Decision Support Tools for the Collaborative Trajectory Options Program

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The FAA currently makes frequent use of Flow Constrained Areas (FCAs) to thin traffic through some region of airspace by assigning departure delay to flights filed to fly through that airspace. An important potential future use of such FCAs is their integrated application within a Collaborative Trajectory Options Program (CTOP) Traffic Management Initiative (TMI). This paper reports the results of cognitive walkthroughs completed with ten recently retired traffic managers. These walkthroughs were designed to evaluate information and information display requirements, as well as other decision support requirements, for software to enable the creation of FCAs for a CTOP TMI.

In this paper we provide the results of a cognitive walkthrough designed to provide guidance on the design of an effective interface for access to the information and decision support tools necessary to plan a CTOP TMI. (See Smith et al., 2019 for a description of CTOP.) Broadly speaking, each FCA in CTOP allows traffic managers to control traffic rates to constrain the volume of aircraft through a certain airspace region. Through the use of multiple (typically adjacent) FCAs within a given CTOP (see Figure 1 at the end of this paper), the traffic managers can manage the traffic flows through these FCAs in a coordinated manner. The definition of a specific FCA includes filters that can limit the included flights by departure and arrival centers, time frame, altitude range, etc., as well as the geographic airspace transited.

To evaluate the information, information display and functional requirements necessary to support effective decision making when using a CTOP, this study focused on completion of a cognitive walkthrough focused on planning a CTOP TMI for a given day. For the cognitive walkthrough, the participants in a group that included experienced traffic managers from the relevant Enroute Centers viewed a storyboard together, evaluating a prototype interface design in terms of the following user interface elements: Filters, FCAs (location and types) and throughputs for five FCAs/FEAs that were included in this CTOP. The walkthroughs were completed over the internet, with participants viewing the storyboard using a shared display.

Step 1. Review of Weather on Date of Interest

The storyboard begins at 1500Z. To begin the walkthrough, the color codings used in the images for the weather displays (actual Vertically Integrated Liquid (VIL) and echo tops; forecast VIL and echo tops) were described. The traffic managers were told that, following a review of the actual and forecast weather, they would be asked to critique a presentation

indicating how a hypothetical traffic manager could use the prototype design to manage a CTOP. They were further told that, when providing their critiques, they should assume that certain other TMIs were being used to move much of the other traffic out of this area. These other TMIs, which consisted of the actual TMIs in use on this date, were presented to them. They were then shown the forecast for the VIL and echo tops from 1500-2100Z in order to understand the forecast weather pattern that required some form of traffic management. (See Figures 1 and 2 at the end of this paper.)

Step 2. Review of CTOP

The traffic managers (who were already familiar with the use of FCAs from their past work experience) were then told that, for the next step, their goal was to evaluate the use of a CTOP TMI. They then were presented with a review describing the nature and design of CTOP initiatives.

Step 3. Walkthrough of Traffic Manager using CTOP

The participants were told that they would would be asked to critique the use of a CTOP by a hypothetical traffic manager to deal with the weather forecast from 1500-2100Z, as illustrated in Figures 1 and 2 at the end of this paper, in order to manage the traffic departing ZDC, ZJX, ZMA and ZTL and arriving ZAB, ZAU, ZDV, ZFW, ZHU, ZID, ZKC, ZLA, ZLC, ZME, ZMP, ZOA, ZOB and ZSE (i.e., all Centers except ZNY and ZBW). The traffic managers were reminded that they had already reviewed the plays and other required reroutes actually used on this day to move some of the traffic around the forecast weather. They were then presented with a walkthrough of a prototype illustrating the use of CTOP to manage the remaining traffic.

