Practitioner's Commentary: The Outstanding Aircraft Queueing Papers

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The problem addressed by these papers is one of assisting air-traffic controllers in determining the order in which aircraft should be allowed to depart from an airport so as to minimize passenger and airline dissatisfaction.

To my knowledge, no models are currently being developed to assist controllers with this decision. Currently, controllers generally process aircraft on a first-come-first-served basis.

There are several reasons for the difficulty in providing assistance in this situation, including time constraints on controllers, the unavailability of accurate and timely data regarding the passengers on board an aircraft, and the physical restrictions at an airport which prevent reordering of aircraft once they have left the gate and are on the taxiway.

This is not to say that models are not being developed to try to minimize passengers' dissatisfaction with airline travel. For example, at American Airlines we are developing models to assign gates to minimize travel distance for passengers making connections, as well as models that help determine how long to hold an aircraft at the gate to allow for late arrivals to make the connection.

Currently most major airlines in the US use a *hub-and-spoke* system for domestic travel. The term "hub-and-spoke" comes from the resemblance of the airline system to a bicycle wheel, with the hub corresponding to a central connection point and the spokes to inbound and outbound flights from individual stations. This system provides service by routing planes from spoke city to spoke city via a connecting hub.

Passengers are often required to make connections at a hub during a period of concentrated activity called a *complex* or *bank*. These complexes are precisely timed to allow passengers to make connections while not requiring aircraft to spend too much time on the ground.

Given this nature of most airlines' route systems, one can understand the repercussions of aircraft being held on the ground past scheduled departure time. Not only are the passengers on the aircraft delayed, but the entire system may also suffer a chain-reaction delay. For example, if a DC-10 flying from New York to Dallas, a major hub for American Airlines, is delayed, then several aircraft in Dallas may have to wait on the ground to accommodate the connecting passengers. Once those planes become late, there may not be any opportunity later in the day for them to get back on schedule, and many later complexes may also be adversely affected.

While airlines place a high value on dependability and do include a component in the scheduled flying time to reflect delays in the air and on the ground, overestimation of this component may cause a reduction in the number of flights that an airline can fly per day (more time is spent on the ground) and thus a reduction of service and revenue.

One can see that while a model that would allow air-traffic controllers to order aircraft departures to minimize customer and airline dissatisfaction would be of great assistance in this environment, such a model would require a great deal of data to serve as an accurate decision-support tool.

The five student papers all provided a reasonable first-cut approach to this problem. All of the teams built some form of dissatisfaction function that made use of the data as presented. This function was generally a sum of various components that the students felt contributed to passenger dissatisfaction. The students generally overlooked or underestimated the impact of late flights on the airline itself.

Four of the teams then developed several schemes or rules to order the aircraft, and then tested these schemes using a series of computer simulations. The scheme that resulted in the lowest level of aggregated dissatisfaction was considered superior to the others. Often there appeared to be a bias for large aircraft, so that small aircraft might have to wait an unacceptably long time to depart. Some of the teams realized the situation and placed an upper bound on time spent waiting. The fifth team, Harvey Mudd, used an optimization approach, the *assignment model*, to order departures, rather than a rule-based approach.

Only one team, the University of Dayton, used real data for arrivals and departures, taken from actual flight schedules. The others used either randomly generated data or built a representative table of arrival and departure information.

The University of Dayton was also the only team to simulate days when weather problems cause the airport to shut down for a period of time. This type of analysis is extremely crucial, since most schedules are designed to work in the absence of significant delays.

The strengths of the students' approaches are that they make use of the data at hand and developed models that made quick-enough decisions for controllers to use in a real-time environment.

The major weaknesses are in the underestimation of the downline impact of a delay on an airline's schedule, as well as the impracticalities of holding aircraft at the gate or in a holding pen pending assignment to departure runway. Surprisingly, none of the team developed or discussed the use of an expert system for this purpose.

About the Author

Bruce W. Patty is a senior consultant with American Airlines Decision Technologies. He received his Ph.D. and M.S. degrees in operations research from Southern Methodist University, as well as the B.S. degree in systems engineering from the University of Arizona. He previously worked as an associate engineer for General Dynamics and served for three years as assistant professor of industrial and systems engineering at the University of Southern California, during which time he was awarded a Summer Faculty Research Fellowship at the Naval Personnel Research and Development Center. He is a member of both ORSA and TIMS and has acted as the liaison between ORSA and COMAP in coordinating ORSA's support of the Mathematical Competition in Modeling. His research interests lie primarily in the application of network optimization techniques to airline-related problems.