iFly final project presentation

What en-route traffic demand can safely be accommodated?

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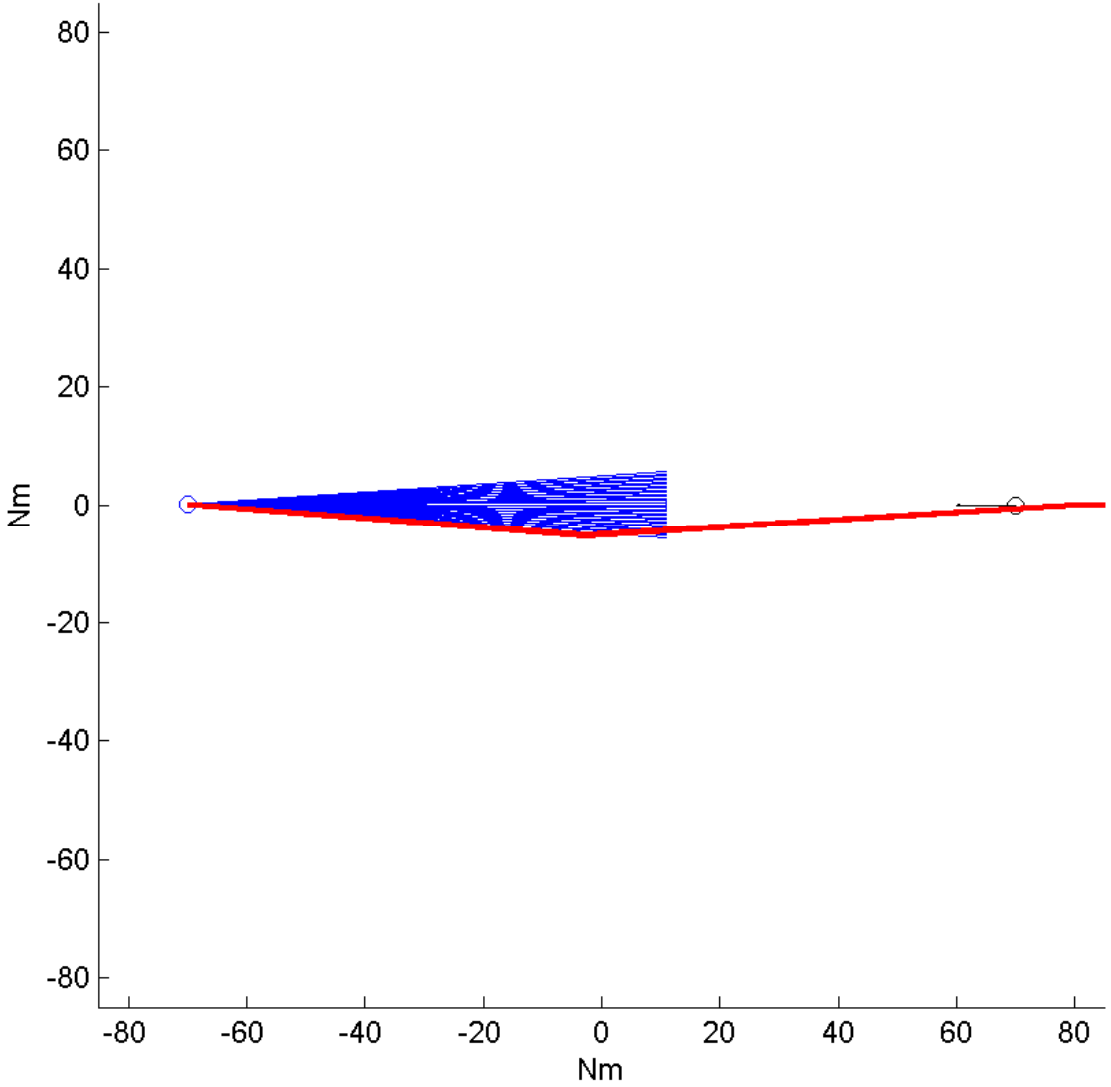
What en-route traffic demand can safely be accommodated?

- CD&R approach
- A3 ConOps modelling
- Monte Carlo simulations
- Conclusions

Medium Term CD&R approach

- Each a/c broadcasts its current 4D plan and its destination; SWIM transfers this over-the-horizon.
- Each aircraft detects conflicts (5NM/1000ft) 10 min. ahead
- a/c nearest to destination has priority over other a/c.
- a/c with lowest priority has to make its 4D plan conflict free (15 min ahead) with all other plans.
- Undershooting of 5Nm/1000ft is allowed if there is no feasible conflict free plan and it does not create a short term conflict (this way everyone keeps on moving)
- Then such aircraft broadcasts its non-conflict-free 4D plan together with a message of being “Handicapped” (which is priority increasing)