Participants

The primary group studied consisted of five recently retired traffic managers, one each from ZDC (Washington), ZID (Indianpolis), ZME (Memphis), ZTL (Atlanta) and ATCSCC (Air Traffic Control Systems Command Center). They had 12, 4, 29, 13 and 22 years of experience respectively as traffic managers in these facilities. The intention was to run a second session with five other traffic managers from the same facilities. However, due to scheduling and technical (internet) difficulties, it was not possible to conduct this session. We did, however, conduct the walkthrough on two additional dates, with other traffic managers representing the key facilities. One group (Group 2) had a traffic manager from each of ZID, ZME and ZTL with 2, 1 and 12 years of experience respectively; the other (Group 3) had traffic managers from ZDC and ATCSCC, with 14 and 10 years of experience respectively. Since these sessions did not represent the full set of relevant expertise, we simply report results from those sessions that provided insights that were significantly different from those of the Primary Group and that did not appear to be affected by the fact that the full complement of relevant traffic managers was not present.

Results and Discussion

Following the review of CTOP, the participants were shown the prototype design and its components were described. The left pane was used to specify filters for the FCAs; the upper

right to show the current and forecast weather (VIL or echo tops); and the lower right to set and display the rates through FCAs in a CTOP. They also were shown the CTOP (with FCA locations and filters) as set up by a hypothetical traffic manager to manage the traffic flows for flights departing ZDC, ZJX, ZMA and ZTL and arriving ZAB, ZAU, ZDV, ZFW, ZHU, ZID, ZKC, ZLA, ZLC, ZME, ZMP, ZOA, ZOB and ZSE (i.e., all Centers except ZNY and ZBW).

Assessment of Filters

After reviewing the left pane for entering parameters for the filters, during the walkthrough the participants were each asked *individually* to respond to the following questions: Is this a reasonable set of filters? What would you add or delete from this set? Why? They were then given an opportunity to respond to what they heard from the other traffic managers.

Primary Group.

ZID: "The only thing I'd add is that you might want different tops for different FCAs. If a Citation can go to 41,000 over the tops, then you should let them."

ZTL: "The European traffic to Hartsfield needs to be picked up in the total count even though they are exempt from delay with these filters."

Groups 2 and 3.

ATCSCC: "I might leave ZDC out of the filter for departure centers and focus on the traffic to the Midwest with the CTOP. You could handle the rest of the traffic separately."

ZDC: "I'm ok with ZDC being included. There will be crossing flows, but that's the reality of what we live with. In addition, I'm going to be running EDC or TBFM for Chicago. The flights are going to get whacked twice, for CTOP and EDC or TBFM."

"The forecast doesn't show major input west of New York. I'm not worried about them. New York to Detroit or Chicago won't file into DC."

Assessment of FCA Locations and Types

Regarding the FCA locations and types, the interface to draw or edit the FCAs using the FCA Locations tab was not shown. Instead, the traffic managers were shown a pre-defined set of FCAs. Four FCAs (solid colored lines) and one monitoring Flow Evaluation Area or FEA (a dashed line segment) are shown in Figures 1 and 2. Note that the directional FCAs and FEA used for this example were designed so that they each capture different major flows focusing on flights from the Southeast to the Midwest, Northwest, West and Southwest that were likely to be used as initial routes or as alternative reroutes (FEA1A captures traffic routed through MEM; FCA1B traffic through BNA; FCA1C through IIU and FLM; FCA1D through the vicinity of BKW; and FCA1E for traffic crossing the line of weather further to the north, with each placed to capture traffic slightly north and east of the preceding one).

After viewing the forecast for a given one hour period, each traffic manager was asked to individually critique the FCAs shown relative to the forecast for that hour. Responses are indicated below for the 1600Z hour. (Results for other forecast times are in a full report.)

Primary Group:

ZID: "They look pretty good. Maybe move 1D a little northwest. Move it closer to the boundary, align it more north/south."

