ERASMUS Server

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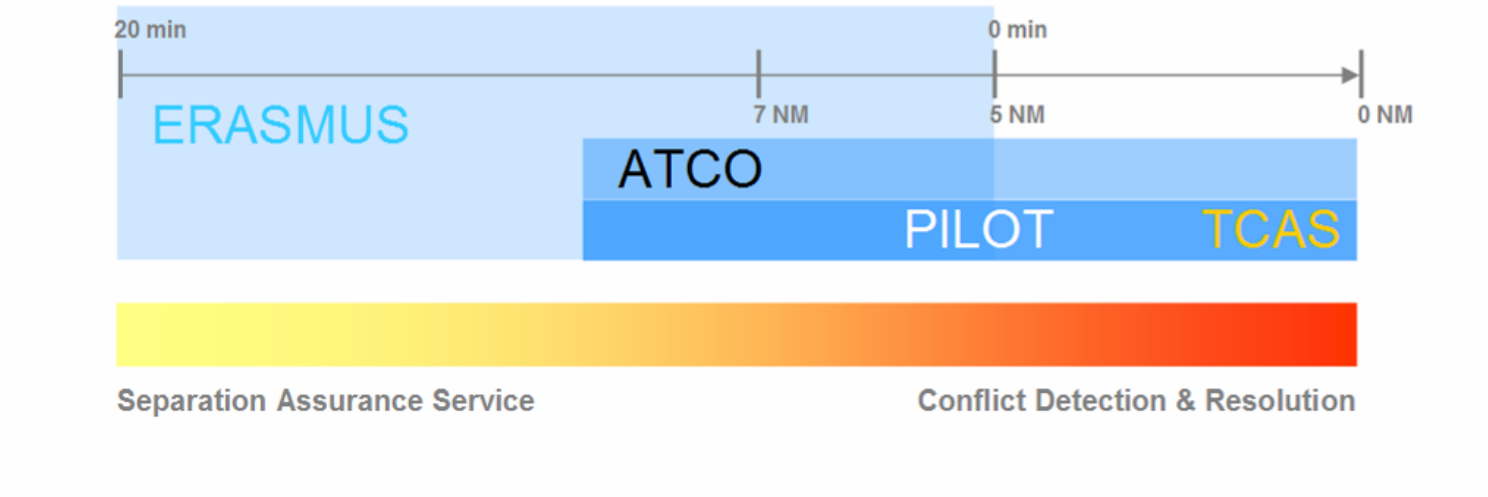
Research conducted by
Honeywell, DSNA and ETH

Presentation Outline

- ERASMUS Server
- Airborne Trajectory Prediction
  - Accuracy and sensitivity studies
  - Further Investigations
- Ground Trajectory Prediction
- Ground & Air Integration
- Demonstration