Velocity Obstacles = Collision Cones
Medium Term (10 min & 5 Nm)



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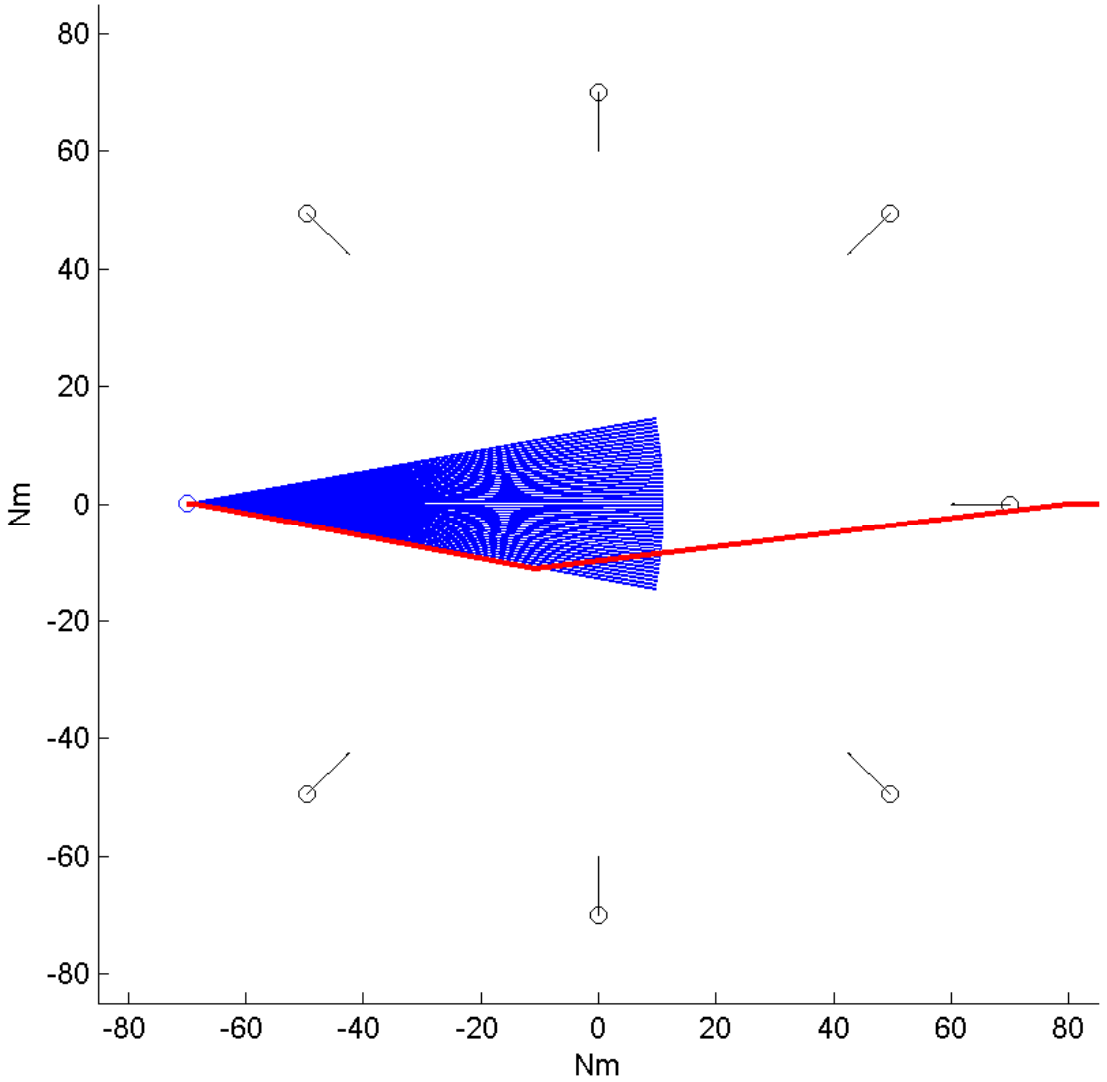

