GLORIA

Migration of LORAN-C for Land Navigation

(GLORIA Results)

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Paris, October 9th, 2001

Aims of GLORIA

- Provide Reliable Navigation for Rail & Road

- Application-List
  - Road pricing on major highways
  - Electronic ticketing for public transport
  - Electronic payment of parking fees
  - Public transportation in rural areas
  - Control of traffic flow for public transportation
  - Monitoring of hazardous goods
  - Support of Automatic Train Control (ATC)

Static testing (1)

- Test layout
  - Navigation and augmentation systems tested
    - GPS, GLONASS
    - EGNOS (ESTB)
    - LORAN-C (NELS), Chayka (Western Russian chain)
    - Eurofix (Feasibility phase)
  - Testing objectives
    - Determine the performance of the single systems
    - Answer specific questions on GNSS and LORAN-C behaviour
    - Generate input information for the kinematic testing

Static testing (2)

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- Testing parameters
  - Positioning accuracy (95%) north, east (and height)
  - Time availability
  - Local availability
  - Maximum outage duration
- Restrictions
  - No kinematically applicable equipment available at the beginning of the tests
  - Testing area is centred in The Netherlands:

    Testing of a system outside its nominal coverage area does not allow to determine meaningful performance parameters of the system.

Static testing (3)

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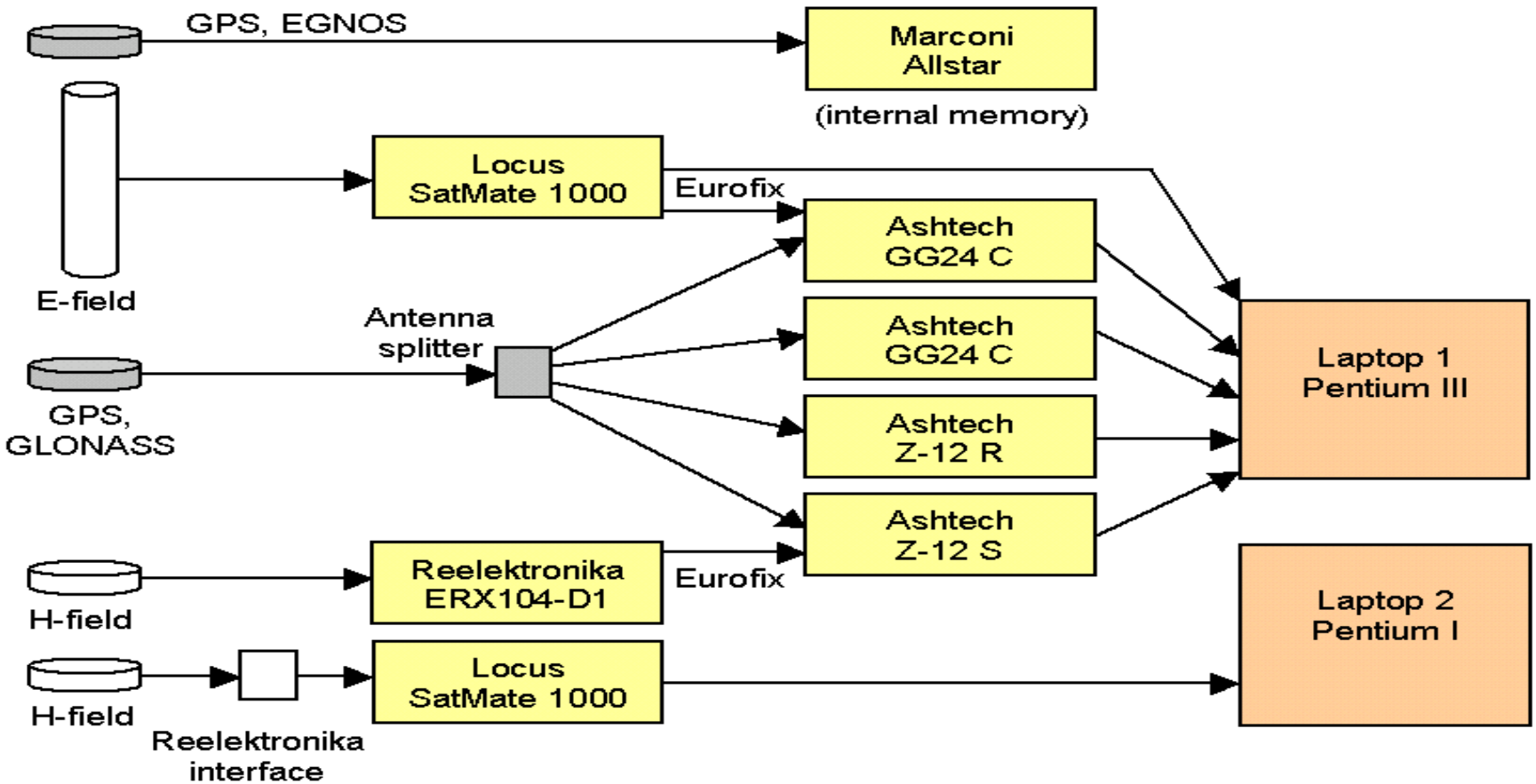
- Test execution – Receiver system



