

# Visitor Research Report

**Visitor Name:** Mr. Fernand Clermont  
Delft University of Technology, The Netherlands

**Area of Research:** Air Traffic Management and Aviation Safety

**Period of Visit:** June 1, 2009 – August 21, 2009

## **Goal:**

The goal of the research during the 12 week internship was to investigate the influence of aircraft dynamics on the separation performance of state-based CD&R. More particularly, the research was applied on the CD&R part of the mathematical framework of ACCoRD. ACCoRD is a tool, build for the Air Traffic Management systems, that detects conflicts between aircraft during flight and computes resolutions to avoid these conflicts. To be able to formally verify the tool with PVS, simplifications were made. One of these simplifications was the assumption that the aircraft would turn instantaneously on the proposed resolution vector and neglect all of the aircraft dynamics. The research done was to investigate the influence of the aircraft dynamics on the save separation, when an aircraft would follow the resolution, using its aircraft dynamics.

Next to this, a sensitivity analysis of the tool ACCoRD was made using the same simulation tool. And new developed mathematical formulas to compute the relative distance mathematically, were tested on correctness.

## **Strategy:**

The goal of the internship was achieved by building a simulation tool to simulate the paths of the aircraft in the conflict. One of the two aircraft performs a resolution maneuver using dynamics based on a macroscopic and kinematic aircraft model. This was the most reasonable choice of dynamics with which it was possible to investigate the influence in a general perspective, not needing any specific aircraft parameters that would limit the analysis. By simulating both aircraft, one going straight and the other making a turn maneuver, the relative distance at every time step can be computed, leading to a minimum value during the entire movement. This minimum relative distance during the complete maneuver gives an indication on to what extend the aircraft dynamics would influence the save separation.

This whole analysis was done for two types of resolutions, for which two simulation tools were written. One resolution type was the track angle change and the other was the vertical speed only change. The computation of the resolutions was done by using the algorithm, set up for ACCoRD, to find the correct resolution speed vector for both resolution maneuvers.

**Accomplishments:**

After the simulation tool was build, analyses were done and results were obtained to be able to answer the question to what extend aircraft dynamics influence the save separation. It was found that the dynamics in the track angle change resolutions have a high influence on the save separation and following the resolution, as proposed by ACCoRD, always leads to a conflict situation with sometimes very low separation distances. It was suggested that the aircraft turn dynamics are incorporated in determining a resolution for a conflict situation.

The sensitivity analysis of ACCoRD gave some interesting insights: in general it can be said that right maneuver resolutions yield larger heading angle changes at lower sensitivity, when compared to left maneuver resolutions. For some conflict situations, the sensitivity was extremely high, leading to an unacceptable resolution maneuver. It was suggested that the sensitivity is taken into account in ACCoRD.

For the vertical speed resolution case, this was slightly different. The dynamics only have a very small influence on the relative vertical distance. Further research is necessary though, to give a firm conclusion about this resolution case.

**Future Work:**

Future work in the research will include the investigation in influence of pilot reaction times and acceleration times on the vertical speed resolution maneuver. Next to this, the influence of the dynamics on the ground speed resolution maneuver should be investigated.

**Pending Publications:**

A publication of this research solemnly will not be done, but currently, a publication of this research is prepared in cooperation with other research going on in the same field.

**Seminar Presented:** The research is presented at a seminar at NIA at Friday, August 21<sup>st</sup>, 2009, 11:30pm.