ZTL: “I don’t have a problem. The FCAs run along my northern boundary. I think it’s gonna give me some good numbers to look at. I’d make 1A an FCA right away because of the volume we’ll want to move to the west of the weather.”
ZDC: “The goal is to get rid of structured routes. The way 1D and 1E are set up, they’re not in a good position. They’re not capturing J6 New York traffic. New York/Boston can file through this weather. You need to draw 1D at the Indy/Cleveland/Washington Center boundary.” “I would absolutely use a CTOP. You just have to define the FCAs right. CTOP won’t solve the whole problem. It might be more efficient in some scenarios than others.” “It gives you breathing room to solve problems more granularly and efficiently at the facilities.”
ZME: “1A needs to be an FCA. Most of the airplanes aren’t going to go through 1C. They will go around the edges. I’d extend 1A further south down into Fort Worth and then put an FEA down from there to the coast line. Every CTOP ought to have 1-2 monitoring FEAs at each end.”

Group 2 and 3:

ATCSCC: “Don’t filter by direction.”
ZDC: “I’d put 1D along the Indy line and 1E along the Cleveland line.”
ATCSCC: “Using Center or sector boundaries is a good idea because jet routes don’t normally go along Center or sector boundaries.”
ATCSCC: “I don’t believe Memphis will buy off on an FEA. The planes will go around as tightly as they can and there is some weather in 1A.”
ATCSCC: “We treated 1A as an FEA. It needs to be an FCA. We are going to hurt them badly. And we need an FEA at each end.”

FCA Rates. The traffic managers again were shown the actual weather (VIL and echo tops) for 1500Z and the forecast weather for 1600Z and 1700Z (see Figures 1 and 2 for the one hour forecast of VIL and echo tops at 1600Z). They also were again shown the actual weather at 1500Z for the entire U.S. Then, they were each asked to individually write down the rates (% reduction relative to maximum capacity) that they would recommend for the second hour (1600-1700Z) based on the one and two hour forecasts (1600 and 1700Z). The results are shown in Figure 3 at the end of this paper, with the bold type indicating traffic managers with the most expertise for a particular FEA/FCA. (Similar results are available in a full report for the 3 hour and 5 hour forecasts.)

Note especially the differences in some of the recommended rates for traffic managers with expertise covering the same airspace (e.g., up to a 50% difference for the two traffic managers from ZDC for FCA1E).

Conclusion

At an abstract level, the feedback from the traffic managers generally indicated that, at a conceptual level, the traffic managers were comfortable with the use of the filters and the number and general locations of the FCAs presented and the use of a directional filter. Their feedback regarding FCA designs did indicate possible refinements in the locations of the FCAs, a desire to turn the FEA1A into an FCA and a desire to add FEAs at both ends of the CTOP. Important exceptions raised by some of the traffic managers, however, included recommendations to:

- Add required reroutes for specific FCAs.
- Draw FCAs on Center boundaries when possible to enhance coordination and communication within and across Centers.
- Include flights traversing the FCAs from north to south as well as from south to north to address southbound traffic.
- Use polygons or boxes instead of line FCAs to capture traffic in any direction.
- Use moving FCAs to deal with weather movement over time.
- Move the FCAs after 3-4 hours to deal with weather movement over time.

The individual differences in rate estimations of up to 50%, however, are a significant concern regarding the use of dynamic FCAs in a CTOP. Further research is needed to understand how to best determine rate reductions due to convective weather.