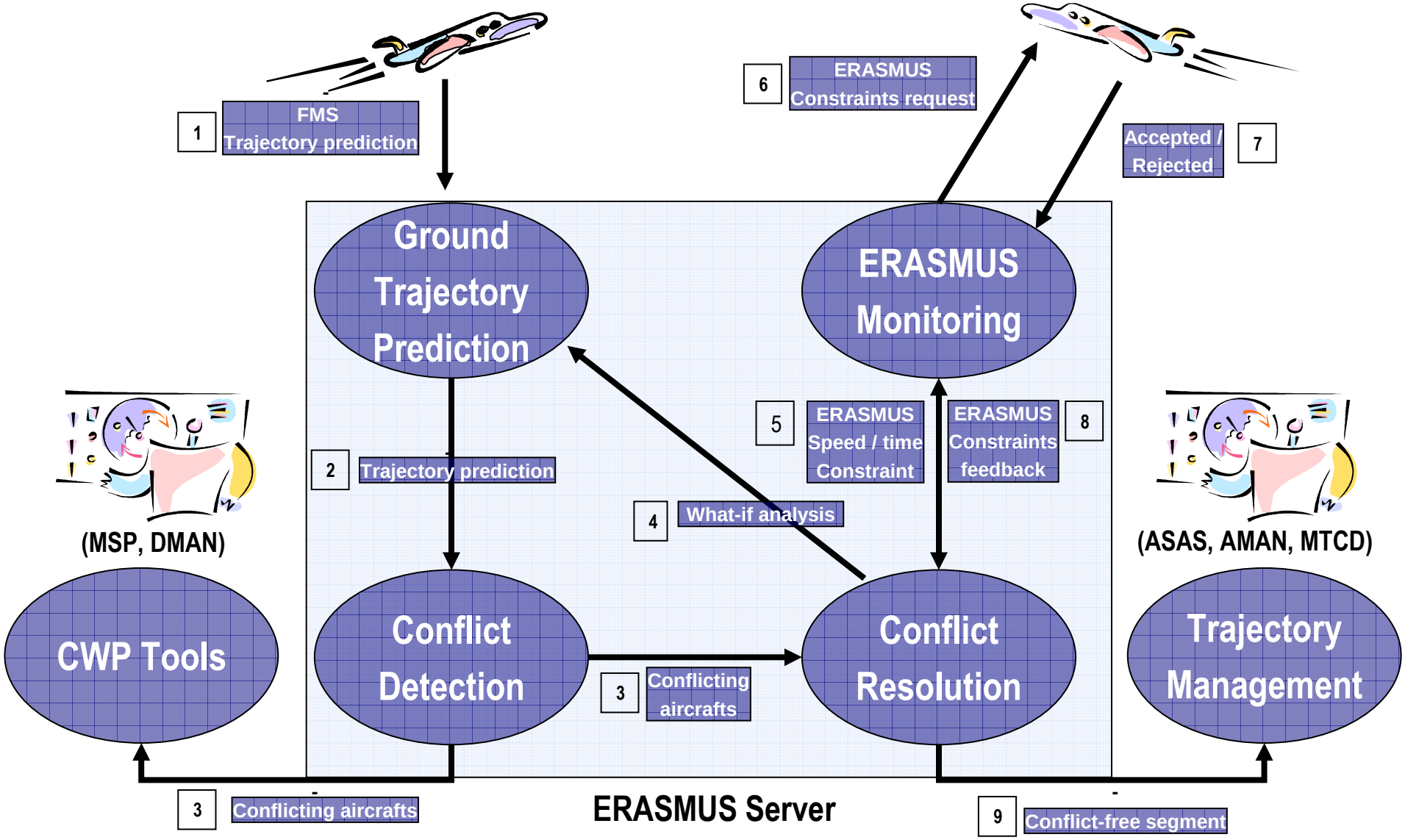
ERASMUS Server

- The ERASMUS server is a ground-based, **subliminal** Conflict Detection & Resolution **automation system** developed to lower controller workload.
  - strategic, medium term CD&R, 15-20 minutes ahead of conflict.



  - small adjustments (-6%, +3%) in aircraft horizontal or vertical speed
  - Speed or RTA clearances negotiated between Server and pilot.
  - small changes below perception of controller.

ERASMUS Server Services



Research Questions

1. How reliable is the trajectory prediction?

2. How precisely can the aircraft meet the contracted constraints?

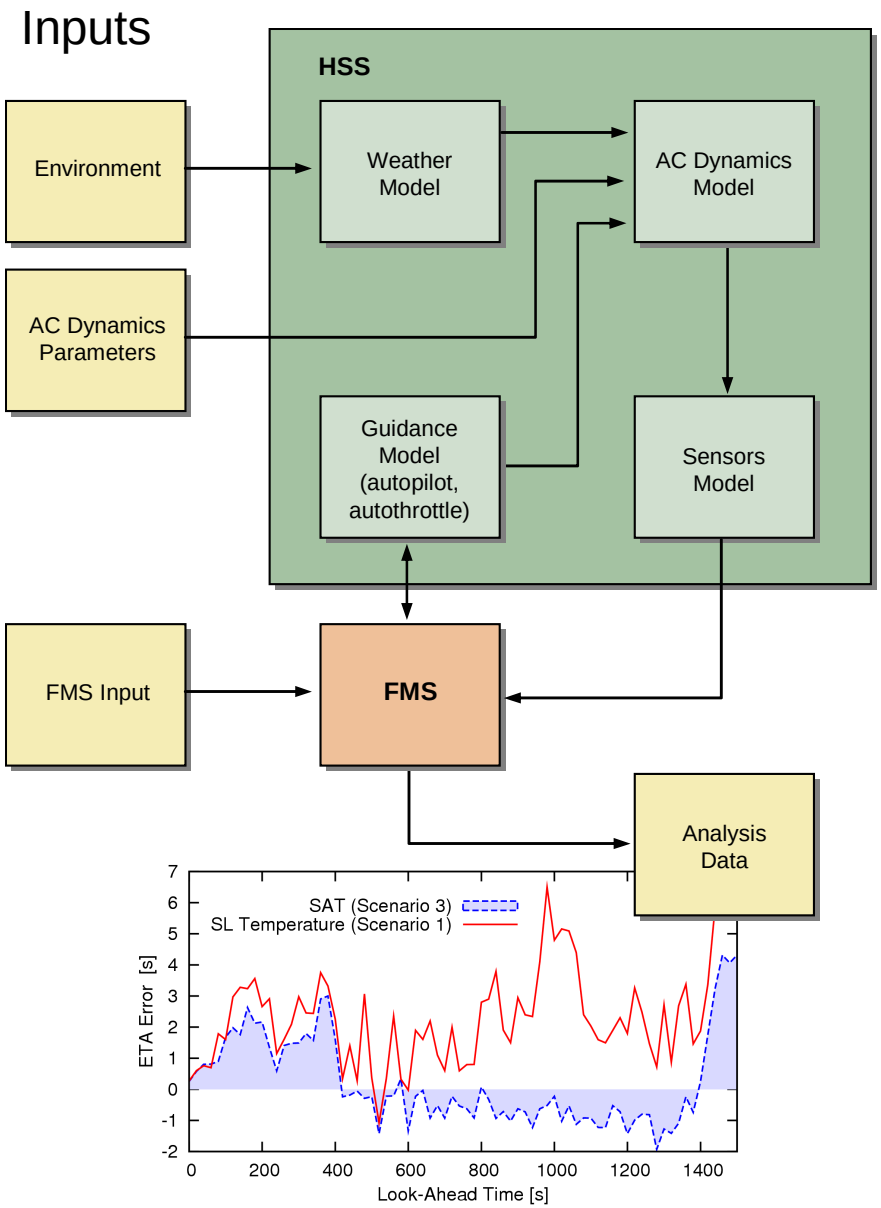
3. What is the impact of disturbances on the airborne and ground Trajectory Prediction accuracy?

