Supporting AMAN by Visualizing Uncertainty

Background
To balance the flow of inbound aircraft and the capacity at airports, more and more Air Navigation Service Providers use Arrival Management (AMAN) systems. These provide decision support to air traffic controllers in planning inbound flights to optimize capacity, flight efficiency, and predictability. All AMANs are based on predictions of an aircraft's arrival time. Due to various disturbances the error of these predictions grows larger with the prediction horizon. Planners will therefore not be able to effectively use the support at a certain horizon due to the lack of confidence in the provided information. This project proposes and tests enhancements to controller interfaces based on the probability density function of the expected arrival time, allowing planners to include uncertainty in the decision making process.

Problem
Most current AMAN display interfaces are based on a moving timeline on which the expected or planned arrival times are shown. This display provides limited information on the available capacity, the required spacing, the limits on the accuracy of the arrival time, or an aircraft's capability to meet that time. The lack of such information results in either a need for extensive knowledge and experience of the planner, or is not accounted for leading to lower overall performance.

Approach
The research will comprise of three steps:
- Development and testing of a visualization concept suitable to a generic arrival management problem subject to uncertainty.
- Develop a method to estimate the uncertainty on an estimated arrival time based on information available at Air Traffic Control using techniques based on historic data (e.g. evidence based decision making).
- Test the visualization and estimation in a real-time simulation with operational controllers.

Visualization approach
The AMAN process is controlled by expert operators who use their knowledge of the system and their experience to interpret the available information and make decisions.
By starting out from the limitations in possible actions, the resulting display is not limited to one particular strategy and the operator is free in making decisions. The abstraction hierarchy by Rasmussen provides a powerful framework to evaluate the constraints imposed by the working domain.

Deriving visualization from the work domain
1. By displaying the uncertainty as PDF, the information is provided. Its meaning to the operation is unclear.
2. The spacing interval between two aircraft presents the demand that each aircraft imposes on the runway.
3. Stacking the demand makes the relation between separation, capacity, and demand evident.
4. By comparing areas, expected excesses in demand are translated to expected delay.
5. When the arrival time is presented as a PDF, demand can be presented as its expectation value.
6. The combination allows simultaneous evaluation of both high level objectives as well as individual arrival times, even when such times are not accurate.

Progress and objectives
- Display design tested in new ATM Lab with human subjects. Results under analysis.
- An implementation with multiple runways has been designed and tested.
- Collected 1 year of AFTN messages for Amsterdam Airport Schiphol. Currently being processed for development of an online uncertainty modelling technique.
- Application of uncertainty modeling in full ATC simulator for testing with operational controllers.
- Analysis of effects of interaction between automated sequencing systems and human planning using uncertainty based display.

Publications

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