Simulated collision risk of uncoordinated airborne self separation

by

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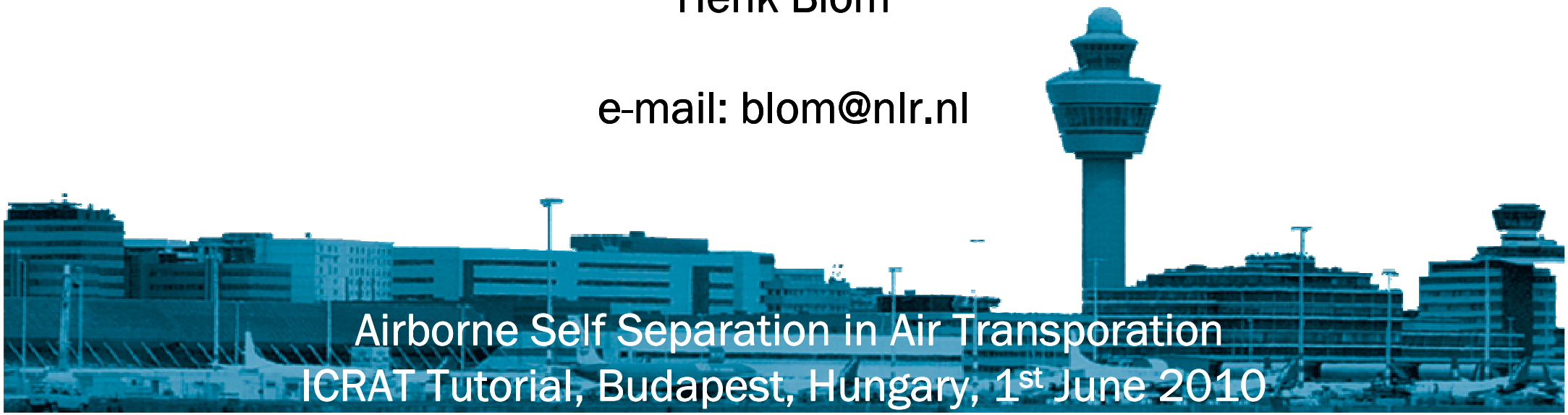

Airborne Self Separation in Air Transporation
ICRAT Tutorial, Budapest, Hungary, 1st June 2010

Simulated collision risk of uncoordinated airborne self separation

- Motivation
- AMFF (Autonomous Mediterranean Free Flight)
- MC simulation modelling
- MC simulation results
- Conclusions

Motivation

- Free Flight has been “invented” as a potential solution for high density airspace
- During recent years ATM community research trend is to direct self separation research to situations of less dense airspace (e.g. MFF, ASSTAR)
- Key question: up to which en-route traffic density is safe free flight feasible?

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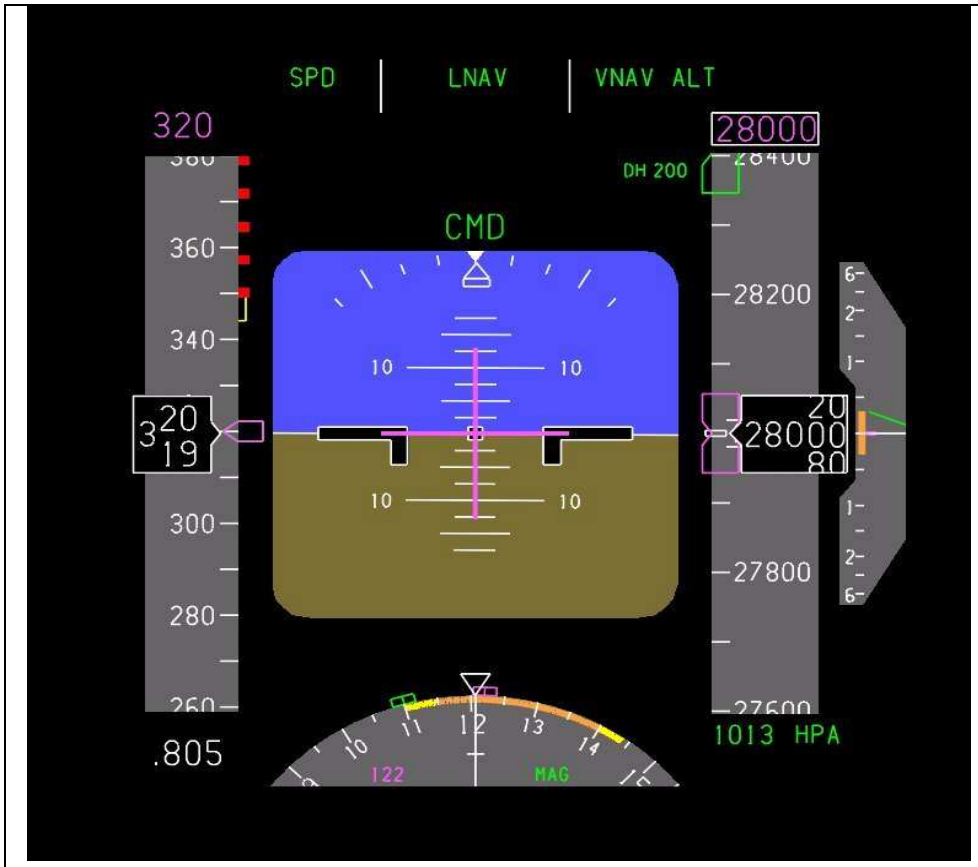
Autonomous Mediterranean Free Flight (AMFF)

