21st Century, Fast-time Airport and Airspace Modeling Analysis with Simmod

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Denver International Airport's (DIA) ramp tower manager, Keith Mays, looked out of the tower on a snow-covered day in 2009. The snow event had been under way for several hours and was beginning to pile up. And even though they were well-prepared for de-icing operations at the airport's five main de-icing pads (A, B, C, J, and WA), the number of departures making it to the runway and taking off seemed to be fewer than what he expected.

Frequently, several aircraft would push back from their gates, but would wait in line to de-ice, even though there were empty and available slots at other de-ice pads nearby on the airfield.

Ground operations at any airport can be tricky, but introducing this additional level of complexity is something that DIA and many other airports throughout the nation do on a regular basis. Many airlines at Denver enter into specific de-icing relationships with vendors that provide de-icing services. In some cases, this even involves self-de-icing, when an airline uses staff and equipment services provided by the airlines to service their own aircraft.

The end result of these various arrangements at DIA is that each airline is limited to specific vendors and, in turn, specific pads. As Keith Mays observed on that winter day in Denver, because of these relationships, the capacity of the de-icing pads as a whole was being under-utilized. If the current structure continued indefinitely, the airport would need to invest in additional de-icing facilities and resources to accommodate the de-icing operation.

The additional infrastructure in this case would be expensive, due to the complicated nature of capturing and recovering the de-icing material fluid – it's never just as simple as pouring additional concrete. There had to be a better way. The problem that DIA now faced: how to *quantify* what seemed like an excellent idea on paper – de-icing aircraft on a first come/first served basis at each de-ice pad.

ASDE-X Data Opens the Door

Prior to the 2009 snow season, DIA had been studying the concept of moving DIA's de-icing services to a first come/first served basis as a means of improving the

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Photographs provided courtesy of Denver International Airport

de-icing efficiency, facility utilization, and aircraft departure capacity. However, the airport had limited quantitative aircraft ground-tracking data. Because of this lack of data, DIA was limited in the ability to properly assess changes to their current de-icing operation.

Performance measurement and analysis were needed to conclusively determine if the new approach would deliver the improvements necessary to change from the current multiple service provider approach. With the installation of Airport Surface Detection Equipment Model-X (ASDE-X) ground surveillance data system in the winter of 2009, DIA now had the missing link to the data analysis and modeling requirements they needed to perform this study.

The Analysis Process

As the 2009-10 winter season came to an end, DIA enlisted a team including ATAC Corporation to perform two primary analysis tasks:

- Past performance analysis, and

- Fast-time simulation analysis.

The first task involved a detailed analysis of the ASDE-X data across the entire 2009-10 snow season focusing on the snow events that required de-icing at the airport. This would ensure that any fast-time modeling performed would be based on sound, accurate data.

"It's always essential to be sure that we are accurately measuring the past first, before moving forward to any other modeling exercises," Jason Bertino, Program Manager of ATAC's Airport and Analysis

group, explained. With support from the FAA's Denver Terminal Radar Approach Control (TRACON) and the Performance Data and Analysis Reporting System (PDARS) program office, ATAC was able to access ASDE-X data for 44 days of de-icing and ten days of good weather data.

The good weather days were used for comparison purposes. Measurements such as de-icing throughput per pad, average de-icing times, pad utilization, taxi times prior to de-ice pads, and taxi times after de-icing were all distilled from the ASDE-X data.

Once all of these metrics were produced, analysts at ATAC began the second task–fast-time simulation modeling of the existing de-icing rules in

comparison to the first come/first served scenario. This was done using ATAC's fast-time simulation model of choice, Simmod *PRO!* This powerful software is used by many air navigation service providers, engineering firms, and research organizations worldwide to conduct a large range of analysis tasks.

It installs from a CD on Windows XP, Vista, and 7, and features an easy-to-use graphical user interface to design, build, and execute simulation models. These models can range in size from a single airport to a multi-airport "metroplex." All of the simulation inputs can be created and modified by the user, so it is a straightforward task to model such things as new proce-
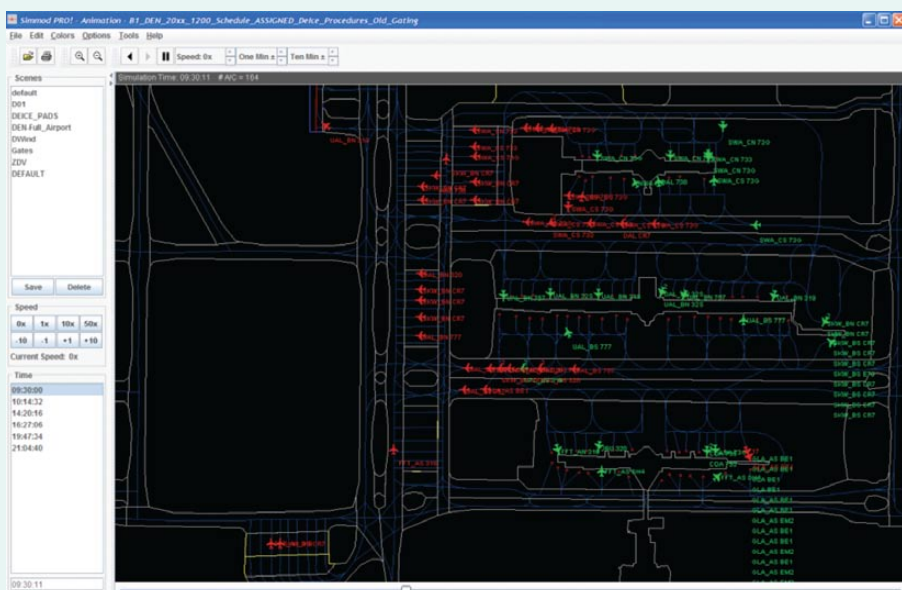

Figure 1 - Simmod Animation of De-icing Operations.
Red aircraft are departures and green ones are arrivals.

dures for air and ground operations, new aircraft types, and new airport layouts.

