Operational Evaluation of the NAS Constraint Evaluation and Notification Tool

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The National Airspace System Constraint Evaluation and Notification Tool (NASCENT) analyzes the routes of airborne aircraft in the contiguous United States to find wind-corrected, time-saving reroutes around air traffic constraints and weather. This paper presents the results of a nine-month operational evaluation of NASCENT at the American Airlines (AAL) Integrated Operations Center in Fort Worth, Texas. During this evaluation, if all the advisories had been implemented, AAL would have potentially saved 14,225 minutes of flying time for 1,951 proposed amendments. A summary of the numbers of amendments accepted and rejected are presented, along with a discussion of the comments from users of the system. While the reasons cited for rejecting proposed reroutes were weather proximity and mandated air traffic reroutes, these reasons were also concerns for acceptable reroutes in some cases. A method to identify potential inefficiencies in commonly used airline routes is also presented.

Nomenclature

ACARS	=	Aircraft Communication Addressing and Reporting System
AR	=	Atlantic Route
ARTCC	=	Air Route Traffic Control Center
ATC	=	Air Traffic Control
ATM	=	Air Traffic Management
CIWS	=	Corridor Integrated Weather System
CWAM	=	Convective Weather Avoidance Model
DFW	=	Dallas/Fort Worth International Airport
FAA	=	Federal Aviation Administration
FACET	=	Future ATM Concepts Evaluation Tool
IOC	=	Integrated Operations Center
MEL	=	Minimum Equipment List
NAS	=	National Airspace System
NASCENT	=	NAS Constraint Evaluation and Notification Tool
SUA	=	Special Use Airspace

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SWIM	=	System Wide Information Management
TMU	=	Traffic Management Unit
VNC	=	Virtual Network Computing
ZME	=	Memphis Air Route Traffic Control Center

I. Introduction

OVER the course of two decades, researchers at NASA Ames Research Center and the NASA North Texas Research station have partnered with the Federal Aviation Administration (FAA) and local airlines for field demonstrations of concepts and tools that identify time-saving reroutes for enroute aircraft. One concept evaluated was an airline-centric tool that involved American Airlines, called Dynamic Weather Routes (DWR)[1]. DWR combined algorithms developed under the Direct-To[2] decision support tool with the Future ATM Concepts Evaluation Tool (FACET)[3] to display the current and projected congestion of airspace sectors. Additionally, information from the Corridor Integrated Weather System (CIWS)[4] and its derivative, the Convective Weather Avoidance Model (CWAM)[5], was incorporated into the display to help the operator judge the viability of suggested reroutes with respect to the current position and projected movement of convective weather, the cause of most of the delays in the National Airspace System (NAS). The DWR tool was evaluated over the course of two years at the American Airlines Integrated Operations Center (IOC), where DWR reroutes in Fort Worth Air Route Traffic Control Center (ARTCC) and four adjacent ARTCCs were reviewed and executed during the course of routine American Airlines flights. Potential savings for proposed reroutes that were acceptable to American Airlines were 6.25 minutes per advisory (ref. 1), while the potential savings for proposed reroutes that American Airlines attempted to execute were 5.38 minutes per advisory (ref. 6). Over 90% of the time-saving reroutes that DWR recommended were for departures from Dallas/Fort Worth International Airport (DFW) rather than overflights, a consequence of limiting the area of the evaluation to five ARTCCs.

The NAS Constraint Evaluation and Notification Tool (NASCENT) expanded the DWR operational domain to the entire NAS, and implemented it in FACET[7]. NASCENT has undergone an operational evaluation for over a year in the American Airlines IOC. This paper presents a brief overview of the features of NASCENT, describes the scope of the field evaluation, and then examines the results from nine months of use in American Airlines' operations.

II. NASCENT System Description

A. System Description

The National Airspace System Constraint Evaluation and Notification Tool (NASCENT) analyzes the routes of airborne aircraft in the contiguous United States to find wind-corrected, time-saving reroutes around airspace constraints and weather. Detailed descriptions of the inputs to the NASCENT system and its user interface appear in References 7 and 8. To summarize, NASCENT uses System Wide Information Management (SWIM) data for flight plan and aircraft position track data, with a one-minute update rate. FAA website data can be harvested for the status of Special Use Airspace (SUA) and traffic management initiatives that the FAA establishes. CIWS, CWAM, and forecast winds aloft (Rapid Refresh winds from the National Oceanic and Atmospheric Administration) complete the atmospheric conditions for the algorithm and display. The system uses these data to generate time-saving, wind-corrected reroutes of aircraft that avoid forecast constraints. An Alert Threshold, typically set for five minutes, determines which flights generate adequate savings for a reroute, and the NASCENT operator is informed with an audible alert. Candidate aircraft appear in a list on the display; when selected, the current route of the aircraft, the time-saving reroute, and the predicted congestion of the sectors through which both these routes pass are displayed. Figure 1 shows an example of the display, with a candidate flight selected. The current flight plan appears graphically in green, and the proposed reroute (or weather "Avoidance" routes) shows as a yellow line. The limit polygon, in this case as applied to Memphis ARTCC (shown as ZME in the figure), which appears in blue, represents the extent to which air traffic controllers in that airspace have historically rerouted aircraft[8]. While the aircraft is in Memphis ARTCC, NASCENT will suggest reroutes to fixes on the current flight plan within this polygon and not beyond it. In this way, the tool will not suggest an amended route that a controller could not grant without coordination much farther beyond that controller's Center. Additional information on the display includes active SUAs, current convective weather cell and echo tops, as well as the CWAM Weather Avoidance Fields. The NASCENT operator can manually modify this route by dragging it on the display. The next section explains in more detail the procedure used at American Airlines to make these recommendations into flight plan amendments.

