AIRCRAFT OPERATING EFFICIENCY ON THE NORTH ATLANTIC

A Challenge for the 1980's

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Introduction

It is anticipated that more United States air carriers than ever will be providing service across the North Atlantic during the 1980's. As additional cities in both the south and the mid-west achieve gateway status, the twice daily setting of the North Atlantic Organized Track System will become more demanding. This will be compounded further by the need to fly minimum fuel tracks in order to maintain a competitive edge in today's deregulated environment.

There are a number of changes which will take place within the next 24 months which could have important consequences for Atlantic flight operations for the next decade. The purpose of this paper is: (1) to identify these changes and discuss their impact on aircraft operating efficiency, (2) to review possible alternatives for North Atlantic air carriers and (3) to suggest strategies and actions which may have a considerable impact on fuel savings for years to come.

Background

The North Atlantic Track System (NATS) consists of an array of movable tracks which are designed to provide safe transit for high volume air traffic crossing the North Atlantic and normally consists of seven to ten tracks each separated by 222 km*(120 miles) and each providing a choice of altitudes between 9.5 km (31,000 feet) and 11.9 km (39,000 feet) with a 600 m (2000 foot) vertical separation. The air traffic control centers at Gander, Newfoundland and Prestwick, Scotland are respectively responsible for the east- and west-bound traffic flow. The location of the NATS changes twice in any given 24-hour period and is dependent mainly on the current weather, air traffic control (ATC) considerations, desired routing, and traffic density. A detailed knowledge of the wind and temperature fields is essential if the traffic flow is to take full advantage of prevailing meteorological conditions.

Changes on the North Atlantic

A number of important changes relating to the track spacing, numerical forecast models used for weather prediction and ATC operations will be occurring over the next 24 months, which if considered singularly could have an

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*Changed to 110 km (60 miles) in October 1980.

important impact on flight operations; however, when taken collectively they have the potential for determining the operating efficiency on the North Atlantic for the next decade. I refer specifically to the following:

1. The change in the latitudinal track separation from 222 km (120 nautical miles) to 110 km (60 nautical miles). This reduction, in the latitudinal separation, will provide an opportunity for a greater number of aircraft to fly closer to the minimum fuel track (MFT).

   However, in order to take full advantage of this change and improve operating efficiency, it will be necessary to more accurately define the location and intensity of the jet streams as a function of time. In short, a more representative prediction model is needed to maximize the advantage of this change to the air carriers.

   There is one view that if one is able to better define the optimal route then every carrier would request the same track (and altitude), and the delays thus created would have, on balance, a negative impact. While there is a modicum of truth in this especially if one could always predict the location of the most fuel efficient route, the fact of the matter is that our current information concerning the exact whereabouts of the jet streams is far from perfect. Figure 1 shows the route requests from five carriers between London and New York. This case is not atypical and indicates that there is a difference of opinion. In a closely spaced track system this difference could be critical. A small error in the placement of the jet stream can place an aircraft in substantially differing wind regimes and could lead to a dramatic reduction in a tail wind (ending up on the cyclonic shear side of the jet) or worse still, an increase in air temperature accompanying the drop-off in wind speed.

2. The availability of an advanced operational forecast model from Bracknell (British Weather Service) outputted in the Suitland format. Bracknell plans to provide an advanced analysis and forecast model which is expected to be operational in early 1982. While many of the details have not been released, it is anticipated that Optimal Interpolation will be used in the analysis and a 15 level grid point model will be used to advance the analysis in time, with the data outputted in the Suitland (Marsden Square) format of $2\text{-}1/2^{o} \times 5^{o}$. Bracknell will be using a Cyber 203 computer which should greatly increase the computing power available for the 1980's. In fact, four complete daily analyses and forecasts are probably within the capability of this system. The current forecast from Bracknell is available about 4-1/2 hours after synoptic time (0000Z, 1200Z) and is transmitted within 1-1/2 hours. Bracknell is also planning to develop a fine-mesh model limited to the North Atlantic Ocean basin.