Static testing (4)

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- Test execution
  - Testing area

Static testing (5)

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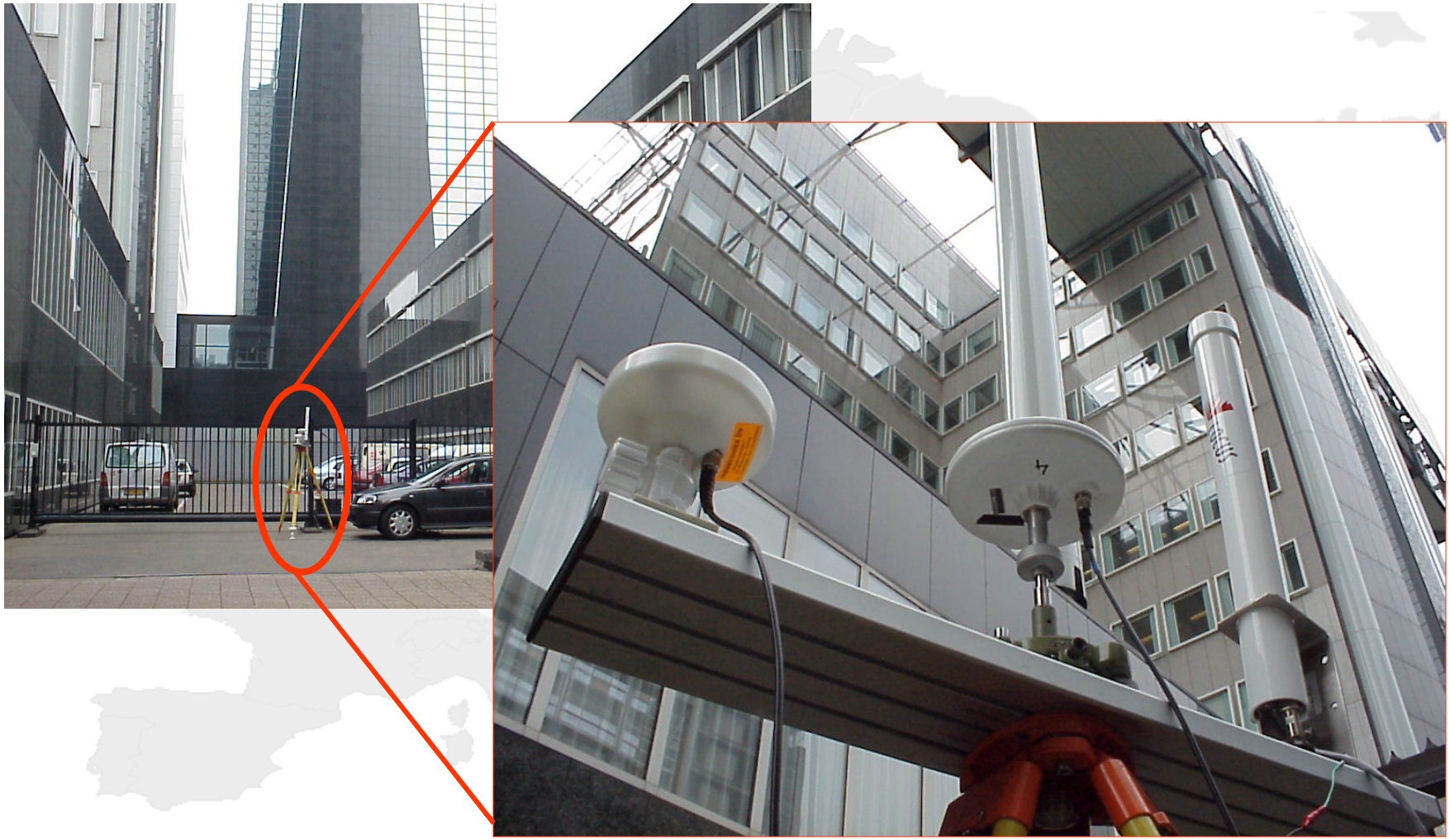