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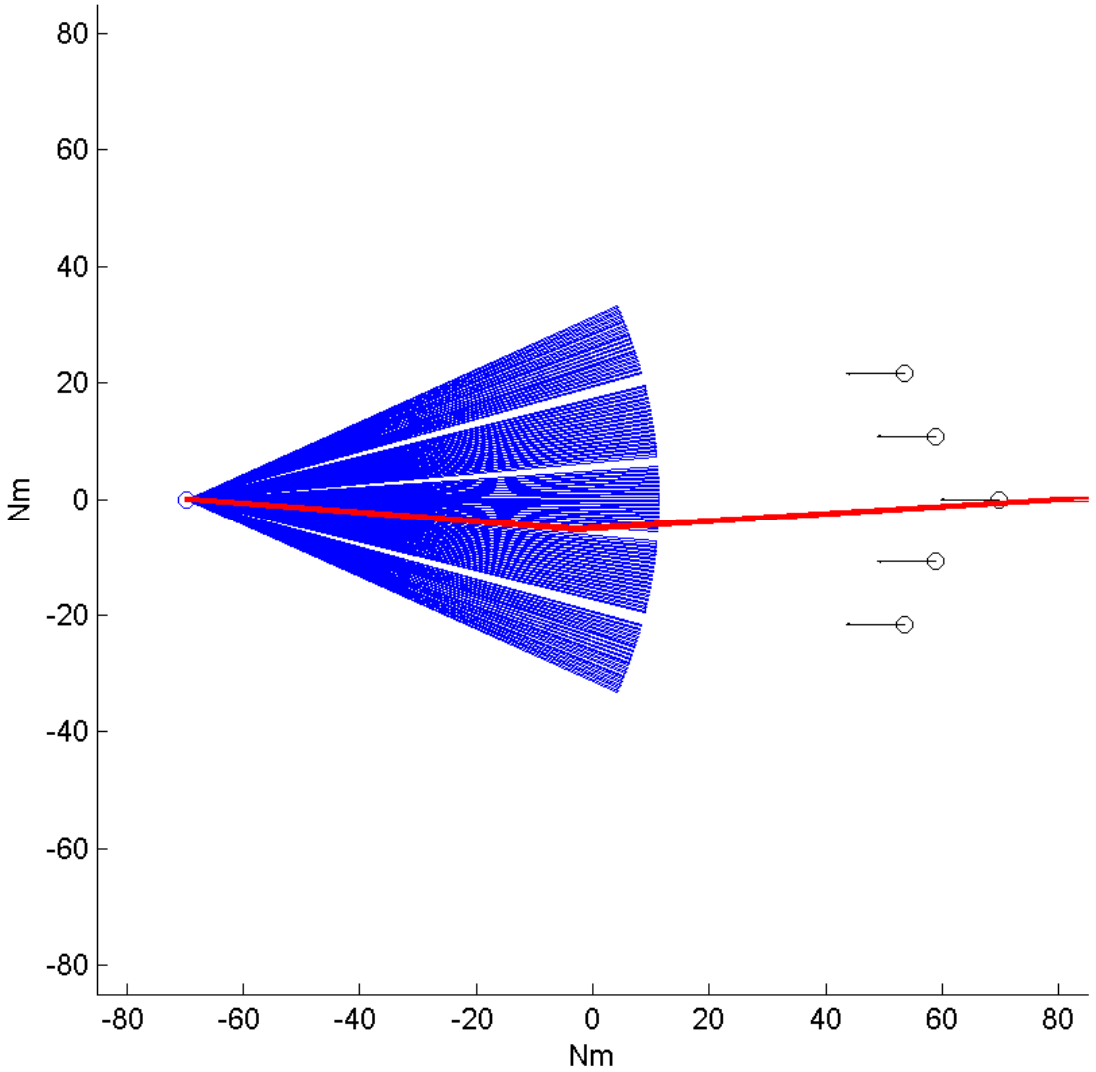
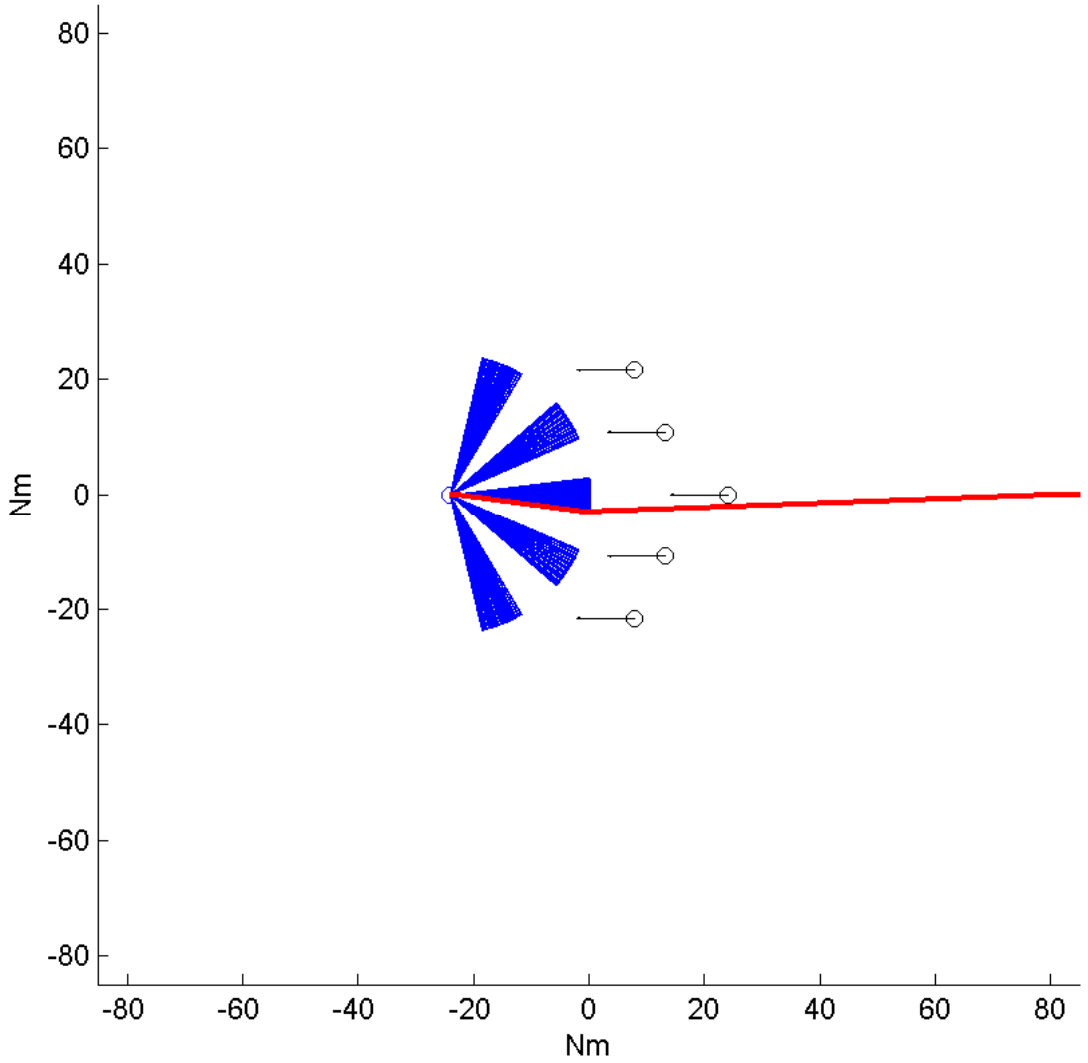