4. What set of DL parameters provide significant gain in TP accuracy?

5. Can CD&R occur within a time margin that allows the aircraft to adjust its flight path within acceptable limits

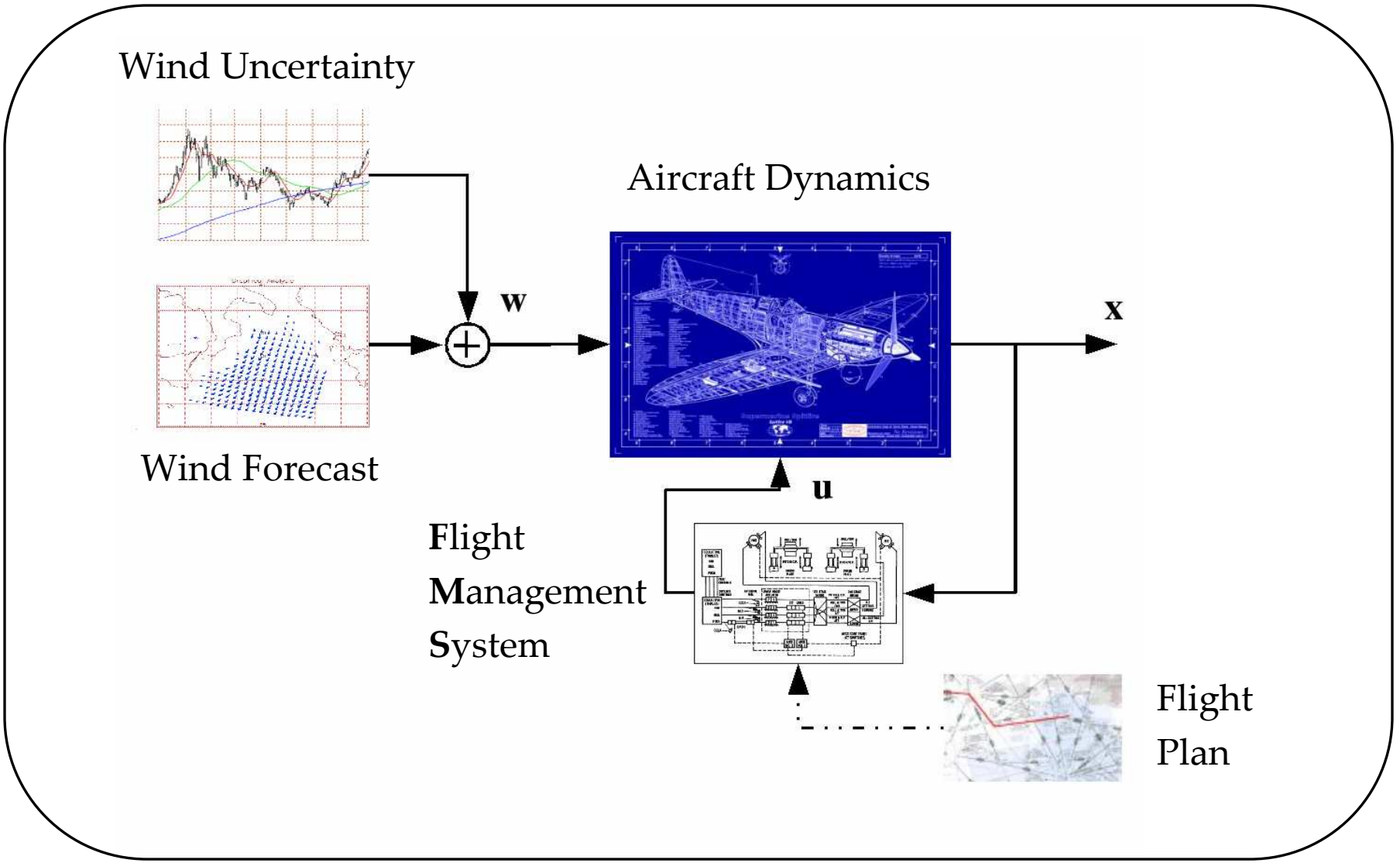
6. Are existing DL standards sufficient to provide the data exchange deemed beneficial on ERASMUS?

Honeywell Host-based Simulation System (HSS)

