WIND, FRIEND AND FOE

By Dennis Hart

Dennis Hart is the EUROCONTROL Aviation Meteorology Expert. In summer 2007, Dennis Hart was recruited by EUROCONTROL with the clear task to facilitate the needed interaction between the MET and ATM community to better integrate meteorological information into ATM decision making.

Some of the stories in this edition of HindSight clearly demonstrate that surface wind and wind at lower altitudes is of real significance for day-to-day operations. What has become apparent is the clear need for fit-for-purpose information on the wind to support the different phases of flight and flight support in general, translated in the most suitable way possible for the situation. One could argue that the wind information provided today is already insufficient to cater for some of today's ATM needs and the decisions we are forced to make in our daily operations.

So wind information itself, and the interpretation and the overall translation of this information into the decision-making processes both for aircraft and on the ground, are certainly issues to be considered as we gradually move towards a completely time-ordered ATM system: an ATM system where the 4-D trajectory will prevail and the need for truly fit-for-purpose wind information will be paramount. Clearly, we have to move away from the traditional type of 'ICAO wind information' and introduce the ability to measure, forecast and report wind information that can fully support this 4-D trajectory approach to ATM.

As we have already seen, wind and its turbulent nature heavily influence the take-off and landing phase, even of modern aircraft. We have moved some distance away from the time when a light gust of wind could cause serious structural damage to an aircraft, such as the break-off of a wing which happened to one of our early aeronautical pioneers (Otto Lilienthal — 1848-1896) and resulted in a fatal injury. Still, strong winds have been a major contributor to a number of take-off and landing-related incidents and accidents over recent years and contribute significantly to weather-related delays at European airports.

In addition to the accident described in 'Getting the wind up', we could also mention the 1999 China Airlines MD11 Hong Kong, the 1999 American Airlines MD80 Little Rock and the 1997 Transavia Airlines Boeing 757 Schiphol Airport events as a demonstration that high-wind environments can be a significant contributor to accidents, some of them with fatal consequences. Besides the immediate impact on flight operations, airports such as Frankfurt and Schiphol operate in an environment where relatively high crosswinds are day-to-day occurrences necessary to meeting the required demand for capacity; factual wind information is key to ensuring that this is done safely.

It is fair to say that the common practice of reporting the surface wind near touchdown and 'working' with forecast surface winds extracted from a TAF will not be sufficient for the future ATM world; as already stated, one could argue that it is already insufficient for today's operations. A clear need is seen, not only for detailed wind information - observed and forecast - at surface level, but also for levels aloft, to determine the 'perfect' 4-D trajectory, at least from a meteorological perspective.

Courtesy: Dutch Transport Safety Board/Dutch Airpolice

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The current methodology of wind observations, forecasts and reporting practices is based on guiding principles laid down by both ICAO and the World Meteorological Organization (WMO). But before discussing these guiding principles, it is worthwhile having a closer look at the wind itself. This will provide increased understanding of why today's wind information is what it is!

Wind is commonly referred to as the movement of air from one place to another, but may be viewed in detail from different perspectives and scales. For take-off and landing, interest is focused on the lower levels of the atmosphere where wind is variable, as we all witness every day. Scientists call this 'the turbulent mixing of momentum in the atmospheric boundary layer, which is stochastic by nature'. In other words, wind in the lower levels of the atmosphere is synonymous with 'turbulence'; moreover, it is a random phenomenon and therefore could never be described in a deterministic way. The latter is the most important message to be conveyed; surface wind is a random phenomenon and therefore needs to be characterised using a statistical method. This is the key element when moving from the phenomenon, surface wind (turbulence), towards wind measurements and wind information required for ATM decision-making.

According to ICAO and WMO requirements, the characterisation of wind near the earth's surface shall be described as a two-dimensional (horizontal) vector specified by two numbers representing direction and speed. The extent to which wind is characterised by rapid fluctuations shall be referred to as gustiness, and single fluctuations are called (peak) gusts.

Without going into too much detail on instruments and the overall process of obtaining a discrete sequence of measurements of wind, there is something which should be kept in mind when moving towards describing surface and lower-level winds, or in other words, describing boundary layer turbulence. An important question is: when might wind fluctuation influence our operations or even be seen as harmful? This directly relates to the 'mixing of momentum' described earlier, and the related energy to move or damage structures; it can be easily understood that a gust with a short duration has neither the time nor the power to exert its full effect on an aircraft. Averaging the wind over a 3-second period is more useful in describing potentially harmful conditions for structures such as aircraft.
Another consideration concerns the time period over which the wind should be averaged to give the best characterisation of its turbulent nature. This brings us immediately to the next question: why do we need an average for wind speed and direction and why don't we use the instantaneous read-out as a prime source for our decision-making? Having an average speed and direction available is essential to understanding the turbulent environment in which we have to perform our operations, and this brings us back to one of our first observations: turbulence can never be described in a deterministic way. This adds up to the fact that an atmospheric variable in general can never be actually measured or sampled. In general, sensors respond more slowly than atmospheric changes over time, which is certainly true for wind. Therefore, techniques such as averaging, filtering and smoothing should be applied to provide a wind report that is representative in time and space.

