FORUM

The Value of Meteorological Forecasts for Airline Operation

from J. E. D. Williams

A number of members have been invited to contribute to a general discussion on the value of meteorology to navigation. It is hoped to follow Mr. Williams' contribution with others dealing with different aspects of the subject.

YEARS ago there was weather in which birds and airmen alike walked. Now, although operations through particular airports affected by below-minima weather may be interrupted, airline services are rarely cancelled because of weather en-route. As aircraft tend to fly faster and higher, and navigational aids slowly improve, the weather information required by the short-range operator tends to be conditioned by the question: Can my aircraft operate through airport *X* at time *T*? The long-range operator is still interested in two other questions: What route will give the most favourable component, and What is that component? Having the meteorologist's answer to these and other, less vital, questions, the operator plans his flight on the assumption that the forecast is quite correct and equips and fuels his aircraft on the assumption that it is wholly false. The operator has learned to compensate for the errors of forecasting; possibly all the airline accidents in recent years in which unexpected weather deterioration played a major part could have been avoided with sound airmanship. The most realistic way, therefore, to consider the value of forecasting to airline operation is to attempt to evaluate the cost to operators of the measures they take to protect life and equipment against forecast error and speculate on what would happen if no forecasting were attempted. The protection against error in forecasting terminal weather is simple. It is a normal practice (a requirement in many states) to carry a fuel reserve specifically for flight from destination to furthest alternate. The premise is that at no time prior to actual arrival at destination may it be assumed confidently that a favourable forecast for destination is true. The consequent loss in potential revenue to a long-range operator is up to £2000 per flight because of the limitation on total weight and consequently on payload. If the landing is for refuelling purposes it is, surprisingly enough, relatively unimportant whether the aircraft has to divert or not; the primary penalty is the carriage of the fuel to do so. The only kind of improvement which would reduce this problem would be the certainty that, at a given interval before arrival, the forecast then available would be correct. Thence it would only be necessary to carry fuel from this point to alternate.

If the landing is being made to pick up passengers there is a different sort of penalty. For example, a service operating *through* Paris and London to New York has passengers in London for New York. If London and nearby alternates will be fogged in at E.T.A., the most economical course for the long-range operator is often to transfer his New York passengers to Paris before London Airport is closed by fog, then when his aircraft arrives in Paris, overfly the U.K. The penalty of a wrong decision on the question Will there be fog in London is obvious. For such cases the value of forecasting (however inaccurate) is quite different to that considered above. Quite simply, the more often the question is answered correctly, the better the operation.

The need for accuracy in forecasting upper air mean component on a route, and upper wind at a point, arises from different problems. The primary purpose of a forecast component along a given path is to enable flight time and hence fuel requirement to be calculated. Reserve fuel must be carried to compensate for error in the forecast component. The need for more accurate forecasting of 'wind at a point' arises partly from the requirements of air traffic control for aircraft separation and partly from the desire of operators to fly a least-time path. The accuracy of upper-wind and component forecasting has been studied extensively by the Meteorological Office. Durst and Harley have shown [1] that the annual mean standard error of forecasting component at 500 mb on the Shannon–Gander route is 86 per cent of the error which would be encountered if the latest 'actual' were used. Murray [2] has shown that on routes forecast by the Air Ministry at a similar altitude, the standard error of wind forecasts is about 75 per cent of the standard deviation from seasonal mean winds, so that the whole forecast machinery only reduces slightly our uncertainty as to what the mean wind component will be in twelve hours' time. There is reason to believe that on some tropical over-water routes the error of forecast is at least as great as the wind deviation from seasonal mean, in which case the upper-air forecast serves no useful purpose.

Because turbine and jet aircraft need greater freedom to change and select altitude than piston-engined aircraft, it may be expected that lateral separation will in the future be used more. Lateral separation of aircraft is adequate if the sum of the fixing error at the time separation is established and the error of D.R. until the next communicated fix cannot produce a collision. Since wind forecasts in mid-Atlantic are often 50 knots in error vectorially, the D.R. error one hour after obtaining a perfectly accurate fix is frequently 50 n.m. if the navigator uses the forecast wind. As a result air traffic controllers have to establish an enormous buffer of space around each aircraft, with the result that the North Atlantic tends to resemble Oxford Circus on a foggy morning. At present, uncertainty as to the position of the aircraft in one and two hours' time consequent on the D.R. errors is the cause of the major element of this buffer.

The problem of determining the minimal time path ultimately depends on wind at a point. The advantages theoretically obtainable from minimal time path flight are well known [3] and it is certainly true that such advantages are not fully realized. However, it is difficult to assess the loss resultant on forecast error, for the route actually flown depends partly on weather and air traffic control considerations; also captains are properly reluctant to make a large diversion from track when the advantage is doubtful, and navigators re-assess the pressure situation in flight and modify their path accordingly.

In short, reliable and accurate forecasting would alter radically the operation of airlines. The order of priority of desired improvement is: landing forecast, wind component for the route, wind at a point, en-route weather. Present landing forecasts are invaluable for, unreliable though they may be, some guidance on probable landing conditions is essential until electronic advances enable operators to reduce considerably their landing and take-off minima. The remainder of the forecasting service is not generally *essential* to airline operation, but there would be a significant increase in airline operating costs due to the slightly greater uncertainty on wind and icing if 'actuals' were relied on.

For the sake of simplicity and generality, the special problems of the short-range operator consequent on the unreliability of landing forecasts have not been mentioned in this note; they have been fully discussed by Vivian[4] and others.

There is no wish to imply here that any part of the meteorological service is unjustifiable, nor is any criticism of meteorologists implied. The fact remains that the operational requirement is not met. Like other twentieth-century techniques, meteorology must potentially be capable of radical improvement, however insuperable the immediate technical problems appear. The questions we ask are determinate, if not at present determinable, problems.

REFERENCES

1 Harley, D. G. (1954). Equivalent tailwinds on the Shannon to Gander route. This *Journal*, **7**, 16.

2 Murray, R. (1954). *Meteorological Office Professional Notes No. 10*, H.M.S.O.

3 Sawyer, J. S. (1949). *Theoretical Aspects of Pressure Pattern Flying*. (Meteorological Report No. 3), H.M.S.O.

4 Vivian, J. (1953). A variable fuel reserve policy. This *Journal*, **6**, 255.

Alexander Neckham and the Pivoted Compass Needle

from Commander W. E. May, R.N.

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HISTORIANS of the mariner's compass (particularly those of the last century) have introduced into the literature of the subject a number of statements which can be shown to be incorrect, or at the least to be extremely doubtful. Unfortunately it is just these 'facts' which have been seized upon by later historians and appear in one authoritative book after another. I have myself fallen into one stock trap or another in the past.

One of these errors concerns the introduction of the pivoted compass needle. It is commonly supposed that the pivoted needle was preceeded by the floating variety. The earliest report which we have of the floating needle is that given by Alexander Neckham in about the year 1187 and this type was still in use for at least the greater part of the next century.

Neckham's description in *De Naturis Rerum* is perfectly clear, but that in *De Utensilibus* is obscure. It runs:

> Quia ergo munitam vult habere navem . . . habeat etiam acum jaculo suppositam; rotabitur enim et circumvolvetur acus, donec cuspis acus respiciat orientem sicque comprehendunt quo tendere debeant nautae cum cynosura latet in aeris turbatione.

(Therefore he who wants to have a well-equipped ship . . . let him also have a needle placed under a dart; for the needle will rotate and revolve until the point of the needle looks towards the East, and thus sailors perceive in which direction they ought to go, when the Little Bear is hidden in disturbed weather.)

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