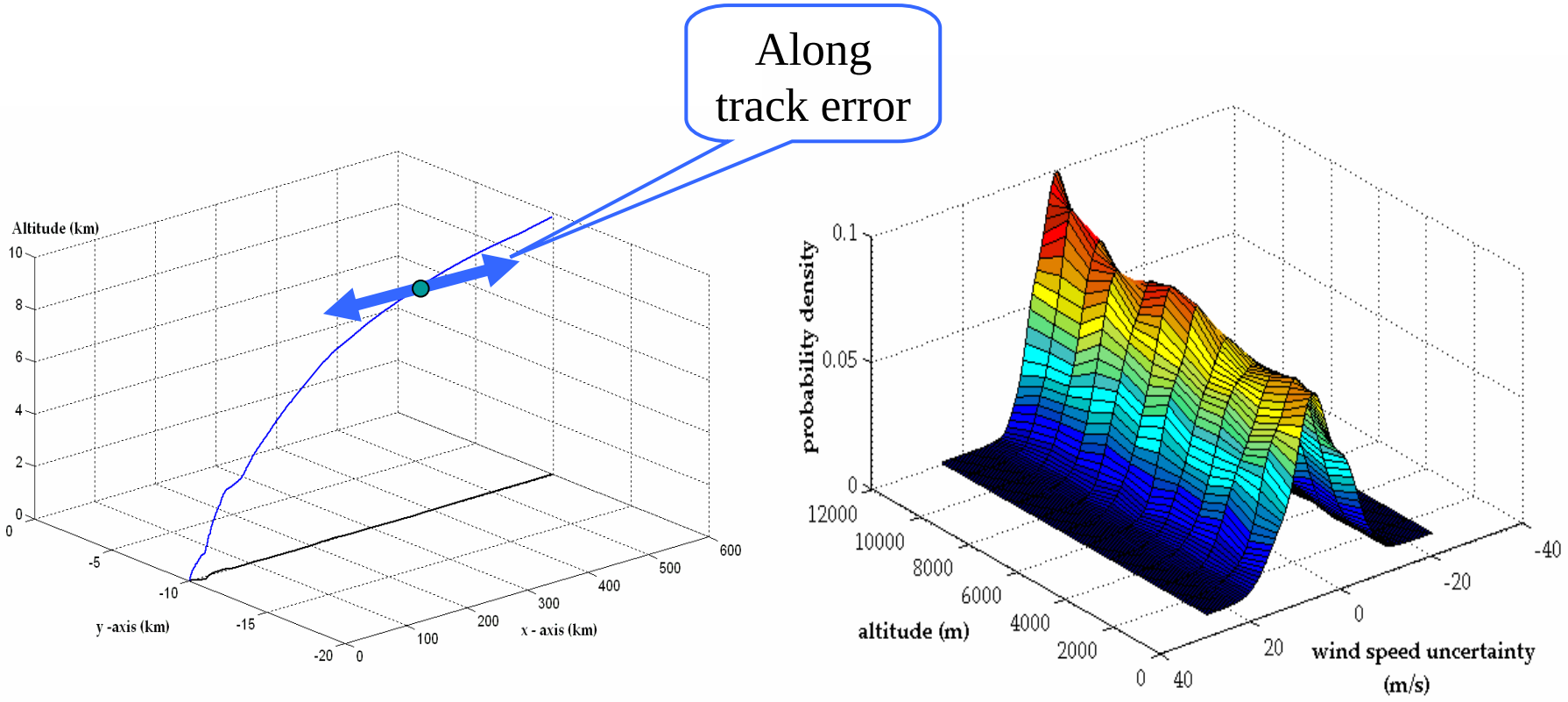


- HSS simulates specific aircraft type
  - avionics displays,
  - control panels,
  - aircraft dynamics,
  - aircraft guidance,
  - sensors, etc.
- HSS simulates the aircraft environment
  - time-independent nominal wind for different altitudes
  - stochastic wind factors (e.g., gusts, Dryden model of turbulences, or windshear).
- Executes actual FMS software implemented on this aircraft.
  - FMS input = pilot entries of initial AC state (e.g., gross weight) and forecast data.

Aircraft model used in GTP studies



Sequential Monte Carlo Methods



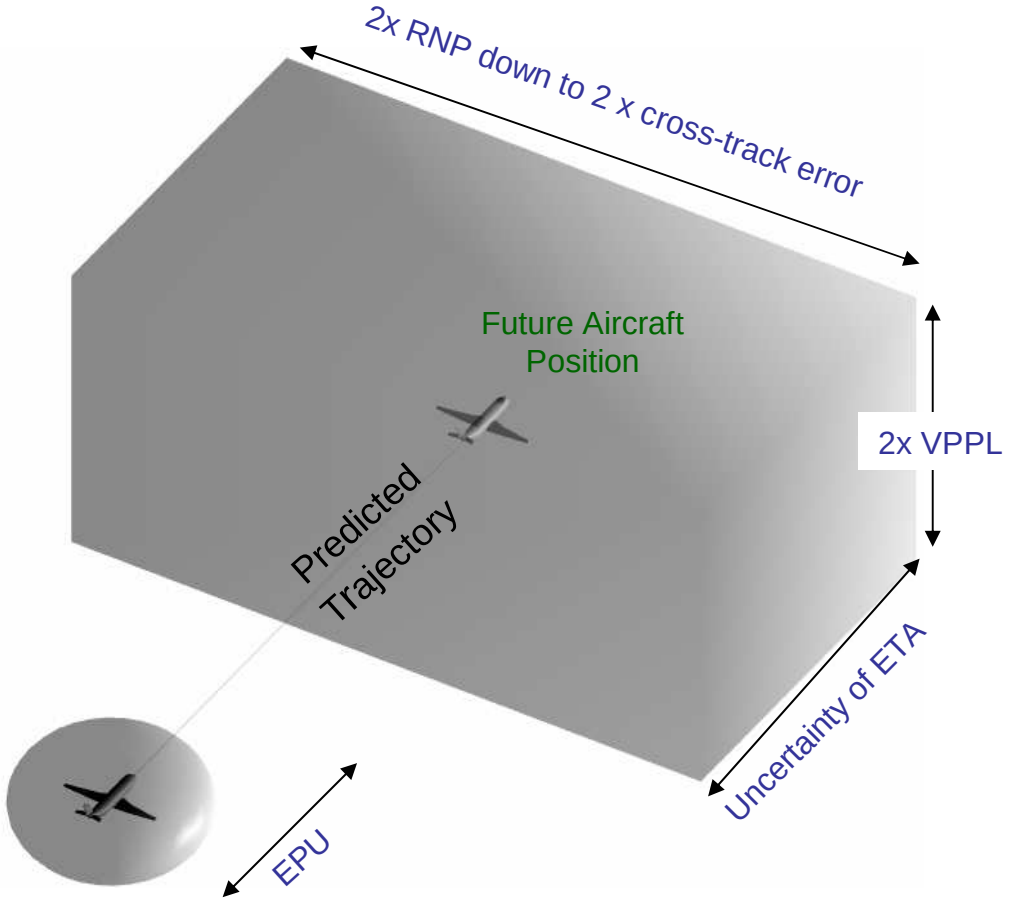
Radar measurements every 30 seconds
to reduce uncertainty

Trajectory Prediction sensitivity and accuracy Results (15 minute time horizon)

1. **Parameters uplinked by the ground**
   - Wind Forecast Errors
     - Inaccurate forecasts generated worse results than flights with no forecast.
     - Absence of Meteorological forecast does not significantly degrade prediction accuracy in level flight.
     - Accurate wind forecast significantly affect climb and descent TP accuracy
   - Temperature forecasts
     - Larger effect on Cross-track error:
   - Calibration errors (using sea-level temperature)
     - Larger effect on Time-based errors.
2. **Data downlinked by airborne system**
   - Gross Weight Errors
     - Cross-track inaccuracy: Relatively strong impact
     - ETA accuracy: no significantly effect.
   - Measurement errors, airborne navigation sensors
     - FMS generated Estimated Position Uncertainty (EPU), significant effect
3. **Unpredictable stochastic wind**
   - Slight decrease in TP accuracy due to random gusts.