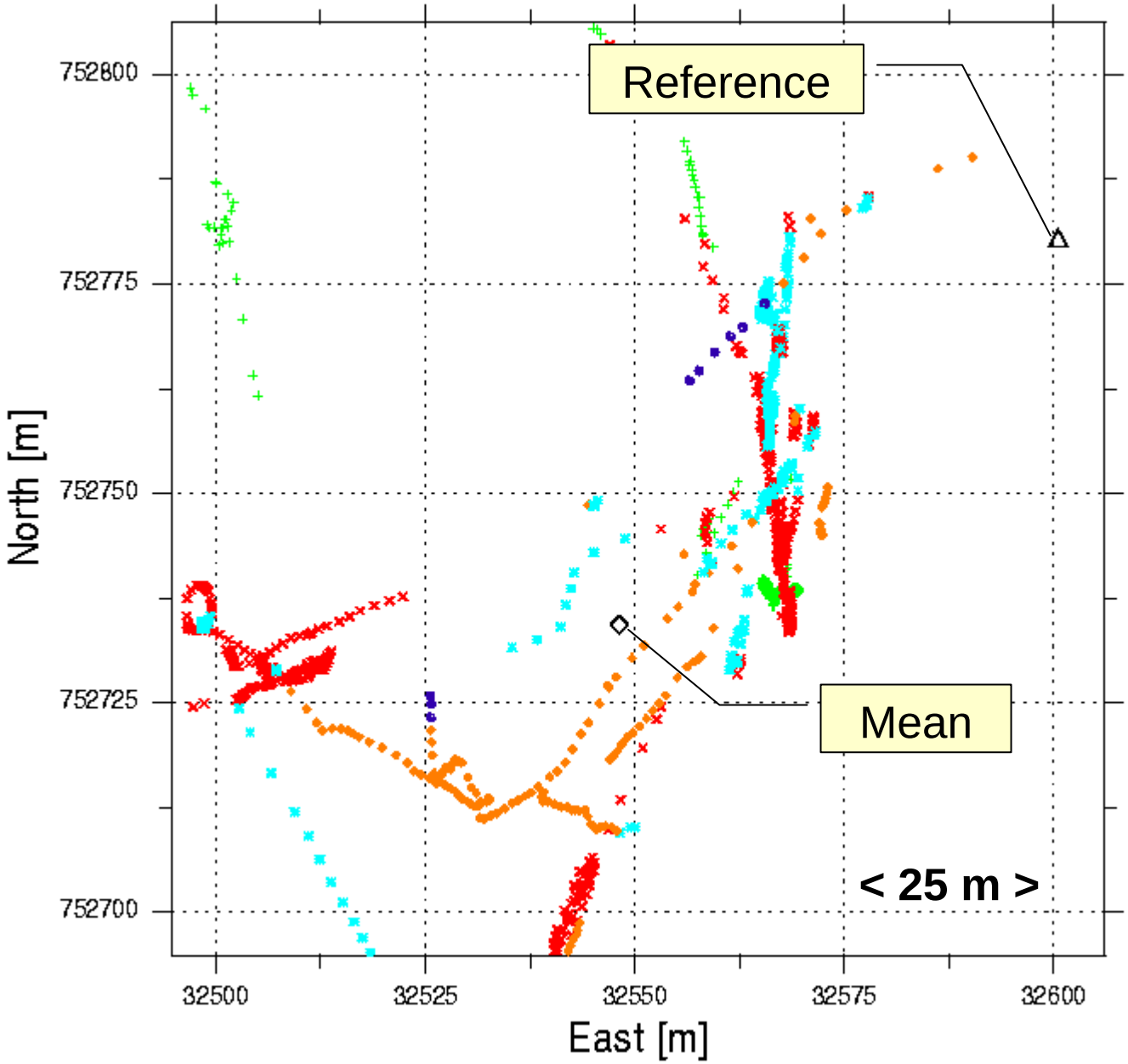

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