Short Term CD&R approach

- a/c which detects conflict is obliged to resolve the conflict without awaiting any of the other aircraft
- Course change is identified using Velocity Obstacles (3 min. ahead)
- Conflict free means 3Nm/900ft minimal predicted miss distance
- Undershooting of these values is allowed if there is no feasible alternative (this way everyone keeps on moving)
- a/c broadcasts its new course or rate of climb/descend

Velocity Obstacles = Collision Cones
Short Term (3 min & 3 Nm)



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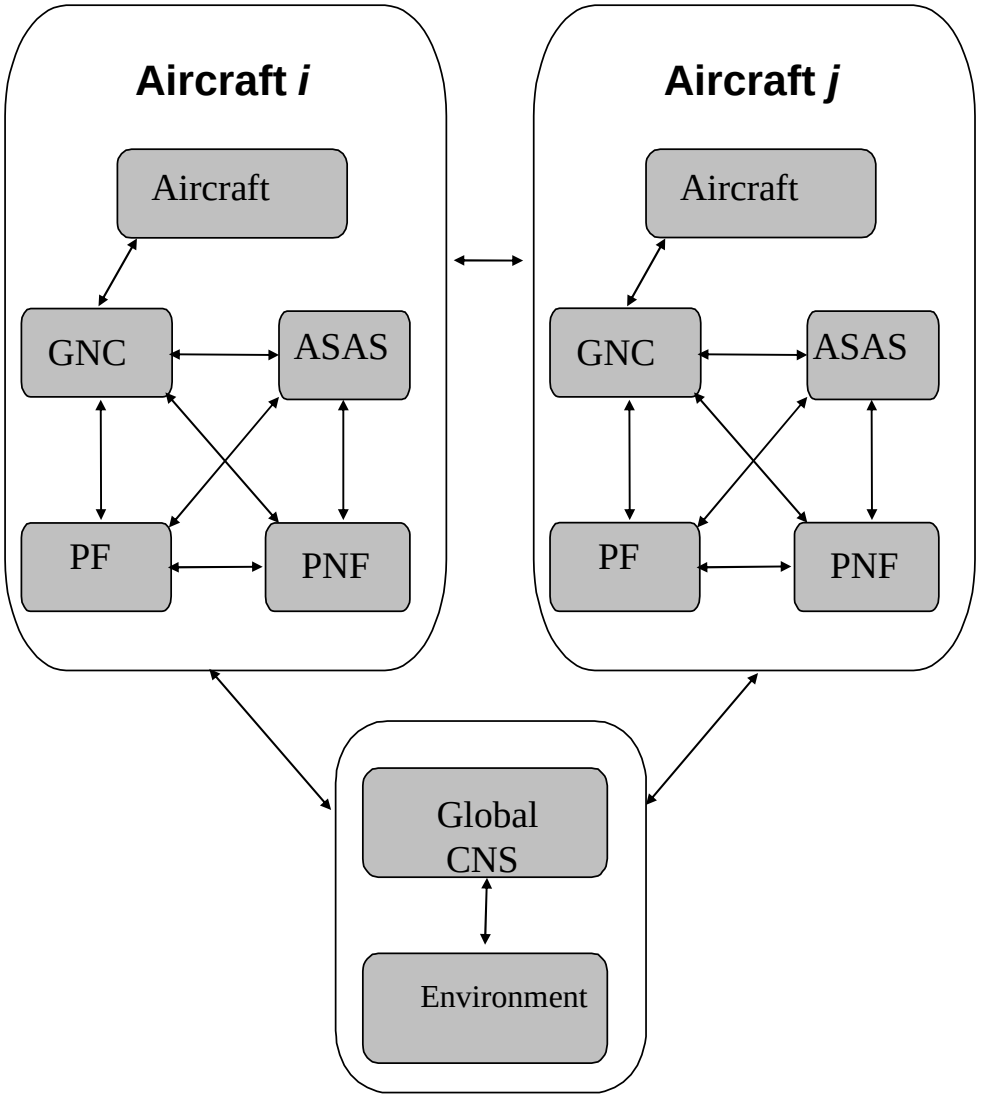
Stochastic modelling and MC simulation