- Future concept developed for traffic over Mediterranean area
- Aircrew gets freedom to select path and speed
- In return aircrew is responsible for self-separation
- Each a/c equipped with ASAS (Airborne Separation Assistance System)
- Conflicts are solved one by one (pilot preference)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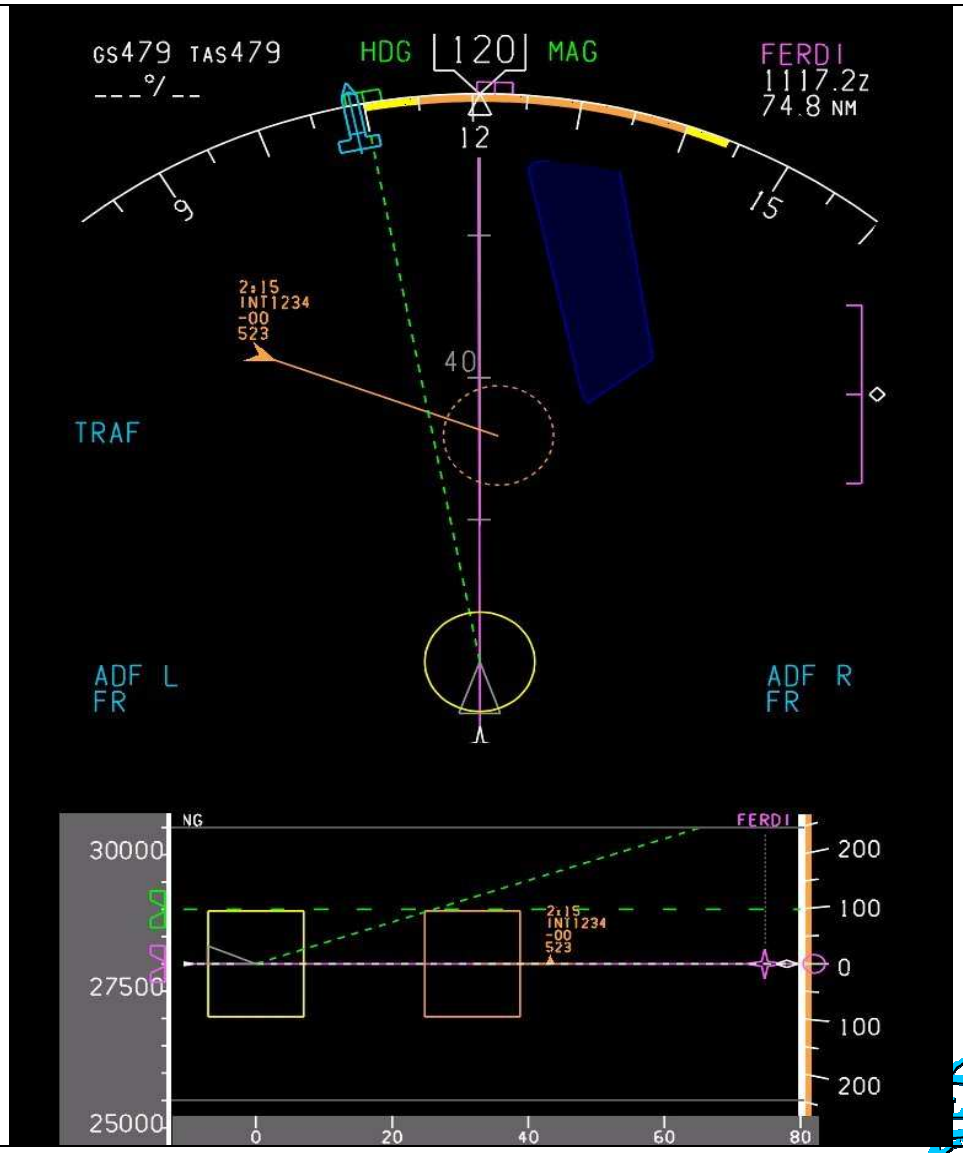
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Evaluations performed by MFF project

- Real-time pilot-in-the-loop simulations
- Eurocae/RTCA ED78a safety assessment

Can AMFF accommodate high traffic demand ?

