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Recent Developments on Meteorological Information Datalink at the Hong Kong International Airport

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RECENT DEVELOPMENTS ON METEOROLOGICAL INFORMATION DATALINK AT THE HONG KONG INTERNATIONAL AIRPORT

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ABSTRACT

Prompt transmission of the latest weather information and alerts to aircraft is essential to their safe landing and taking off at the airport. With recent advances in telecommunications technology, it has become viable for the digital transmission of weather information directly to the cockpit as well as meteorological data collected on-board aircraft to the meteorological office. This paper describes recent developments in meteorological data downlink and uplink to enhance the weather service, including the application of automatic AMDAR observations for low level windshear reporting as well as the potential use of standard ARINC 623 message type 'Terminal Weather Information for Pilots (TWIP)' in existing available ACARS facilities to uplink text based windshear/turbulence alerts to aircraft to enhance aviation safety.

1 Introduction

At SEATI 2003, the Hong Kong Observatory (HKO) presented a paper titled "Recent Developments to Enhance Windshear and Turbulence Alerting at the Hong Kong

International Airport" (Shun et al, 2003), which highlighted the benefits of uplink and downlink of meteorological information in the context of windshear and turbulence alerting. The major benefits are the improvement of the timeliness and accuracy of weather forecasts from the availability of weather data collected onboard the aircraft downlink to the meteorological offices and enhancement of pilots' awareness on weather situation through uplinking of weather products to the cockpit. The emerging communications technologies and potential application of new uplink/downlink of meteorological information to/from aircraft offer great potential in improving the aviation weather services, thereby enhancing aviation safety, regularity and efficiency. The following paragraphs will present recent developments and applications of meteorological datalink at the Hong Kong International Airport (HKIA).

2 Downlink of Meteorological Data

2.1 Background

A number of facilities for downlink of meteorological information from aircraft have become available in recent years. These include:

(a) Automatic Dependent Surveillance (ADS) datalink

ADS is an air traffic management datalink application specified in the Standards of the International Civil Aviation Organization (ICAO). It is primarily used for aircraft surveillance and air-ground communication, and they are also capable of transmitting aircraft weather reports including wind, temperature and other optional elements such as humidity and turbulence. HKO conducted trials with the Hong Kong Civil Aviation Department (CAD) during 2000-2001 to demonstrate the capability of automatic reception of aircraft weather data via ADS.

(b) Aircraft Meteorological Data Relay (AMDAR)

AMDAR – stands for "Aircraft Meteorological DAta Relay", through which aircraft weather observations (wind, temperature, and other optional weather elements measured along the aircraft flight path) are transmitted automatically to the meteorological offices. AMDAR is a World Meteorological Organization (WMO) programme, which aims to enhance aviation safety and efficiency through promoting upper-air weather observations using downlink aircraft observations. HKO implemented an AMDAR programme in Hong Kong in 2000 to receive aircraft weather data from Australian and U.S. aircraft operating at HKIA.

2.2 Recent developments

2.2.1 ADS

Currently, the airspace of Hong Kong is covered by surveillance radars. As such, ADS is usually not applied for surveillance and the trial on weather reporting using ADS datalink has been suspended. Similar situations are known in other airspace in the Asia/Pacific Region. Hence, there is a need to identify another alternative for downlink of meteorological data. At the suggestion of HKO, the use of other possible solutions (ADS-B and Mode S) for automatic MET air-reporting in the Asia/Pacific Region are being studied by ICAO.

2.2.2 AMDAR

In 2003, with the assistance of CAD and the Cathay Pacific Airways (CPA), a trial of

AMDAR data collection from one B747 aircraft commenced. After evaluation of the data quality, HKO started the operational dissemination of the AMDAR weather reports via the Global Telecommunications System (GTS), making the data to other weather centres overseas. In particular, the data is also available at the two World Area Forecast Centres (WAFCs) for the preparation of en-route weather forecasts for international air navigation. Since September 2005, the Hong Kong AMDAR programme was expanded to provide additional AMDAR reports from a total of six CPA aircraft. At present, HKO receives about 1,000 AMDAR weather reports daily directly from these aircraft.