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References

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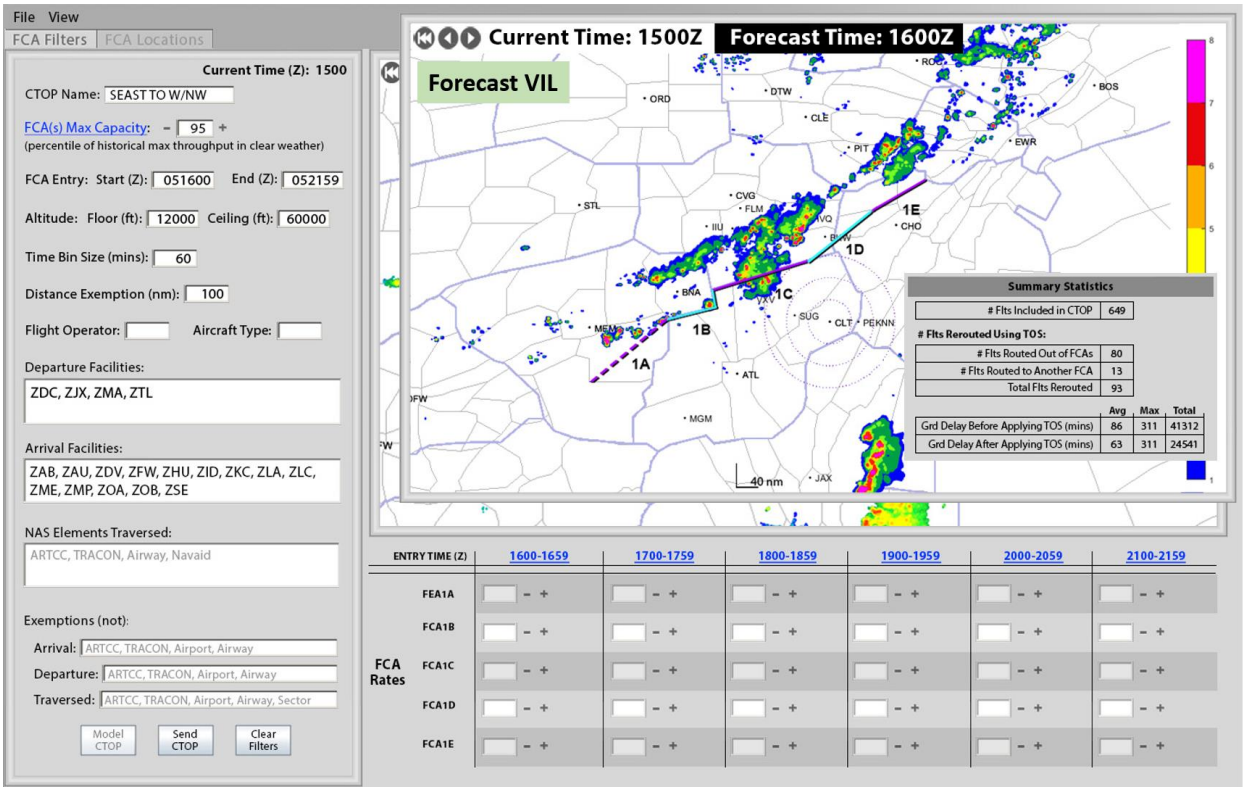

Figure 1. Prototype CTOP interface showing forecast VIL at 1600Z.