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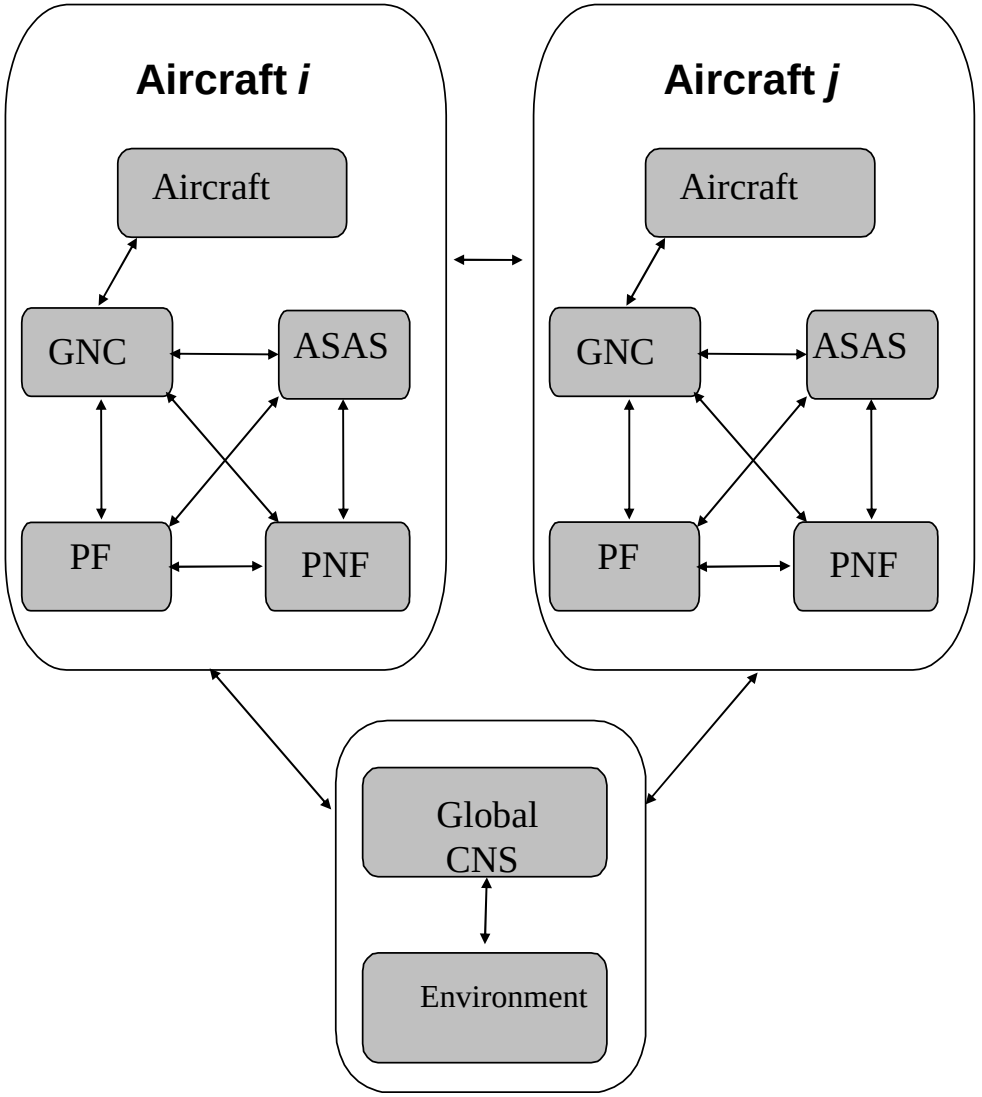
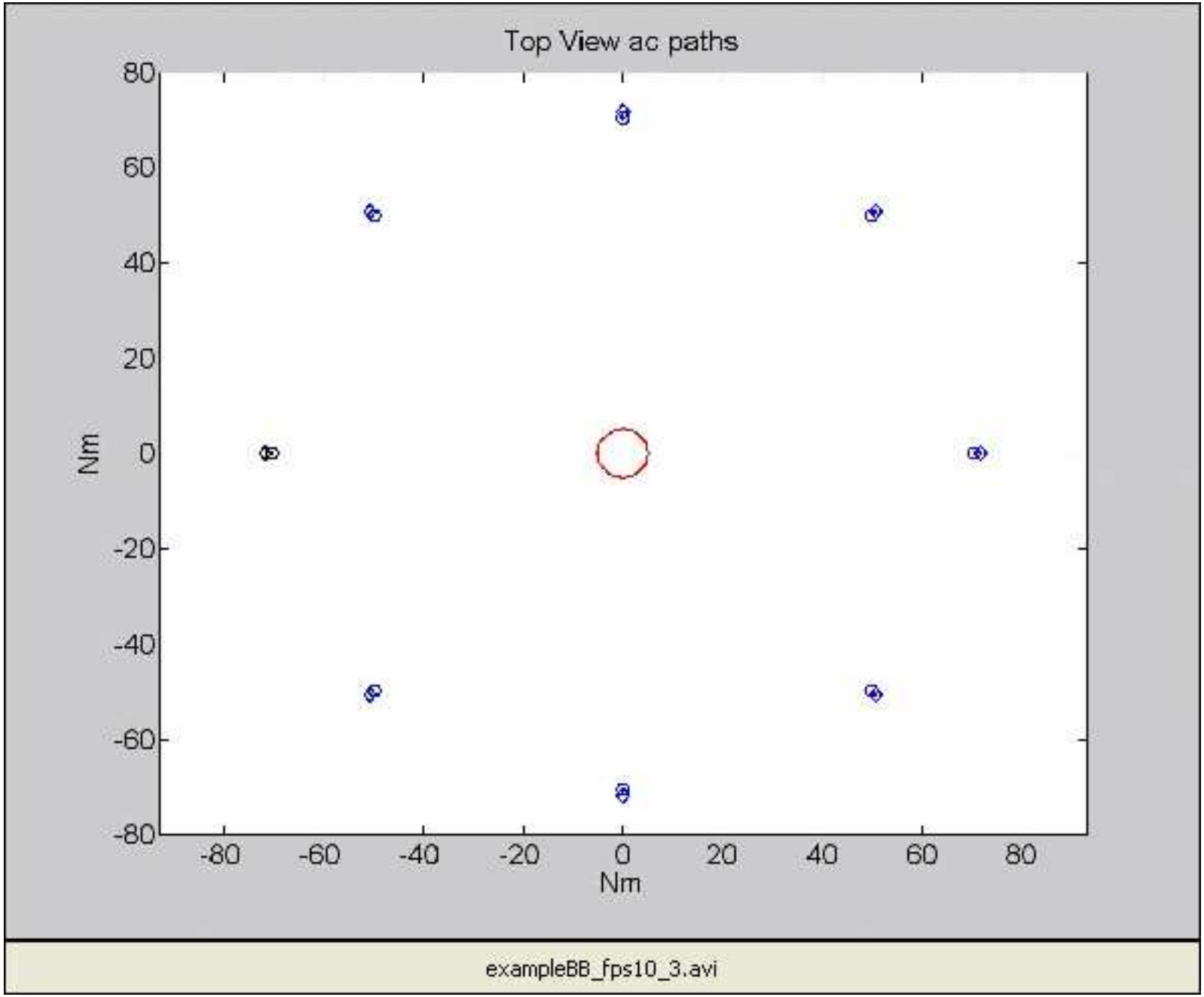
Systemic modelling and simulation using TOPAZ methodology

