DYNAMIC AIRBORNE REROUTE PROGRAM (DARP) APPLICATION IN BUSINESS AVIATION

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Summary: With relatively significant growth of business aviation oceanic operations the need to optimize them raises. With the free flight concept introduction new opportunities are now available for the operators. Dynamic Airborne Reroute Program (DARP) may be one of them. The pros and cons are analysed in this article.

Key words: Air Transportation, Business Aviation, Free Flight, DARP

INTRODUCTION

With the aim of constant need for price optimization free flight concept has found its application in many world´s areas, especially over the oceans. This, hand in hand with the improvement of aircraft, navigation aids and flight planning software, has brought the operators to a new method of long-haul flight planning in free flight areas called Dynamic Airborne Reroute Program (DARP). The DARP allows the operators to save small percentage of fuel which in high volumes of flights mean a significant amount of money. Profitability of such solution for business aviation operators in the low frequency-high-number-of-airports model is to be analysed by this article with a simulation of DARP on the real case.

1. ROUTE SYSTEMS

Several route systems have been created since the beginning of instrument flying. The preliminary designs used beacons as an essential part of the system with aircraft flying from one beacon to another making the routings between two airports significantly long. With the introduction of area navigation and creation of fixes the route system offered broader options with both, fixes and beacons to be used. The routing became more streamlined and shorter, bringing fuel cost savings. The currently available and used route systems are basically two: fixed airways and free flight concepts.

1.1 Fixed Airways Concept

As already mentioned the current route system makes use of area navigation and is thus allowing more straightforward routings. In areas where high volumes of traffic are expected it may be desirable from the Air Traffic Control point of view to unify the flow of aircraft for which the fixed airways concept is a perfect tool. From the flight planning point of view routings going from standard departures (SIDs) via airways and fixes/beacons onto standard arrivals (STARs) are to be planned. Some airports do not have the SIDs and STARs published. Direct connection to a fix or beacon must be found in such a case. In more

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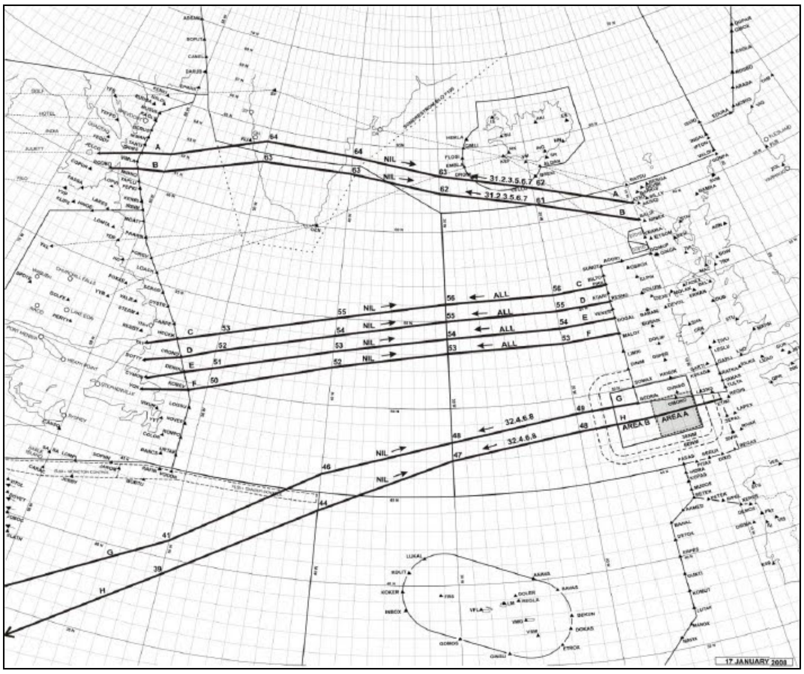
developed systems, such as Integrated Flight Planning Zone (IFPZ) covering most of European airspace a set of specifics rules is created allowing direct routings under certain conditions. In IFPZ this is governed by the so called Route Availability Document (RAD) specifying maximum lengths of directs segment in each of the concerned Flight Information Regions (FIRs). Over oceanic areas this concept is getting increasingly rare as operators seek maximum routing optimisation and the fixed airways is not able to provide any flexibility.

