

Initial Impacts of Reducing the Number of ATC-Preferred Routes

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Abstract

On 13 May 1998, the Federal Aviation Administration (FAA) placed on 6-month test elimination 73 Air Traffic Control (ATC) preferred (pref) routes. This is part of a larger initiative on the part of the FAA to accommodate airspace user preferences and eliminate as many restrictions as possible. Metrics were developed to assess the impacts of eliminating pref routes. No adverse impact on ATC sector workloads was found from suppressing the 73 routes. The study also found no conclusive evidence so far that users are realizing any significant benefits from suppressing the initial 73 pref routes. This is because most suppressed routes had little or no traffic or users were already short-cutting and deviating from the routes before they were suppressed.

Keywords : ATC Preferred Route, Direct Route, Efficiency, Flexibility, Performance Metrics

Background

Currently there are over 2,000 published ATC-preferred (pref) routes listed in the *Airport/Facility Directory* (AFD) (DOC, 1998). Many of these routes were instituted after the 1981 controllers' strike and were intended to help maintain safety and minimize congested airspace. However, these routes often diminish the capacity of today's airspace and require flights to burn more fuel than necessary. Furthermore, many of the routes result in extra controller workload as controllers find themselves responding to pilots' requests to amend their flight plans once airborne in attempts to shortcut or avoid the pref routes.

Two ways of increasing the flexibility of route selection in today's airspace are to make it easier for

flights to fly off pref routes (The National Route Program (NRP) is an example) and to reduce the number of pref routes directly. The FAA has begun the process of reducing the number of pref routes. This process is part of an overall FAA initiative to minimize restrictions throughout the National Airspace System (NAS) and accommodate airspace user preferences.

In late 1997 and early 1998 the FAA proposed 144 published routes for deletion: 112 high-altitude airport-to-airport routes serving 389 departure-destination airport pairs; and 32 single-direction route segments called Special High Altitude (SPEC HI ALT) routes. The initial list was subsequently reduced to 73: 53 high-altitude airport-pair routes and 20 SPEC HI ALT routes. Users were notified by the FAA and the Air Transport Association that these routes were being placed on test elimination. FAA Flight Data and Host computer processing of the routes was also suppressed.

Methodology

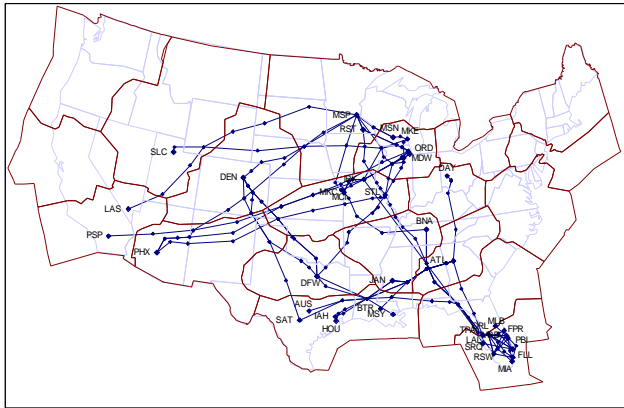
Seventy-three pref routes were suppressed on 13 May 1998. A set of descriptive metrics was developed for comparing controller workload and user flight patterns before and after the routes were suppressed. These metrics include counts of aircraft flying between airports, counts of aircraft following a route, graphical plots of traffic patterns, ATC sector workload, and en route flying times. Metrics were compared and analyzed for potential impacts.

In an effort to develop a model that will help predict the effects of eliminating particular pref routes prior to their elimination, the utility of several possible predictors of future flight patterns was assessed. Such a model should be useful in suggesting further pref routes for elimination.

Location of Routes Deleted

Most of the airport-to-airport pref routes suppressed so far are located in the mid-west United States and Florida (Figure 1). SPEC HI ALT routes suppressed to date are mostly into the Denver terminal airspace. Denver has restructured its Standard Terminal Arrival Routes (STARs), and some of the SPEC HI ALT routes into Denver are no longer necessary. Minneapolis and Tampa are other terminal areas where SPEC HI ALT routes have been suppressed. Minneapolis and Tampa are other terminal areas where SPEC HI ALT routes have been suppressed. The FAA is also examining several hundred additional pref routes for possible elimination.