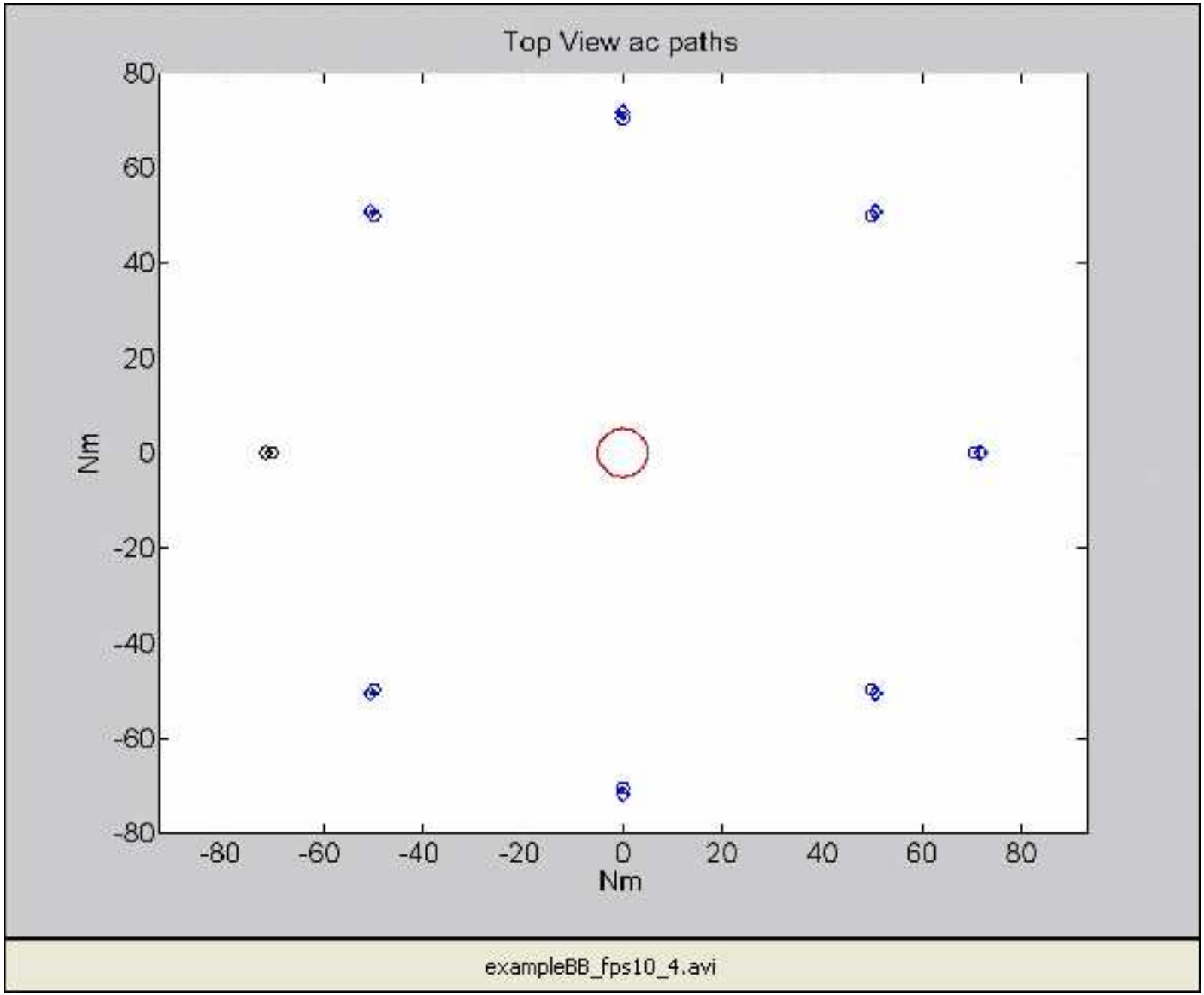
- Hazard identification
- Defining the relevant Agents
- Developing Petri net for each Agent
- Connecting Agent Petri nets
- Parametrization, Verification & Calibration
- Monte Carlo simulation
- Speeding up MC simulation
- Validation

