The WMO AMDAR Observing System

Benefits to airlines and aviation

World
Meteorological
Organization
Weather • Climate • Water

High-quality, low-cost meteorological data

The thousands of aircraft flying through the atmosphere every day provide an efficient and inexpensive opportunity for gathering high-altitude weather measurements. Observations from aircraft supplement the data gathered by other meteorological instruments and help to improve the accuracy of forecasts. To ensure that the data collected by commercial aircraft are widely available to National Meteorological and Hydrological Services (NMHSs), the airline industry, researchers and other users of weather information, the World Meteorological Organization has established the Aircraft Meteorological DAta Relay programme (AMDAR). AMDAR collects and distributes the following meteorological data:

- High-resolution[1] vertical profiles of air temperature, wind speed and direction at airports;
- Regular reports of meteorological variables from airplanes en route at cruise level;
- Accurate measurements of coordinates (time, latitude, longitude and pressure altitude);
- Measurements of turbulence; and
- Water vapour or humidity data (from some, suitably equipped aircraft).

The quality of AMDAR observations is in accordance with WMO requirements for upper-air data measurement:

Variable	Uncertainty
Temperature	±1.0°C
Wind vector	±2–3 m/s
Pressure altitude	±4 hPa

How AMDAR works

AMDAR records meteorological data that is measured by the aircraft's existing sensors through the use of a specially developed AMDAR avionics software package. It then seamlessly transmits the data to the ground via a VHF (very high frequency) or satellite link using the aircraft's communications system (ACARS). When the airline receives the data it sends them to the Meteorological Service. Here they are further processed, checked for quality and incorporated into meteorological applications, including, most importantly, forecasts and other products for aviation (Figure 1).

[1] Vertical resolution of around 100 metres in the lower troposphere (to 700 hPa) and temporal resolution of up to around one profile per hour depending on fleet size and configuration for reporting and AMDAR fleet traffic at individual airports.

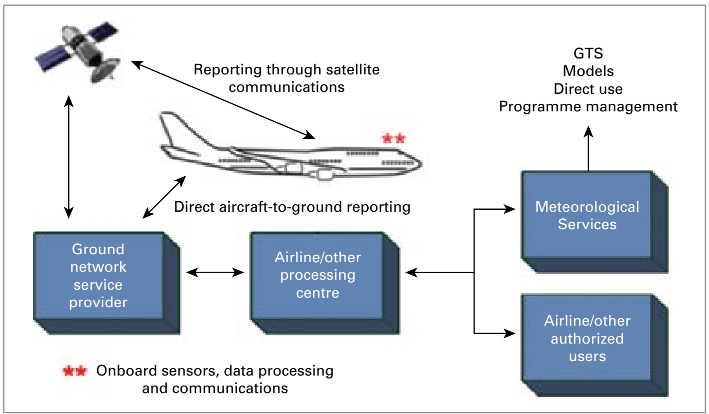

Figure 1

Observations are collected and reports sent when the aircraft is ascending, en route and descending (Figure 2).

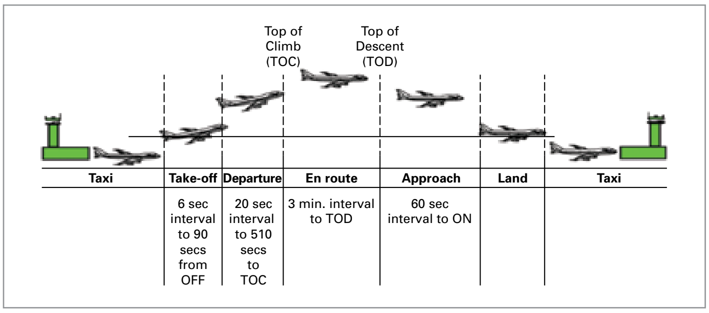

Figure 2, Reporting configuration for the USA AMDAR programme.

Many aspects of the data collection, including the observation frequencies, can be configured within the AMDAR software.

Typical reporting while aircraft is on ascent/descent:

Lower troposphere:
10 hPa intervals
or 6/60 second intervals

Middle to upper troposphere:
50 hPa intervals
or 20/60 second intervals

Reporting while aircraft is en route:
3 to 7-minute intervals

Improved forecasts of key weather parameters and phenomena

Weather is a major cause of air traffic delays around the world. For example, it accounts for around 70 per cent of delays within the USA National Airspace System (NAS); the USA Federal Aviation Administration (FAA) has determined that two thirds of these delays would be preventable with better weather information.[2]

By reducing forecast error, AMDAR and other aircraft-based observations generally improve forecasting skill and accuracy in Numerical Weather Prediction (NWP) systems by up to 15–20 per cent. Airline meteorologists also make direct use of AMDAR data and information for their own forecasts to supplement those produced by governments and other meteorological agencies.