Figure 1. Airport-to-Airport Routes Suppressed

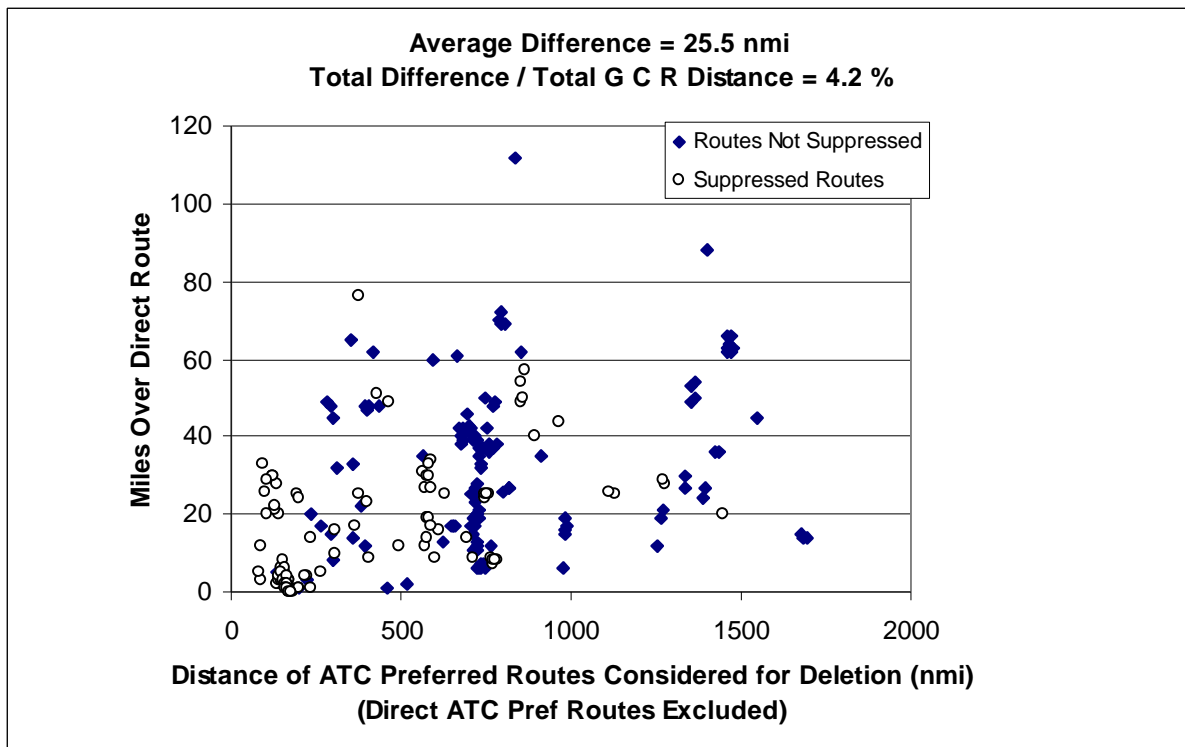


Potential Distance Saving

The mileage difference between a pref route and a Great Circle Route (GCR) connecting two locations is merely the pref route distance minus the GCR distance. For each airport-pair pref route suppressed, Figure 2 plots the mileage difference against the length of the pref route. The total mileage difference for all airport pairs served by the deleted routes is 1,667 nautical miles (nmi). The average difference is 6.3 nmi with a ratio of total difference to total GCR distance of 2.9%. However, if all direct pref routes suppressed are excluded, the average difference is 15.9 nmi with a ratio of 4.2%. Direct pref routes follow a GCR, and several fairly short direct pref routes (under 200 nmi) were deleted on May 13.

There is significant potential distance saving from suppressing and eliminating the remaining airport-pair routes initially considered for deletion. The total mileage difference for all airport pairs served by the routes is 5,887 nmi. The average difference is 15.1 nmi with a ratio of 3.8%. If direct pref routes are excluded, the average difference is 25.5 nmi with a ratio of 4.2% (see Figure 2).

