TUHH
Technische Universität Hamburg-Harburg

On the Accuracy of Flight Data Records for Aircraft Mobility Modelling

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TUHH, ComNets & *DLR, Air Transportation Systems

21. VDE/ITG Fachtagung Mobilkommunikation, 11. May 2016

Agenda

- Motivation
- Data Sources & Methods
- Results
- Conclusion & Outlook

Motivation: European Aviation Network

- Direct Air-to-Ground system (LTE)
  - Telekom
- S-Band satellite connectivity
  - Inmarsat

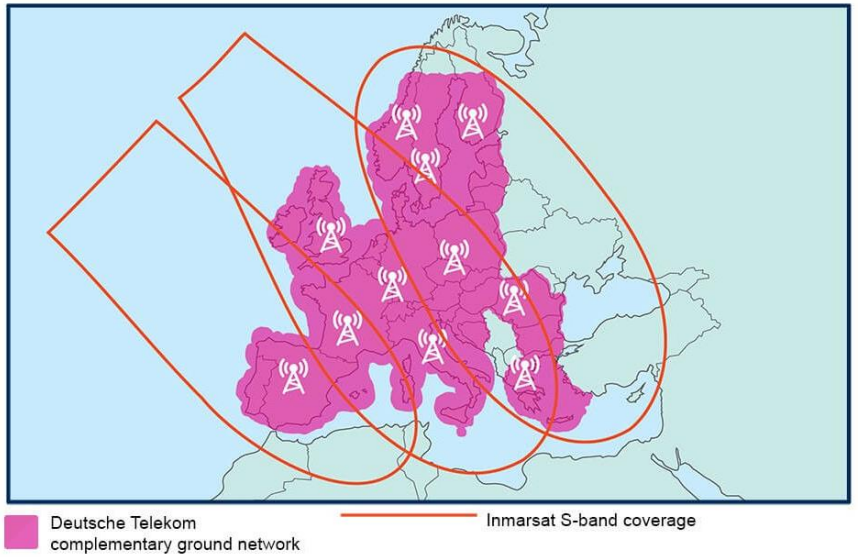
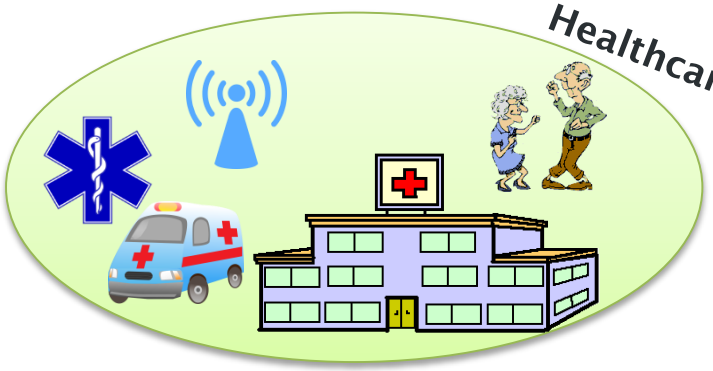
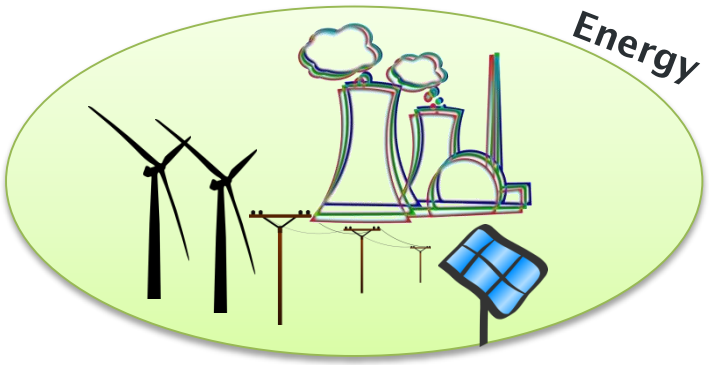


Image Sources: http://www.inmarsat.com/press-release/deutsche-telekom-and-inmarsat-partner-to-deliver-european-aviation-network/
http://winfuture.de/screenshot,1442856518.html