[2] FAA Research, Engineering and Development Advisory Committee; Report of the Weather-ATM Integration Working Group; 3 Oct. 2007

An airliner low on fuel over the Atlantic

"At about 1200 UTC on 6 February 1998, the Miami Center Weather Service Unit (CWSU) was notified that an airliner had encountered sustained, strong headwinds over the Atlantic that were not taken into account when the plane was fuelled in Italy. The pilot was concerned that they might suffer fuel exhaustion en route. He needed an altitude that offered substantially smaller headwinds because he was approaching critical fuel.

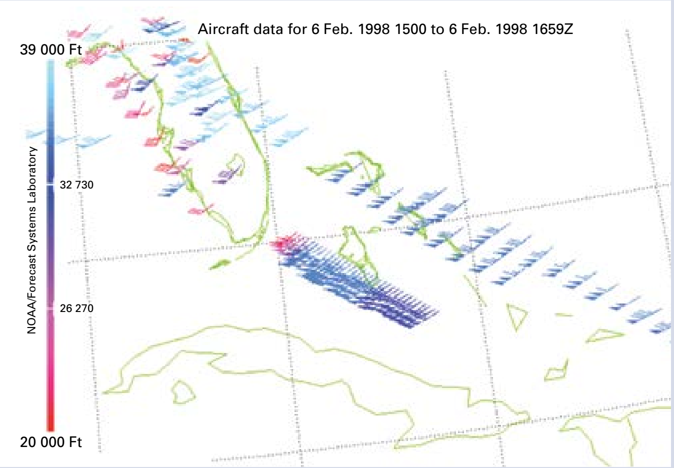

Figure 3

Fortunately, recent information collected by AMDAR reporting aircraft showed a flight track over the Bahamas less than one hour old with headwinds 40 knots (21 m s^{-1}) less than the winds that the airliner was reporting. Controllers immediately assigned the airliner to that altitude and flight path, and the aircraft was able to complete the flight without incident. Figure 3 shows wind reports from three aircraft over the Bahamas for 1500–1659 UTC that day (the aircraft with low fuel did not generate reports)."[3]

The availability of AMDAR data is conservatively estimated to have saved this airline over US$ 10 000 in this single case and potentially averted a significant incident. Fuel savings from avoiding an extra descent and ascent for a flight diversion is typically of the order of US$ 3 000. The extra cost of ground support at the diversion location, crew duty limits, passenger accommodations, extra airline operations support and other costs contribute the remaining US$ 7 000.

[3] *Bulletin AMS*, 84, pp. 203–216

Examples of weather parameters that can strongly impact aircraft and for which better forecasts and products can play a significant role include:

- Surface and upper-air wind and temperature;
- Thunderstorm genesis, location and severity;
- Wind shear location and intensity;
- Detection of zero-degree level (freezing rain);
- Altitude to the boundary layer;
- Low cloud formation, location and duration;
- Fog formation, location and duration;
- Turbulence location and intensity;
- Jet stream location and intensity;
- Precipitation amounts, rates and type; and
- Conditions leading to aircraft icing.

The improved prediction of these weather phenomena strengthens the safety, efficiency and economy of the airline industry's operations.