Figure 2. Potential Distance Saving



If all high-altitude ATC-pref routes in the NAS were deleted, the total potential distance saving would be approximately 4% of the total GCR distance (Bolczak, 1997). These distance savings are potential, not actual. These savings would occur if a flight flew every GCR rather than the pref route. The actual usage of these pref routes is described below.

Metrics Analysis

Flights between all airport pairs served by a pref route on the original pref route delete list were determined for both a “before” day as well as an “after” day. Thursday, 4 December 1997, was selected as the “before” day. Dec 4 was a busy flight day (as most Thursdays are), and weather across the U.S. was relatively benign. Tuesday, 26 May 1998, was selected as the “after” day. Weather that day was also reasonably benign, and traffic usage closely approximated that of Dec 4. Flight data was obtained from the Enhanced Traffic Management System (ETMS), and software was developed to calculate metrics using this data. Select traffic patterns were also plotted for particular routes to obtain a qualitative perspective on the route usage metrics.

Route Usage

389 airport pairs served by a pref route considered for deletion were identified. The ETMS data was then scanned for those airport pairs having any traffic during December 1997. The total number of flights on Dec 4 was compared against the average number of daily flights recorded during the month of December. The correlation was 0.98, and inspection of the two sets of numbers showed they matched very well in terms of magnitude.

Software was developed to calculate the number of flights on Dec 4 that tracked within an average of 6 nmi of the pref route. This provided an initial indication of how many flights were approximating or ‘flying’ the pref route. Reasons for selecting 6 nmi lateral distance include the width of airways.

Only eight airport pairs had 5 or more flights averaging within 6 nmi of a pref route initially considered for elimination. The reason for this is that many airport pairs had little or no traffic, or users were already short-cutting or deviating from the pref routes in order to save time and fuel. Of the eight airport pairs, only four were served by a pref route that was suppressed on May 13. Only three airport

pairs had more than three flights actually flying pref routes during effective route times on Dec 4 prior to the routes being suppressed. These were DFW-DEN, MSP-MDW and STL-MDW.

Only the traffic from DFW to DEN exhibited any real change on May 26 : four flights took a different path than the suppressed pref route, presumably in an attempt to fly a more wind-optimal route. (See Figure 3.) On Dec 4, all but one DFW departure to DEN filed the pref route highlighted, and the bulk of the May 26 traffic continued to file and fly the route. The MSP-MDW and STL-MDW flight tracks showed no significant change after the route was suppressed.