- 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



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
LOS = Loss of Separation
NMAC = Near Mid-Air Collision
MAC = Mid-Air Collision

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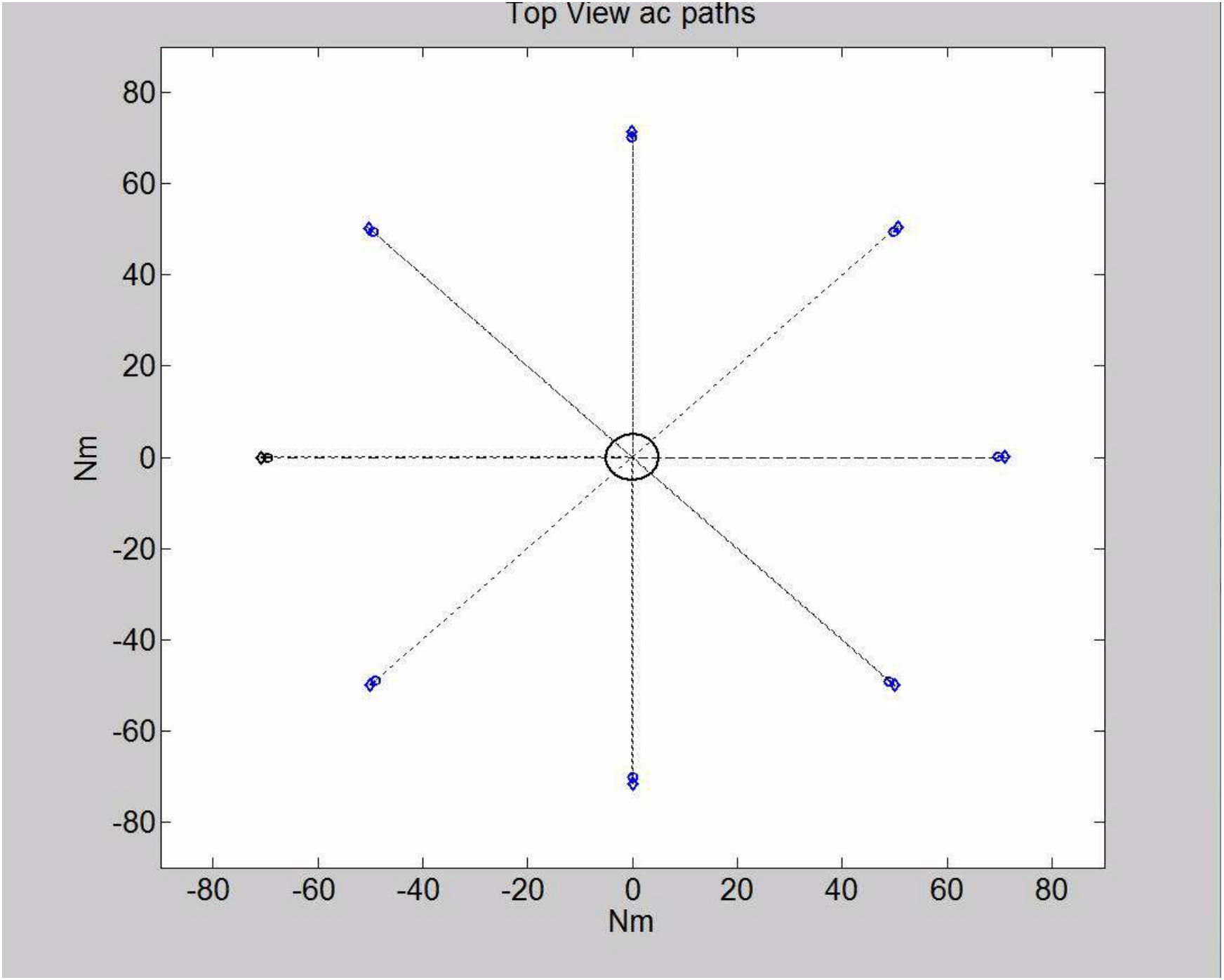
Monte Carlo Simulation Scenarios