3. The availability of an advanced operational forecast model from Suitland (United States National Weather Service). Suitland expects to incorporate an analysis model using Optimal Interpolation in

about 1-1/2 years. Their advanced 12 level spectral forecast model is already operational (August 12, 1980). It is anticipated that Suitland will have a new computer installed by the middle of 1982. Currently, Suitland provides a forecast between 5-1/2 to 6-1/2 hours after synoptic time (000Z, 1200Z) and transmits this data to the air carriers within two to four hours.

4. Gander will shortly be installing a new computer system (GATTS II) which should provide for improved operating efficiency. Although flight following is still done with paper strips, CRT displays are used to advantage throughout. The system has the potential for a considerably faster response time than GAATS I and has built-in provision for expansion. While the algorithm for calculating a minimum time track (MTT) remains essentially unchanged, the Suitland forecast used to develop the MTT no longer requires conversion to punched paper tape, but goes directly into the GAATS II computer. Gander uses the Suitland forecast in the development of an MTT for the east-bound flow.

   Substantial improvements in operating efficiency will be possible as ATC allows more aircraft to obtain requested enroute step climbs. However, any major improvement must await the availability of more accurate and/or timely weather data on which to develop MTT's.

5. Prestwick ATC will go to a fully computerized system. Track analysis, planning functions, allocation of flight paths as well as conflict and avoidance prediction and resolution will be within the automated capabilities of the new computer system. Prestwick presently, although it calculates an MTT, relies on the MFT's sent in by air carriers 20 hours before departure to develop the daily tracks. The MFT's sent in by air carriers are based on at least four forecast models (United States, England, France, Federal Republic of Germany). In theory, the Prestwick approach to the development of an MTT is sound; however, in practice it is somewhat limited because of differences between various weather prediction models as well as differences between the various algorithms used by air carriers to calculate their MFT's.

   Prestwick will also have the ability to talk computer-to-computer with all oceanic ATC centers. It is important that the forecast information base be the same because of the development of estimated times of arrival at check points and is especially important in transferring control of aircraft at 30^o west from Prestwick to Gander.

Possible Alternatives

It is clear that given all the changes which are in progress, the overall impact on carrier operating efficiency will be greatest if the result is a more accurate track determination by Gander and Prestwick. The North Atlantic air carriers also stand to benefit from the introduction of improved weather prediction models, but the extent of that benefit remains to be determined. It may be that even these forecast models may not provide the required spatial resolution. Each time the model resolution is doubled, the computer running time is increased by a factor of eight.

It is possible that a more cost effective approach might be through the use of multiple daily analyses (rather than forecasts) which could provide more timely data. For example, if four analyses were available each 24-hour period (instead of the current 2) it could be possible to fly the Atlantic on a 6 to 8-hour old analysis rather than a 24-hour forecast. Use of the analysis not only has the advantage of providing more current data on which to base an MFT, it also can be made available much earlier (less computer running time) since it does not require a translation in time (a forecast). In reality a simple non-dynamic forecast could be included with no substantial increase in computer running time.

In essence, it is suggested that an alternative to high resolution prediction models might be the use of multiple analyses which retain the meteorologically significant structure (through advanced assimilation techniques) of the atmosphere and provide this information in a timely fashion.

An alternate approach could be to use a fine-mesh model limited to the North Atlantic Ocean basin to provide a more detailed space-time description of the jet streams. This could produce a high resolution forecast yet because the model is not global, would require a much shorter running time on the computer.

Helping the Carriers

The air carriers, including Gander and Prestwick, need to know which advanced forecast model more accurately represents their region of interest (i.e., 20 kN/m^2 (200 mb) - 30 kN/m^2 (300 mb) level). Since both the Suitland and Bracknell products will be available in the same output format, it should be relatively simple to run comparisons on the North Atlantic with actual data to make this determination. A parallel effort also needs to be made to evaluate the potential of using more timely analyses as the basis for an MTT rather than a forecast. In essence, comparisons similar to those suggested above are presently being made in the NASA Commercial Aircraft Fuel Savings Program; however, it will involve comparing the older forecast models in use in 1979, rather than the more advanced assimilation and prediction models which will be in operation within 24 months.