Figure 3. DFW-DEN Before

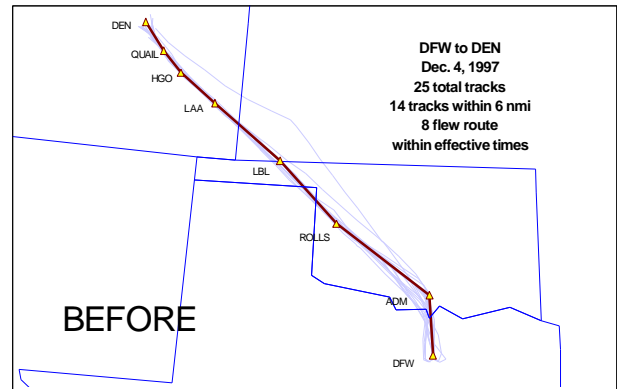


Figure 3. DFW-DEN After

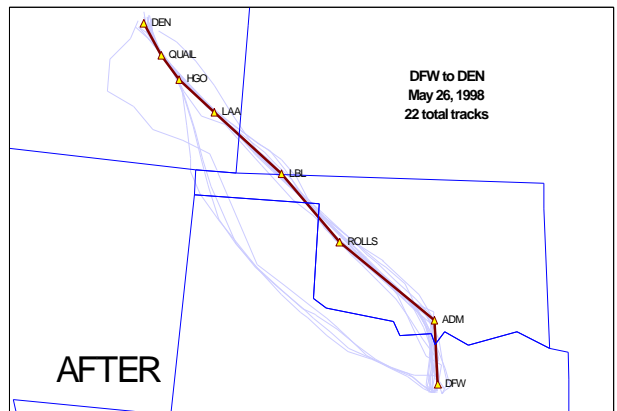
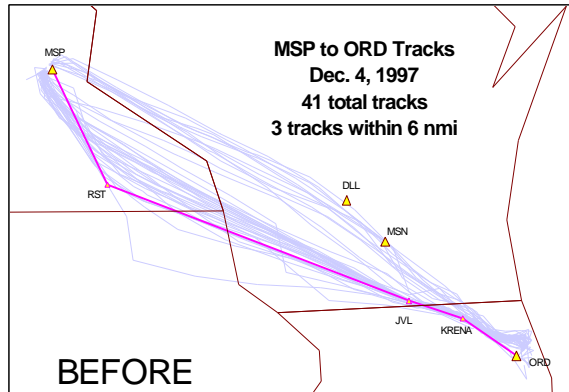


Figure 4 gives a good indication of why so many flights do not track within 6 nmi of their filed pref route. On Dec 4, there were 41 flights from MSP to ORD. 29 flights filed the pref route highlighted. The other 12 flights filed a more northern route. Only three flights flew within an average of 6 nmi of the

pref route. The reason is apparent from the graphic. Very soon after departure, pilots are requesting, and being cleared by ATC, to fly direct to JVL and the JVL-STAR, thus short-cutting the pref route and bypassing RST. On May 26, 24 flights again filed the route, even though the route was no longer a pref route. Only one flight filed a different, more direct, path to JVL than through either RST or DLL.

Figure 4. MSP-ORD Before



This is an example of flights short-cutting the route trunk connecting the SID/STAR transition points when flying the trunk would be inefficient. There are numerous examples where flights also shortcut the STAR if the STAR itself has an adverse impact on the efficiency of the flight path (Gordon & Tornese, 1998). [Note : SIDs are now referred to as Departure Procedures (DP).]

ATC Sector Workload

Only four ATC sectors across the U. S. experienced workload levels on May 26 that exceeded their Monitor Alert Parameter (MAP) for more than 30 consecutive minutes (Gordon, 1998). These sectors did not exceed their MAPs during these times on Dec 4. In trying to associate these increases with the pref routes suppressed, it is noteworthy that only three airport pairs had any significant traffic along active pref routes on Dec 4 before the routes were eliminated. Traffic between two of these airport pairs (MSP-MDW, STL-MDW) continued to fly the same patterns on May 26 as on Dec 4. Only DFW-DEN had 4 flights diverge from the pref route on May 26, but no DFW-DEN flights penetrated airspace where sector workload increased.

20 SPEC HI ALT routes were also suppressed, but none of these routes were situated in a location that might explain any of the sector workload increases. As a result of this analysis, it was concluded that there was no increase in sector workload that could be attributed to the suppression of the 73 pref routes.

Flown Distances

After the routes were suppressed, all traffic between MSP-MDW and STL-MDW continued to file and follow the same routes as before. Flights between DFW-DEN and STL-MDW had a slight average distance increase on May 26 when compared to Dec 4. Four DFW-DEN flights diverged from the deleted pref route on May 26. The four flights filed a route that was 15 miles longer than the deleted route. They may have been attempting to fly a more wind-optimal pattern, or this may have occurred for scheduling reasons. The exact reason is not known. The result was an average distance increase for the four flights when compared to the remaining 15 flights that adhered to the suppressed route.

MSP-MDW and STL-MDW flights followed basically the same pattern on May 26 as on Dec 4. This could be because too little time elapsed between May 13 (when the routes were suppressed) and May 26. Reasons could also include local ATC constraints and the small amount of user benefit that might result from flying more direct over short distances.

Table 1 compares flown distances between these three airport pairs. The only decrease in average flown distance on May 26 was from MSP to MDW. The reason for the decrease in average flown distance between MSP and MDW on May 26 is not clear. The winds may have been a factor. A test for statistical significance of the distance saving was inconclusive. All May 26 MSP-MDW flights filed the same route as before. Furthermore, the May 26 MSP-MDW flights did not save flying time when compared to flights on Dec 4. The pertinent conclusion is that there is no clear statistically significant actual distance saving to users so far from deleting the 53 airport-pair pref routes.