Motivation





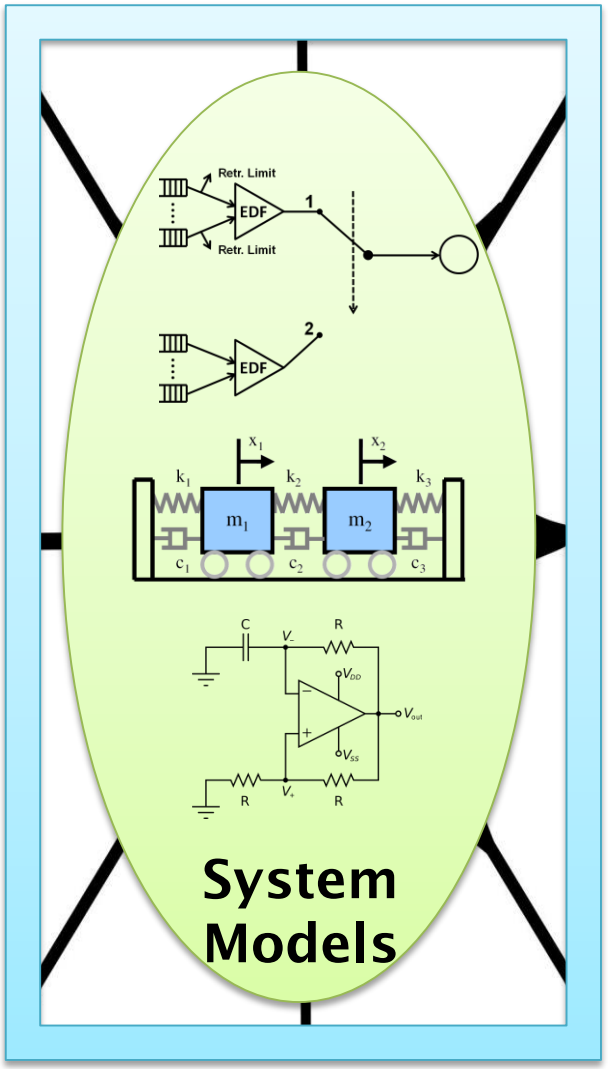
Testbeds,
Simulators,
Result
Evaluation

99.9…%

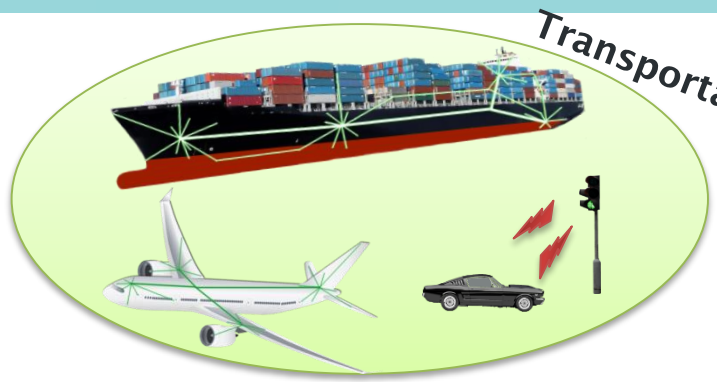
1 - 99.9…%

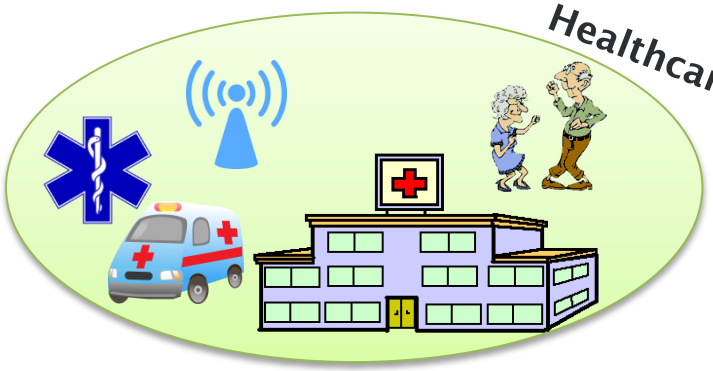
Modelling
Inaccuracy

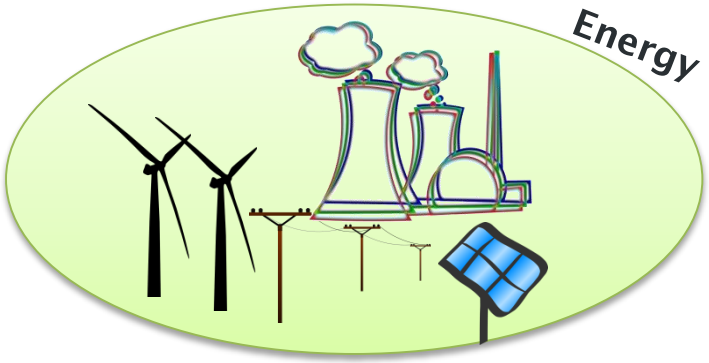
Environment Models



Motivation







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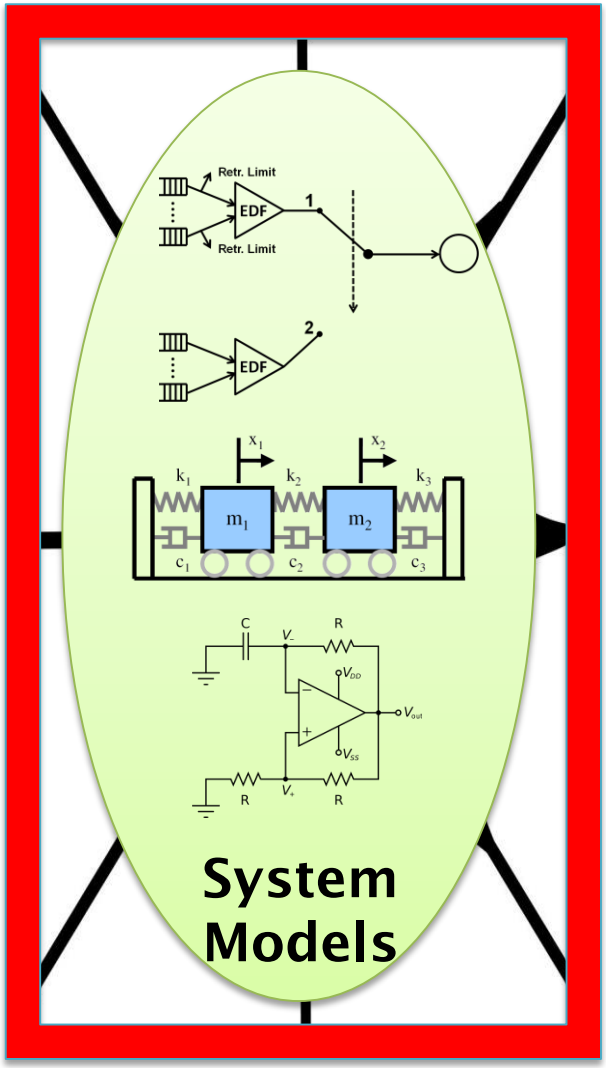


Motivation

- Mobility models can be created and parameterized from traces
- Should be validated [1]
  - Derived metrics (e.g. contact duration, encounter frequency)
  - Statistical distribution
  - Spatial & temporal correlation
- **Accuracy of trace must be determined first**
- Traces for air traffic:
  - Flight Data Recorder (FDR) (absolutely confidential)
  - Radar (different authorities for each country)
  - **Planned flight paths (EUROCONTROL)**
  - **Automatic Dependent Surveillance – Broadcast (ADS-B) (Flightradar24)**

