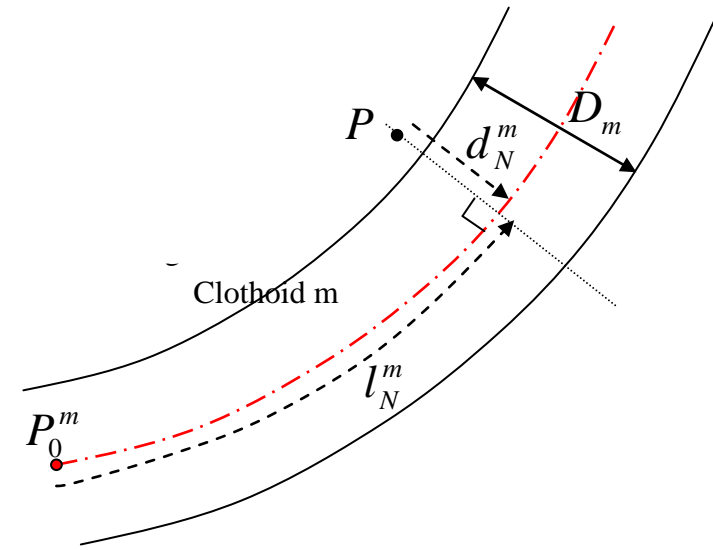


Problem modelling



- Composite state vector $x, y, heading \gamma$ and:
 - curvilinear abscissa (l)
 - transversal position (d)
 - in clothoid element (m)

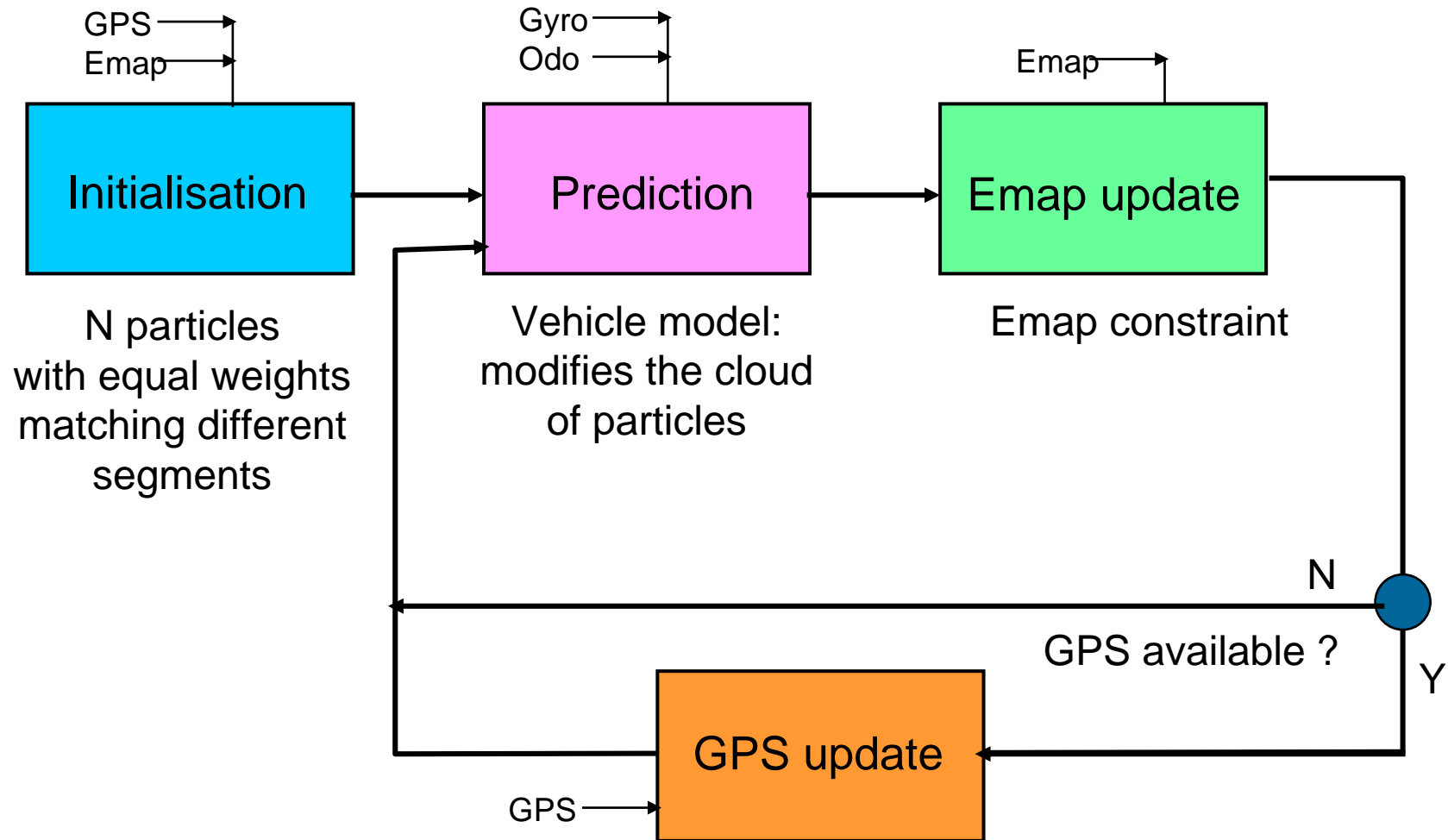
$$X = ({}^C X, {}^F X)^T = ([x, y, \gamma], [l_N^m, d_N^m, m])^T$$