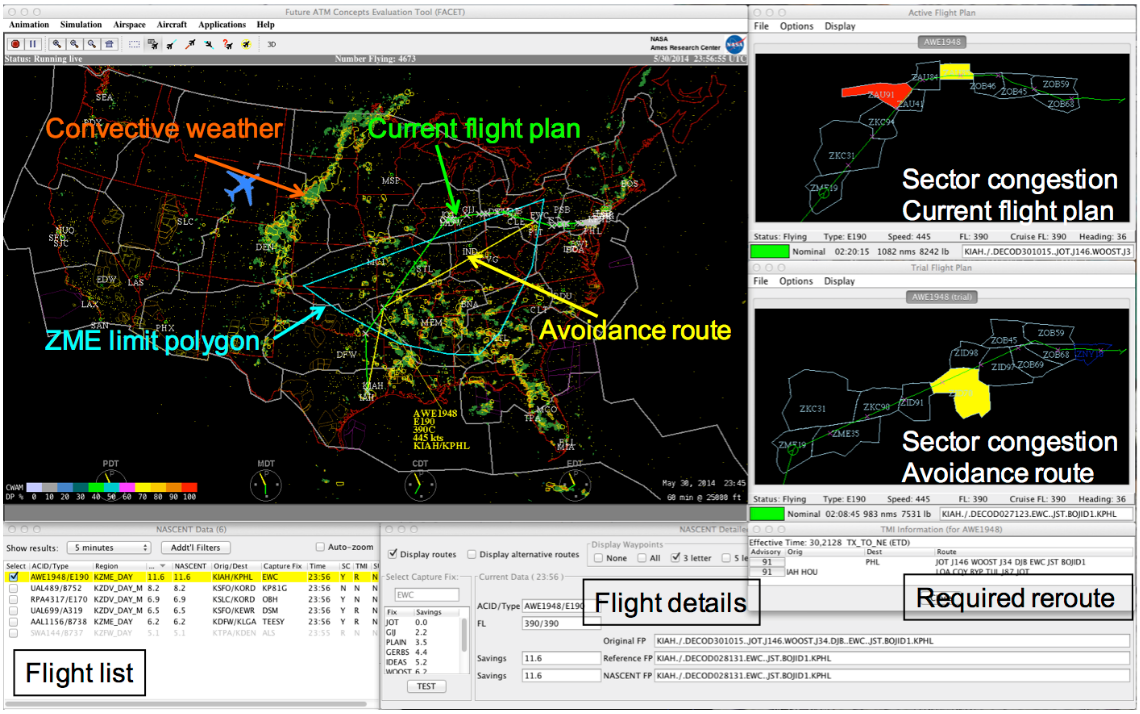

Figure 1. NASCENT Display with Candidate Reroute Selected (as shown in Ref. 7).

Within the IOC, the Air Traffic Control (ATC) coordinator monitors the air traffic situation and communicates with the FAA regarding traffic and weather issues. The ATC coordinator consulted the NASCENT tool, and communicated with the dispatcher of a flight for which NASCENT generated a reroute. A computer connected to an American Airlines monitor used a Virtual Network Computing (VNC) interface to communicate with NASA servers, which in turn provided the computational power for NASCENT and handled the input data. These servers are located at the North Texas Research Station, a few hundred yards from the American IOC, and are connected to the computer via radio link, thereby isolating the system from American Airlines' data infrastructure. Figure 2 shows the NASCENT system in its deployed state at the IOC.

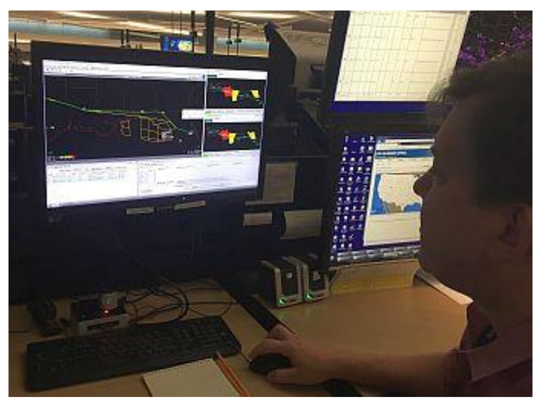

Figure 2. NASCENT Display at the ATC Coordinator Position.

B. Procedure for Using NASCENT

Figure 3 shows the typical sequence of events for a NASCENT advisory to become a flight plan amendment. American Airlines and NASA worked together to develop this sequence during the evaluation of the DWR system[1], in harmony with IOC roles and procedures. Only slight changes were made for the NASCENT evaluation, based on DWR experience.

First, a NASCENT advisory that met the Alert Threshold appeared on the Flight List (see Fig. 1, bottom left). As shown in the right column of Fig. 3, this moment was denoted as the "Advisory" time for this particular proposal. If the ATC coordinator chose to engage with this alert, when ready, the aircraft was selected from the list, initiating a trial plan. The ATC coordinator examined the route, modified it if needed, and could "Accept" or "Reject" the displayed trial plan. These actions concluded the "Advisory to Choice" span of time, shown in yellow in the figure. These choices caused a questionnaire to appear on the screen, and allowed the ATC coordinator to comment on the

NASCENT advisory. A checkbox on the questionnaire allowed the ATC coordinator to indicate if weather was a factor in the decision to reject the candidate reroute. If the ATC coordinator rejected the flight plan, no action other than filling out the questionnaire occurred. Note that the ATC coordinator did not always provide comments.

