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COLLABORATION, COORDINATION AND INFORMATION REQUIREMENTS FOR THE SUPPORT OF AN AIRPORT DEPARTURE METERING PROGRAM

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A simulation system called the Collaborative Airport Traffic System (CATS) has been developed to study human factors issues that arise in the design of a departure metering program to manage the inventory delivered to the spots at an airport over time. CATS is designed to support the role of a Departure Reservoir Coordinator (DRC), whose job is to:

- Manage the inventory at the spots so that the departures queues maintain a “reasonable length” (long enough to avoid having the queue run dry; short enough to avoid unnecessarily high fuel consumption and long tarmac times).
- Manage the inventory at the spots to deal with departure fix constraints, avoiding an inventory at the spots with too many flights to a constrained departure fix. As one Tower TMC put it: “We’ve got to give the Ground Controller a fighting chance”.

This paper describes the design features of CATS and highlights conclusions based on previously reported studies involving cognitive walkthroughs with ARTCC, TRACON and airport Tower traffic managers and with airline dispatchers.

The FAA Surface Office is currently defining and refining an operational concept for metering of departures in order to reduce the time spent in departure queues. They are also defining and refining the procedures and software necessary to support such departure metering. The fundamental concepts are:

- Rather than applying a first-come first-served process for developing departure queues, flights should be assigned to virtual queues so that they do not need to enter the departure queue for a runway as early.
- Similar to current practice with Ground Delay Programs and Airspace Flow Programs, slots in this virtual departure queue should be assigned based on a form of ration-by-schedule. These slots are defined by spot times. Two primary parameters need to be set by the DRC in order to manage this rationing process: Predicted departure rate for a runway and target departure queue length.
- Given such a virtual queue, on average, flights should be able to remain at the gate longer without the need to board passengers as early, thus reducing Out-to-Off times.
- When a gate is needed for an arrival, the departure may have to push back earlier than necessary to meet its assigned target spot time, but may still be able to wait in some staging area with its engines off or with only one engine on, thus reducing fuel burn.
- Within this virtual queue, a flight operator should be allowed to swap its flights in order to expedite the departure of an “important” flight.

In our work, we are focused on the following issues:

- The allocation of roles and responsibilities.
- The support of coordination and collaboration across different facilities and organizations.
- The definition of procedures.
- Information and information exchange requirements.
- Functional requirements for supporting technologies.
- Interface design requirements.

Below, we discuss the design of CATS and, where appropriate, refer to findings from previously reported cognitive walkthroughs. These two cognitive walkthroughs included traffic managers, dispatchers and ramp controllers from the following facilities:

- Towers: JFK, LGA, EWR, IAH, DTW, MEM, PHL, MEM, ORD, LAX, MIA, DFW, SFO
- TRACONS: New York, Detroit, SoCal, Dallas
- ARTCCs: ZNY, ZOB, ZME, ZFW, ZMP; ZKC, ZOA
- Ramp Control: JFK – DAL, JBU; EWR – UAL; MEM – FedEx
- AOCs: JBU, AAL, FedEx
Discussion of the Capabilities Embedded in CATS

CATS is designed to support the role of the DRC, and consists of a set of linked displays, including:

- A Selection Tool for highlighting collections of flights that share some property (such as all flights filed to depart a given departure fix). When such a group of flights is highlighted in the Selection Tool, those flights are also highlighted in a Flight List and on a Surface Map.
- The Flight List shows the flights scheduled to depart, along with a number of properties for each flight (such as its filed departure fix and destination).
- The Surface Map shows the location of flights on the airport surface. In terms of the usefulness of the Surface Map, one Tower traffic manager noted: “With this tool, I won’t have to get up all the time and look out to see where the flights to a restricted fix are located”, (Smith, et al., 2012).
- The Weather Map shows actual and forecast CWIS weather relative to the departure fixes.
- The Control Chart shows actual departure queue length relative to the target departure queue length over time.

It should be noted that CATS has an underlying stochastic model so that the times for pushback, starting the engines, proceeding to taxi, and off (relative to the time when a flight is cleared to depart) are all random variables in order to simulate the variability that routinely occurs during departures.

The displays found in CATS are presented below. Figure 1 shows the basic display layout. The Selection Tool (left window) shows flights organized by departure gate (North, West, South and East) and departure fix (KNAVE, NELYN, etc.).

- Note that next to each departure fix is a number indicating the number of flights that are either currently departing, active (proceeding to the departure runway under ATC control, in the ramp area (proceeding to depart but still under ramp control) or are expected to push back and depart within the next 60 minutes in order to meet their target spot times.
- The controls at the bottom of the Selection Tool allow the user to determine whether to include the flights in all of these different states in the computation of these numbers, as well as to determine which flights will be highlighted in the Flight List and on the Surface Map when a category is highlighted in the Selection Tool.
- The Flight List provides access to a large number of parameters relevant to a given flight. (Only a subset is shown in Figure 1.)
- The yellow markers in the Flight List indicate flights that are within the “Static Time Horizon” or freeze time, meaning that, in order to give the flight operators some level of stability, their spot times should normally be left unchanged if the need arises to modify target spot times. (Input from SMEs regarding the Static Time Horizon has indicated that it is likely to be set at around 15-30 minutes before pushback.) Observation of SMEs playing the roles of ARTCC and TRACON traffic managers and the DRC use these markers to see the level of demand for a weather impacted fix that they can’t affect by changing the metering program to change the inventory delivered to the spots.
- The Surface Map includes an embedded table that indicates the number of actual flights that were off in the last 15 minutes relative to the expected departure rate, and the actual number of flights that are active at the current time relative to the target number of active flights (a surrogate for the length of the departure queue).
- The Surface Map further indicates runway by color (blue aircraft are expected to depart 18C; purple aircraft are expected to depart 18L) and aircraft status (triangles represent aircraft that have pushed back; dots represent aircraft that are at their gates).