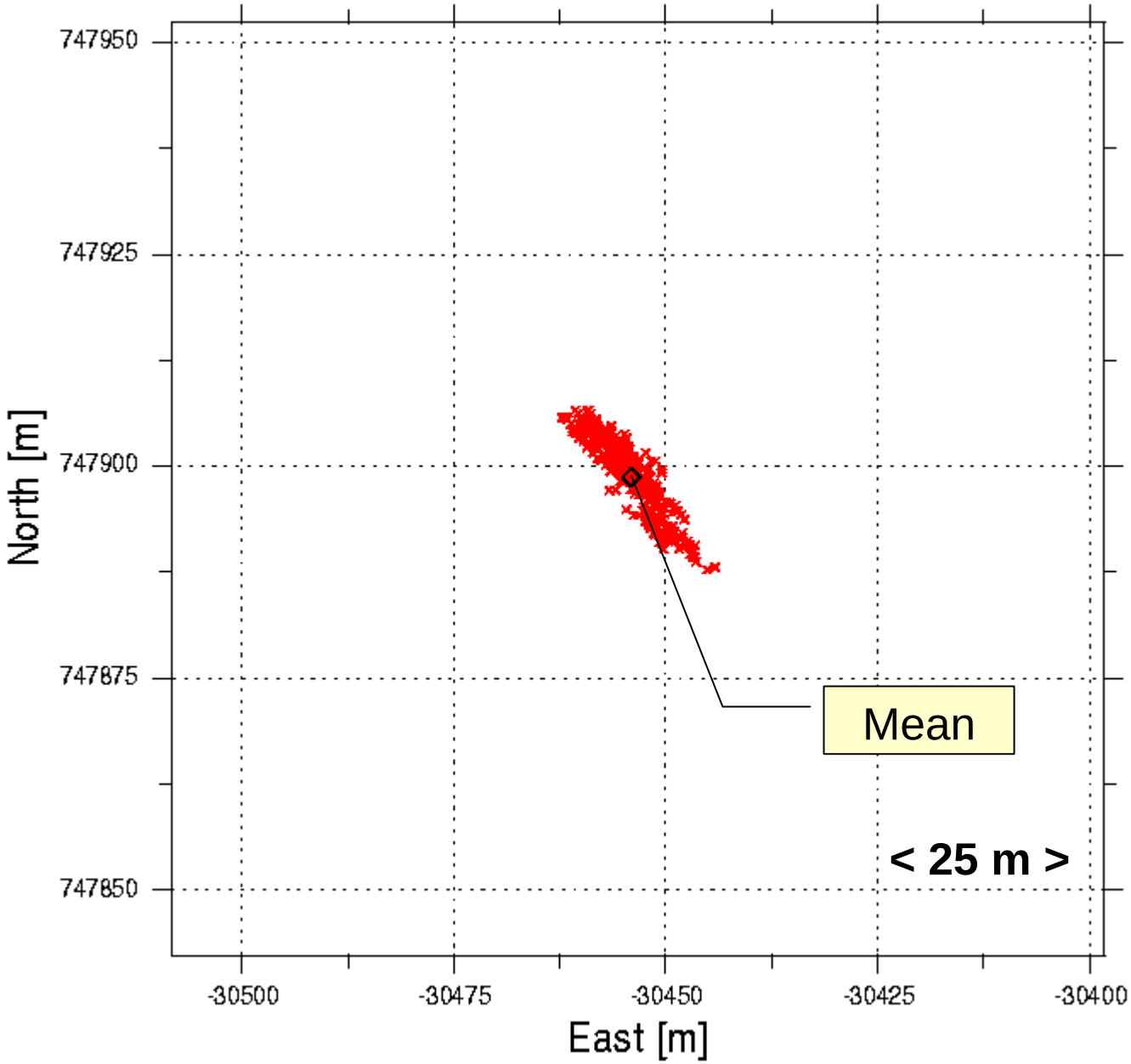
Static testing (6)