Simmod *PRO!* enables the analyst to create user-defined rules unique for the modeling task as well as the ability to define limiting resources such as de-icing trucks or pads. The "fast-time" means that a day's worth of traffic (thousands of flights) can be computed in under a minute, and analysts will typically perform multiple iterations to better characterize variability in the results.

The Simmod animator offers a visual replay of any iteration in forward or reverse at a range of speeds from normal (1x) all the way up to 100 times normal speed (100x) – an excellent way to get a quick understanding of the impacts of change to the operation.

In the case with DIA, ATAC analysts began by first loading the complex assumptions used at the airport to move aircraft from their gates, through the de-ice pads, and out to the runways. A process of calibrating the simulation model with the ASDE-X data was then performed to ensure that the current de-ice operation at DIA was being modeled the same way it currently operates – a highly iterative process of adjusting the input assumptions and re-running the simulation model.

The actual running of the simulation model takes place in about 20 seconds on a standard PC workstation, but adjusting and re-adjusting the model inputs to accurately replicate the past de-ice operation took several weeks in this case.

DIA Alternative Analysis

This alternative analysis provided fast-time simulation and decision analysis to assist DIA with this management study. Several study questions were developed to identify the performance measurement and analysis needs. A series of data analyses and simulation experiments were then defined to guide the analysis effort.

Simmod *PRO!* was used to perform a comparative analysis of the current de-ice operation with a first come/first served operation at the current traffic demand as well as a future demand forecast. The primary conclusions of the analysis were that a first come/first served de-icing operation would improve the current efficiency of the airfield operations during snow events and that the current de-ice pads could be used effectively with demand increases of up to 50 percent of the current demand level.

At the current demand level at DIA, the Simmod modeling revealed that an average of 2.6 minutes could be saved per departure operation, which would equate to approximately **$88 million dollars per day** during de-icing. A future demand schedule increased traffic by 45 percent, resulting in an average savings of 9.7 minutes per departure aircraft. This equates to approximately **$479 million dollars per day** during de-icing – assuming Ground Aircraft Direct Operating Costs (ADOC) of $41.27 per minute.

Data and Analysis to Make Informed Decisions

With the past performance and fast-time simulation analysis information, DIA now has quantitative data to support their discussions with the airlines and the de-ice vendors. As is often the case, good ideas need to be backed up with data to support the decision process. Without this information, DIA may have been out in the cold – literally. ∎
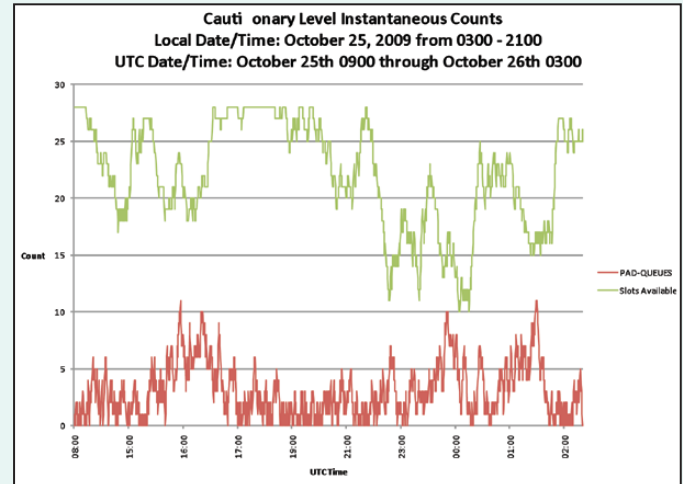

Figure 2 – De-ice Past Performance Analysis

Available Slots versus Aircraft Waiting in Pad Queues from ASDE-X data. The green "Slots Available" line depicts the number of slots that are not in use at any given time throughout the day, while the red "PAD–Queues" line shows the count of aircraft that are being forced to wait for a slot at a pad. As can be seen by comparing the two lines, there are many times when aircraft wait for a de-ice position even though there are positions available.
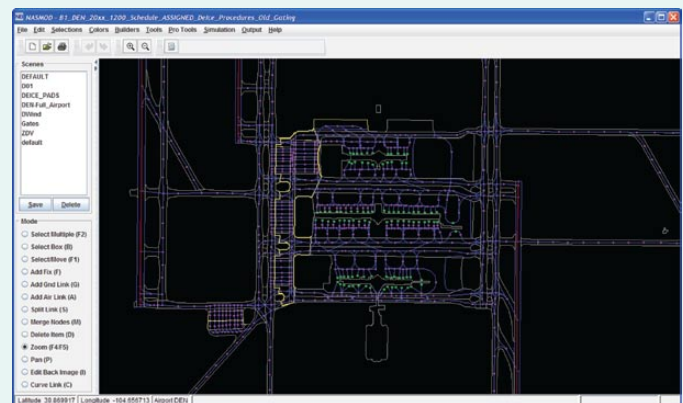

Figure 3 – Simmod Ground Structure

The Simmod ground structure and airfield layout diagram for Denver International Airport are depicted in the graphic. The main de-icing areas are outlined in yellow.