[1] N. Aschenbruck, A. Munjal, and T. Camp: “Trace-based Mobility Modeling for Multi-hop Wireless Networks”, Computer Communication 34, 6, 2011

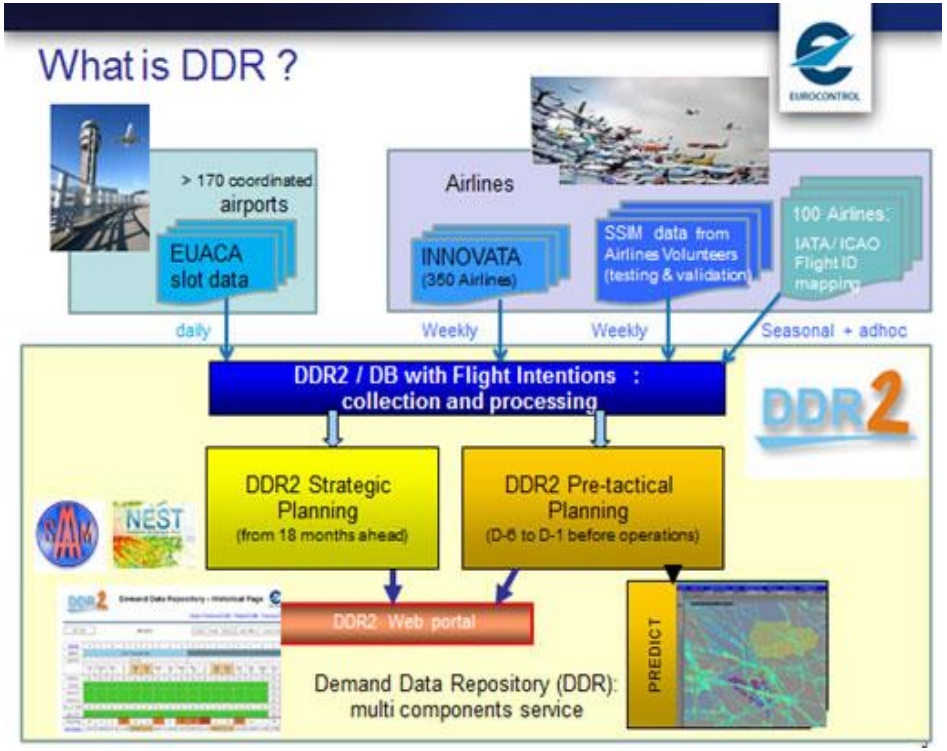
Data Sources & Methods

EUROCONTROL

- European Organization for the Safety of Air Navigation
- Intergovernmental organization with 41 member states
- Provide a “Single European Sky” to achieve a save, fast and environment-friendly way of air transportation

- Demand Data Repository (DDR)
  - Strategic planning
  - Pre-tactical planning
  - Historical data
  - Prediction for next 18 months

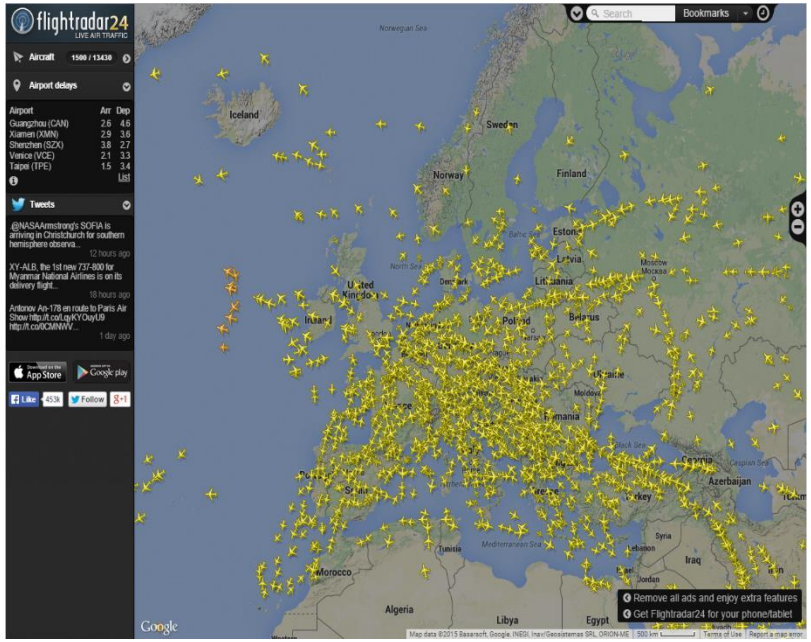
Planned flight paths



Source: www.eurocontrol.int/services/ddr

Data Sources & Methods

- Platform based on Automatic Dependent Surveillance – Broadcast (ADS-B)
  - Aircraft determines position
  - Broadcasts it together with other information
  - Received by ground stations