The limited area fine-mesh model for the North Atlantic basin, which may become available through Bracknell, will also need to be evaluated from a carrier/ATC point of view.

Given the new methods of data assimilation and the higher spatial resolution of the new forecast models, Gander and Prestwick will need to review the way they calculate MTT's. For example, when using the Bracknell 15 level grid point model, a linear interpolation in the vertical near the tropopause may no longer be valid. Also in light of the 110 km (60 nautical miles) longitudinal separation, should a more accurate algorithm be used to develop the MTT?

There is also a question of the methods of interpolation as well as the algorithms presently used by the air carriers in developing their MFT's, since it is these MFT's which Prestwick currently uses as the basis for its daily track determination. There are indications that at the very least these calculational techniques need to be reviewed and perhaps standardized, especially in view of the higher resolution forecast models which will soon become operational.

Since the trend is toward more data rather than less coming from National Meteorological Centers, the current data transmission rates (1050 baud from Suitland) need to be reviewed. As more timely data becomes available, it becomes more important to be able to provide this data to the carriers in a mode such that the time for transmission is only a small fraction of that required to develop the forecast (or analysis). Currently Suitland develops a forecast in 5-1/2 to 6-1/2 hours after synoptic time. The transmission time (including requests for repeats due to errors) runs between 2 to 4 additional hours. Technically there would be no difficulty in going to 2400, 4800 or even 9600 baud to improve the transmission time. More than likely the additional cost for transmission would more than be made up by the advantage gained from more timely flight planning.

Gander and Prestwick have somewhat differing philosophies concerning the daily development of the track system. Although both centers develop the tracks based on a 24 to 30 hour forecast, Gander depends heavily on its computer developed MTT (as well as other ATC considerations) whereas Prestwick depends more on the daily carrier initiated (MFT) route requests. As a result of differences in forecast models and/or carrier MFT algorithms (as well as the location of departure cities) the Prestwick track system tends to be broad while the Gander system more closely straddles the MTT. Because of the somewhat larger track selection offered by Prestwick, it becomes more important that the west-bound carriers develop their flight plans on 12-hour old data rather than 24. In many cases this has not been possible because a forecast based on the 000Z observation is not available in time. This situation can be improved for the carriers if Bracknell's current plans to produce four analyses per day are put into operation. The analysis would have to be outputted in the Suitland format but probably could be available to the carriers within several hours after synoptic time, which should be sufficient for flight planning.

Conclusion

The present economic situation places severe limitations on what individual air carriers can do to improve aircraft operations on the North Atlantic. Yet it is because of the economics superimposed on a deregulated environment that efforts need to be made to assist the United States air carriers in improving their operating efficiency. The author has pointed out areas of interest to the carriers where a continuing and updated knowledge of present and future ATC and National Weather Service operations (here and abroad) as well as carefully considered and developed strategies may be required to maximize opportunities for improved operating efficiency.

It might be beneficial to the carriers if they more fully understood the details of how the new forecast models will impact their future operations. The soon to be available improved prediction models using more sophisticated data assimilation techniques in the analysis scheme as well as increased levels in the vertical hold the promise of more accurately reflecting the observed data and thus representing the space-time distribution Atlantic weather in a more realistic way. However, the carriers need to be able to evaluate these different models as well as multiple analyses schemes on a continuing basis so they can provide both input and direction to the National Weather Service and ATC on meteorological matters before they impact flight operations.

Because the changes which are about to take place over the next 24 months will have such a long term impact on North Atlantic flight operations, it is important that the carriers begin to explore these opportunities now.