Concrete Results (for next 15 minutes of flight).

- What are the uncertainty boundaries to be used during CD&R?
- How precisely can the aircraft meet the contracted (speed/RTA) constraints?



ETA and Along-Track Uncertainty

- For modern aircraft, ETA conformance and time error along predicted trajectory
  - Typical: below 5 to 10 sec.
  - Mean: below 5 seconds.
- Deceleration procedure highly preferential
  - RTA accuracy < 5 sec. deceleration
  - up to 15 s for acceleration)
- Along-track error consistent with time-error
  - Typical: at or below 1.0 NM

Cross-track Uncertainty

- Cross-track error nearly consistent for all flights.
  - Typical: below 0.03 NM.
  - Mean: 0.01 to 0.015 NM

Trajectory prediction accuracy and sensitivity
Further Investigations

1. Is the airborne **multiple RTA** capability required to meet the ERASMUS (CD&R) objectives?

2. Can wind and temperature nowcasts significantly improve AC TP accuracy during **climb/descent** ?

3. How do **meteo downlinks** and AC data impact GTP accuracy ?

4. If air and ground TP deviate what is the overall **CD&R impact**?

5. What is the **overall benefit** of the ERASMUS server? (conflicts solved, fuel saved,…)

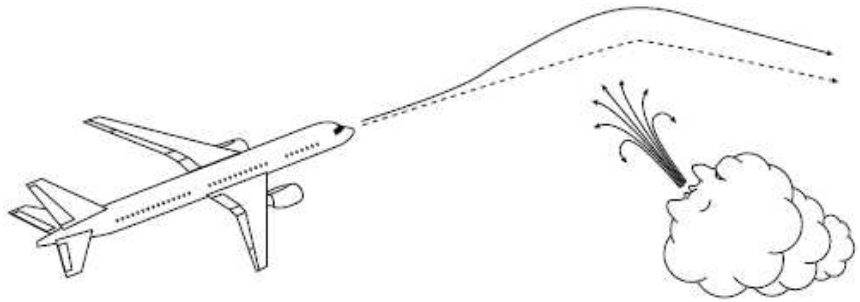
Multiple RTA, RTA in descent

Enroute, climbing & descending flights

Enhanced weather models

- Spatial and temporal wind evolution during flight
- Fusion of downlinked wind measurements

Analysis of Coast Index impact on ERASMUS



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CATS: Genetic Conflict Detection and Resolution

History

studies start early 90's(DTI/LOG JM Alliot,N Durand & All)
7 PhDs

Overview

Flight modes:

- **Direct Routes,**
- **Standard routes,**

Trajectory prediction:

- **Uncertainty according to flight modes (Convex or Segment)**

Manoeuvers Capability :

- **Heading,**
- **flight level,**
- **speed/rta**

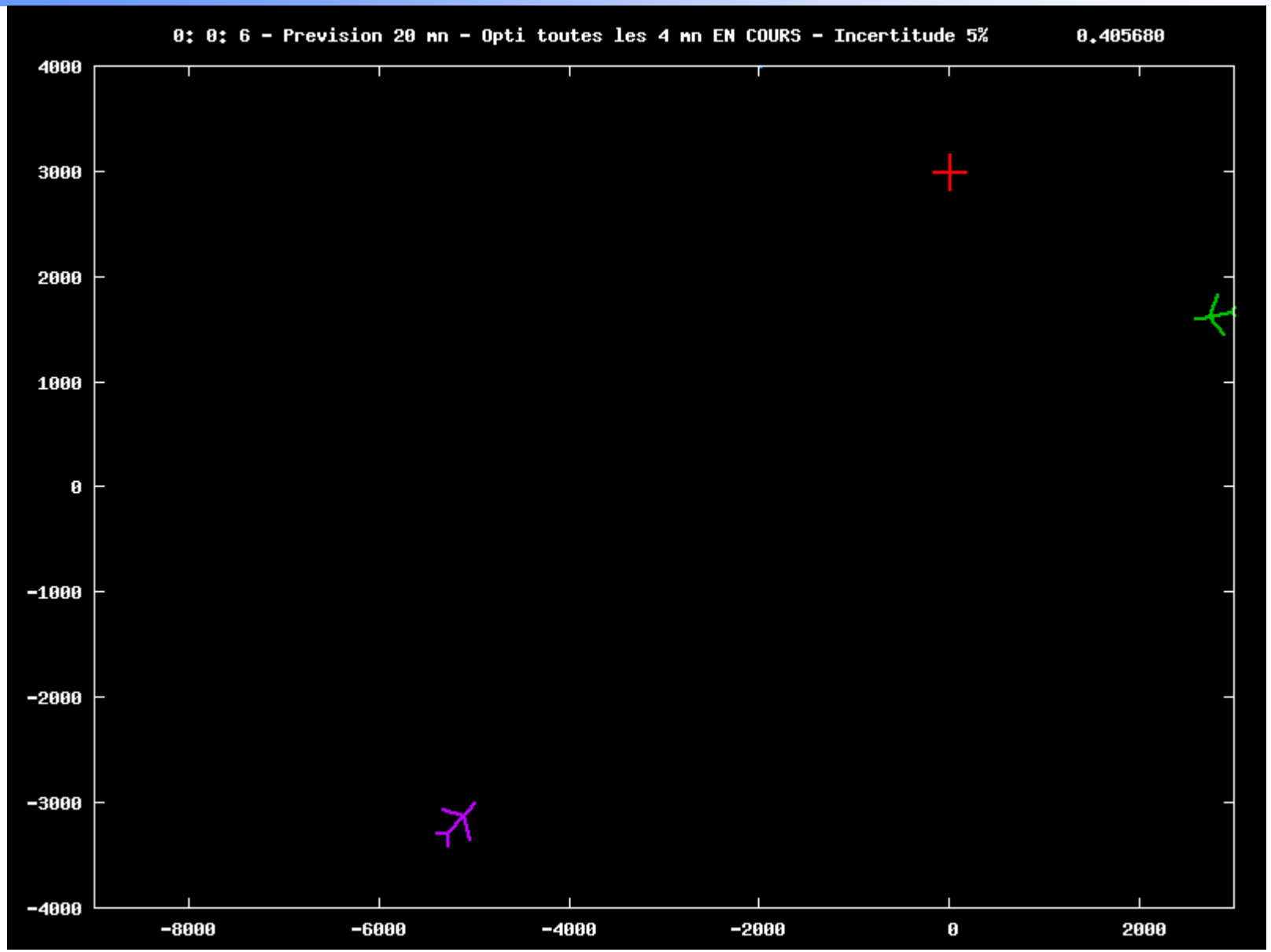
Optimization of the manoeuvers:

CATS

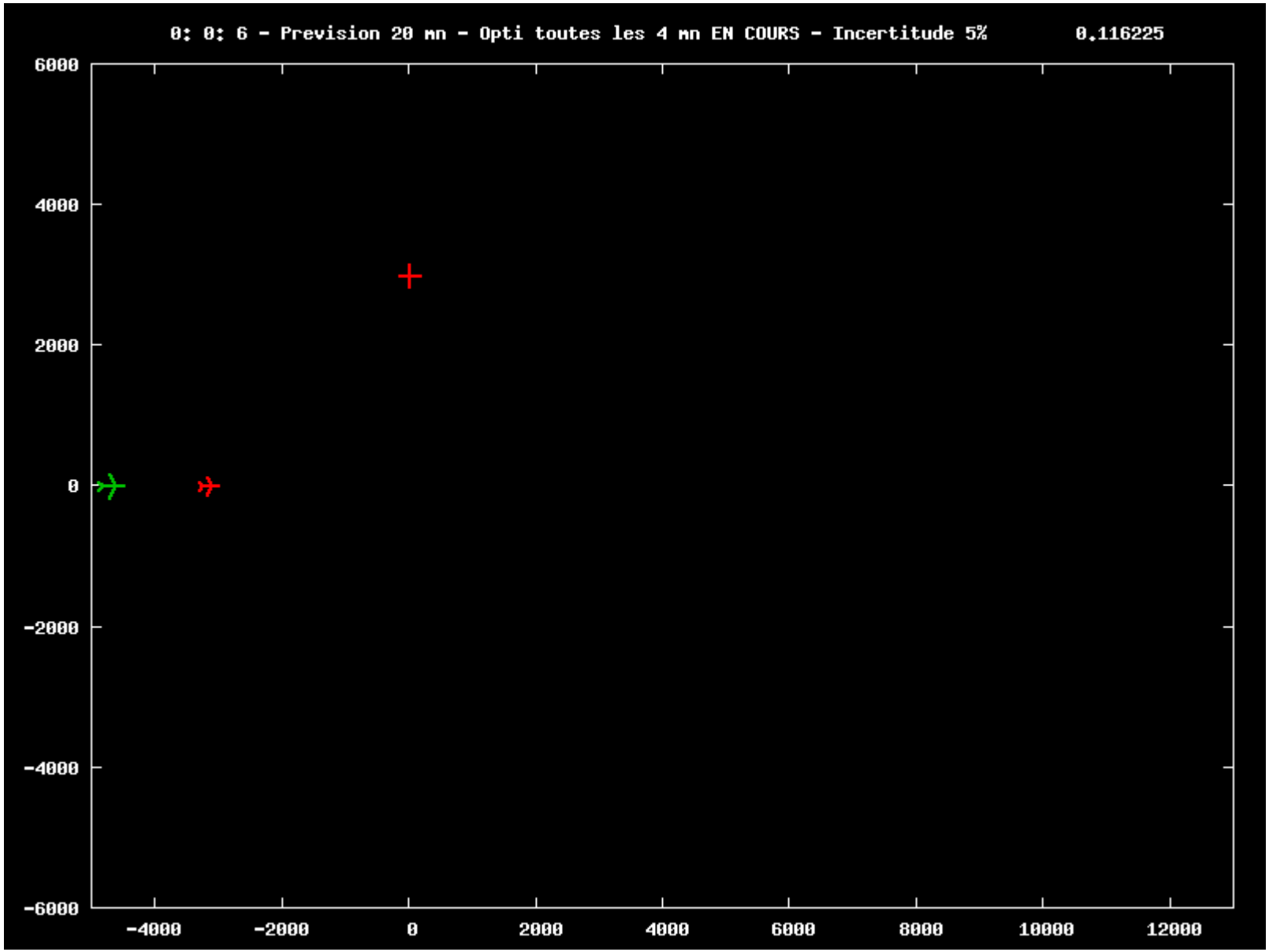
- An ATC simulator to validate the algorithms
- Used to built the « Erasmus Server »
- Using all the variables(HSpeed,VSpeed,Vectoring,FL