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


Top View ac paths
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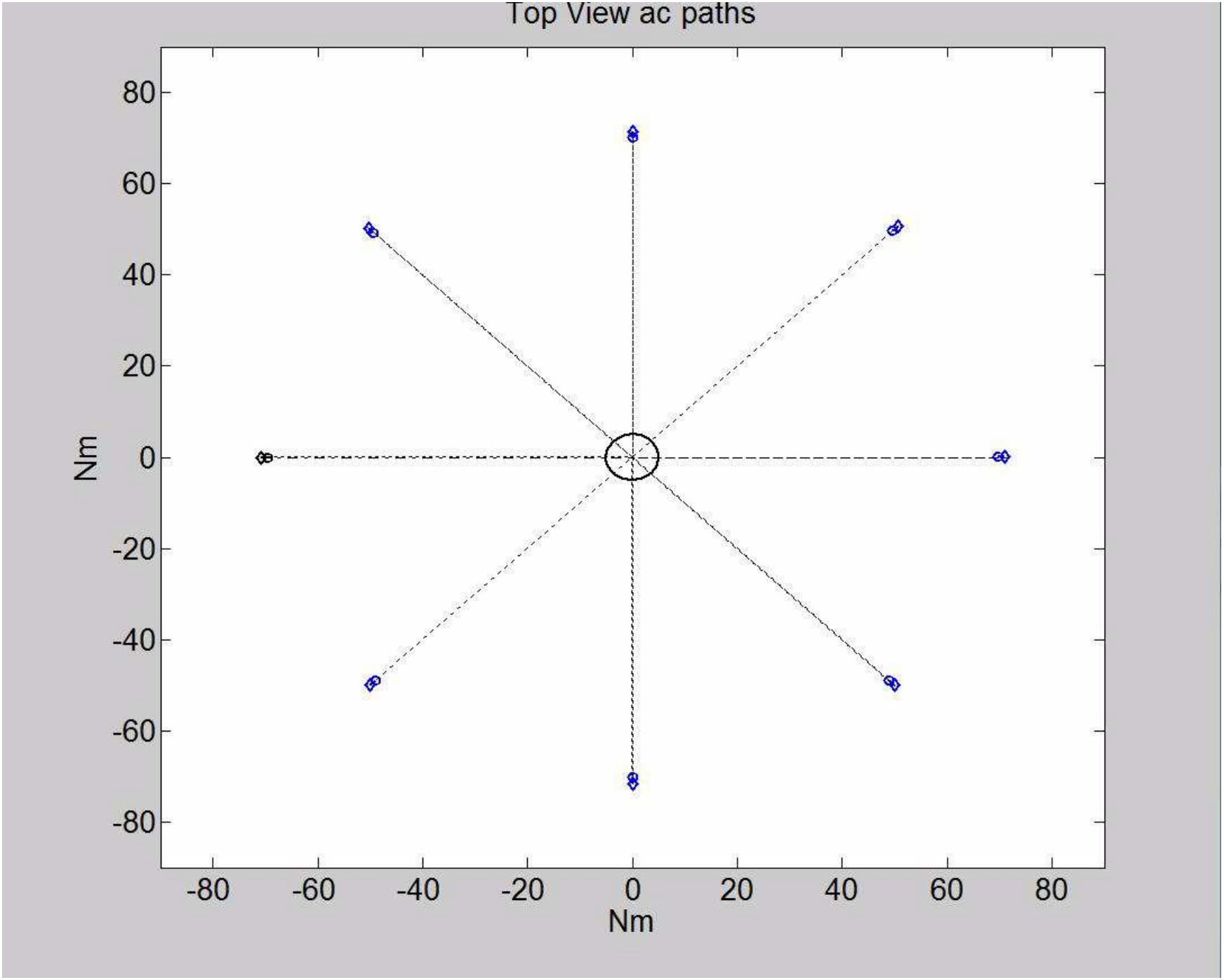
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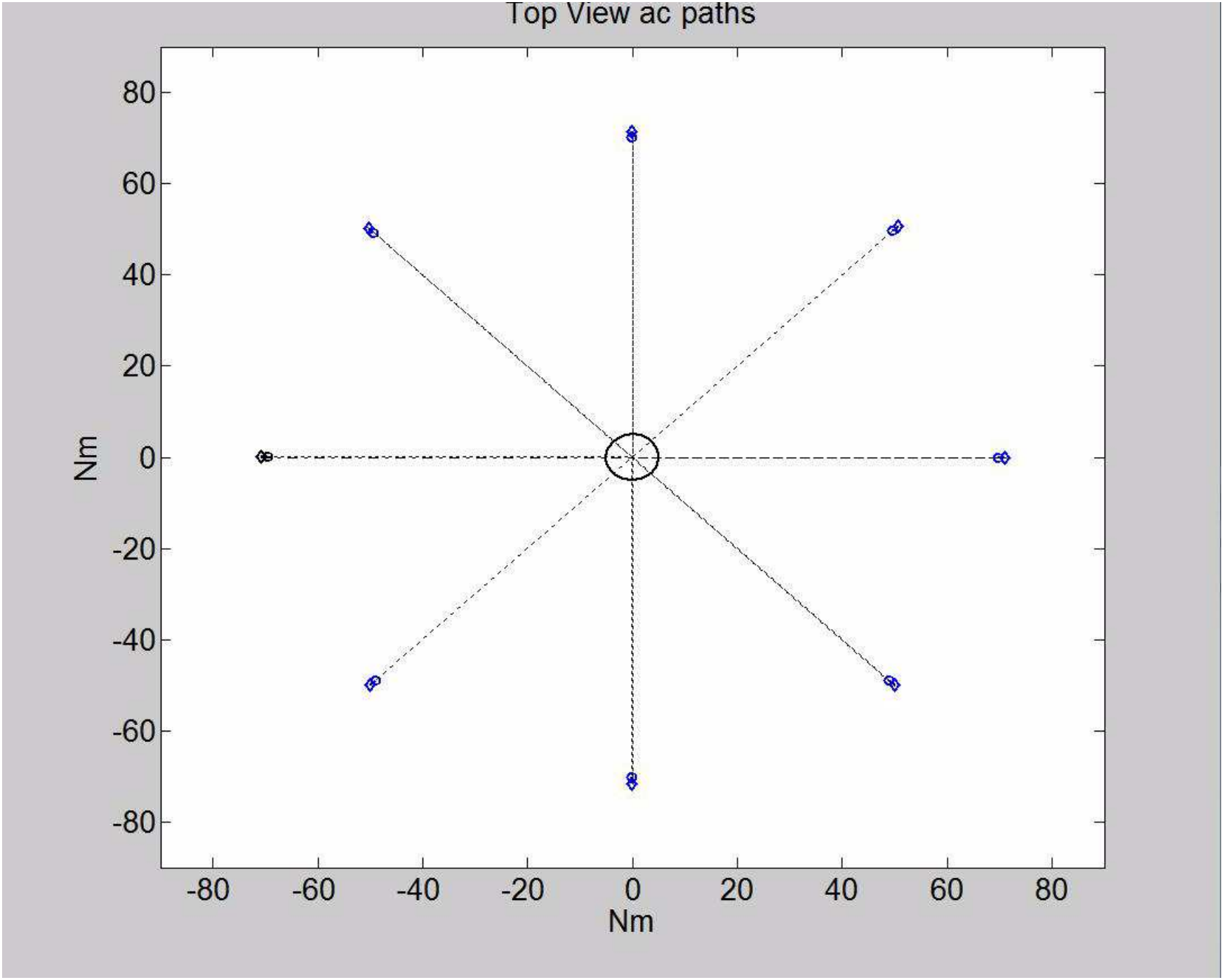
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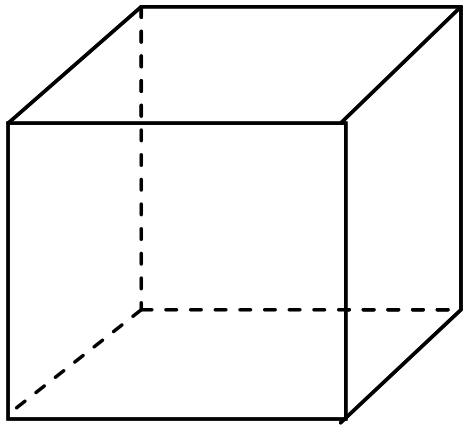
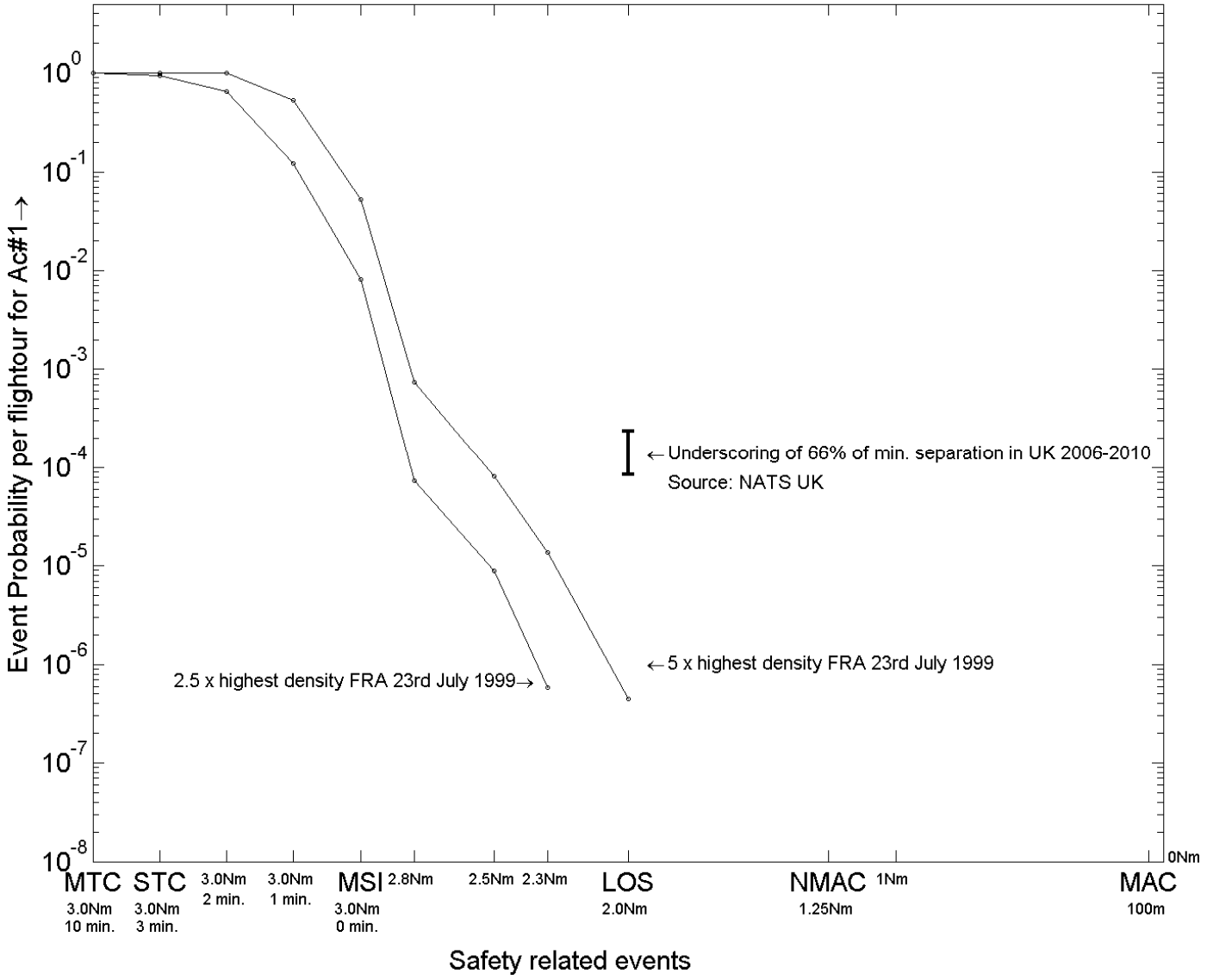
Nm

Random Traffic Scenarios



- Periodic Boundary Condition
- Eight a/c per packed box/ no climbing or descending a/c
- Vary container size in order to simulate:
  - 2.5x as dense above Frankfurt on 23rd July '99
  - 5x as dense above Frankfurt on 23rd July '99

Random traffic



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Conclusions

- A3 ConOps with Velocity Obstacles based CD&R algorithms has very good rare event behaviour under very high en-route traffic demand
- NMAC and MAC events have not been observed during the rare event Monte Carlo simulations
- Aim is to further improve the speed-up of the simulations, and then to perform sensitivity and uncertainty analysis
- Next presentation considers flight efficiency using CD&R algorithms more advanced than Velocity Obstacles

Reporting

Completion of iFly safety analysis and corresponding reports:

- D7.3 Intermediate report on A3 ConOps safety evaluation
  - This will be based on the results reported in this presentation
- D7.4 Final report on A3 ConOps safety evaluation
  - This will include an initial sensitivity analysis
- D7.2g Final report on Monte Carlo speed-up
  - This will explain the techniques that have been used to accelerate the Rare Event Monte Carlo simulations
- Make these reports publicly available on the iFly web site

Questions / Discussion