Multi Agent model



Eight aircraft encounter

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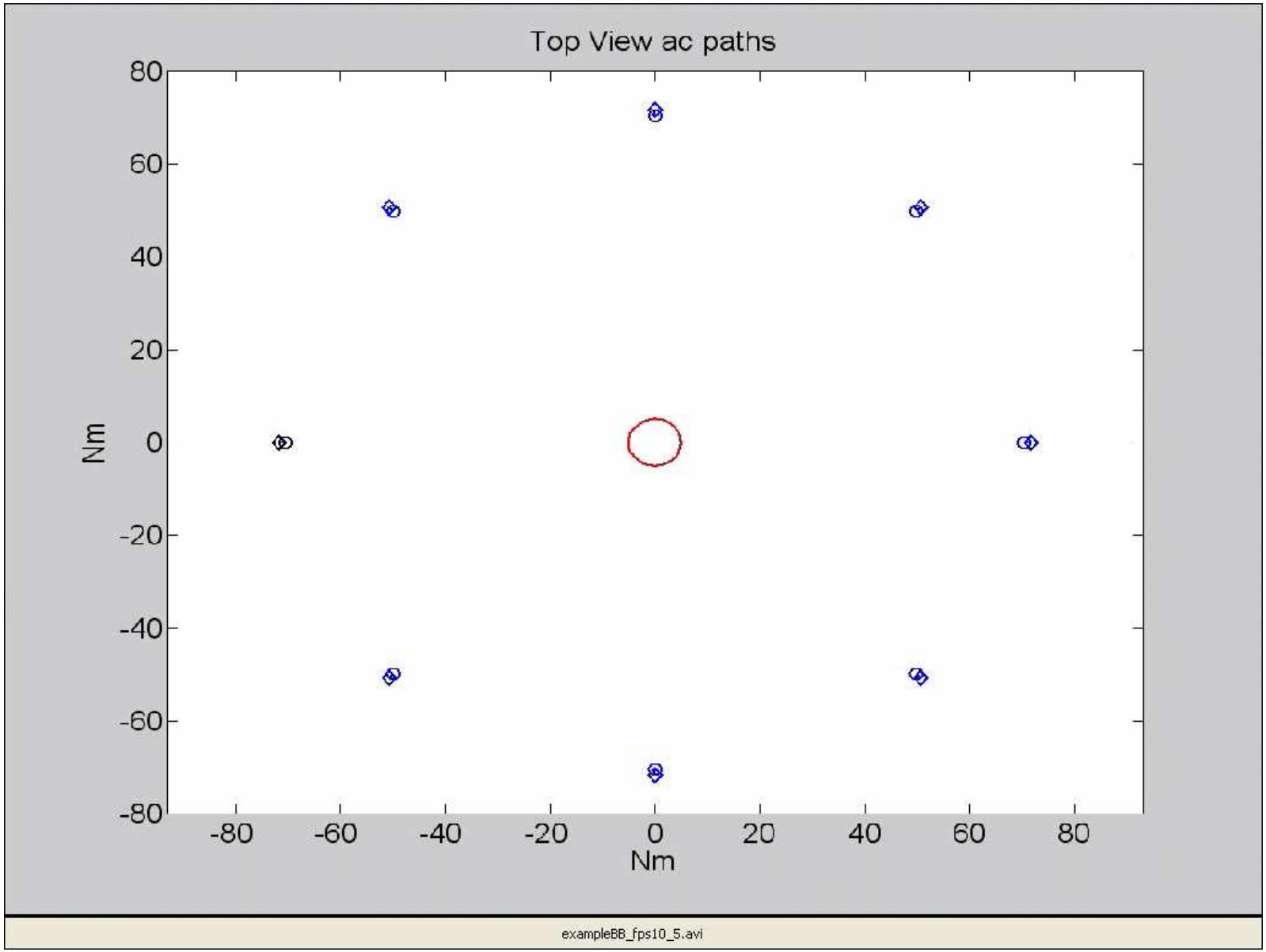
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MC simulation speed up

- Simulate from one conflict level to conflict level
- A fraction of simulations reaches next level
- Multiply fractions of these simulations
- Conditions for convergence (Cerou et al., 2002)

Conflict levels in air traffic

MTC = Medium Term Conflict
STC = Short Term Conflict
MSI = Minimum Separation Infringement
NMAC = Near Mid-Air Collision
MAC = Mid-Air Collision