GPS

Ashtech Z12

Precision:
88 / 48 m (95%)

Bias:
46 / 52 m



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Static testing (7)

LORAN-C

Locus
SatMate 1000,
H-field antenna

Precision:
8 / 7 m (95%)

Static testing (8)

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Spreading of LORAN-C results

The main factor causing the diagonal spreading of LORAN-C results is the dominance of the Sylt-Lessay hyperbola (SatMate 1000 operates hyperbolic).

Measurement Vehicle

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Kinematic Test Campaign

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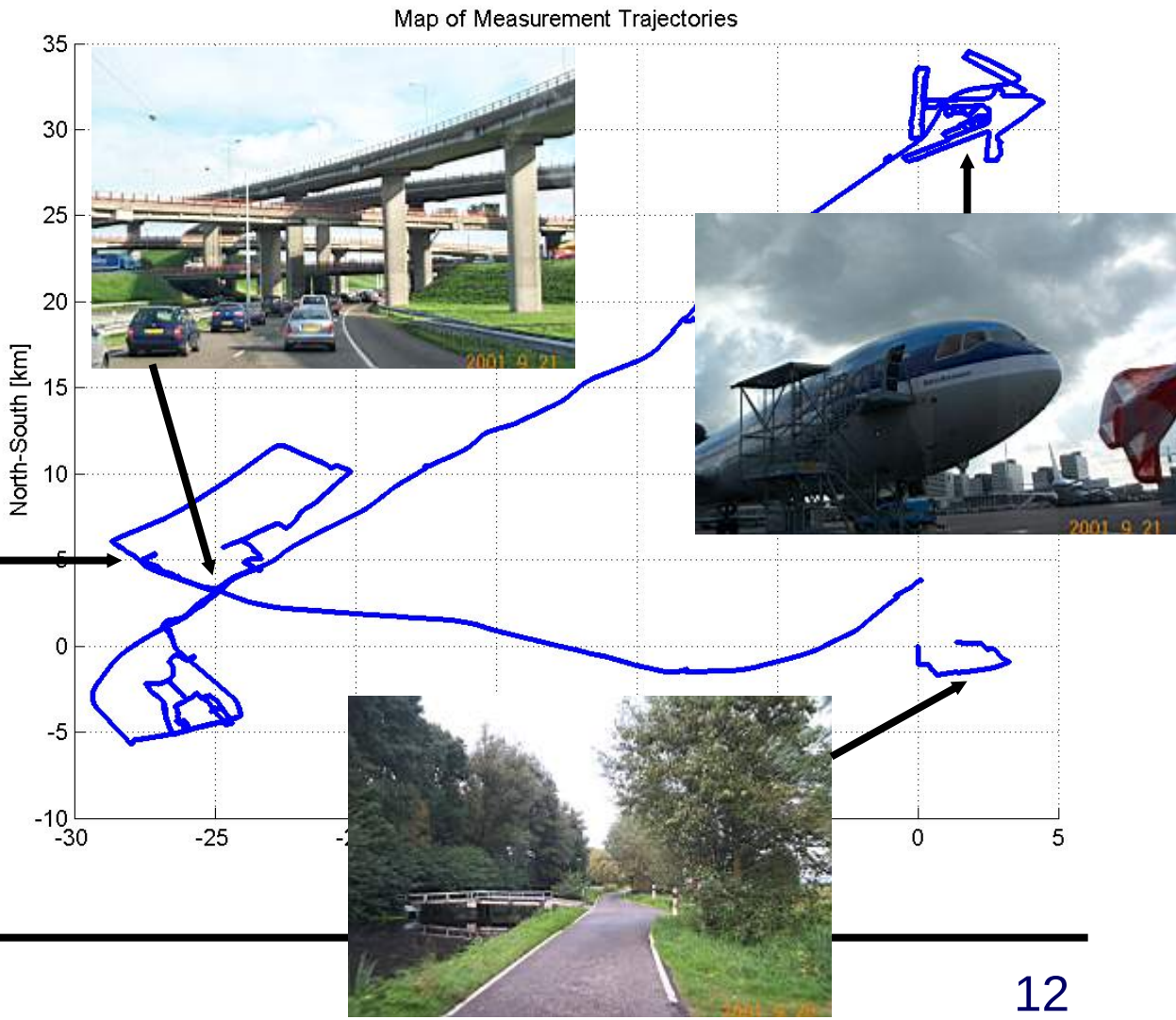
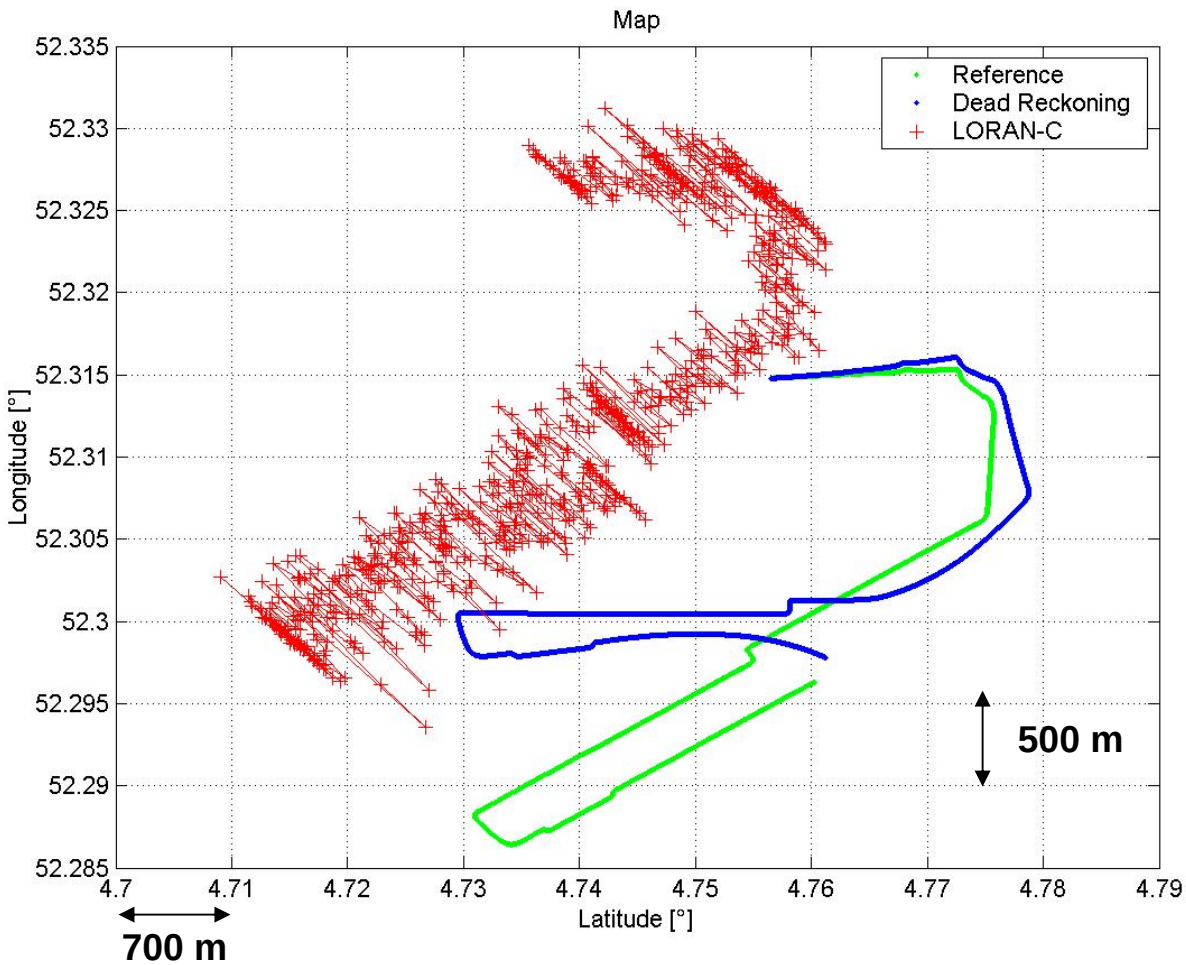
- Airport
- Highway
- Urban Canyon
- Rural Areas