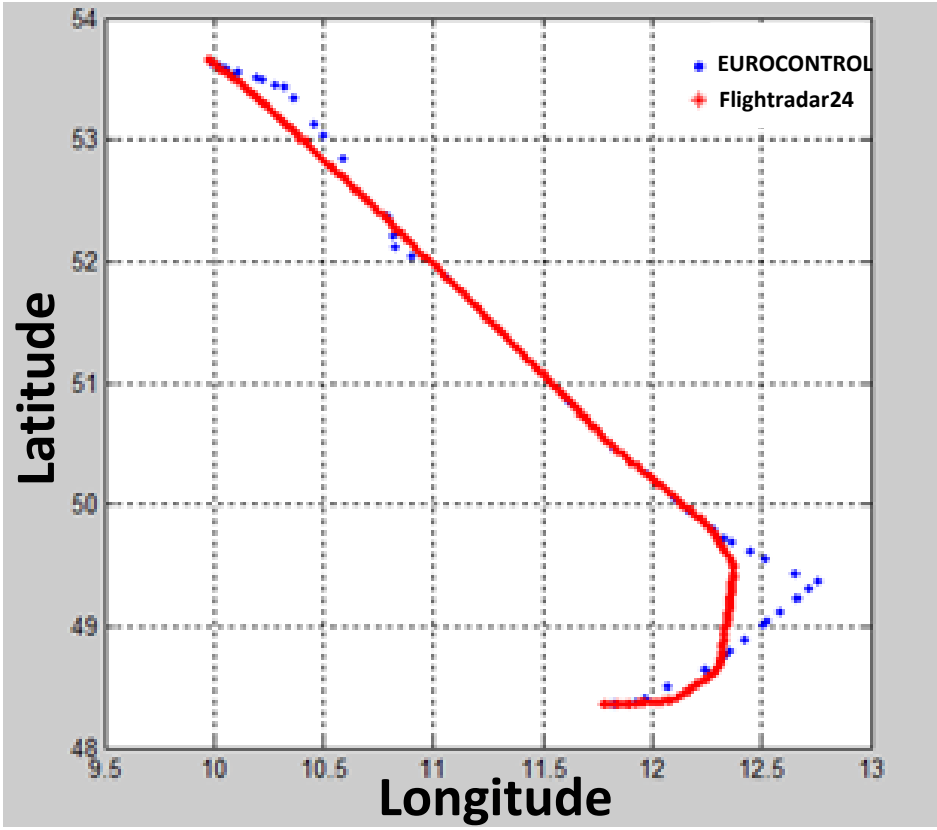
According to www.flightradar24.de:

- Ground station coverage in Europe: ≈ 99% **(not over sea)**
- Commercial passenger aircraft with ADS-B: ≈ 75%
- Aircraft with ADS-B: ≈ 20%

Data Sources & Methods

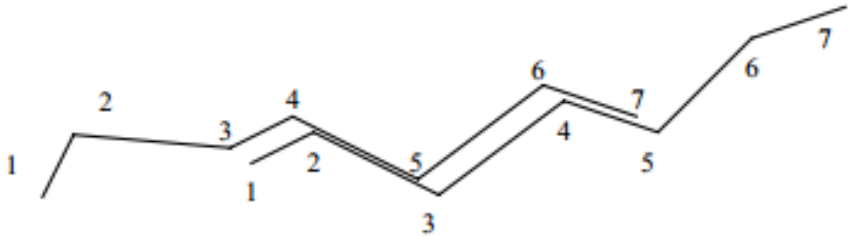
- EUROCONTROL:
  - ± Sparse
  - - Europe only
  - - **Actual flight path can differ**
  - + All aircraft
  - + Over ground & sea

- Flightradar24:
  - ± Dense (updated ~ every 10s)
  - - **Not over large bodies of sea**
  - - Not all aircraft
  - + Actual flight path
  - + Worldwide (different densities)