1.2 Free Flight Concept

This concept available in most of the world´s oceanic airspaces allowing the operators to plan with a great deal of flexibility and thus accommodate the aircraft on a path with the best wind conditions, avoiding areas of turbulence of adverse weather conditions etc. The rules governing over a free flight concept are linked to a system of reporting points in predefined intervals. The typical distribution is composed of FIR border fixes and predefined degrees of latitude and longitude. This is area dependent and may also depend of time between two following reporting points. Free flight concept over oceanic airspaces involves procedural control or satellite based navigation with use of Future Air Navigation System (FANS) such as ADS or CPDLC.

1.3 Organised Tracks Concept

A hybrid solution between fixed airways and free flight concept is called Organised Tracks System (OTS). It takes the best of both of the previous concept creating airways of a temporary validity taking into account the weather as well as wind conditions. The OTS duration is generally very short (less than 1 day). In the periods of validity the OTS is to be used even if the area may well be a free-flight concept area.



Source: http://aviationknowledge.wikidot.com

Picture 1 – Example of NAT-OTS in North Atlantic

2. DARP PRINCIPLES

The effective use of DARP allowing money saving will depend on many factors and is not yet fully implemented with business aviation operators. The method is destined on long-haul flights with several recalculations of the wind and temperature conditions during the flight and adjustment of routing and flight level. The grid winds and level temperature update is released 4 times a day (0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC) and is thus only applicable for flights of longer duration. The overall benefit of DARP takes all the advantages of UPR system and in addition offers routing re-planning while the aircraft is airborne with every new forecast received. The DARP is strictly dependent on the accuracy of the forecast though. In some cases the benefit is zero, in others in-flight rerouting may bring interesting savings. When a new forecast is received it is important to know the current aircraft´s position to apply the new recalculation from the nearest practicably used reporting point. The DARP´s use us very limited in systems where UPR are not available. The finality of using DARP in flight optimisation may be fuel burn decrease (the most common case), flight time decrease or both. According to the actual need the corresponding action is to be applied. In airlines´ air traffic where time is less important than fuel volumes DARP would only be applied in case flight time decrease automatically does not mean fuel burn increase. In business aviation the DARP may be benefiting for optimisation of time without fuel burn increase taken into account. The possible scenarios result after DARP application are described in table 1 for fuel burn optimisation, in table 2 for flight time optimisation and in table 3 for complete optimisation.

Table 1 – Possible DARP outcome with fuel burn preference

	Fuel burn	Flight time	Routing	Action
Results of recalculation	Higher	Higher	Amended	No action
		Lower		
	Lower	Higher	Amended	DARP application
		Lower		
	Higher	Higher	Unchanged	No action
		Lower		
	Lower	Higher	Unchanged	No action
		Lower		

Source: Author

Table 2 – Possible DARP outcome with flight time preference

	Flight time	Fuel burn	Routing	Action
Results of recalculation	Higher	Higher	Amended	No action
		Lower		
	Lower	Higher	Amended	DARP application
		Lower		
	Higher	Higher	Unchanged	No action
		Lower		
	Lower	Higher	Unchanged	No action
		Lower		

Source: Author

Table 3 – Possible DARP outcome with complete optimisation

	Flight time	Fuel burn	Routing	Action
Results of recalculation	Higher	Higher	Amended	No action
		Lower		
	Lower	Higher	Amended	DARP application
		Lower		
	Higher	Higher	Unchanged	No action
		Lower		
	Lower	Higher	Unchanged	No action
		Lower		

Source: Author

It may happen that even if both flight time and fuel burn are higher after recalculation and a new routing is proposed, it is still beneficial to apply the DARP because flying the original route with the updated weather / wind forecast would mean an even higher increase. In such a case the old routing has to be calculated with the new weather information to compare it with the new routing and to define the difference in fuel burn and flight time.