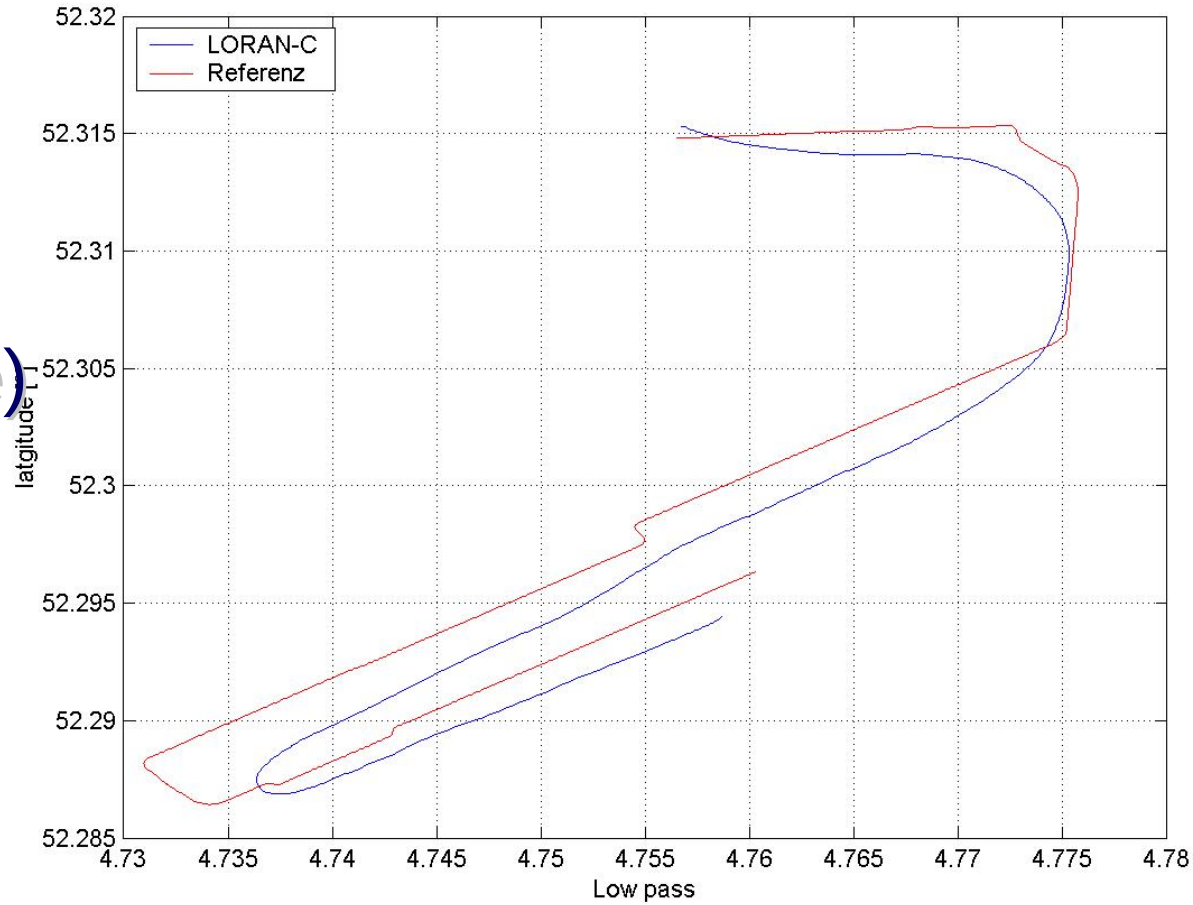
First Results

- Diagram of:
  - Dead Reckoning
  - LORAN-C
  - versus Reference
- Sub-Systems show large Errors!
  - TDAVG 1
  - Batch Limit 0



Error Modelling

- GPS-Delay
- LORAN-C Errors
- Low Pass (Error Mixture)
- Odometer Scale Factor
- VSG Drifts
- Nonlinearities RW, RC, ...