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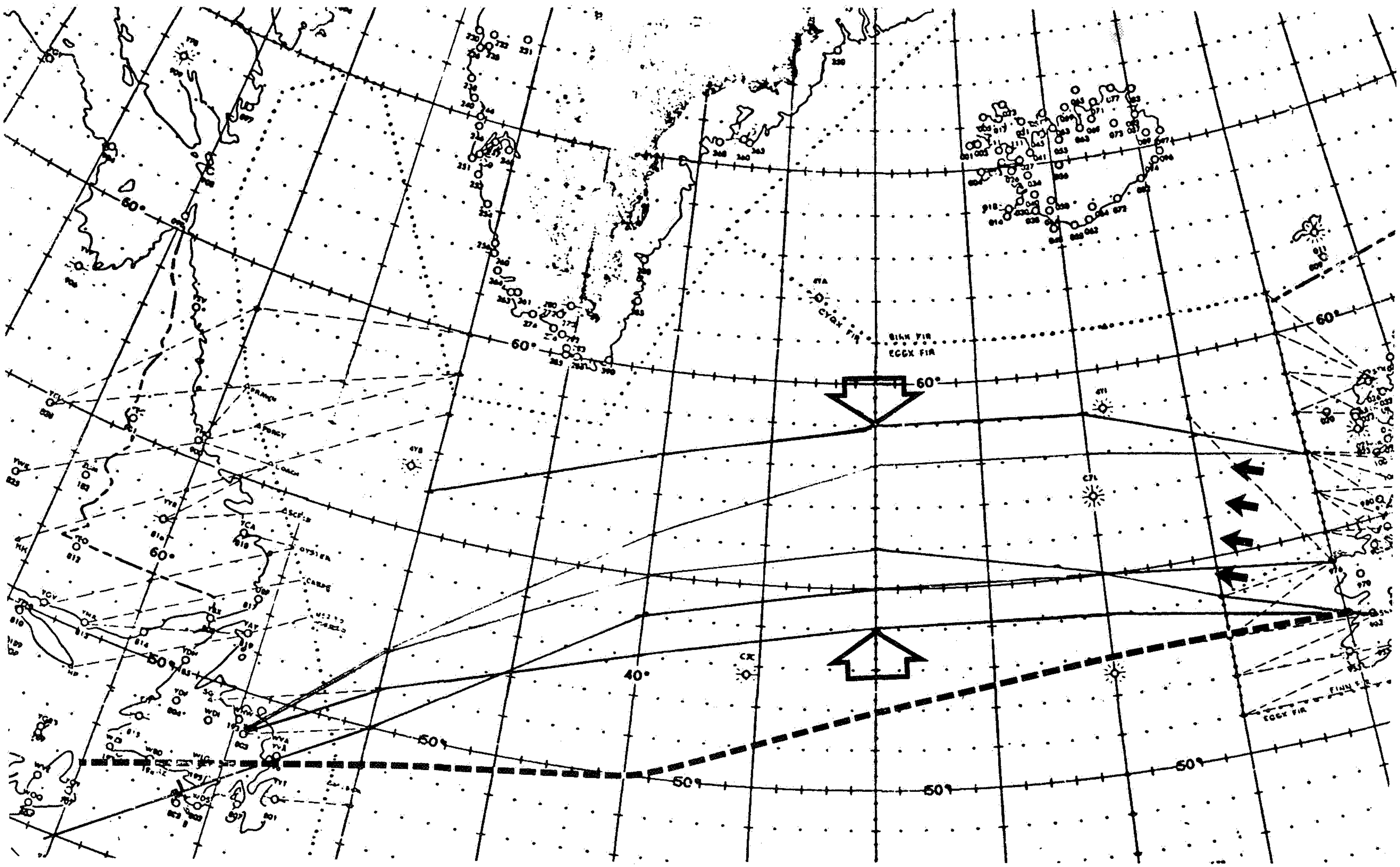

Figure 1.- Route requests from five carriers between London and New York. The dashed line indicates the previous 12-hour east-bound MTT.