In 2005, experiments were conducted in applying the AMDAR observations for low-level windshear reporting. Windshear (i.e. headwind changes of 15 knots or more) experienced by aircraft during the take-off phase was computed from the high-resolution AMDAR reports (at 4-second resolution) received and compared with the Flight Data Recorder (FDR) wind data (at 1-second resolution) recorded on the aircraft (see example in Figure 1). The AMDAR wind reports showed good agreement with the FDR data in respect of the altitude and headwind (along the runway direction) (Figures 2 and 3). In particular, AMDAR data at 4-second resolution was able to capture the significant headwind variations associated with windshear events.

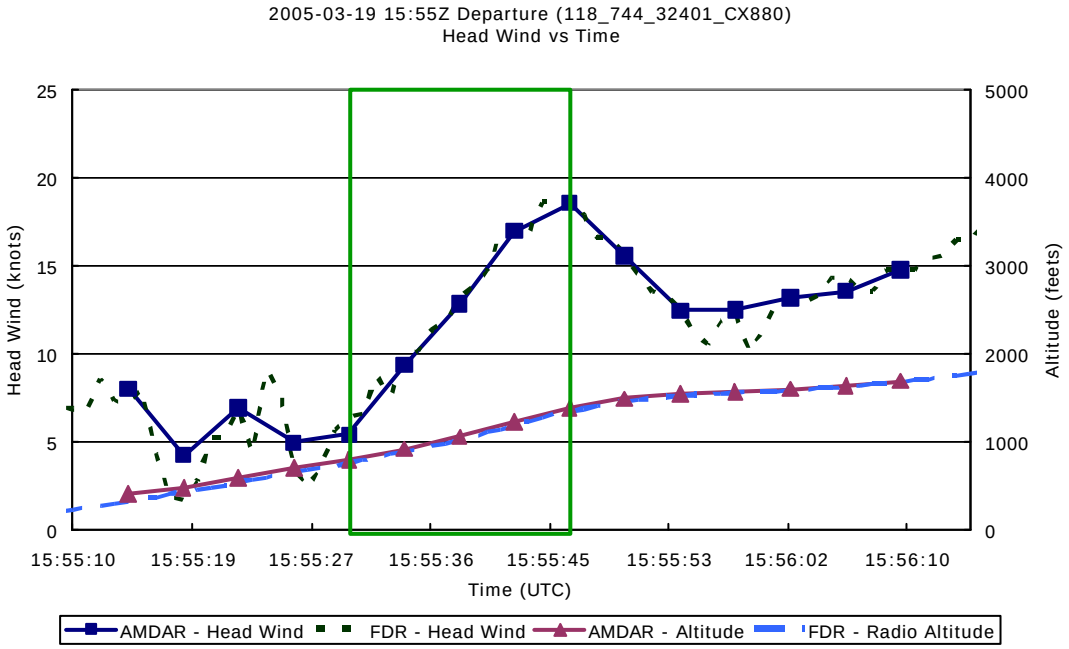

Figure 1. A comparison of the headwinds provided respectively by AMDAR and FDR for the same flight.