Integrated Navigation

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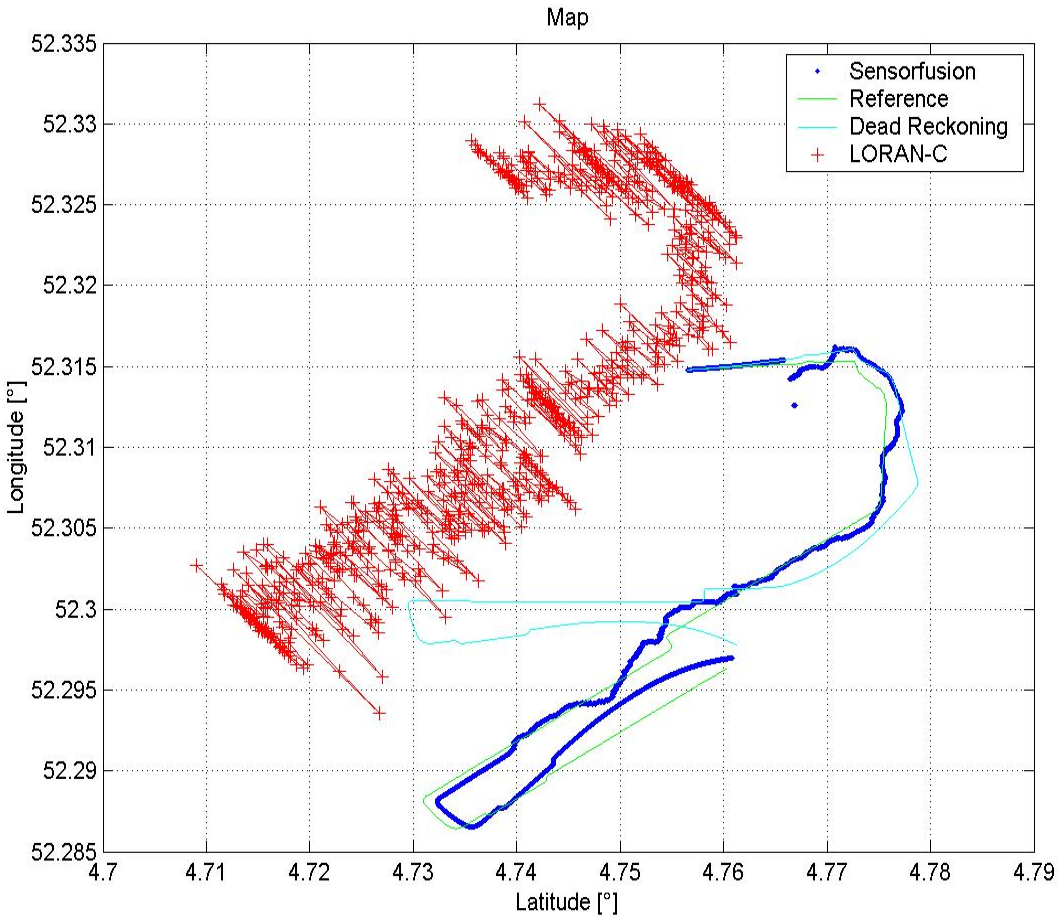
- Combining Dead Reckoning and LORAN-C shows a significant improvement



Migration Process

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- Apply H-field antenna instead of E-field antenna!
- Develop algorithms for interference rejection!
- Provide genuine measurements (no filter inside!)
- Provide measurements without time delay!
- Provide independent position information at 1Hz!
- Measurements must be independent of speed!
- Deliver detailed integrity information!
- Improve power consumption, size, weight and cost, for market penetration.

Conclusions (1)

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- Conclusions
  - The accuracy of LORAN-C is as low as 5-10 m (95%) using sophisticated signal tracking techniques.
  - The temporal availability of LORAN-C is usually 100%.
  - The diagonal spreading of LORAN-C results is due to the dominance of the Sylt-Lessay hyperbola.
  - Further transmitters are required for covering the region of Central and Southern Europe (low costs of only 6M€ per transmitter station).
  - The most promising augmentation system for land applications is Eurofix.

Conclusions (2)

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- Kinematic testing
  - Distinguish between Concept Idea and the current Technical Implementation
  - Sensor fusion of LORAN-C and DR gives strong indication for the correctness of the Concept
  - Development of a LORAN-C receiver for automotive applications
  - Currently available receivers are on the way of the migration path, but they have to go on further!