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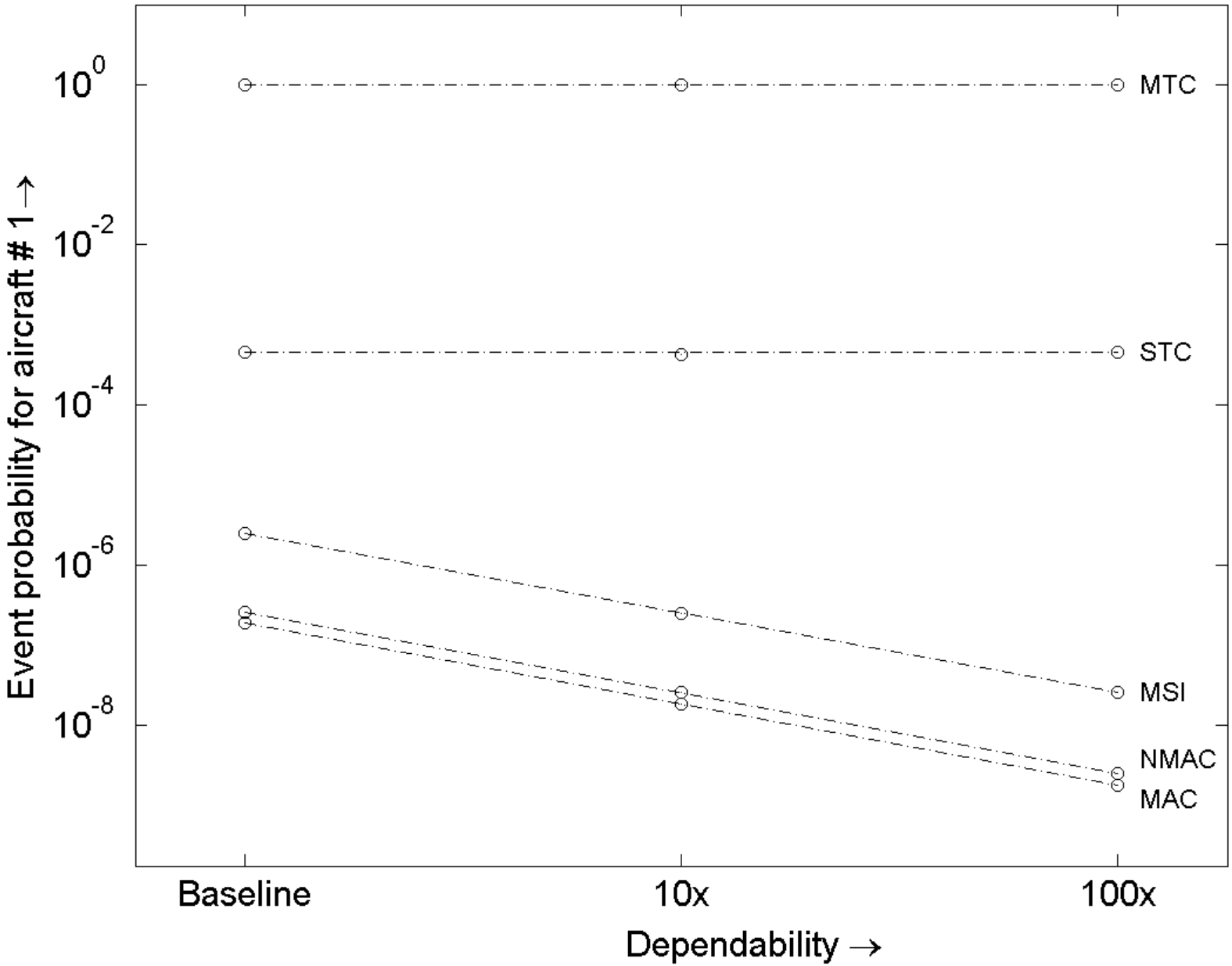
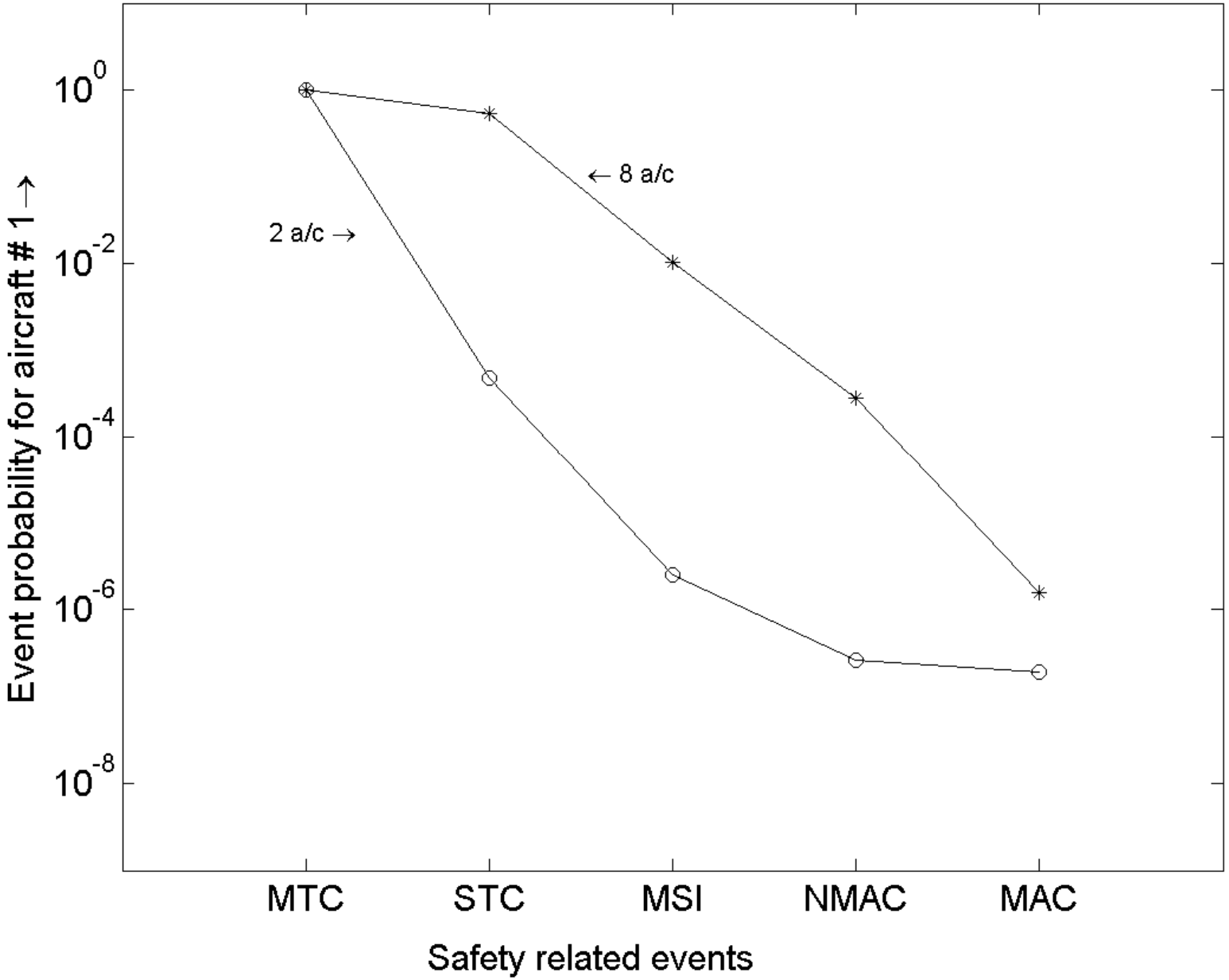
Scenarios

- Two aircraft encounter
- Eight aircraft encounter
- Random traffic high density