If the ATC coordinator recommended that the crew should act on the advisory, he/she forwarded the proposed flight plan amendment to the flight's dispatcher by populating and sending an electronic form designed for this purpose, and sometimes followed up that message with a phone call. The dispatcher analyzed the proposed amendment and determined if the crew should ask for clearance from the air traffic controller for the flight plan amendment. If willing to proceed, the dispatcher sent this proposed route modification to the crew via the Aircraft Communication Addressing and Reporting System (ACARS); otherwise, the dispatcher would take no action for an amendment he or she rejected. This action completed the "Choice to ACARS" time segment, shown in orange in Figure 3.

The crew chose whether or not to pursue the flight plan change after receiving the ACARS message, and would verbally request the NASCENT route modification from their current air traffic controller. Using today's normal procedures, the controller assessed the impact of making the flight plan amendment, arranged coordination with other sectors and/or the Traffic Management Unit (TMU) if needed, and amended the flight plan if the new route was cleared by ATC. Note that the crew or the controller had discretion to reject the proposed flight plan amendment. This final time segment, involving just the crew and air traffic controller, is defined as the "ACARS to Amendment" time span, shown in green in Figure 3.

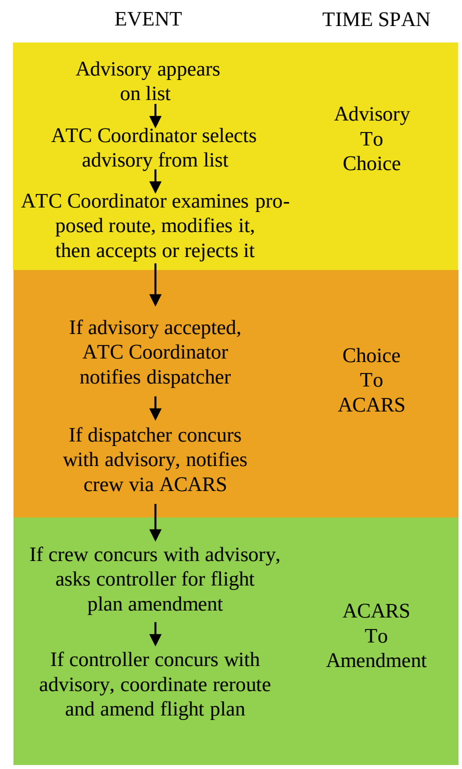

Figure 3. Typical NASCENT Event Timeline

III. Data Collection and Assessment

A. Scope of Evaluation and Data Collection

Following a period of training from September 2016 to February 2017, American Airlines began regular daily use of NASCENT in March 2017. In addition, American Airlines briefed both pilots and dispatchers about the NASCENT advisories, so advisories could be acted upon immediately, without any additional time spent evaluating the procedure of processing or sending the advisories. Approximately eight ATC coordinators regularly use the tool at the American Airlines IOC.

All NASCENT input data were recorded, as were the selections and manually-entered ATC coordinator comments. Additionally, as the NASCENT system uses a VNC-based user interface distribution system, researchers could remotely observe the display as it was operated at American Airlines. This proved useful not only for monitoring the system, but also for assessing problems and discussing functionality with anyone actively using the system at the American Airlines IOC. Lastly, the VNC allows replay of the display itself, which allows for troubleshooting software problems or understanding ATC coordinator observations.

American Airlines provided ACARS messages, which were helpful in determining when pilots received the suggested reroutes from the dispatchers, and in some cases indicated acceptance or rejection of the reroutes by either the pilots or air traffic controllers.

B. Proposed Amendment Suitability and Process Execution

Covering the March-to-December period of the evaluation (298 days), a total of 4,042 NASCENT amendments were proposed and acted upon in some way by the AT coordinators. Of this number, 1,705 of the proposed NASCENT amendments were accepted "as is" and 2,091 were rejected. The ATC coordinators further modified 246 of the amendments to make them acceptable; this resulted in a total of 1,951 accepted amendments, so that the total potential time savings of the accepted proposed amendments was 14,225 minutes. This averages to 7.29 minutes per proposed amendment, a minute higher than the equivalent time savings determined from the DWR operational evaluation[1]. The increase in savings per amendment likely results from NASCENT sampling the 20 ARTCCs, while DWR was constrained to Fort Worth ARTCC and adjacent Centers. Any modified but ultimately rejected amendments were counted as "Rejected" and are included in the total mentioned previously.

Table 1 shows a month-by-month breakdown of the number of NASCENT-proposed reroutes that ATC coordinators accepted, modified, or rejected. As a "modified" NASCENT advisory meant that the ATC coordinator had changed a NASCENT advisory to make it acceptable to him or her, the sum of these modified and acceptable advisories can be divided by the number of advisories that the ATC coordinator reviewed, creating an acceptance rate percentage. These monthly acceptance numbers appear in the last row of Table 1, with the overall acceptance rate for the trial appearing on the right, 48.3%.

Table 1. Distribution of Accepted, Modified and Rejected NASCENT Reroutes by Month

Month	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Number Accepted	73	149	209	207	204	312	171	172	99	109	1705
Number Rejected	57	192	182	220	327	396	219	281	99	118	2091
Number Modified	14	38	31	22	34	40	14	27	14	12	246
Acceptance Rate, percent	60.4	49.3	56.9	51.0	42.1	47.1	45.8	41.5	53.3	50.6	48.3

Comparing these acceptance rates to comments that the ATC coordinators entered, as shown in the next section of this paper, more NASCENT advisories were accepted than rejected when less convective weather appeared in the NAS, and when fewer reroutes issued from ATC were in place. This is reflected in the highlighted rates in Table 1 for March, May, and November. July through October, conversely, when more NASCENT advisories were rejected than accepted, corresponded to months with thunderstorms and hurricanes. Note that this doesn't reflect the total number of advisories that NASCENT generated, and that convective weather events that disrupted the NAS meant that the ATC coordinators had less time to dedicate to checking NASCENT-recommended reroutes. This was similar to what was observed in the evaluation of DWR[6], in that some convective activity meant that the tool would generate feasible reroutes, but large fronts moving across the NAS constrained air traffic routes significantly, making it difficult to find large gaps between storms or for ATC to allow deviations from FAA-implemented, required reroutes, or Playbooks.