  » 80 % Conflict Removed

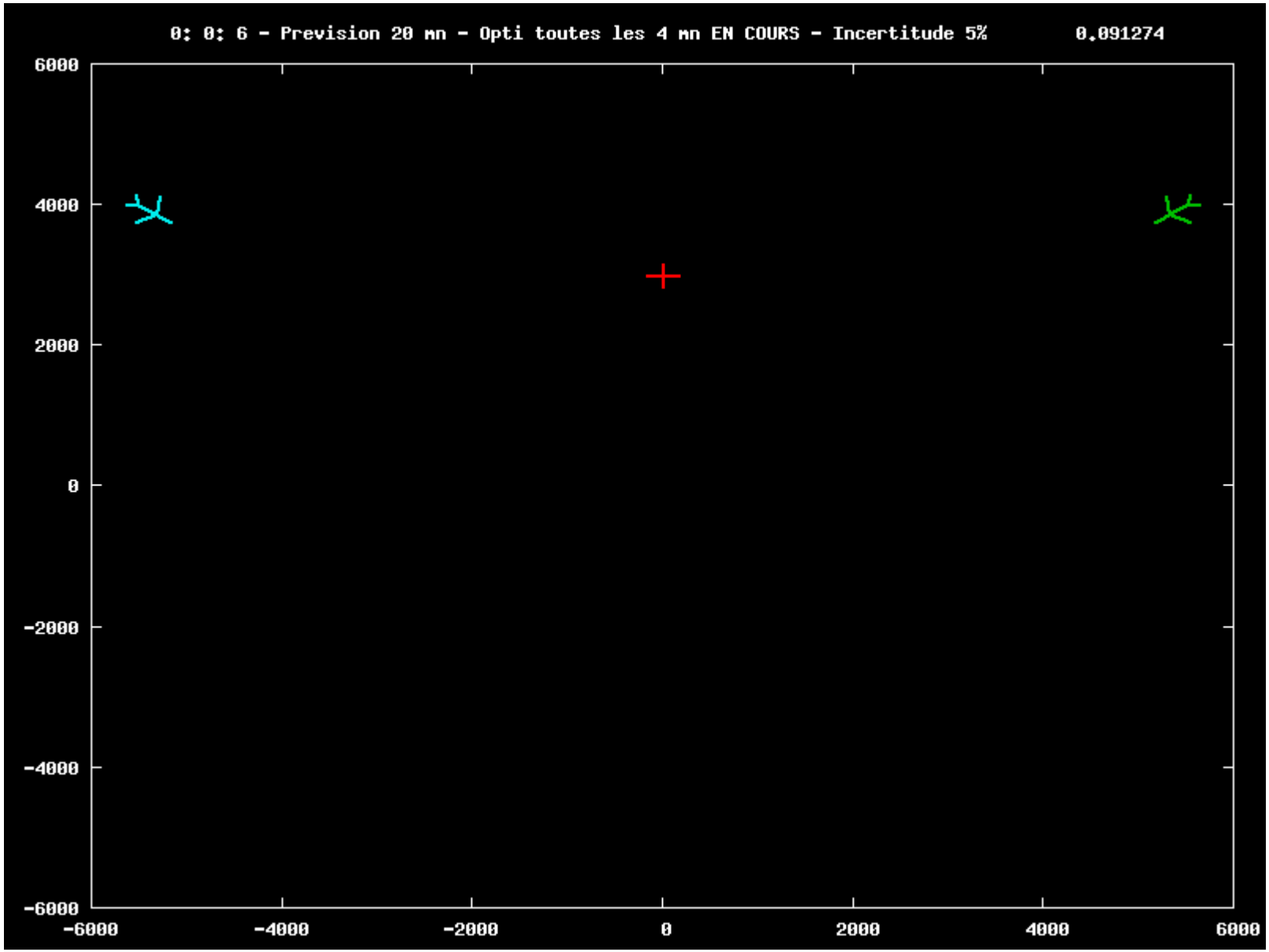
4 aircraft concerned only two move



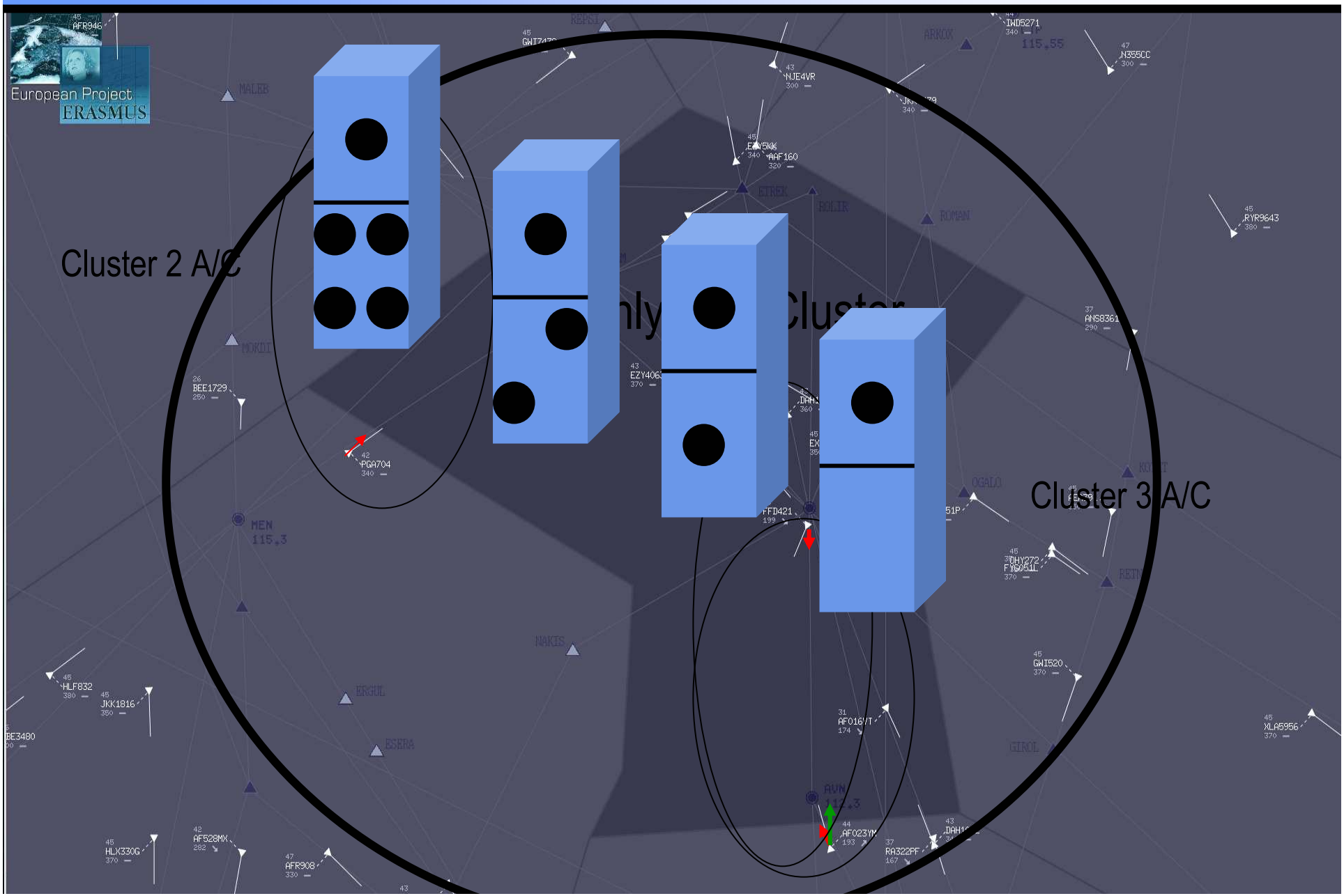
Catching Up situation



Turn about situation