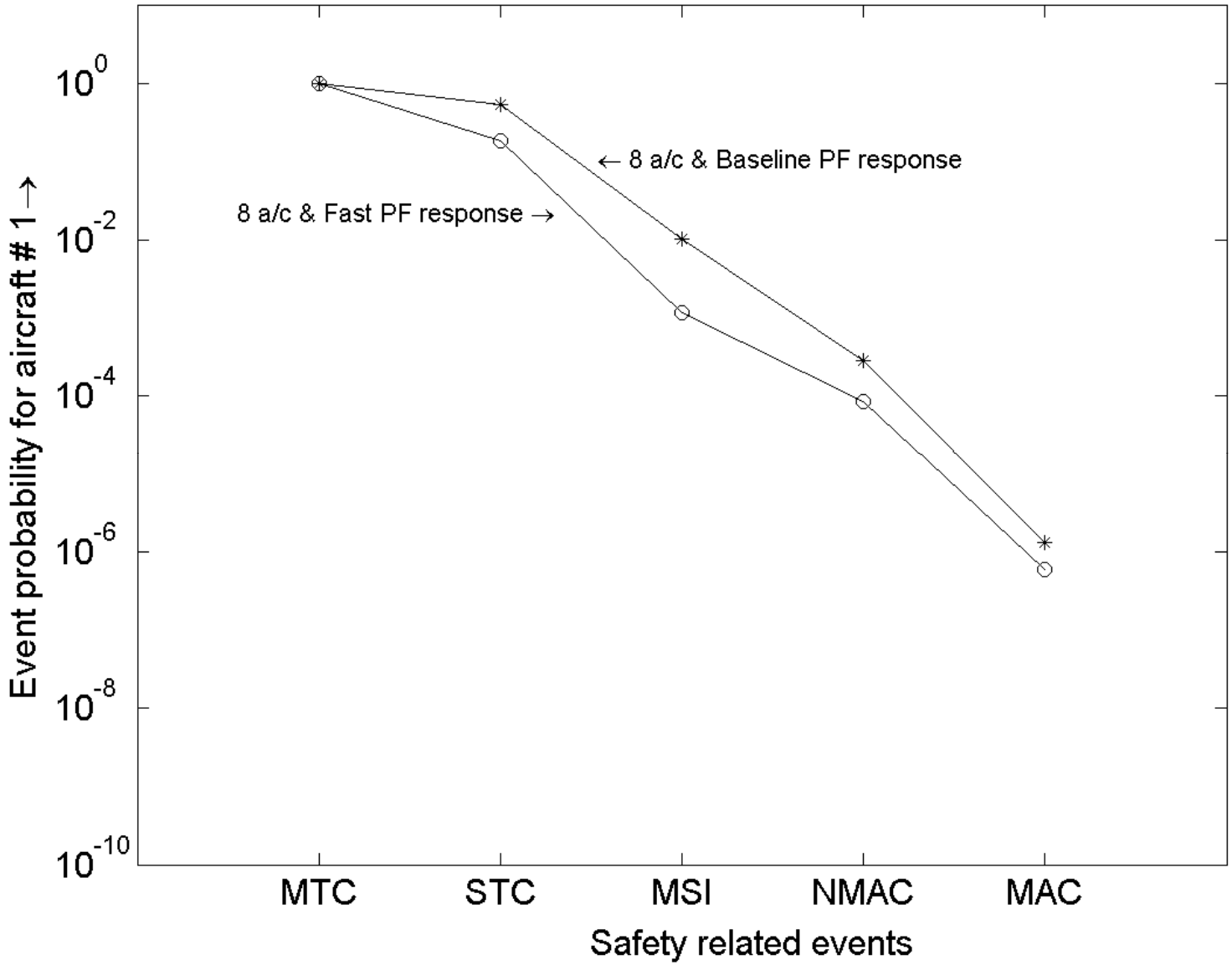
Two-aircraft head-on encounter



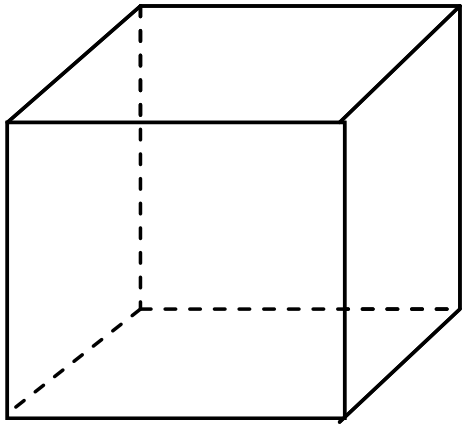
Two-aircraft vs. eight-aircraft encounter.