A sample of ACARS data provided by American Airlines, covering approximately six months from May 4 to November 3, 2017, was used in combination with NASCENT input data to determine how much time elapsed from the appearance of an advisory to the aircraft receiving an amended flight plan. While days covered in the ACARS sample are fewer than the duration of the NASCENT evaluation, 75% of the accepted NASCENT amendments occurred in this ACARS sample. These data allowed for a calculation of the average "Time Spans" represented in Figure 3, and while this analysis does not include every aircraft that eventually received a reroute based on NASCENT information, it does indicate which processes might be shortened to improve time savings. This is summarized in Table 2.

Table 2. Minutes elapsed from Advisory to Flight Plan Amendment, based on 105 Accepted Advisories

Segment	Advisory to Choice	Choice to ACARS	ACARS to Amendment	Advisory to Amendment	Choice to Amendment
Minimum	0.98	0.45	0.55	7	3.98
Maximum	30.0	30.6	25.1	46	39
Average	7.17	7.63	5.44	20.21	13.04

Each of these segments will be discussed to review how time could be saved. First, the "Advisory to Choice" segment starts with the NASCENT alert and the flight appearing on the list of recommended advisories. Time that passes from that moment until the ATC coordinator selects the flight could be time that the coordinator is spending on a number of other job duties. After selecting the flight, the coordinator has to review the current flight plan and the proposed reroute on the display, assess any convective weather near either route, examine the portions of the display that show projected sector loadings, look for SUAs that might be near the proposed route, and see if any air traffic directives are listed for the relevant route segments or the destination of the aircraft. While all of this information conveniently appears on the screen, observations at the IOC and data recordings show it usually requires a minute or two for a prudent assessment. The ATC coordinator might spend some additional time looking at the situation in the same manner as a dispatcher would, determining if the flight is equipped to execute the reroute (for example, flight over water) or if the flight will be too heavy to land because of the magnitude of fuel savings relative to its originally estimated landing weight. While the "Advisory to Choice" segment was not measured in the same manner in Reference 6, the time from selecting an amendment for examination to the decision to accept or reject it is a similar process. Many of the direct routes generated during the trial documented in Reference 6 were shorter; most of these were accepted or rejected in two minutes or less, and some as few as 15 seconds reflecting decisions made on simple (or completely unreasonable) reroutes. Therefore, the amount of time spent in the Advisory to Choice segment is probably related to the current workload of the ATC coordinators, in that they have duties to perform other than immediately responding to each NASCENT proposal.

The "Choice to ACARS" Time Span is of a similar duration. This Span is comparable to seven examples of American Airlines acting on proposed flight amendments from the DWR evaluation[6], which showed an average time of 7.12 minutes. This Span involves (1) the dispatcher receiving the message from the ATC coordinator, (2) conducting an analysis on the viability of the proposed flight plan, and then (3) sending this proposal to the crew via ACARS. It is reasonable that the duration of this segment is similar to the previous one. In theory, one could eliminate the first part of this span by sending the proposed reroute directly to the dispatcher, but the ATC coordinator, being more often in communication with managers in the ARTCCs and the FAA Command Center, might reject certain reroutes as unmanageable, instead of wasting the dispatcher's time. Therefore, rather than looking at the time spent in this portion of the process in isolation, the overall duties of the ATC coordinator and the dispatcher have to be considered to determine how an airline can most efficiently consult NASCENT and propose flight plan changes.

The "ACARS to Amendment" segment involves the flight crew looking at the amendment, determining if they want to execute the reroute, requesting the route amendment from their current air traffic controller, and actually getting the flight plan changed. This is the shortest segment, averaging 5.44 minutes and close to the 5.22 minute average for the DWR cases[6]. A portion of this segment, the air traffic controller's decision and actions, is outside of the airline's control. Certainly some tools in the cockpit might help shorten this segment, but for the procedure used here with NASCENT, it is likely easier to recover time in the first two Time Spans.

On average, just over 20 minutes passed between the appearance of a NASCENT reroute and the aircraft starting to implement the modified route, as shown in the "Advisory to Amendment" column. More relevant to the actual decay of benefit, however, is the final column, "Choice to Amendment." At the point the ATC coordinator has accepted the proposed reroute (or modified it to make acceptable), the process of getting the modified flight plan to the air traffic controller before a significant loss of savings becomes important. While the table shows a wide variation between the minimum and maximum time expended to complete this part of the process, the average time of 13.04 minutes compares favorably to data collected during the DWR trial[6]. While the decay of NASCENT-predicted benefit over this time interval was not determined for these data, direct routes in the DWR trial typically would have lost one to two minutes of savings with this amount of delay.

One way to reduce the overall delay on the airline side of this process would be to simultaneously present the NASCENT advisory to both the ATC coordinator and the appropriate dispatcher of the flight. With a change of interface and a "voting" mechanism, their direct collaboration via NASCENT might lead to better choices in the proposed amendment. The evaluation of a simultaneous advisory presentation to the coordinator and the dispatcher was beyond the scope of this NASCENT evaluation.