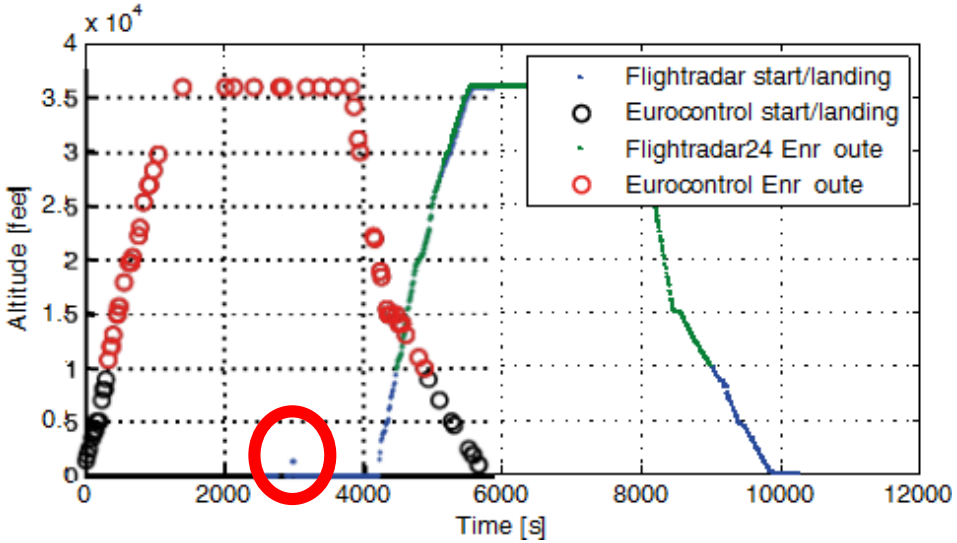


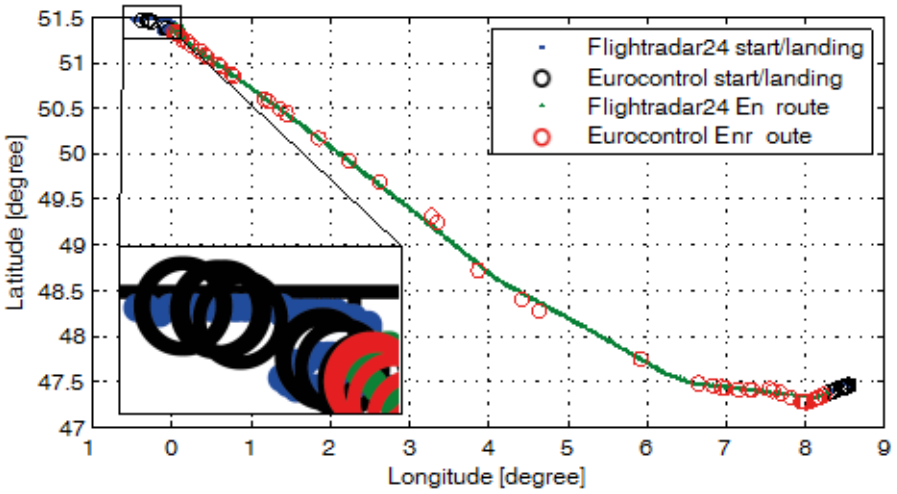
Data Sources & Methods

Spatial impairment (systematic error)
➔ do not correct



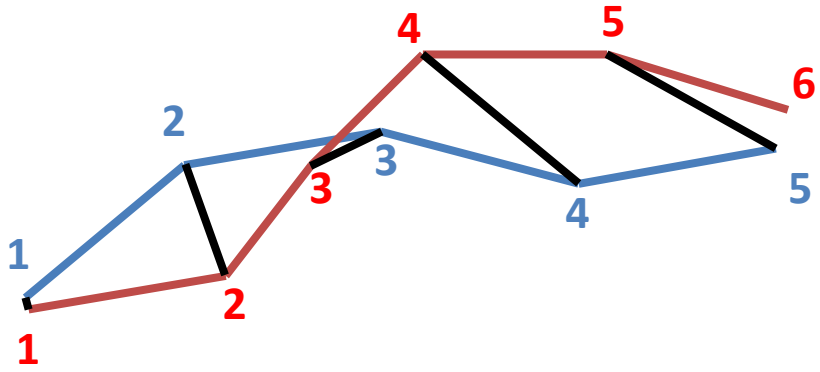
Temporal impairment
➔ Shift to minimize distance



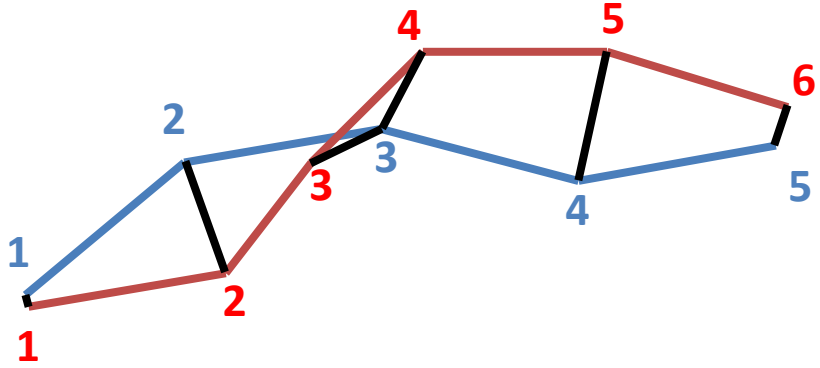


On ground, start, landing ➔ Remove (en route only)