- State vector prediction using odo and gyro measurements
- GPS and EMAP observations



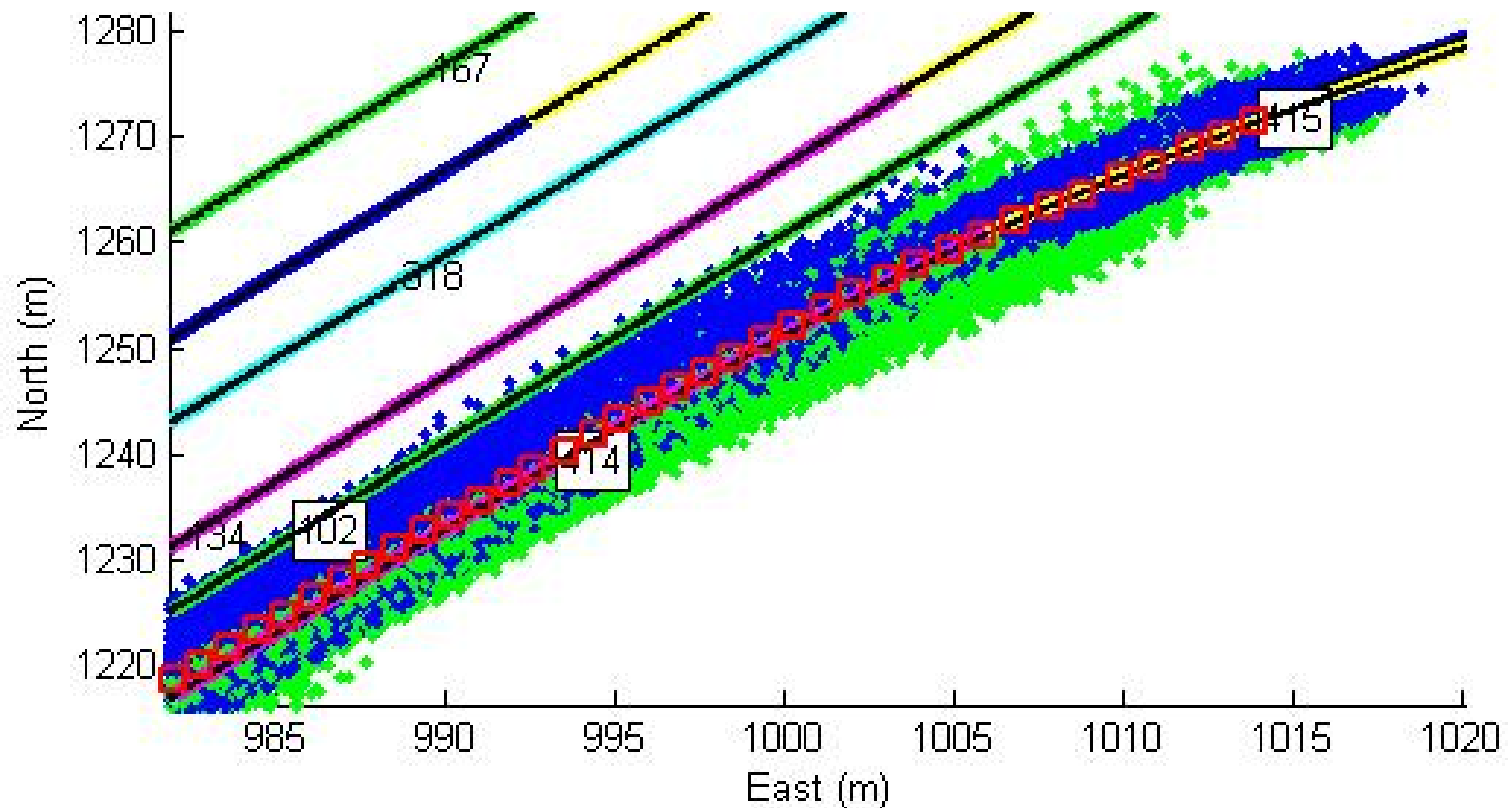
Particle filtering process





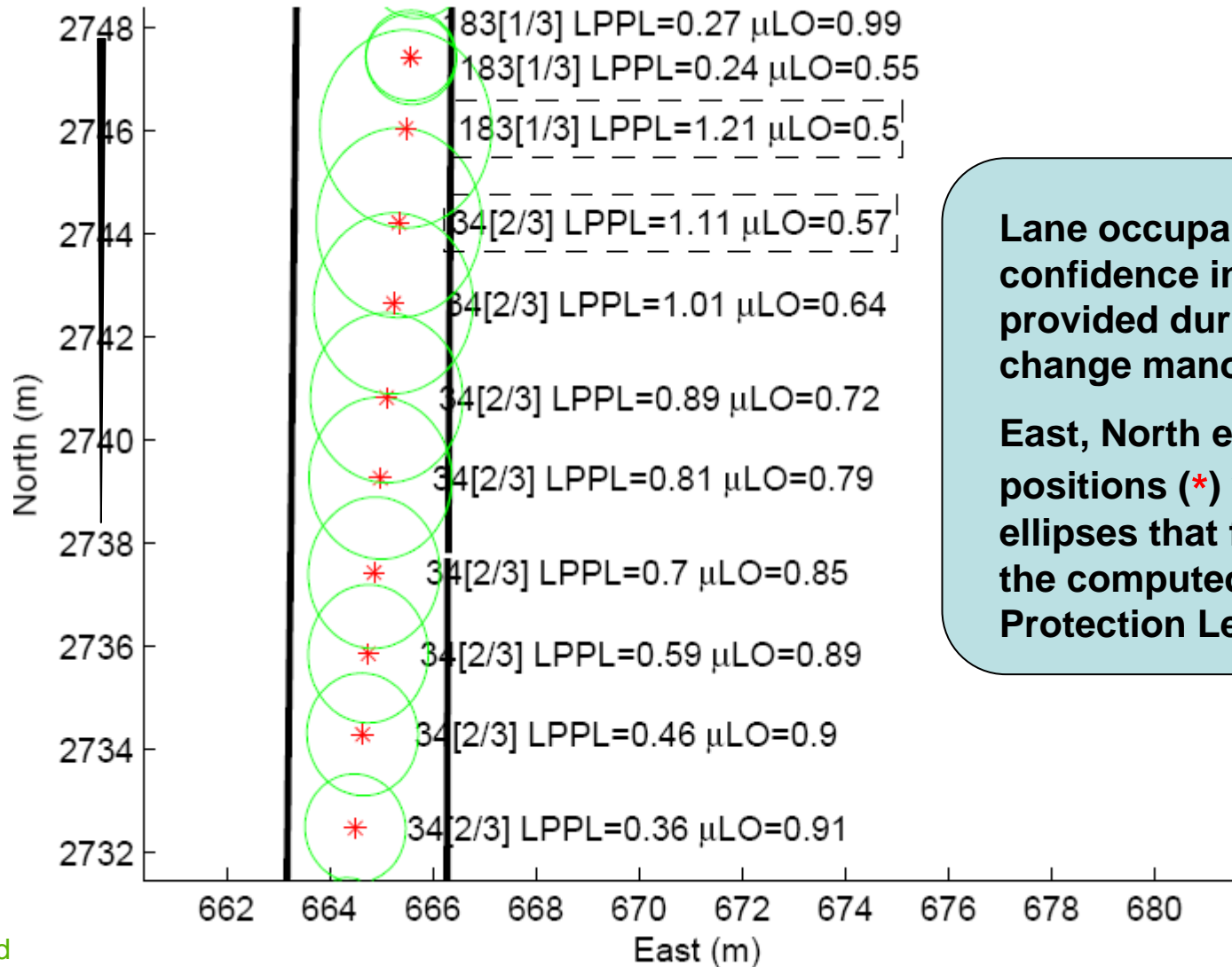
Emap aided localisation

- Green: predicted positions (using vehicle dynamics)
- Blue: Emap constraint





Lane occupancy + confidence



Lane occupancy and confidence indicators provided during a lane change manoeuver.

East, North estimated positions (*) with ellipses that figure out the computed Protection Level



Conclusion



- POMA map-matching solutions for real-time applications
- Macro and meso-scale map-matching
- Macro-scale
 - Standard maps, fully compliant with TeleAtlas and NavTeQ maps
 - up to 10 candidates, confidence indicators
- Meso-scale
 - Emap
 - one candidate, lane positioning, confidence indicator
- Implementations
 - Particle filtering
 - Macro-scale: real-time C++, 100 Hz
 - Meso-scale: Matlab implementation



Thanks for your attention...

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