IV. Comments on the Use of NASCENT

The eight ATC coordinators who worked the position with the NASCENT tool were asked to provide comments when viewing and using recommended reroutes. A questionnaire was provided to allow for easy input of remarks during the use of the tool. This section reflects summary data about the comments provided by ATC coordinators when using NASCENT. Due to field trial constraints, comments from dispatchers and pilots were not available. In addition, comments were not provided for each usage, and the data do not reveal who provided the comments for the purposes of anonymity; therefore, these data are anecdotal. However, the feedback from the ATC coordinators may offer insight into how procedures or requirements for NASCENT could be modified to enhance efficiency and safety.

The 246 comments that ATC coordinators entered with "Accepted" NASCENT reroutes are summarized in Table 3. ATC coordinators provided comments for 14% of the accepted reroute total of 1,705 NASCENT reroutes accepted without modification. These comments are not necessarily the exact phraseology that was entered into the system, but rather a consolidation of the meaning of similar comments in most cases. These are presented with a letter ("A" for this table) and case number for easy comparison with other comments, and for cross-referencing with comments in tables that follow. The quantity notes the number of times that similar comments appeared in the data sample, and are presented in order of decreasing frequency. Note that comments A1, A3, and A4 are comments about the status of the accepted reroute, noting that it is being acted upon in some manner, and constitute about 135 of the comments for the "Accepted" reroutes. The others comments, however, give reasons why the reroute was acceptable, or note that the ATC coordinator expressed doubts about the reroute being executed despite being "Accepted." Case A2 notes that 51 of these NASCENT-generated proposals might not be acceptable to air traffic controllers because of playbooks or other air traffic management initiatives that were in place at the time. Similarly, 11 accepted reroutes (Case A6) crossed Atlantic Routes (AR) and were likely unworkable because of this airspace structure. In contrast, Case A10 notes that 6 accepted NASCENT reroutes were feasible because an air traffic management initiative had expired, while Case A7 indicates that air traffic controllers implemented the NASCENT-proposed route before the dispatcher sent it to the pilot on 11 occasions. Case A9 covers 7 instances where the proposed reroute was acceptable, but still close to weather. Rather than modifying the proposed reroute manually, Case A8 notes 8 times when the ATC coordinator simply waited for the NASCENT tool to re-draw the route as the aircraft proceeded, producing a course which was eventually far enough from convective weather. Lastly, in only one instance (Case A12) did an ATC coordinator express doubt about the crew accepting the NASCENT reroute.

Table 3. Comments Entered with "Accepted" Reroutes

Case	Quantity	Comment
A1	103	Mentioned ACARS message sent or will be sent
A2	51	Accepted, but doubts ATC will allow because of reroutes
A3	18	Message sent to dispatcher
A4	14	Confirmed flight received direct, possible fuel/time savings
A5	14	Accepted, but dispatcher too busy or doubts dispatcher will send
A6	11	Accepted, but crosses AR
A7	11	Controller gave reroute before dispatcher could send proposal
A8	8	Good direct, now past weather
A9	7	Close to weather and/or SUA
A10	6	Was on ATC reroute, but reroute cancelled
A11	1	Moderate confidence
A12	1	Accepted, but crew might not accept reroute
A13	1	Accepted, but may not be executed because of weather change

In the same way as Table 3, Table 4 shows the 60 comments associated with NASCENT reroutes that the ATC coordinator manually modified before deeming them acceptable. ATC coordinators provided comments on 24% of the 246 proposed amendments that were modified. These comments may be of more interest since the modification indicates that the coordinator had a concern about the initial NASCENT route. As was the case with Table 3, many of these comments were about the "status" of the reroute as it made its way through the event timeline (Cases B1, B3, and B4), covering 43 comments. Case B2 basically states that the modification to the proposed reroute was an addition of a way point, which was mentioned 9 times. Case B5 is identical to Case A7 in that the aircraft received a reroute before the dispatcher could ask the crew for the reroute.

Table 4. Comments Entered with "Modified" Reroutes.

Case	Quantity	Comment
B1	35	Mentioned ACARS message sent or will be sent
B2	9	Mentioned adding fix to make reroute more acceptable/practical
B3	5	Message sent to dispatcher
B4	3	Mention of fuel/time savings
B5	2	Received proposed reroute before coordinator/dispatcher acted
B6	2	Moved a point further away from weather
B7	2	Weather change/development
B8	1	Unsuccessful attempt to modify reroute
B9	1	Doubts ATC will allow because of reroutes

Compared to Table 3, doubts about ATC allowing the reroute (Case A2 versus Case B9) are relatively low compared to the other concerns in Table 4. Modification of the reroute no doubt plays into the probability that ATC will allow the reroute, as the ATC coordinator might have tailored the reroute to account for current traffic and weather conditions for which the tool might not have compensated.

Table 5 presents the 405 comments for “Rejected” NASCENT reroutes. Unlike Tables 3 and 4, only one of these comments is about the status of the proposed route within the American system; rather, we see more about the reasons these reroutes will not work. About a third of the data, 135 of the 405 comments, cite current FAA reroutes and playbooks as the reason that the ATC coordinator would not accept the NASCENT reroute (Case C1). These FAA air traffic management initiatives are usually a response to traffic congestion, as well as a means to direct traffic away from convective weather (often pre-departure). The ATC coordinators noted a period of time over the summer when FAA reroutes were used earlier in the day compared to their previous experiences, and speculated that this may have originated from an FAA personnel shortage or an attempt at more conservative traffic management practices in place. The second most frequent reason for a rejection of a proposed reroute (63 counts, or 15% of the Rejected comments) was because of errors in the depiction of the original route or reroute (Case C2). This usually appeared as a portion of the route doubling back on itself, and resulted from an error in the way the route was entered, or possibly a NASCENT adaptation file error. Case C3 relates to reroutes of aircraft on overseas routes, which are not eligible for reroutes because of the way these aircraft are tracked and controlled. These rejections are similar to those of Case C5, but in the latter instance these are aircraft that aren’t equipped for operations over water, which may or may not include oceanic airspace. In both of these cases, these reroutes should be filtered from the candidate list presented to the ATC coordinator. As a consequence of this analysis, flights from the Caribbean airports in Miami ARTCC have been removed from the Flight List display.