Flight track distances were not calculated for traffic along the deleted SPEC HI ALT routes, but users were already short-cutting these routes before they were deleted (Gordon & Tornese, 1998, Appendix A). Hence any actual distance saving from deleting the SPEC HI ALT routes is marginal at best.

Table 1. Flown Distances

		4 Dec '97					26 May '98				
Dep-Dest	Pref Route ID #	# of Dep-Dest Flights	# filing Pref Route	# not filing Pref Route	Avg filed dist. (nmi)	Avg flown dist. (nmi)	# of Dep-Dest Flights	# filing Route	# not filing Route	Avg filed dist. (nmi)	Avg flown dist. (nmi)
DFW-DEN	296	25	24		575	583	19	15		575	596
				1	579	578		4	590	619	
MSP-MDW	728	17	17	0	379	390	14	14	0	379	380
STL-MDW	1625	16	16	0	219	236	15	15	0	219	241

Flying Times

Of the 3 airport pairs having significant traffic along an active pref route before the route was suppressed, MSP-MDW and STL-MDW had no significant difference in average en route flying times after the route was deleted. (See Table 2.) Traffic between DFW-DEN did have a significant reduction in flying times after the route was suppressed, but the time saving was due to a change in the winds, not elimination of the route. The four May 26 DFW-DEN flights that diverged from the suppressed pref route did not have a reduced flying time when compared with the 15 flights that continued to file and follow the route. Hence, there is no flying time saving to users so far from deleting the 53 airport-pair pref routes. Flying times were not calculated for traffic along SPEC HI ALT routes, but any actual flying time saving is marginal since users were already short-cutting these routes before they were deleted.

Table 2. Flying Times

		4 Dec '97				26 May '98			
Dep-Dest	Pref Route ID #	# of Dep-Dest Flights	# filing Pref Route	# not filing Pref Route	Avg En Route Flying Time (mins.)	# of Dep-Dest Flights	# filing Route	# not filing Route	Avg En Route Flying Time (mins.)
DFW-DEN	296	25	24		83.2	19	15		72.7
				1	84.2		4	75.9	
MSP-MDW	728	17	17	0	49.4	14	14	0	50.6
STL-MDW	1625	16	16	0	28.0	15	15	0	29.6

Initial Benefit to Users

As shown above in Figure 2, there is a considerable potential distance saving benefit to users from deleting all pref routes initially considered for elimination. However, potential distance saving is not the key metric when it comes to anticipating user benefits. In many cases, actual distance saving will be much less than the potential saving. Furthermore, many flights do not fly direct; they fly wind-optimal. Also, user costs are dependent on fuel burn, which is more a function of flying time than distance flown. Since there is no flying time saving so far from eliminating pref routes, there is no actual user operating cost saving benefit thus far from deleting the 73 pref routes.

There are some potential benefits from eliminating pref routes that have not yet been realized. First of all, there is no evidence yet that users are filing or flying more efficient routes in significant numbers since the initial pref routes were deleted. Once they begin doing this, their flight patterns may become

more efficient, resulting in reduced flying times and cost savings. In addition, a reduced pilot-controller workload may result from this as pilots file fewer en route flight plan amendment requests with controllers and controllers initiate fewer reroutes.

Predictors of Future Flight Patterns : Some Preliminary Observations

Some preliminary observations on the utility of several possible predictors of future flight patterns are the following. The route distance is important, since longer routes over 500 miles tend to see flights deviate from the pref route to a greater extent than shorter routes. This is due to their flying more wind-optimal patterns and NRP. The route's efficiency is important since routes with a relative inefficiency of 0.05 or higher are prime candidates for short-cutting by flights. The relative inefficiency of a route is defined as the distance saving (miles over direct route) divided by the GCR distance.

