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Papers & Analysis

The session on Network and Strategic Flow Optimization had eight papers with a range of timeframes from the nearer-term through the far. All the papers have a heavy emphasis on trajectories and the use of trajectories for network management and strategic flow. Trajectories are used to establish overall plans based on aggregate demand to the management of the flow within the network by establishing individual flight trajectories that meet a strategic goal.

Paper 149, The Area Flow Multi-Sector Planner: A Fast-Time Study of MSP Coordination Activities, presented by Kenny Martin, ISA Software, opened this theme. The analysis reported in the paper was conducted by a US/European company ISA Software in collaboration with the FAA. In human-in-the-loop (HITL) simulation the FAA had "down-selected" its Multi-Sector Planner (MSP) concept to the role of Area Flow Manager. Since HITL is by its nature limited in terms of geographic scope and participants, fast-time simulation has been used to extend the analysis to a larger region. The fast-time environment was set to model 150 sectors and 50 MSP positions. While the analysis shows the benefits of the MSP, it fast time results also highlighted in greater detail the need for establishing clear coordination rules among the MSPs to further refine the concept and its implementation. This paper documents a good example of "spiral development" - using fast-time can extend HITL results to a meaningful population of actors and then using the fast-time results to refine inputs and objectives in follow-on more detailed HITL simulation.

The second paper 143, 4D-Trajectory Deconfliction Through Departure Time Adjustment, was presented by Nicolas Barnier, ENAC (École Nationale de l'Aviation Civile). As noted in the briefing, the current scheduling of en-route airspace uses a slot allocation process to minimize the occurrence of demand greater than capacity. The purpose of the slots is to assure that workload is not exceeded - including time to resolve conflicts. This analysis evaluate the cost in terms of delay and benefit (delta delay from current practice) by resolving 'all" conflicts in upper airspace through ground holding. "All" because it was acknowledge that flight entering the region from external source e.g. oceanic flights must also be accommodated. A large scale combinatorial optimization solution was presented. Among other issues to yet be resolved, the first is technical with respect to technique - large problems will require refinement to the optimization method to make solutions feasible in times allowed. The second is the matter of trajectory error bounds around departure to assure the solution holds and the delay cost associated with the bounds. Both issues are subjects of additional work.

The sixth paper in this session, paper 55, Airport CDM Network Impact Assessment, presented by Eduardo Goni Modrego, EUROCONTROL, is also an assessment of departure/trajectory uncertainty and enroute capacity. In this case the analysis was on how the improved accuracy of the Target Take-off Time could improve the efficiency of the current process. The paper reports on the success of Airport CDM for local operations at Munich where Airport CDM has demonstrated local benefit such as a reduction in average taxi times and has shown an improvement in CFMU CTOT conformance. This analysis explores how that improvement at 42 airports could influence the CFMU planning. The improved performance with respect to the mean and the variance of the CTOT conformance can be equated to less likelihood that sector overloads would occur. Since planning capacities are set lower than actual to assure that variance in the delivery of the flights to sector in actual operations will not exceed the maximum declared value, it was estimated that increases to the planning capacity of up to 4% would be possible – an increase of 1 or 2 aircraft per sector. Improvements to local airport operations and improved information directly lead to improved network performance.

The third paper 152, Evaluating a New Formulation for Large-Scale Traffic Flow Management, was presented by Andrew Churchill, University of Maryland. The paper provided a new approach to the classic problem of aggregate flow as modeled by Bertsimas, Lulli and Odoni and modified the approach to consider airspace volumes e.g. capacity constraints as opposed to modelling all sectors within a given airspace. This results in a simpler model of the strategic flow decision focussing on the areas of interest. This not only reduces the problem size, it is very much in line with the operational model used by the FAA's strategic flow planners in their daily activities. Another interesting aspect of the paper is the "resolution" of the aircraft tail number versus flight issues. By using fixed aircraft to flight pairing at feeder airports and conservation of aircraft flow at airports in which an airline has a major presence, the model overcomes a perennial problem related to substation of aircraft. It is interesting to see how a traditional approach to aggregate flow can be modified to more closely reflect the approach to airspace that is inherent in US daily operation.