Table 5. Comments Entered with “Rejected” Reroutes

Case	Quantity	Comment
C1	135	FAA required route/reroute in place due to traffic/weather
C2	63	Errors in original flight plan or proposed reroute makes no sense
C3	53	Aircraft in non-radar area, uncontrolled airspace, overseas route
C4	40	Received proposed reroute before coordinator/dispatcher acted
C5	30	Minimum Equipment List (MEL) does not permit reroute, not equipped for flight over water
C6	26	Too late to get benefit, or not enough benefit
C7	14	Military operations, SUA prevent re-route, difficult to coordinate
C8	8	Comments indicate already sent/duplicate
C9	8	On current route because of hurricane
C10	7	Reroute would go into turbulence
C11	6	Reroute too close to storms
C12	4	Rejected because dispatcher was unwilling to send
C13	4	Directly asked air traffic controller, who rejected reroute
C14	3	Coordinator expected delays for early arrival, congested airspace
C15	2	Aircraft would be too heavy to land
C16	1	Crew rejected reroute
C17	1	Rejected because dispatcher was too busy to send

The 40 rejections grouped together under Case C4 deserve attention and could possibly be re-classified. These flights basically received the equivalent of the reroute before the coordinator and/or dispatcher acted on the proposal, the same as Cases A7 and B5. The ATC coordinators did not indicate why they selected the “Reject” option. Did the controller/dispatcher disagree with the change that was actually made to the flight plan, or were these “Rejected” as the proposed reroute became the new route of flight, and thereby made the proposal unnecessary? In the previous instance, it’s a rejection of the NASCENT proposal, but in the latter it’s actually an “Accepted” reroute via air traffic controller and pilot interaction alone. It is possible that some of these 40 “Rejections,” therefore, could be considered “Accepted.”

The 26 rejections in Case C6 indicate that the reroute itself was not the cause of rejection, but rather the benefit was not significant for the effort in obtaining it, or the process of reviewing the proposed reroute took too long to garner the proposed benefit. In these instances, a more rapid means of getting the information to the flight crew might have made the reroutes acceptable. The rejection in Case C16 is similar in that dispatcher workload was a factor in not getting the proposal to the aircraft.

Case C7 covers those instances when NASCENT did not have proper information on an SUA, or an evolving law enforcement or military response made a reroute infeasible. Some of these are similar to Case C6 in that the reroute might be good, but the time required to implement the change might eliminate the benefit due to decay as previously described. Case C8 is somewhat different, but reflects that another reroute for a flight was proposed while a previous one was in the process of being reviewed and sent.

Cases C9 through C11 indicate instances where the reroute was too close to weather (and was not worth revising), or the current route was chosen because of hurricane activity and changes to surrounding traffic. Note that these are not the same as the cases where the ATC coordinator specifically checked the “weather” box on the questionnaire; those will be covered in Table 6. Some of these rejections might be misclassified as a result.

Case C12 covers four instances where the flight’s dispatcher rejected the proposed reroute. The dispatcher cited conditions unknown to the ATC coordinator in two instances; one was a proposed reroute into an area of severe turbulence, while the second reroute would have entered an area with military activity. The other two cases cited a dispatcher who chose not to send the proposed reroute without specifying a reason.

Cases C13 and C16 are those explicitly rejected by either air traffic controllers or the flight crew. The relatively small number could indicate that most of the proposed reroutes that the dispatchers forwarded to the aircraft were well-received, and that the ATC coordinators and dispatchers did a good job not acting on those that the crew would deem unacceptable. Not all the NASCENT reroutes received sufficient comments about the choice the ATC coordinator made, so conclusions about this are premature.

Lastly, Cases C14 and C15 reflect the kind of analysis that experienced ATC coordinators and dispatchers bring to reviewing these reroutes. In the first case, the savings would likely not be realized because of holding near the destination airport, or other air traffic management initiatives that controllers might use because of projected airspace congestion. In the latter case, the aircraft has already been fueled in anticipation of flying a longer route. Selecting a shorter route would mean that the saved fuel would make the aircraft too heavy to safely land.

The 132 comments in Table 6 also reflect reasons for rejecting the NASCENT-proposed reroutes, but in these cases the air traffic coordinator also selected the “weather” checkbox on the questionnaire, which was provided for users to indicate when weather was a factor in their decision. Not surprisingly, nearly two-thirds of these comments indicated that the reroute was too close to convective weather (Case D1). Cases D3, D7,

Table 6. Comments Entered with “Rejected” Reroutes, with “Weather” Option Selected