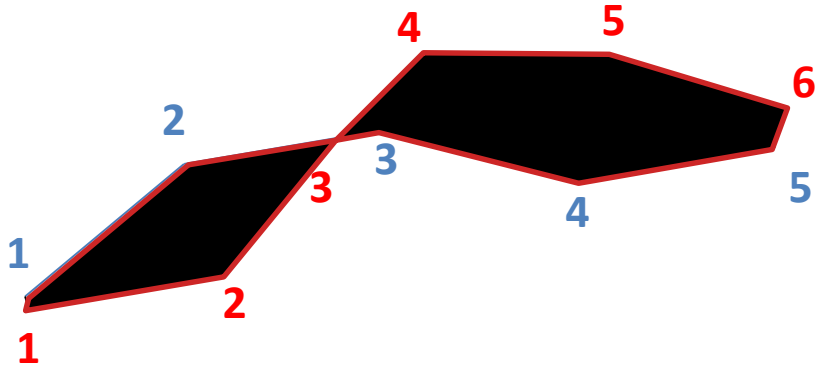
Data Sources & Methods



(Mean) Pointwise Distance



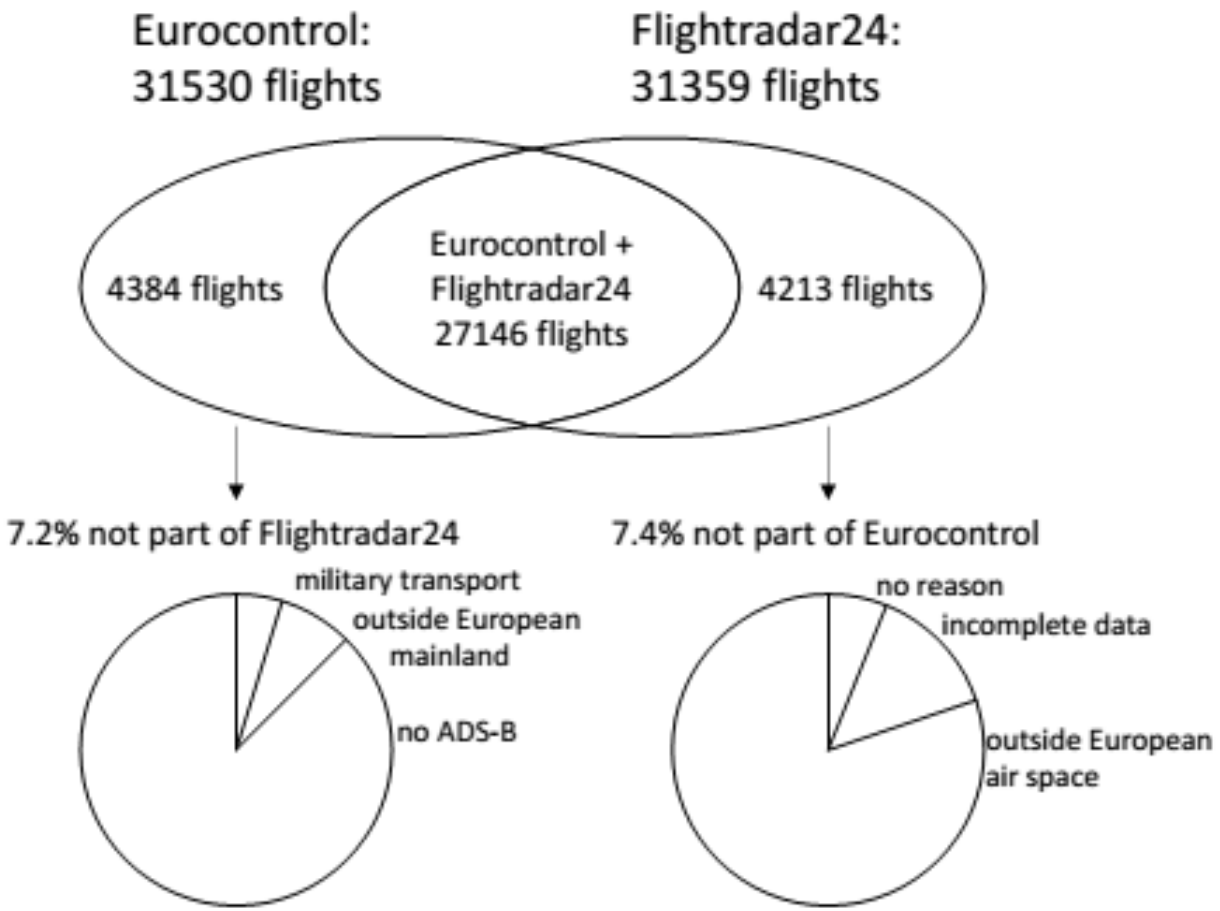
(Mean) Shortest Distance



Area (normalized to length)

Results: Database Completeness

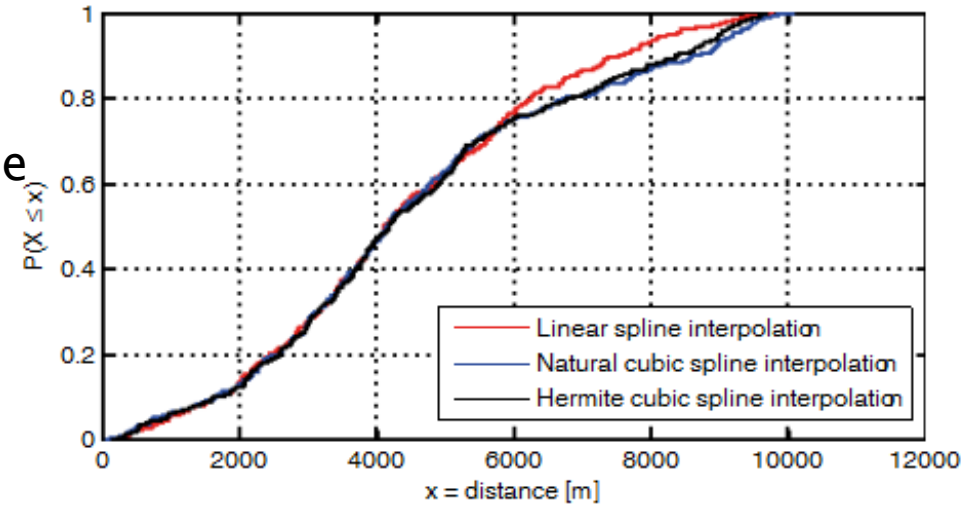
All flights on 27.06.2014 (most busy day in databases)



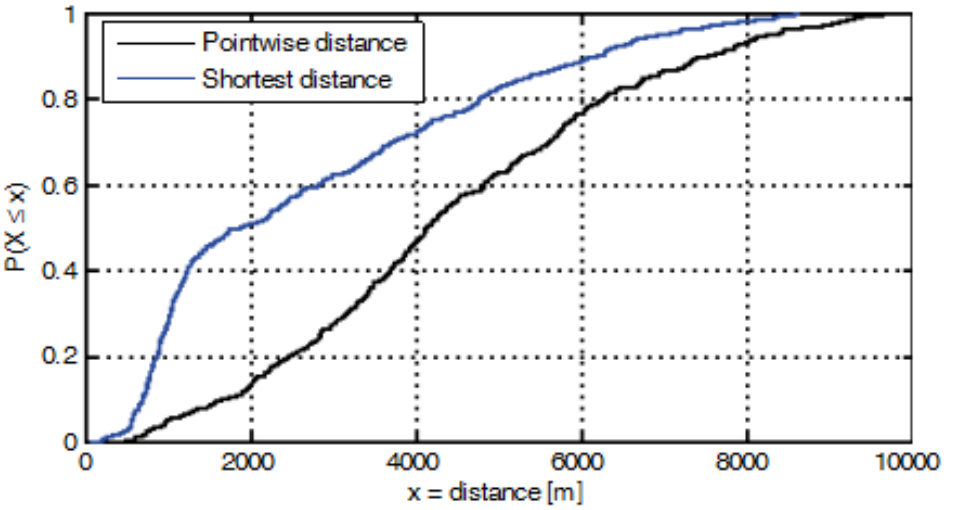
Results: Accuracy

Flight BAW3ZL 26.07.2014 Zurich to London

- Linear interpolation almost as accurate as spline interp.
- No significant difference between natural & hermite cubic spline interp.