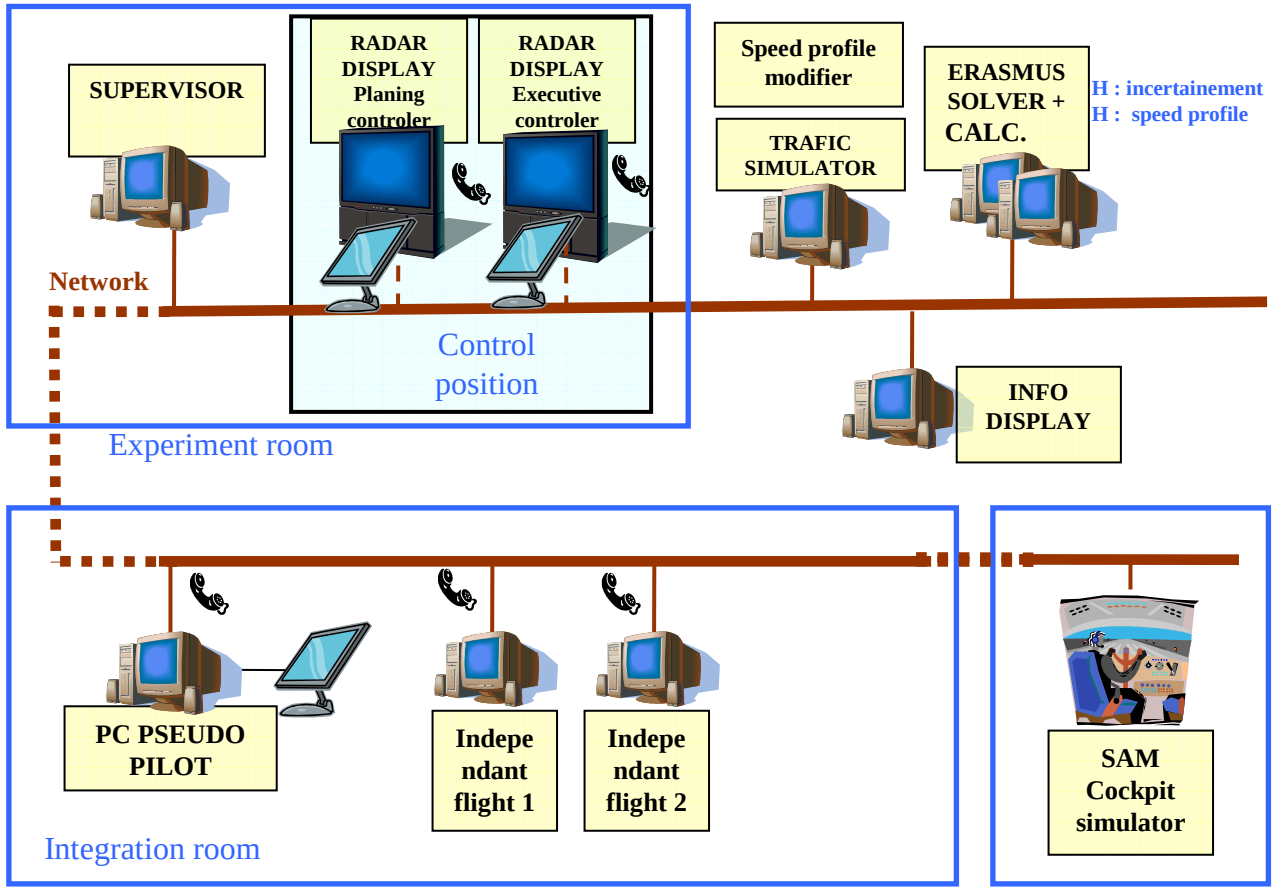
How It Works ?



ERASMUS SERVER Services

Platform overview

PHYSICAL ARCHITECTURE



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