Figure 2 shows flights to 4 different departure fixes highlighted. This highlighting of 4 fixes in two colors was used by a pair of ARTCC and TRACON traffic managers to evaluate the impact of putting two MIT restrictions in effect to deal with weather constraints (12 MIT off the ground for WICKR and WILEY as one and 12 MIT off the ground for WORTH and WYMON as one). Our studies have shown that the traffic managers representing ARTCCs, TRACONS and Towers, along with the DRC, make extensive use of the Selection Tool in order to
efficiently determine the predicted demand for weather constrained departure fixes (Smith, et al., 2012).

Figure 1. Selection Tool (left window), Flight List (center window) and Surface Map (right window).

Figure 2. Flights filed to depart via WICKR and WILEY highlighted in gray; flights filed to depart via WORTH and WILEY highlighted in green.

Figure 3 shows the use of the Selection Tool after the two MIT restriction have been put in place (12 MIT off the ground for WICKR and WILEY as one; 12 MIT off the ground for WORTH and WYMON as one). Note that this has been done by highlighting these two active restrictions in the Selection Tool. Note that in this figure we have also introduced the weather display:

- The weather in the pane to the left of the Weather Map window shows the current actual CWIS weather.
- The weather in the pane to the left of the Weather Map window shows the forecast CWIS weather. (This CWIS weather data which is integrated into CATS is for a summer day in ZFW and was provided by MIT Lincoln Labs.)
The forecast weather can be moved forward in time up to 2 hours in the future, so the user can watch the forecast progression of the weather.

The actual weather can be moved back in time (a feature requested to make shift change handovers more effective as well as to assess past performance).

Figure 3. Use of the Selection Tool to highlight the flights affected by two different MIT restrictions.

Figure 4 shows the Control Chart. In CATS, we are using this to monitor past performance. The FAA Surface Office, however, is using a similar chart to predict future departure performance and guide decisions about whether a departure metering program is needed.

Figure 5 illustrates a situation where there is a need for the DRC to manage the inventory at the spots. A 12 MIT restriction off the ground has been put in place for WICKR and WILEY, and the Flight Table shows that there will be a large inventory of flights to these fixes delivered to the spots in a short time period if nothing is done to insert splitters into the spot delivery plan. Figure 6 shows the swapping of flights to insert such splitters, thus “giving the ground controller a fighting chance”. CATS automatically made these swaps upon request by the DRC, thus eliminating the need for the DRC to make numerous manual swaps to achieve this reviews plan for delivering inventory to the spots.

Figure 4. Control chart showing historical performance. The horizontal green line indicates the target number of
active flights; the vertical green line indicates the current time.

### Important Human Factors Considerations in Using CATS

Figures 1-6 show an illustrative design of a tool to support the management of departure metering plans by the DRC. Previous studies (Smith, et al., 2012) have highlighted a number of important design considerations, which are summarized here:

- **The use of the Selection Tool to highlight flights based on filed departure fix or inclusion in a MIT restriction is of considerable value to ARTCC, TRACON and Tower traffic managers, as well as airline ATC coordinators and dispatchers and the DRC. This tool facilitates individual situation awareness. It also facilitates shared situation awareness and collaboration among the ARTCC, TRACON and Tower traffic managers and the DRC.**

- **In terms of some specific features of these displays**
  - Provide a selection/highlight function that makes it easy to see at a glance a collection of flights based on departure fix, restriction, etc.
  - View by departure fixes or restrictions
  - Link with Flight Table and Surface Map
  - Support at least 2 colors for highlighting
  - Use a background color that provides high contrast with a number of other colors to be used for objects and for highlighting

- **Provide a control to determine the flights that are highlighted based on their status (Departing, Active, Ramp, at Gate – Based on Time before TOBT).**

- **Provide access to a number of flight parameters in the Flight Table (such as weight class and assigned spot), but give the user the ability to order the columns (parameters shown) and sort by different columns.**

- **ARTCC and TRACON weather restrictions get translated into an airport plan, which should in turn determine the strategy for feeding inventory to the spots in a departure metering program. Thus, inventory needs to be managed to support the airport taxi plan, not just the airspace plan. This makes it important to ensure that the DRC is in the loop regarding the ground controller strategy for feeding the departure queues. (Keeping in mind that there are other considerations as well, this finding supports the concept that the DRC should be an FAA function with the DRC in the Tower.)**

- **Support a variety of strategies to deal with dynamic convective weather constraints (developing a plan for assigning flights to departure queues by departure fix, inserting splitters to deal with departure fix constraints, change the inventory delivered at the spots to support ground controllers strategies, reroute departures, move flights to holding areas). Different strategies are determined by different individuals. The ARTCC and TRACON traffic managers, for instance, determine what MIT restrictions to put into place, while the ground controller determines how to move aircraft into different departure queues based on departure fix, while the DRC decides how to deliver the appropriate inventory to the ground controller. Thus, coordination between these individuals is critical to effectively manage departures.**
Figure 5. Original plan to deliver WICKR and WILEY flights (highlighted in gray) to the ground controller.

Figure 6. Plan to deliver WICKR and WILEY flights to ground controller after CATS has inserted splitters.

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