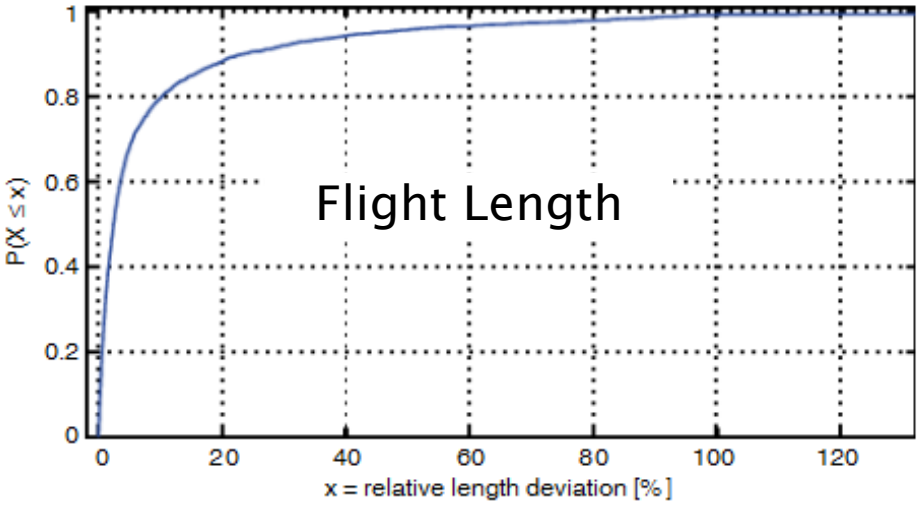
- "Shortest distance" much shorter than "Pointwise distance"



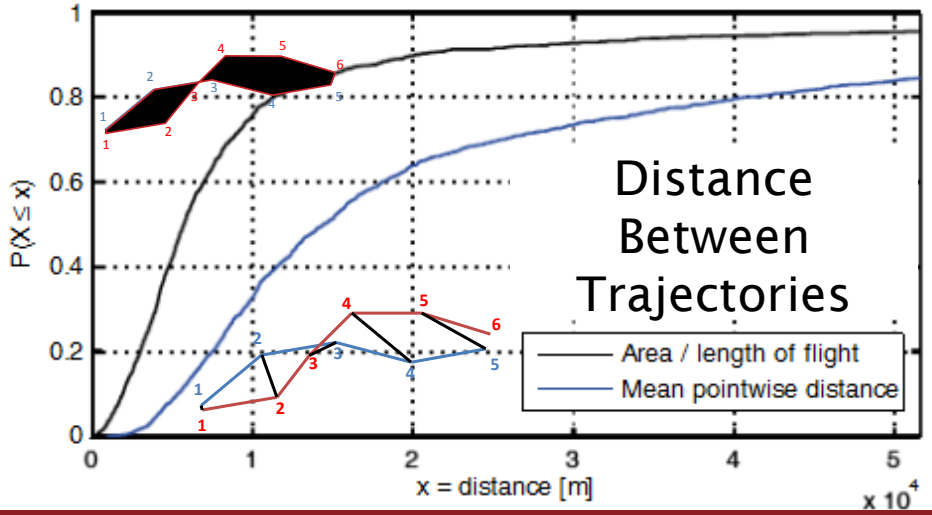
Results: Accuracy

All flights on 27.06.2014 (most busy day in databases)

- Less than 10% deviation of flight length for 80% of the flights
- Rarely even more than 100% deviation (distance doubled)
- From data inaccuracy & permitted shortcuts

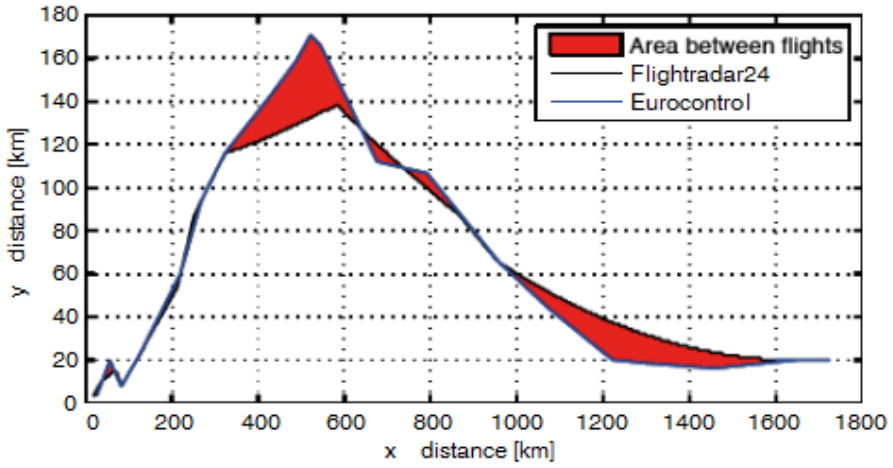


- Two methods to determine distance show significant deviation
- "Area" method is preferred since not affected by sampling point impairments
- 80% of distances <10km
- >50km also sometimes occurs

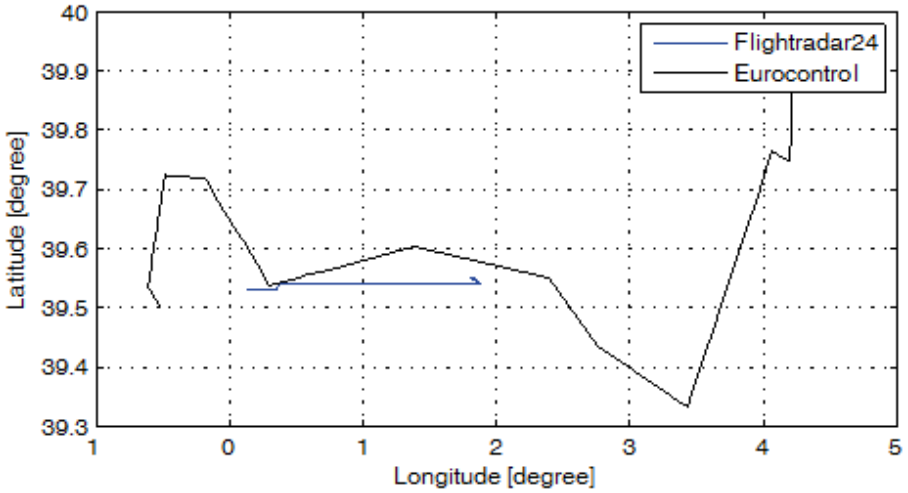


Results: Accuracy

- Large deviation caused by permitted shortcut not captured by EUROCONTROL waypoints