In the quest to obtain the most representative observation of the wind with an acceptable degree of certainty in the estimation of its true value as it was seen decades ago, taking the mean of a large number of independent samples is often used. In addition, by applying the ICAO recommended time period for averaging of 2 minutes, we achieve spatial representativeness for the entire touchdown zone; with a 10-minute averaging time period, the spatial representativeness broadens to the whole airport. Returning to the instantaneous read-out, it gives an idea of the windspeed and its variability but is subject to major errors when the reporting of wind with the appropriate level of (spatial) representativeness and certainty is required. Again, wind is a random phenomenon and is difficult to capture in the deterministic way we all like.

Moving away from wind measurements and the statistical processes for providing the most representative observation of wind, we enter the area of wind reporting. This is the exclusive domain of ICAO; they set the criteria for wind reports as part of Local Reports (ATIS), METAR and TAF. In general, these generic criteria are also used in the display systems used by air traffic controllers and other ATM stakeholders.

I would invite you to read the relevant chapters of ICAO Annex 3 on wind reporting and see if, in combination with the theory behind wind provided in this article, they still match up to the interpretation you formed when you last looked at the wind information provided to you.

ABSTRACT (ED.) FROM APPENDIX 3 CHAPTER 2.3 AND 4.1, ICAO ANNEX 3 16TH EDITION, JULY 2007

In Local Reports:

a) variations from the mean wind speed (gusts) during the past 10 minutes shall be reported when the maximum wind speed exceeds the mean speed by 10 kt or more, they shall be reported as the maximum and minimum values of the wind speed attained.

b) variations from the mean wind direction during the past 10 minutes shall be reported as follows, if the total variation is 60° or more:

   1) when the total variation is 60° or more and less than 180° and the wind speed is 3 kt or more, such directional variations shall be reported as the two extreme directions between which the surface wind has varied; or

   2) when the total variation is 180° or more, the wind direction shall be reported as variable with no mean wind direction;

An intermediate report should be issued:

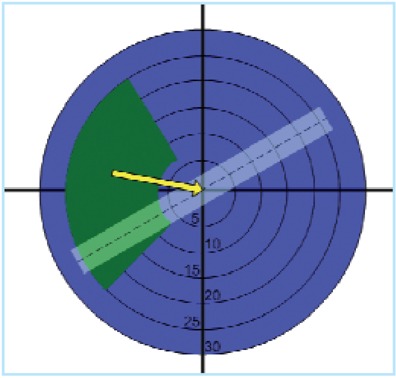
a) when the mean surface wind direction has changed by 60° or more from that given in the latest report, the mean speed before and/or after the change being 10 kt or more;

b) when the mean surface wind speed has changed by 10 kt or more from that given in the latest report;

c) when the variation from the mean surface wind speed (gusts) has increased by 10 kt or more from that given in the latest report, the mean speed before and/or after the change being 15 kt or more.

EXAMPLE

Imagine a display with a wind report stating a 2-minute average direction of 280 degrees and a speed of 16 knots. The actual wind could already been changed to a direction somewhere between 230 and 330 degrees or changed in speed too a value between 7 and 25 knots in for instance the 30 minutes between regular reports. As a consequence, the wind could already be in the North-Northwest quadrant reaching the upper limits for desired or allowed cross wind operations without a 'warning' in the actual wind report. The following illustration depicts this graphically and includes a virtual runway 24-06. The actual wind could be in the green area where only the yellow vector is reported.



So the reasoning behind why we do the things the way we do today is now made somewhat clearer. Hopefully, this will shed new light on wind, wind information and its limitations. But will these limitations hinder safe operations in today's working environment and the future, as envisaged by the different ATM strategies around? Is the spatial representativeness and associated uncertainty of observed and forecast wind direction, speed and gustiness achieved by applying the WMO and ICAO guidelines to the letter? Should we look at it as something developed in the 50s but unable to support future needs? Or is the problem in the reporting of wind information instead of the actual measurements, forecasting and processing?

It is fair to say that the performance of meteorological systems for the measurement and forecasting of wind has improved over the last decades, but we are by no means fully able to utilise these developments. Perhaps this is due to the lack of supporting regulations, but more probably it is because of a lack of awareness of the ATM world and a failure to envisage the best utilisation of the available information. So before jumping to generic statements such as 'we need more accurate wind information' we should also focus on what can be made available today.

We read already about the sophisticated (remote) sensing systems for wind at surface level and along the glide path at Hong Kong. Furthermore, meteorological service providers are already looking into (short-term) wind forecasting at vertical and horizontal resolutions of a couple of hundred metres; but are we as yet able to use this information, in the sense of having a common situational awareness of the wind we need to improve our operations? At the moment, there are no harmonised guidelines on how to exchange and use the information from these new or improved systems; moreover, the focus today is basically on surface wind only.

We are not at a stage where the answer to all the questions posted can be answered. This is an area where different disciplines should work together to find the optimum choices of information, its utilisation and the improvements we should make when moving towards that 4-D trajectory - and the associated tripling of air traffic in a safe and cost-effective environment. A major step may result from the planned METATM Symposium from 24 to 26 November 2008.

EUROCONTROL, on behalf of ICAO's EANPG and supported by WMO and FAA, will host this symposium, which will address the current and future capabilities of aeronautical meteorology and ATC, and will define the new user requirements for MET.