Case	Quantity	Comment
D1	82	Reroute too close to storms
D2	12	FAA required route/reroute in place due to traffic/weather
D3	8	Reroute would go into turbulence
D4	7	Other aircraft deviating north/south of weather
D5	5	On route because of hurricane, tropical storm
D6	5	No flights going through gap, reroute between cells
D7	4	Reroute would have gone over top of tropical system
D8	2	Received proposed reroute before coordinator/dispatcher acted
D9	1	MEL does not permit reroute, not equipped for flight over water
D10	1	Aircraft would be too heavy to land
D11	1	Flight deviated to the west
D12	1	Area covered in lightning
D13	1	Air traffic control metering due to weather
D14	1	Errors in original flight plan or proposed reroute makes no sense
D15	1	Crew rejected reroute

and D12 are related, but offer more detail into the kind of weather that makes the reroute unacceptable. In particular, Case D3 mentions turbulence, which does not appear on the NASCENT display but does appear on other weather displays in use at American Airlines. Case D4, mentioning that other aircraft are deviating north or south of the displayed weather, and Case D6, mentioning the lack of traffic in a weather gap, are somewhat different, but indicate that the ATC coordinator appears to be judging the scenario based on the actions of other aircraft, in effect using a “pathfinder” to determine just how closely most aircraft are approaching areas of convection. Cases D2, D5, and D13 are all rejections related to the way the proposed reroute interferes with the way FAA traffic management coordinators are structuring the traffic to deal with the weather. The remaining cases in this table cover relatively small numbers of rejected reroutes.

As mentioned previously, some accepted and rejected proposed reroutes were enacted before the dispatcher sent the ACARS message to the aircraft. Examining the comments across the tables reveals several groups of comments that are similar, yet are linked to dissimilar ATC coordinator actions (accepted, rejected, rejected+weather, and modified). These cases are shown in Figure 4, with bars to show the number of cases associated with each comment.

The largest group, shown at the bottom of Figure 4, represents either concerns or outright rejections of the NASCENT reroute because of ATC reroutes, usually associated with convective weather and/or traffic volume. This reflects both the way these measures impact the traffic, but also the general concerns of the FAA air traffic manager,

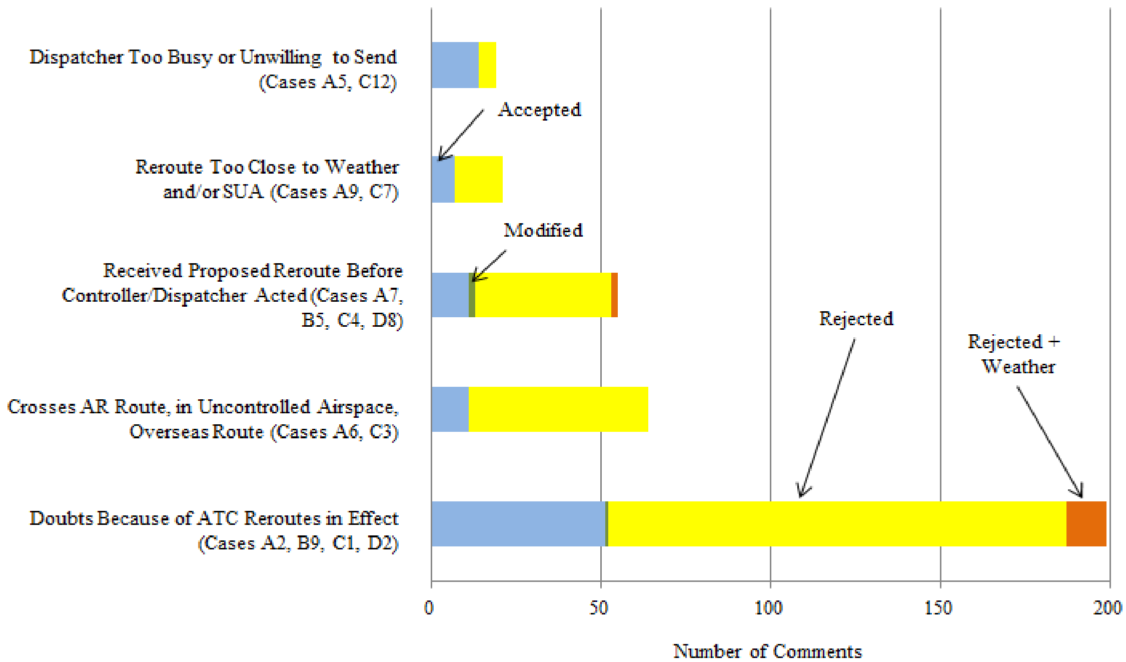

Figure 4. Comments Shared Between Dissimilar Choices

who is actively accounting for the measures that the air traffic controllers must take in handling the traffic. The second-largest group, second from the bottom of the figure, covers the flights that were either in transoceanic airspace, or had reroutes which crossed into the traffic structure used for those routes. For these cases, the "accepted" ones were probably judged as generating time savings even if they were not feasible, while the ATC coordinator "rejected" others to confirm that the reroute was not workable regardless of the time savings. These cases could likely be filtered from the proposal list for algorithms developed from NASCENT, and the meaning of "accept" and "reject" might have to be clarified in training. As mentioned previously, this clarification of "accepted" or "rejected" applies to the third group, third from the bottom, where aircraft received the proposed reroute before the mechanism of getting the proposal to the aircraft could act. The meaning of the rejections in these cases are not clear given that the ATC coordinator and dispatcher appear to have been acting on the NASCENT proposal. The fourth group of comments, appearing second from the top in Figure 4, is like the largest group in that it is tied to the proximity of weather and/or SUAs to the reroute. The ATC coordinator's experience in dealing with the current ATC reroutes again impacts which of these reroutes might be considered feasible or not. The final group of comments, shown at the top of the figure, concerns whether or not the dispatcher could act on the proposed reroute. Again, the meaning of "accepted" or "rejected" in this context is not exactly clear, but it might be presumed that the "accepted" reroutes were cases when the dispatcher was too busy to act, while "rejected" means the dispatcher disagreed with the reroute. Both kinds of cases fortunately represent a small number of reroutes.