Routes adding 10 miles or more to a direct path tend to see many flights short-cutting or deviating from the route, regardless of the route's inefficiency. Aircraft that fly a pref route prior to its being deleted so far generally do the same afterwards, and aircraft that do not fly a pref route but could continue to do the same afterwards. En route and terminal winds are especially important in predicting flight patterns for longer routes (over 500 miles). They have less of an impact on shorter routes. Locations of hazardous weather are clearly important in predicting future flight patterns, but this study did not encounter any pref routes impacted by hazardous weather. Nor did this study examine any pref routes that are known to have been deleted due to cancellation or relocation of restricted airspace. These preliminary observations are summarized in Table 3 below. They are subject to change as more routes are eliminated and the impacts are analyzed.

Conclusions and Summary

This study found very little impact on aircraft flight patterns as a result of suppressing the initial 73 pref routes. There is little or no traffic at all between many of the airports served by a suppressed pref route. Of the pref routes that do serve airports having significant traffic, users more often than not have already found ways to shortcut or deviate from the route in order to save time and fuel. A useful rule of

thumb is that if a pref route or STAR associated with the route adds 10 or more miles to a direct path to the destination airport, then the likelihood is that users will deviate from the pref route for some significant portion of the route. Longer flights over 500 miles tend to deviate greatly from pref routes regardless of how direct the pref routes are. This is due to these flights flying wind-optimal paths that rarely approximate the pref route.

The study found no conclusive evidence so far that users are realizing any significant benefits from suppressing the initial 73 pref routes. There are two as yet unrealized benefits from suppressing the routes. These relate to users filing and flying more efficient routes than they are now and a consequent reduction in pilot-controller communication workload dealing with en route flight plan amendments and reroutes. Neither of these is yet occurring in significant numbers. There is so far no adverse impact on ATC sector workloads. No sectors show a workload over their Monitor Alert Parameters due to suppression of any pref routes.

The FAA is attempting to minimize restrictions throughout the NAS in an effort to better accommodate airspace user preferences. As part of this effort, the FAA is examining several hundred additional pref routes for elimination. Attention is focusing on factors such as maintaining aircraft separation, impact on controller workload, the efficiency of the route, potential mileage saving, and likely changes to flight patterns should the route be eliminated. The FAA has also instituted changes to Host computer software processing in the En Route ATC Centers that will permit more efficient and economical pref routes to be designed and instituted.

References

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Table 3. Observations on Predictors of Future Flight Patterns

Possible Predictor of Future Flight Patterns	Useful Predictor?	Comments
Route distance	Yes	<ul style="list-style-type: none"> - routes longer than 500 miles tend to see flights not follow the route if it isn't wind-optimal, even if the route is very efficient - shorter routes: depends on the route's efficiency; if either the route trunk or route STAR adds more than 10 miles to direct path, then flights tend to shortcut the route
Altitude strata	No	
Route direction and location	No	
Route efficiency	Yes	<ul style="list-style-type: none"> - routes with inefficiency above 0.05 are prime candidates for route short-cutting - if either the route trunk or route STAR adds 10 or more miles to direct path, then flights tend to deviate from the route, regardless of route's efficiency
Number of aircraft that fly the route	Yes	Aircraft flying the pref route prior to its elimination tend to do so afterwards
Number of aircraft that do not fly the pref route but could	Yes	If few or no aircraft are flying a pref route, then few or no aircraft will continue to fly the route after it is deleted
Alternate pref routes available	No	
Time of day of flight	No	
En route and terminal winds	Yes	Especially important to influencing flight patterns on longer pref routes (over 500 miles)
Locations of hazardous weather	Yes	Cannot predict future flight patterns without knowing locations of hazardous weather
Locations of restricted airspace	Yes	Unknown if any pref routes were deleted due to cancellation or relocation of restricted airspace

Laurence M. Gordon is a Senior Systems Engineer in the Center for Advanced Aviation System Development, The MITRE Corporation. He is currently involved with assisting the FAA implement near-term procedures related to improving traffic flow management. He has nine years experience directly related to aviation systems engineering. Prior to that, he was a senior engineer with TRW, Titan Corp., and was a systems engineer with MITRE's Washington C3 Center for nine years. He has a B.A. in mathematics from the Univ. of North Carolina, Chapel Hill, an M.A. in philosophy from the Univ. of Chicago, and an M.S. in operations research from American University. He is a member of IEEE and the Society for Computer Simulation.