The seventh paper 33, Hybrid Demand and Capacity Balance Model for the Future Air Traffic Management Concept of Operations, presented by Juan José Rebollo, GMV Aerospace & Defence, provides a demand and capacity model for the air traffic network optimization problem, in which Lagrangian air traffic measures are calculated for individual flights. Like the third paper, its theme is on developing a flexible network model of an airspace system and uses capacity of the elements of the network to set the queues in the model. Delays are compute for every volume defined airspace or airport. The example case included delays computed in each elementary volume - airspace and airport. The process converts individual flights to flows and calculates an optimal flow. This solution can then be disaggregated back into individual flights. The example case used this technique to model the traditional case where each part of the airspace was modelled as part of a queue with capacity and a flow. Thus, unlike the third paper, it is focused on all operations not just off-nominal, although there does not appear to be anything inherent in the model to keep it from being applied to the problem as defined in the third paper.

Paper 147, Air Traffic Flow Management in the Presence of Uncertainty, presented by Senay Solak, University of Maryland, was the fourth paper in this session and it is a product of researchers now at University of Massachusetts Amherst, Georgia Tech's Air Transportation Laboratory and University of California Berkeley. This is also related to the third paper in that it focuses on constrained airspace. In the previous paper the capacity of the constrained area is set, here the work is on establishing a stochastic capacity for a volume of airspace given the forecast weather and associated uncertainty. The capacity of the volume of airspace is established by modelling the flow of aircraft into the constrained volume. This modelling includes conflict free routings within this constrained volume and establishing a maximum flow. In this respect this is similar to the second paper in that capacity is set by conflict free trajectories. It is also similar in that the process proposes that these routings are more than just a volumetric calculation, they are also guidance on aircraft routings.

The fifth paper 97, Resource Allocation in Flow-Constrained Areas with Stochastic Termination Times-Optimistic Approach, presented by Moeiin Ganji, University of Maryland, considers stochastic planning in the temporal component. What happens if the airspace volume constraint does not have the same duration as originally planned for in the traffic management initiative or in fact not occur? What is the best planning strategy for a flight trajectory to optimize for the removal of the constraint or the extent of the constraint before its "scheduled" time? For each flight a strategic decision must be made to either reroute to avoid the constraint or delay the flight or follow the original trajectory. In the reroute case if the constraint is reduced the aircraft can return to or close to its original trajectory. Note in this formulation the strategic reroute of the aircraft can include following the original trajectory with a "fly around the fence" component if the constraint remains. While there is more work to be done, considerable operational procedures would need to be developed by the ANSP for tactical management of an airspace flow program.

Our eighth and final paper 134, Equitable Allocation of Enroute Airspace Resources, presented by Mike Ball, University of Maryland, had a different focus from the other network analyses. It looked at potential changes to the airspace flow program equity. An airspace flow program (AFP) is different than a ground delay program in that an operator can choose to operate a flight subject to a flow program by rerouting the aircraft around the constraint and out of the program. The method proposed uses operator preference and randomization to determine assignments versus the first scheduled first served approach. It is an interesting approach which still requires refinement. Any implementation would also require a shift on stated policy for managing AFPs. But it is reminiscent of the process by which the ground delay program was researched and modified over the last 20 years.

General Aspects

The Network and Strategic Traffic Flow Optimization session was very well attended. The presentations were followed by a series of very good question and robust conversation. All but one paper focussed on strategic flow. Of the other 7 papers all but one dealt with the mechanics of establishing the model of the flow and the allocation of flights to the flow.

What is interesting is the shift is almost entirely to airspace. The traditional ground delay program papers from the US do not appear here as the more interesting research questions become management of demand to capacity in the air. There is of course still a split on emphasis. The US papers' emphasis is on the off-nominal constraints while the European focus is on daily operations and en-route capacity across the airspace. Still it is clear that much of this research can be applied to either situation.