2.1 DARP prerequisites

The DARP is not to be used in all flights and it expects certain level of aircraft equipment, ATC flexibility and OCC support. It is dependant of the availability of accurate weather reports. The application also requires active participation of all three components of the system:

1. Operations Control Centre (OCC)
2. Air Traffic Control Centre (ATC)
3. Operating crew

The OCC must be aware of the position of the aircraft at the time of recalculation to be able to suggest a rerouting beginning at one of the upcoming points (avoiding rerouting from an already passed point). A reliable communication link must be available between the OCC ad the operating crew, for example satellite datalink, to receive the reroute proposal and consequently apply with the ATC to accommodate the request. The final decision to reroute or not to reroute may be with the OCC in case of shared-responsibility system or with the operating crew in case of non-shared responsibility system. The ATC unable to accommodate the request may deny the crew request resulting in no optimisation.

3. DARP SIMULATION

A simulation of the DARP has been performed to verify the assumed facts and confirm possible benefits for business aviation operators. In the model situation a flight from Kiev (UKBB) to Caracas (SVMI) operated by a long-haul Bombardier Global Express twin-jet (GLEX) was selected for its length and the fact that more than a half of the flight is operated in the free-flight area of the Atlantic Ocean. The estimated time of departure (ETD) was set to 1000 UTC allowing to perform the first recalculation with the next available weather update, in this case at 1200Z. Recalculations were made in 3 consequent dates for the same airports pairs. The following assumptions were applied on the flights:

1. The same flight planning software was used for the calculation.
2. The same payload and no extra fuel were applied in all cases
3. European fixed-airways system was respected
4. Rules applied in NAT-MNPS oceanic areas were respected
5. Flight level optimisation was not taken into account and only horizontal optimisation was sought (FL430 was used in all cases)
6. Optimisation was applied in free-flight concept area only (approximately after 5h of flight from Kiev)
7. European prescribed fuel reserves (according to EU-OPS) were respected

4. SIMULATION RESULT

The simulation has shown several results. On the first occasion the same routing was suggested after recalculation with 1 minute shorter flight time and 979Lbs expected fuel burn increase. The difference is due to the updated weather conditions, for example differences in headwind/tailwind, and in this case DARP would not be applied since the same route is to be considered and the flight planning software was unable to find any shorter. More precise information about fuel burn would be obtained but no significant optimisation performed. The details of the first case are illustrated in the table 5 (free flight portion of the flight is marked with the green colour).

Table 5 – Recalculation results: case 1

Time of calculation	ETD UKBB	Valid weather	Original route	Flight time (min)	Expected fuel burn (Lbs)		
0835Z	1000Z	0600 UTC	KR P27 VI M141 LADOB UM141 OKR UL856 TRA Z69 OLBEN UN869 TBO UN995 PPN UN976 ZMR UL155 ADORO DCT LUTAK DCT MANOX DCT 34N020W DCT 29N030W DCT 25N040W DCT 21N050W DCT 18N060W DCT BEVAD DCT PPR DCT DUNTA UA550 MIQ	705	37305		
Time of recalculation	**Rerouting point**	**Valid weather**	**New route**	**Flight time**	**Expected fuel burn**	**Flight time increase**	**Fuel burn increase**
1220 UTC	LUTAK	1200Z	KR P27 VI M141 LADOB UM141 OKR UL856 TRA Z69 OLBEN UN869 TBO UN995 PPN UN976 ZMR UL155 ADORO DCT LUTAK DCT MANOX DCT 34N020W DCT 29N030W DCT 25N040W DCT 21N050W DCT 18N060W DCT BEVAD DCT PPR DCT DUNTA UA550 MIQ	706	36326	-1	979

Source: Author

The second simulation recalculation did not bring any rerouting proposal either. The same route was suggested by the software again. A difference in fuel burn and flight time was encountered saving 2min of time after recalculation and adding an additional fuel burn of 86Lbs. In this case DARP would again not be applied as the suggested routing is identical with the original one and the fuel burn difference is only 86Lbs which is, compared to the amount of total fuel, negligible. The details of the second case are illustrated in the table 6 (free flight portion of the flight is marked with the green colour).

