INTERNATIONAL CIVIL AVIATION ORGANIZATION

WORLD METEOROLOGICAL ORGANIZATION

MET/14-IP/11
CAeM-15/INF. 11
9/5/14
English only

Meteorology (MET) Divisional Meeting (2014)

Commission for Aeronautical Meteorology Fifteenth Session

Montréal, 7 to 18 July 2014

Agenda Item 2: Improving the safety and efficiency of international air navigation through enhanced meteorological service provision

2.2: Enhanced integrated meteorological information to support strategic, pre-tactical and tactical operational decision-making from 2018 (including ASBU Module B1-AMET)

NOWCASTING SERVICES TO SUPPORT AIR TRAFFIC FLOW MANAGEMENT AND AIRPORT OPERATIONS AT THE HONG KONG INTERNATIONAL AIRPORT

(Presented by China)

SUMMARY

This paper presents the aviation nowcasting services in Hong Kong, China, for the provision of near-real time weather information in support of air traffic management (ATM) as well as airport operations in line with aviation system block upgrade module B1-AMET. This paper also exemplifies how aeronautical meteorological (MET) information providers, in collaboration with ATM users, can help translate MET information into aviation constraints and assist in impact assessment for aviation decision-making.

1. INTRODUCTION

1.1 ICAO has developed an Aviation System Block Upgrade (ASBU) methodology to achieve a harmonized upgrade of the air navigation services in a systemic manner. ASBU Module B1-AMET aims at reliable identification of air traffic management (ATM) solutions, through ATM and aeronautical meteorological (MET) integration, when forecast or observed MET conditions impact aerodromes or airspace. The decision-time horizons range from minutes to several hours of the ATM operation (this includes optimum flight profile planning and tactical in-flight avoidance of hazardous MET conditions). There are four elements in ATM-MET integration, namely 1) MET information, 2) MET translation, 3) ATM impact assessment for MET, and 4) informed decision (MET/14-WP/9| CAeM-15/Doc.9, Appendix A refers).

1.2 In support of ICAO ASBU initiative, CAeM of WMO has established an Expert Team on Meteorological Services to ATM (MSTA) and Meteorological Information Exchange (ET-M&M). ET-M&M was tasked to identify and propose candidate MSTA in response to user needs and in coordination with ICAO. Demonstration projects that fit nicely to ASBU Module B1-AMET were carried out to ensure that the products/services are grounded on sound scientific basis.

1.3 In support of ET-M&M demonstration project and to lay the groundwork for ASBU B1-AMET implementation in Hong Kong, China, the Hong Kong Observatory (HKO), as the MET authority providing aviation weather services in Hong Kong, China, developed a number of tailor-made convection and lightning nowcasting products and services to support air traffic flow management (ATFM) and airport operations respectively. The traditional convection nowcasting product has been translated into various impact levels on aircraft operation for ATFM to forecast the airport and airspace capacity. The airport lightning nowcasting product has also been integrated with the airport lightning warning system for alerting ground operators of approaching lightning strokes. This paper presents the latest development in Hong Kong, China in providing additional MET information on significant convection and the presentation of the translated information to support ATFM.

2. ATFM CONVECTION NOWCASTING MET INFORMATION

Runway capacity estimation

2.1 Convective weather over the airport, on final approaches, and base area can significantly affect the runway capacity. Apart from the need for aircraft to avoid the convective weather, when the weather conditions deteriorate below specific criteria, the mode of the parallel runway operation at the Hong Kong International Airport (HKIA) will have to be changed from independent mode to dependent mode. The airport acceptance rate (AAR) will thus be affected. TAF, the current MET product defined under ICAO Annex 3, focuses mainly on the aerodrome traffic zone (ATZ) and does not cover the approach airspace. MET products focusing on these weather thresholds will facilitate the ATFM to predict the AAR as well as ATC to determine the runway operation mode.

2.2 The aviation thunderstorm nowcasting system (ATNS) developed by the HKO is a system specifically tailored for the above purposes. The core of ATNS is a nowcasting system developed by HKO which can automatically track the past movement and forecast the future location of storms. Successfully demonstrated in international demonstration projects organized by WMO for significant high-profile events, e.g. for the 2008 Beijing Olympics and 2010 Shanghai World Expo, it was adapted for aviation application to provide forecast of thunderstorm activities at specific flight routes or significant areas/points in the airspace for the next 60 minutes (Figure 1). The output of the system is disseminated to the Hong Kong Civil Aviation Department (CAD), viz. the ATS authority in Hong Kong, China, for overlaying on their new generation flight control system. Besides, the forecast from ATNS is used for generating the 1-hr convection nowcast for arrival/departure corridors (Figure 2). These forecast products are updated automatically every 6 minutes.

Airspace capacity estimation and application of flow control measures

2.3 There are three primary holding areas (namely ABBEY, BETTY and CANTO) for arriving aircraft to HKIA in the terminal airspace (blue circles in Figure 3). Inclement weather in these holding areas will reduce the airspace capacity significantly. Even though Hong Kong, China has established various contingency holding patterns to handle the issue tactically, these measures are not adequate when Hong Kong FIR (HKFIR) is covered by extensive convection. MET products to forecast whether inclement weather will affect these holding areas are necessary to determine whether ATFM measure is required. Whenever application of flow control measures is required to balance the arriving traffic demand and airport/airspace capacity, it is always better if the aircraft can be held on ground at the departure aerodromes. With a catchment area of 1 500 NM from HKIA, ATFM endeavours to provide 4 to 6 hours advance notice to upstream ACCs and airlines through a capacity notification before the application of flow control measures. MET products with similar lead time are required.