Eight-aircraft encounter: Baseline PF response vs. Fast PF response

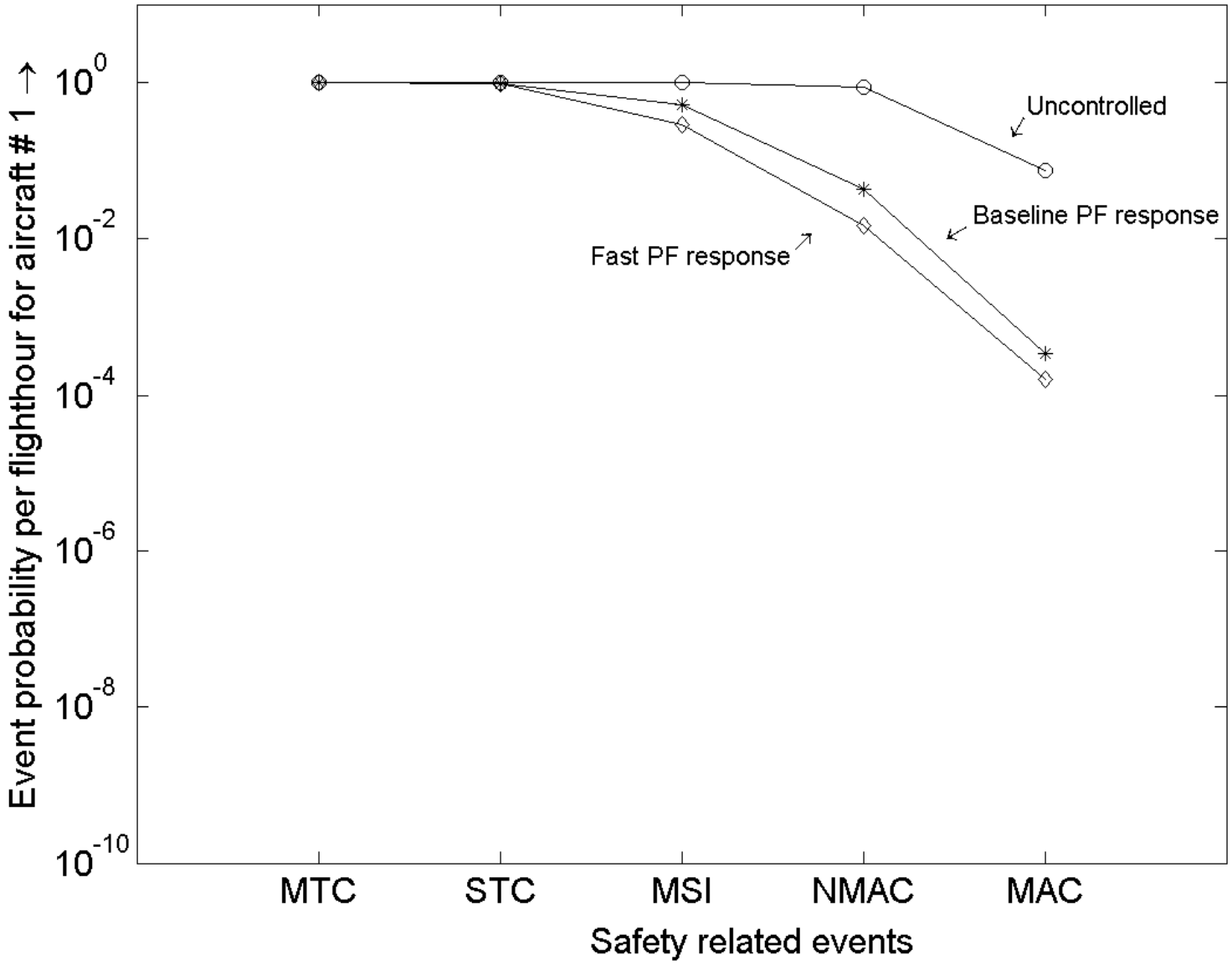


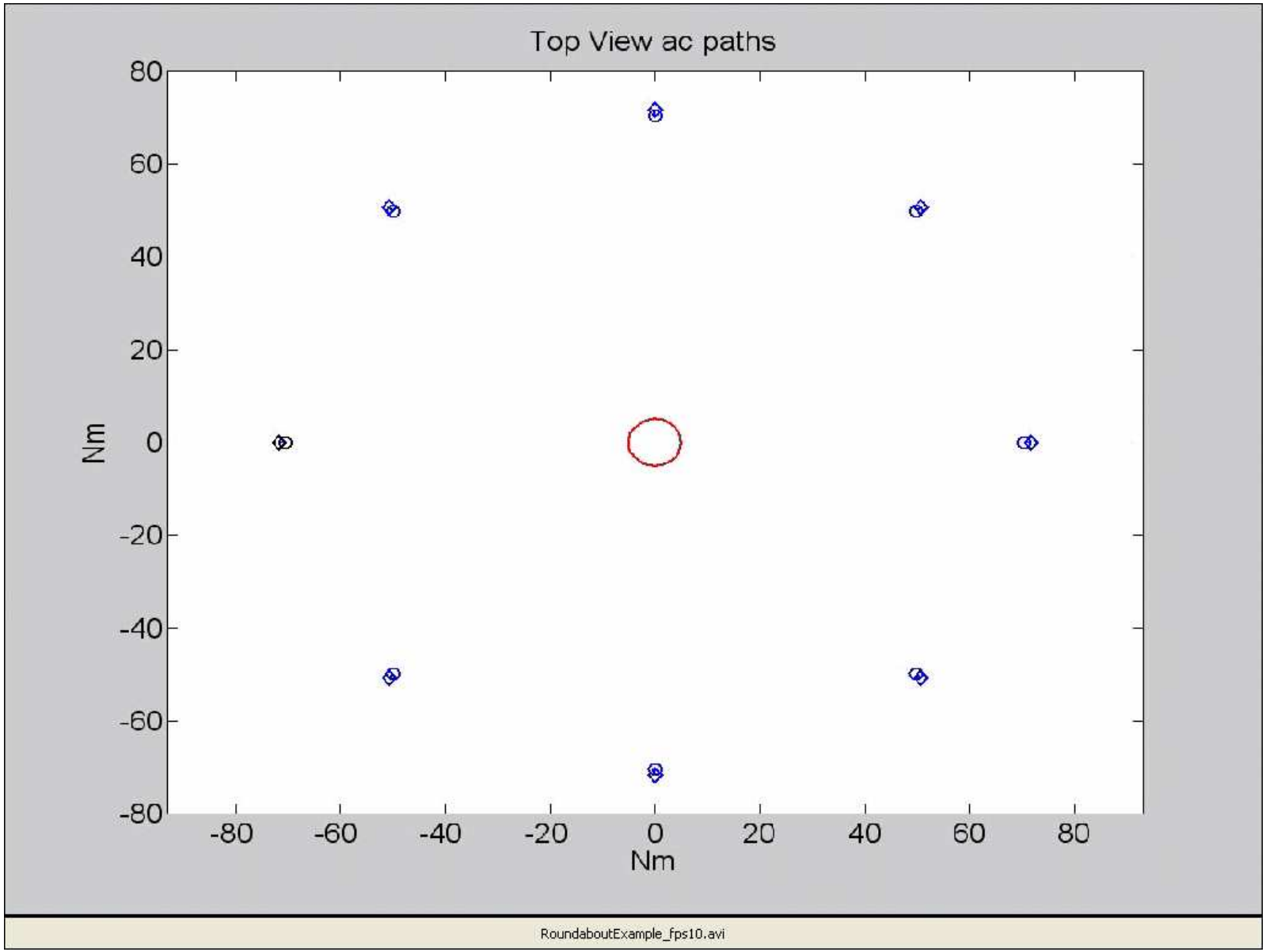
Random traffic, high density



- **Eight aircraft per packed container**
  - 3 times as dense above Frankfurt on 23rd July ’99

Random high traffic: Uncontrolled vs. AMFF controlled

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Conclusions

- Uncoordinated conflict resolution falls short in safely accommodating high en route traffic demand
- Advanced airborne self separation might do much better
- Follow-up work on risk assessment:
  - Evaluate advanced airborne self separation concept
  - Include ACAS in simulation model
  - Further improve simulation speed-up
  - Validation of assessed risk level

To be continued

http://iFly.nlr.nl