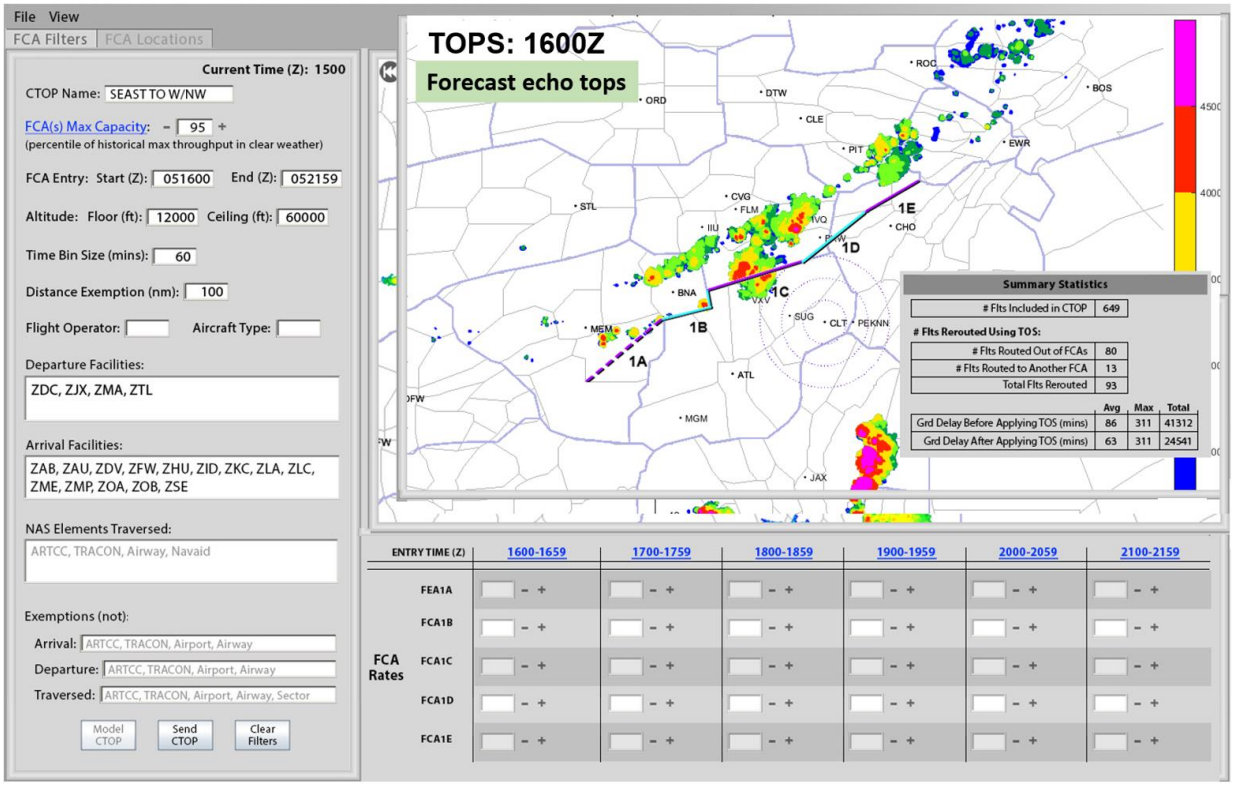

Figure 2. CTOP filters and associated FCAs: 1 hour forecast of echo tops at 1600Z.

Results

Set rates for FCAs for 1600Z hour (view 1 hour forecast and then write down individually on form). Then discuss.

Primary Group:

- 1600-1659Z:

	FEA1A	FCA1B	FCA1C	FCA1D	FCA1E
ZDC	60%	70%	50%	**70%**	**40%**
ZID	40%	40%	**35%**	**50%**	60%
ZME	**80%**	**70%**	40%	40%	60%
ZTL	80%	**80%**	**40%**	50%	60%
DCC	80%	80%	50%	50%	80%

- ZTL: "Because of deviations, we don't want to go over 100% for 1A."
- ZDC: "1E is normally a departure corridor. It will be affected more because you've got flights lower in altitude."

Group 2:

- 1600-1659Z:

	FEA1A	FCA1B	FCA1C	FCA1D	FCA1E
ZID	60%	40%	**30%**	**10%**	30%
ZME	**80%**	**50%**	50%	80%	80%
ZTL	80%	**75%**	**60%**	80%	70%

- *ZTL: "For FCA 1C, Atlanta and Indy would work together to find a number that works for both of us."*

Group 3:

- 1600-1659Z:

	FEA1A	FCA1B	FCA1C	FCA1D	FCA1E
ZDC	90%	90%	65%	**65%**	**90%**
DCC	90%	80%	50%	40%	80%

- *And for 1A you easily have 30 miles for deviations that won't cause a workload issues, that won't require point outs."*
- *DCC: "I'm looking at those tops. It's not a solid line at 40,000. I'm allowing more room to pick through. There's so much room to handle some minor deviations."*

Figure 3. Rates generated by individual traffic managers (% reduction in throughput relative to maximum capacity) that they would recommend considering the actual weather at 1500Z, the one hour forecast weather at 1600Z and the two hour forecast (VIL and echo tops) for 1700Z.