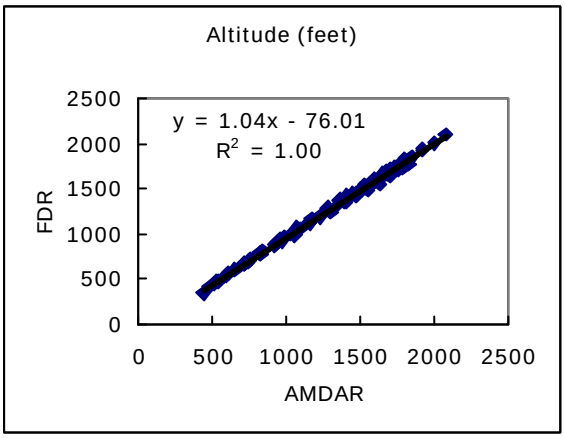

Figure 2. Scatter diagram of altitude

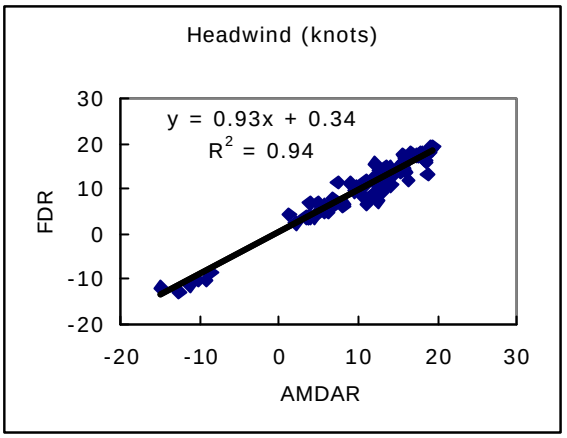

Figure 3. Scatter diagram of headwind

After consulting the users and stakeholders of the windshear alerting service at HKIA, it is planned that these automatic AMDAR observations will be used in operational windshear reporting to alert aircraft operating at HKIA in early 2006 through the Automatic Terminal Information Service (ATIS) (see schematic in Figure 4) or via the Air Traffic Control (ATC). The necessary data quality control and automated windshear identification algorithms are being developed by HKO for operational implementation. This is first step in the world in applying high-resolution AMDAR weather observations measured onboard in low-level windshear reporting.

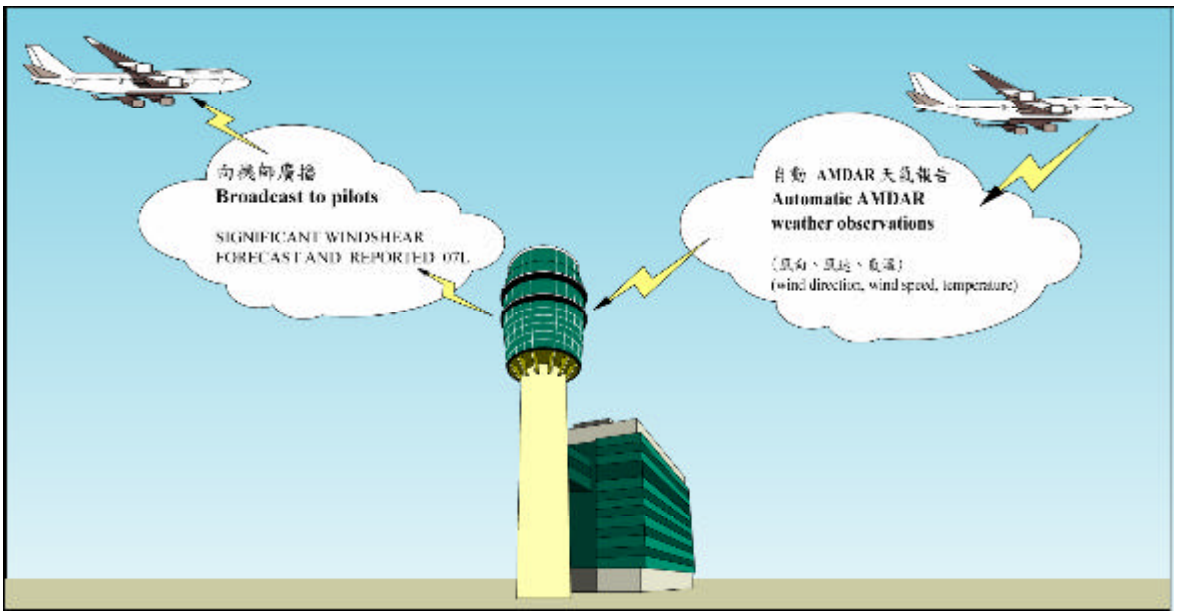

Figure 4. The automatic AMDAR observations transmitted from aircraft will be used in operational windshear reporting to alert aircraft operating at HKIA via the Automatic Terminal Information Service (ATIS).