- Missing data points in Flightradar24 trajectory over the Mediterranean Sea (Menorca ➔ Valencia)



Conclusion & Outlook

- Both databases cover almost all flights over Europe
  - Good indication of expected traffic for avionic networks
  - 18 month prediction possible using EUROCONTROL data

- Trajectories are not completely accurate
  - Shortcuts and detours not covered by EUROCONTROL
  - Missing data over large water bodies and some errors in Flightradar24 trajectories

➔ It depends on the task if data quality is sufficient:
  - Number of aircraft of cell (how large is the cell?)
  - Aircraft density and relative movement for ad-hoc networks
  - Pollution monitoring (50 km X 50 km resolution)
  - …

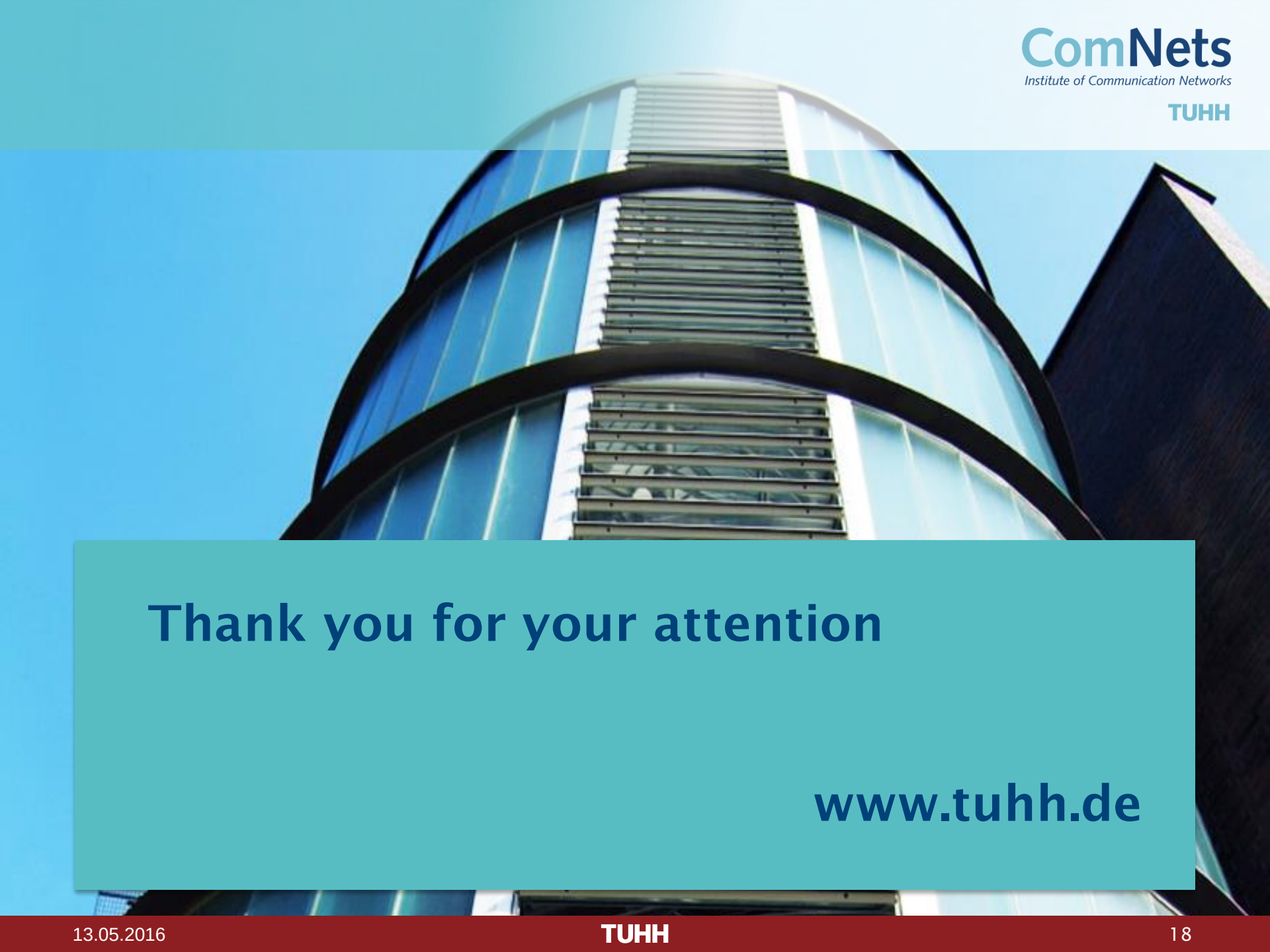
Outlook:
- Find and parametrize appropriate mobility models

ITG FG 5.2.1 Summer School

ComNets
Institute of Communication Networks
TUHH

ITG Summer School on “Network Performance Evaluation and Optimization”
28. August – 02. September in Hamburg (TUHH)

	28. Aug. 2016	*29. Aug. 2016*	*30. Aug. 2016*	*01. Sep. 2016*	*02. Sep. 2016*
	Deep Medhi Network Design and Optimization	Deep Medhi Network Design and Optimization	ITG 5.2.1 Workshop "Performance Evaluation and Optimisation of Communication Networks"	Machine Learning TBC	Anusch Taraz Graph Theory
	Lunch Break	Lunch Break	Lunch Break	Lunch Break	Lunch Break
	Hans Daduna Single Server Queues	Hans Daduna Queueing Networks	ITG 5.2.1 Workshop "Performance Evaluation and Optimisation of Communication Networks"	Machine Learning TBC	Anusch Taraz Random Geometric Graphs
	Reception	Dinner at own expenses (e.g. Caspari)	Conference Dinner	Dinner at own expenses (e.g. Gröninger)	



Thank you for your attention

www.tuhh.de