Table 6 – Recalculation results: case 2

Time of calculation	ETD UKBB	Valid weather	Original route	Flight time (min)	Expected fuel burn (Lbs)		
0900Z	1000Z	0600 UTC	KR P27 VI Q560 LONLA UM986 SVR UY582 DIMLO UM859 DOL UP63 RIFEN UM196 LAGEN UM859 VAMTU UM984 DIVKO UN975 CCS DCT LUTAK DCT 34N020W DCT 30N030W DCT 27N040W DCT 23N050W DCT 18N060W DCT BEVAD DCT PPR UA550 MIQ	718	36413		
Time of recalculation	**Rerouting point**	**Valid weather**	**New route**	**Flight time**	**Expected fuel burn**	**Flight time increase**	**Fuel burn increase**
1206 UTC	LUTAK	1200Z	KR P27 VI Q560 LONLA UM986 SVR UY582 DIMLO UM859 DOL UP63 RIFEN UM196 LAGEN UM859 VAMTU UM984 DIVKO UN975 CCS DCT LUTAK DCT 34N020W DCT 30N030W DCT 27N040W DCT 23N050W DCT 18N060W DCT BEVAD DCT PPR UA550 MIQ	720	36327	-2	86

Source: Author

In the third simulation recalculation, the optimal (in terms of fuel and time) track was calculated with a suggested rerouting starting from the fix LUTAK. Even though the new routing is at the time of calculation the optimal one, it still brings a fuel burn increase of some 197Lbs and 2min of flight time. DARP would be suggested in this case as the original routing with the new weather forecast would mean an even higher increase values (flight time 3 min and fuel burn 200Lbs)

Table 7 – Recalculation results: case 3

Time of calculation	ETD UKBB	Valid weather	Original route	Flight time (min)	Expected fuel burn (Lbs)		
0845Z	1000Z	0600 UTC	KR P27 VI Q560 LONLA UM986 SVR UY582 DIMLO UM859 DOL UP63 RIFEN UM196 LAGEN UM859 VAMTU UM984 DIVKO UN975 CCS DCT LUTAK DCT 34N020W DCT 30N030W DCT 27N040W DCT 23N050W DCT 18N060W DCT BEVAD DCT PPR UA550 MIQ	723	36525		
Time of recalculation	**Rerouting point**	**Valid weather**	**New route**	**Flight time**	**Expected fuel burn**	**Flight time increase**	**Fuel burn increase**
1215 UTC	LUTAK	1200Z	KR P27 VI M141 LADOB UM141 OKR UL856 GUKTU UM138 ABRUK UM984 DIVKO UN975 CCS DCT LUTAK DCT 33N020W DCT 28N030W DCT 23N040W DCT 18N050W DCT BGI DCT TAB UR515 POS UA563 CUP UA552 MIQ	721	36328	2	197

Source: Author

SUMMARY

The basic components and principles of DARP were introduced in the article with a simple simulation based on three recalculations made on three different days. Only one of the cases would actually bring benefit if DARP was applied. The applicability of DARP depends very much on the length of flight and also time of operation. The drawback of the method is the predefined weather update publication time that limits any recalculation of the time of departures shortly after the weather update has been received. Another drawback of the method are fixed-airways and or compulsory routings areas where the flexibility to optimise the routing is very limited. The savings after DARP are very low in both time and fuel burn and only high volumes of operation could justify its use for business aviation operations. Percentage benefit of the only situation where DARP could be justified (the third case) would bring approximately 0,7% in terms of flight time and 0,6 % in terms of fuel burn. This could only be benefiting on a long term basis where high volumes of flights are operated, otherwise the amount of work and money needed to keep the DARP functioning does not bring the expected outcome.

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