3 Uplink of Meteorological Data

3.1 Background

Data uplink facilities provide a means of sending weather products, in the form of text or graphical format, directly to the cockpit. Data uplinks reduce potential misinterpretation due to poor quality of voice communication, thereby reducing ambiguity in the transmitted information. The workload of air traffic controllers can also be reduced as a result. More variety of weather products, particularly information on hazardous weather such as low-level windshear alerts, can be made available to the pilots. Pilots can receive the weather information at regular intervals, or upon request. The availability of weather information in graphical format in the cockpit could also enhance the situational awareness of the flight crew. Flight safety as well as aviation efficiency could be enhanced as the most updated weather information can be made available to assist the pilots to take appropriate decisions to avoid hazardous weather and to optimize their routes during the flight.

A number of datalink applications for uplinking meteorological information to aircraft have been established in the recent years. They include the Digital - Automatic Terminal Information Service (D-ATIS) and Digital VOLMET (D-VOLMET) service. Both services were introduced by CAD in Hong Kong in 2001 in parallel with the conventional voice broadcasts. The D-ATIS provides the latest runway weather conditions at HKIA, in particular low-level windshear and turbulence warnings, together with the other aeronautical information important for landing and take-off operations. The D-VOLMET provides operational meteorological (OPMET) information, including airport observations, forecasts and warning of hazardous en-route weather. In the past couple of years, the number of

uplink requests for D-ATIS messages has increased by four-fold to more than 20,000 requests per month (Song and Fong (2005)).

3.2 User Requirements of Weather Information Uplink

Building on the success of D-ATIS in uplinking weather information to the cockpit, HKO conducted a survey in early 2004 to solicit user requirements from pilots for further developments of weather information uplink. A total of 66 replies from pilots of 10 airlines were received. Specifically, windshear and turbulence alerts are identified by pilots as the most needed weather product for uplink. Other products include radar and satellite images, runway weather information and forecasts at higher frequencies. Further details of the survey results can be found in Cheng (2004).

Windshear and turbulence are by nature transient and sporadic and so the windshear/turbulence alerts generated from automatic systems are highly perishable. It is desirable that the latest windshear and turbulence alerts be made available to the pilots, particularly during the approach phase of the flight. Understandably, it is not possible to relay the windshear and turbulence information to the pilot on a minute-to-minute basis (or when a significant change occurs) via ATIS/D-ATIS. It would however be possible to do so via data uplink, preferably using a dedicated data link. In this connection, HKO, in consultation with CAD, airlines and pilots made an effort to identify cost-effective means for uplinking windshear/turbulence products to cockpit.

3.3 Recent Developments of Weather Information Uplink

3.3.1 Uplink of windshear information

The feasibility of using an available technology : standard ARINC 623 message type "Terminal Weather Information for Pilots (TWIP)" has been explored. TWIP was developed in the US for uplinking Terminal Doppler Weather Radar (TDWR) information (including microburst and windshear alerts, and precipitation information) to aircraft equipped with standard ACARS VHF data link facilities and avionics supporting ARINC 623. Trial operations of TWIP in the U.S. in the mid-90s were successful and well-received by users. Sample TWIP messages from the trials are given in Figure 5. From pilot surveys, it was found that the pilots rated the TWIP service positively and considered that it could provide more timely and accurate situational awareness of terminal weather hazards. In view of the favourable responses from users on the TWIP trial operation, it was employed in full operation at each of the 47 TDWR sites in the U.S. from 1998 onwards.

In Hong Kong, local airlines were approached in 2005 to explore the technical feasibility of a trial uplink of the HKIA windshear and turbulence alerts via TWIP. It turned out that the aircraft avionics would require software upgrades to receive TWIP messages and such upgrades were considered not cost-effective for the purpose of conducting a trial.