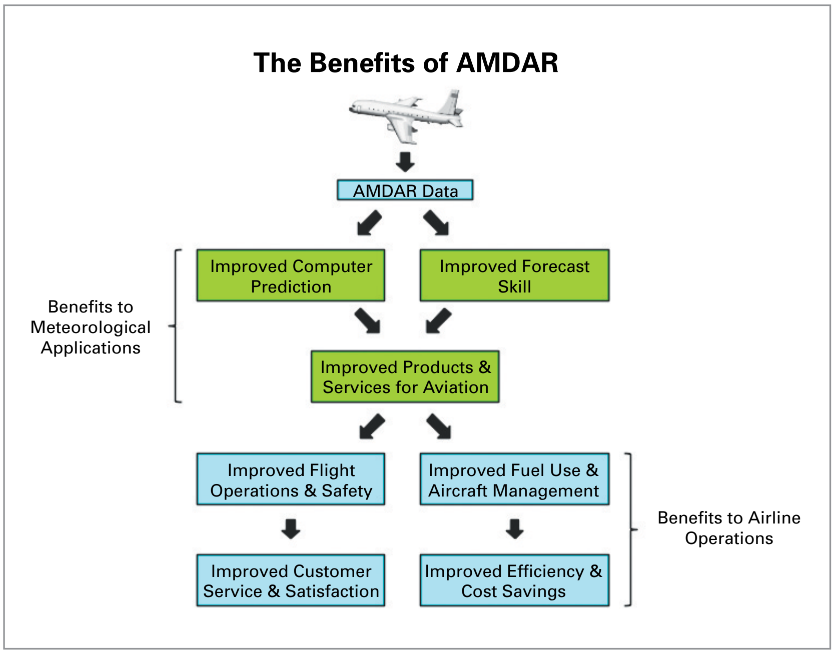

Figure 4

Benefits to airline operations

Strengthening forecasting services and meteorological products using AMDAR data have a positive impact on many areas of aviation operations (Figure 4).

Specific areas of flight operations that can benefit from better forecast services and products include:

- Planning routes when facing severe weather to reduce unplanned flight deviations;
- Selecting the flight altitude to optimize efficiency;
- Avoiding severe weather that could increase maintenance requirements and costs;
- Avoiding severe turbulence;
- Optimizing planning for fuel consumption and refueling; and
- Planning for crew scheduling and passenger notifications.

Dynamic fuel planning at South African Airways

South African Airways operates a fleet of 24 Airbuses, including the A330-200, A340-300 and A340-600. By applying dynamic fuel planning, based on zero fuel weight and current prevailing weather conditions, the company's savings on fuel costs per year are of the order of US$ 2 million to 3 million. SAA also uses in-flight, en-route updates to ensure optimized tactical in-flight planning with the latest weather forecast so that planes always fly at the optimal altitude.

Weather information, made more accurate by the provision and use of AMDAR data over the flight routes operated by a participating airline, will increase the savings made by the airline from using dynamic fuel planning.

Improved safety and cost savings

More timely and accurate warnings of severe weather phenomena reduce the potential for damage to aircraft, for example, by minimizing the accelerated fatigue caused by wind and storms. Better warnings can also reduce injuries to passengers and crew.

Wind forecasts are likely to be significantly more accurate for routes and otherwise data-sparse areas where AMDAR data are obtained by participating airlines.

The enhanced quality of meteorological products for aviation-related operations will positively affect the accuracy of flight planning operations, significantly reduce costs through reduced fuel consumption and also increase the safety of operations.

Additional benefits provided by Meteorological Services

When Meteorological Services use AMDAR data, their computer modelling systems can very precisely determine the accuracy or uncertainty of the data provided by each aircraft. As a result, the Meteorological Service can quickly detect and report back to the airline when an aircraft sensor drifts outside of the required calibration limits. (This service is only available to airlines participating in the AMDAR programme.)

A temperature error of more than a few degrees can have a dramatically negative impact on engine performance, fuel-burn efficiency, and aircraft safety. Early detection of such errors in aircraft sensor performance and feedback to aircraft maintenance teams allows a rapid response and can yield significant financial benefits for airline partners.

Additional benefits for airlines

The higher quality of meteorological information for aviation forecasting made possible by AMDAR provides more detailed and accurate guidance for air traffic control for en-route operations. This in turn leads to both airline cost savings and greater customer satisfaction.

The aviation industry also benefits significantly from improved air traffic management at airport facilities. This includes better departure and arrival management, more efficient gate allocation, the avoidance of holdings and re-routings (for which accurate wind information is needed), better runway management (which is affected by wind strength and shear, fog conditions, etc.), and improvements to many other air traffic activities affected by weather-related phenomena.

The aviation industry inevitably contributes to the problem of global warming associated with the production of greenhouse gases (GHGs). Environmental monitoring through the use and expansion of measurement systems such as AMDAR is a critical supplement to climate research and the understanding of how aviation affects climate issues.

One way to reduce the emission of carbon dioxide and other GHGs is through the introduction of so-called Green Landings, also known as Tailored Arrivals or Continuous Descent Approach (CDA). In many countries, such procedures using high-frequency AMDAR wind parameters directly, or products derived from them, are being tested or are in a pre-operational phase.

More Information

To learn more about the benefits of AMDAR, download the comprehensive WMO WIGOS Technical Report 2014-01, *The Benefits of AMDAR Data to Meteorology and Aviation,* from the WMO AMDAR Resources website.

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