V. City-Pair Analysis and Strategic Impact

American Airlines flight plans between certain city pairs consistently triggered reroutes from NASCENT. This suggested that portions of these routes were not efficient, especially when NASCENT produced these reroutes on clear-weather days with no air traffic management initiatives. American Airlines analysts noted the number and consistency of these proposed reroutes. These analysts examined the standard routes that the airline filed between these city pairs. Their goal was to determine if these standard routes should be altered, or if the structure of the airspace precluded these changes because of traffic volume or activation of SUAs. The consistency of these reroutes in clear conditions suggested that standard filed route could be made more efficient.

The first step in organizing the data was to determine which routes, based on departure and arrival city pairs, produced frequent and consistent NASCENT time-saving reroutes. Additionally, the frequency of accepted NASCENT reroutes for city pairs was also examined. Table 7 presents a sampling of this data over the course of the nine-month NASCENT evaluation.

Table 7. A Sample of City-Pairs Which Produce Frequent NASCENT Advisories

City Pair	Number of flights with advisories/ total flights in sample	Percentage of flights with advisories	Percentage Accepted
Los Angeles – Eagle County CO	70/104	67.3	4
Dallas/Fort Worth – Gunnison CO	55/130	42.3	2
Chicago O'Hare – Tucson	170/665	25.6	24
Austin – New York JFK	42/360	11.7	10
Fort Lauderdale – Dallas/Fort Worth	167/1919	8.7	7
Minneapolis-St. Paul – Dallas/Fort Worth	30/431	7.0	38
Miami – Seattle	30/431	7.0	30
New Orleans – Chicago O'Hare	42/525	0.8	24
Dallas/Fort Worth – St. Louis	49/2494	0.02	29

One trend appearing in the table is that the first four city pairs with the higher percentage of advisories are generally east-west routes. Small variations in the predominant west-to-east direction of the jet stream over long routes could trigger a higher number of NASCENT advisories. In contrast, both the New Orleans-Chicago O'Hare and Dallas/Fort Worth-St. Louis city pairs have routes that are oriented south to north; NASCENT generated a time savings reroute for a low percentage of these flights.

Figure 5 shows one of these typically filed routes, and the frequently-recurring NASCENT reroute appears in Figure 6. For the cases that have been identified, further investigation will focus on why the standard American

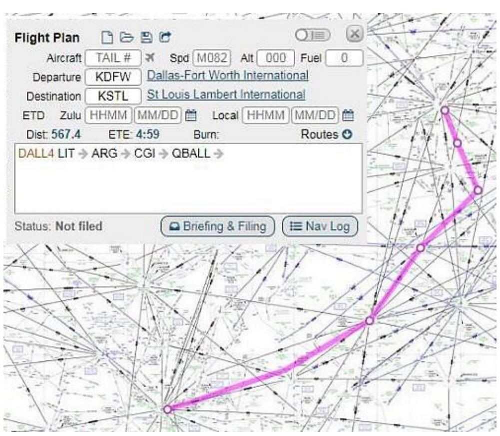

Figure 5. The Dallas/Fort Worth – St. Louis Standard Route

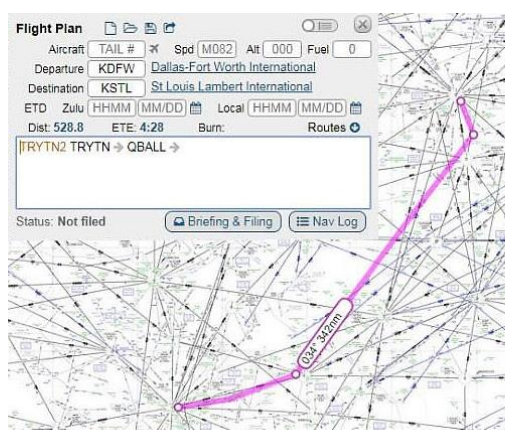

Figure 6. NASCENT-Recommended Reroute for the Dallas/Fort Worth – St. Louis Standard Route

route can or cannot be revised to resemble the reroute. It is also of interest to determine if the NASCENT reroute opportunity can reliably save time, meaning flights can be filed using it regardless of time of day, or if elements of it depend on the status of SUAs, are susceptible to frequent changes because of air traffic management initiatives, or otherwise restricted by air traffic rules. This finding through NASCENT reroute proposals is prompting American Airlines to re-examine standard routes between these city pairs that otherwise might have been overlooked. In this way, NASCENT can be used to identify potential inefficiencies in an airline's overall route network.

VI. Conclusions

The NAS Constraint Evaluation and Notification Tool (NASCENT) has undergone an operational evaluation in the American Airlines IOC. This paper presents a brief overview of the features of NASCENT, describes the scope of the field evaluation, and examines the results and user feedback from nine months of use in American Airlines' operations. American Airlines potentially saved 14,225 minutes of flying time from 1,951 proposed amendments.

This field demonstration of NASCENT shows that expanding the scope of the test from one ARTCC and its adjacent Centers to the airspace of the contiguous United States can provide cost-saving system benefits. Instead of using direct data feeds from an ARTCC as DWR did, NASCENT delivered time savings through the use of SWIM feeds, a widely available data source that will make implementation of the tool possible for a variety of airline users. Nearly equal numbers of proposed reroutes were accepted and rejected throughout the nine-month trial. Comments from the ATC coordinators using NASCENT illustrate the importance of both ATC coordinators and dispatchers reviewing the proposed reroutes. Both specialties contribute a point-of-view that ensures the feasible reroutes reach the crews, so that they and air traffic controllers are not distracted with questionable changes. Lastly, a new use of the tool has emerged from investigating standard airline routes that frequently trigger time-saving recommendations, in that the initially filed routes might warrant revisions to fly more efficient routes, even in the absence of convective weather.

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