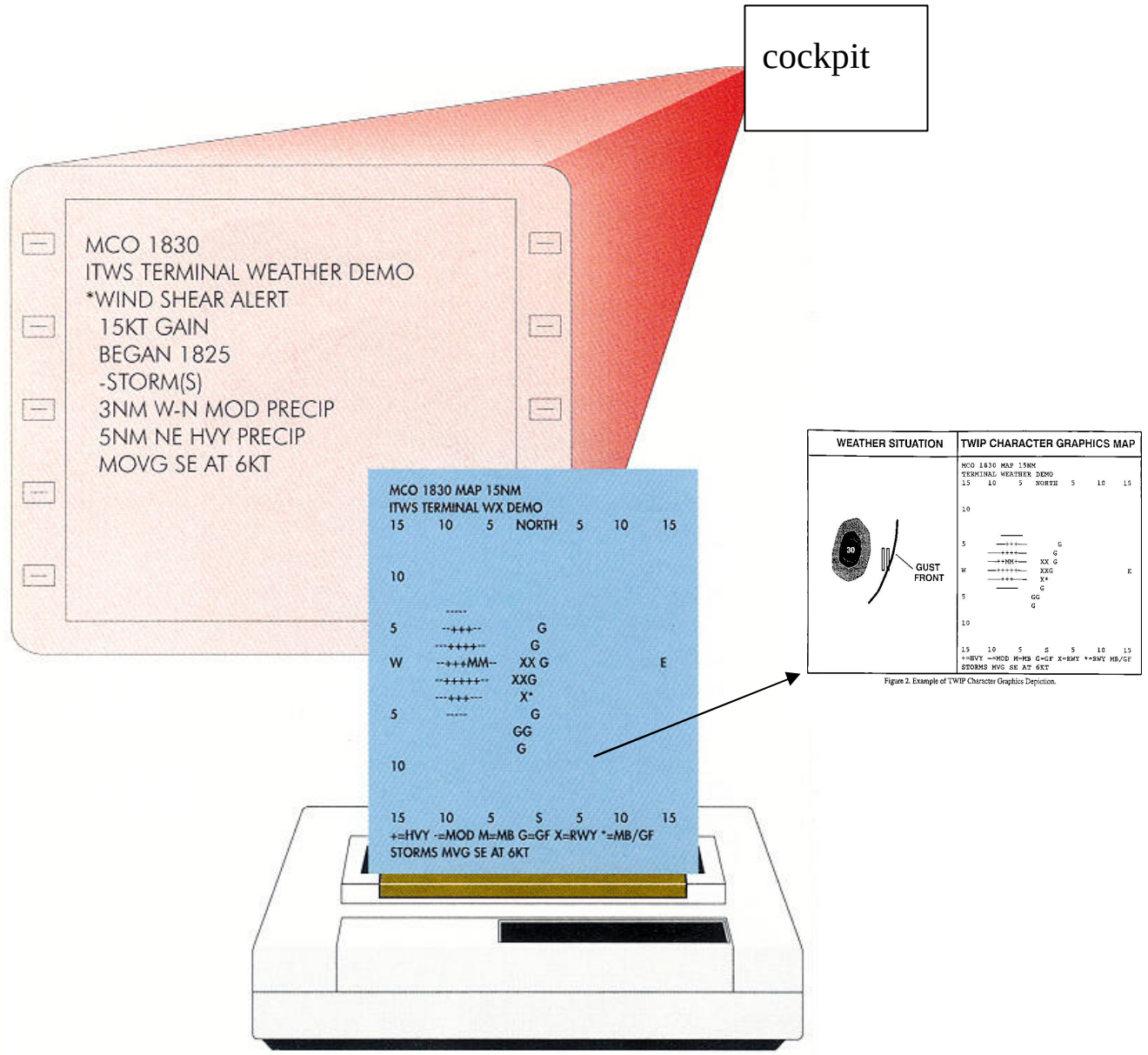

Figure 5. Sample “TWIP” messages in US:

(a) text messages (on-screen version) – upper left corner

(b) character graphics (printed version) – middle

Considering that TWIP has been successfully implemented in the U.S. for uplinking TDWR information to the cockpit and the corresponding procedures are already in place for a number of U.S. carriers, HKO sought the collaboration of the Northwest Airline (NWA) to test the capability to uplink the alphanumeric microburst and windshear alerts generated from the Hong Kong TDWR to NWA aircraft operating at HKIA (Fahey et al, 2006). To date, testing of the generation of TWIP messages from the TDWR alerts (Figure 6), and ground-ground transmissions of TWIP messages from HKO to NWA host computer via the ARINC AviNet Mail service have been successfully conducted. It is planned that operational trial uplink to NWA aircraft will commence during the peak windshear seasons in spring and summer this year.

```
   0123456789012345678 9
0  VHHH 0429
1  TDWR TERMINAL WS INFO
2  *MICROBURST ALERTS
3  TDWR ALERT
4   30KT LOST
5   BEGAN 0430
6
7
8
9
```

Figure 6. Sample TWIP microburst alert generated from the Hong Kong TDWR

3.3.2 Uplink of graphical weather products

Apart from the uplinking of textual windshear alerts mentioned in Section 3.3.1 above, a number of recent developments in weather information uplink are taking place around the world. In particular, model templates for the graphical display of SIGMET information of en-route hazardous weather (including volcanic ash, tropical cyclones and other hazardous weather such as icing, turbulence and thunderstorms) have been developed for incorporation

into the international standard of ICAO and WMO. In particular, the model template for tropical cyclone SIGMET (Figure 7) was developed by HKO (Wai, 2005). Concurrently, HKO has also been tasked by ICAO to develop model template for future uplink of graphical windshear and turbulence products. Work is also being progressed in the development of guidance material for the display of meteorological information in the cockpit.

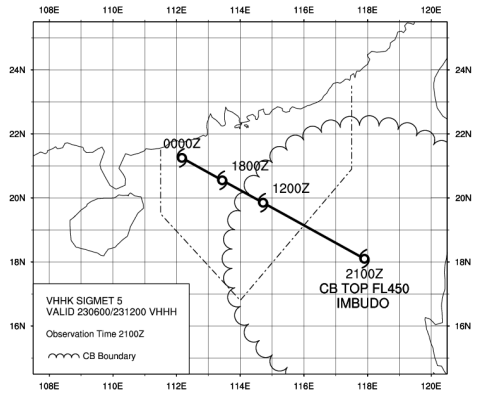

Figure 7. Graphical tropical cyclone SIGMET model template formulated by HKO.

3.3.3 Communication channels for uplink

Since more weather products, especially those in graphical format, are planned to be made available in the future, communication channels with wider bandwidth for uplink would be required. Due to the limitation of the air-ground ACARS VHF communications bandwidth (2.4 kbps), only simple text-based information such as D-ATIS, D-VOLMET and TWIP could currently be uplinked. In view of this, ICAO accepted HKO's proposal to identify a datalink to support future uplinking of graphical weather information (Shun, 2005) and to develop relevant international standards and guidance to facilitate implementation. One possibility is the new VHF Digital Link (VDL) - Mode 2 which has a larger bandwidth (31.5 kbps) and is being progressively implemented in parts of North America, Europe and Asia. Another possibility is the commercially available Internet service which has already been launched by a number of airlines for use by in-flight passengers.

4 Conclusion

The new uplink and downlink technologies offer unprecedented opportunities for meteorological services to transmit real-time weather information to and from aircraft-in-flight for enhancing aviation weather services and ultimately safety, efficiency and regularity of aviation. Their applications and values in windshear alerting at HKIA are demonstrated. HKO will continue its efforts in developing other weather information uplink applications to suit the needs of airlines and pilots, taking into consideration the latest available technologies and international standards.

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