2.4 HKO developed an extended nowcasting system named RAPIDS to predict up to 6 hours ahead any significant convection development in the vicinity of HKIA and the nearby airspace. RAPIDS blends the extended ATNS with high resolution regional numerical weather prediction (NWP) model forecast to obtain 1 to 6 hours ahead significant convection nowcast (Figure 4). The 6-hr forecast product is finer in temporal resolution in the first 3 hours, reduced to hourly forecast for the next 3 hours. RAPIDS focuses mainly the aerodrome area and the above mentioned three critical holding areas. The nowcast is generated automatically and updated every hour. The products can also be adjusted manually by the aviation weather forecaster when necessary.

Translation of nowcasting products into aviation impact

2.5 To facilitate decision-making by ATC and ATFM Unit (ATFMU), the above nowcasting products are translated into three levels of colour code representing the various impacts to air traffic, viz GREEN for mild or no impact, AMBER for medium impact and RED for significant impact. This helps the ATC/ATFMU to quickly assimilate the potential impact on air traffic caused by adverse weather so that they can take immediate responsive actions. The objective thresholds for defining different colour levels are different across various nowcast products and are fine-tuned based on user feedback, historical cases and aircraft weather avoidance studies (see MET/14-IP/15|CAeM-15/INF. 15).

2.6 For easy access to all of the above products, a web-based integrated display, named Significant Convection Monitoring and Forecast, has also been developed to provide a "one-stop shop" for ATC/ATFMU (Figure 5). Based on the information available on the integrated display, aviation weather forecasters will conduct weather briefings twice a day with ATM on the possible weather impact to air traffic in the HKFIR to facilitate flow management and the issuance of the capacity notification. The information, together with the capacity notification message issued by ATM, is made available to airline users through a dedicated website to facilitate collaborative decision making (CDM). The sharing of the briefing video with airline users will be considered in the future.

3. AIRPORT LIGHTNING NOWCASTING MET INFORMATION

3.1 To secure the safety of airport ground staff from being struck by Cloud-to-Ground (CG) lightning strike at HKIA, the AAHK operates an airport lightning warning system (ALWS) over HKIA. In this regard, HKO developed a lightning nowcasting system named Airport Thunderstorm and Lightning Alerting System (ATLAS) and integrated it with ALWS to issue the lightning warnings via ALWS automatically. If CG is predicted within 5 km from the airport reference point (ARP) or detected within 10 km, ATLAS will issue the AMBER lightning alert. If CG is predicted or detected within 1 km from the boundary of defined zones (zone A and B, see Figure 6) within the airport island, ATLAS will issue the RED lightning alert. Whenever ATLAS issues an alert, ALWS will immediately issue light signal and audio alarm (siren) over the HKIA. When AMBER alert is in force, all non-essential activities on apron areas will be suspended. When the RED alert is in force, all apron staff must take countermeasures immediately and passengers need to stay in safe areas.

3.2 Figure 7 shows a schematic diagram of ATLAS. ATLAS combines the weather radar data and the lightning location data from HKO's lightning location information system (LLIS) to detect and nowcast the future movement of CGs in the vicinity of HKIA. It consists of two modules, namely the detection module and the prediction (nowcasting) module. The detection module gets the latest information (position and type) of each lightning stroke from LLIS. The nowcasting module, based on tracking of radar echoes, automatically predicts up to 12 minutes ahead the future positions of lighting strokes using sophisticated artificial intelligence and ensemble techniques. Depending on the detected or forecast positions of the CGs, ATLAS issues the RED or AMBER lightning alerts for each zone.

3.3 ATLAS was first put into operation in March 2008 without zoning after a full year of verification and fine-tuning of the algorithms to maximum the system performance to ensure it meets the airport users' needs. To further reduce the interruption to airport operation while maintaining an acceptable level of performance to ensuring safety of personnel, zoning (i.e. zone A and B) was introduced in 2013 at the request of AAHK. The zoning scheme successfully reduces the alert duration by 5 hours (one-third) compared with that without zoning. Meanwhile, it maintains a high hit rate of above 90% for both zones (RED alert).

3.4 From past experience, when RED alert, especially for Zone A, was in force for more than 30 minutes at HKIA, all airport ground operation would effectively put to a halt and hence bring significant impact to the capacity of the airport. Effort is underway to include ATLAS in the airport collaborative decision making (ACDM) system. One of the main outputs of ACDM is more accurate target take-off times, which focuses on the aircraft turn-round and pre-departure sequencing process. With input from a system such as ATLAS, the level of availability of ground resources could be objectively calculated based on the lightning procedures (with respect to AMBER and RED) set out by ground handlers and other stake holders, hence facilitating the optimised utilisation of resources to reduce delays.

4. CONCLUSION

4.1 The paper presented a number of recent developments in the provision of MET information on significant convection at HKIA. The products/services, as well as the method of presentation, are the result of collaborative efforts between MET and ATM in Hong Kong, China and are very much welcomed by local ATM and other airport operators. Local ATM users comment that the significant convection nowcasting products/services help them regulate the air traffic, thus achieving more efficient airspace operations. The local airport authority also compliments that the lightning nowcasting products help protect ground safety while maintaining efficient aerodrome operations under inclement weather. Regular meetings and workshops are held to facilitate closer understanding between frontline MET and ATM staff and to exchange views on future development of these products.

4.2 The provision of MET information on significant convection in Hong Kong, China highlights the importance of the local observation and high resolution regional NWP data capabilities possessed by many MET services nowadays in the prediction of high-impact weather. The local knowledge of the operation environment and close interaction with the downstream users by the MET services are important to ensure that the services provided is fit for purpose, credible and meet user expectation. These are expected to become even more important in the future as aviation weather services evolve under the ASBU.

5. ACTION BY THE MEETING

5.1 The meeting is invited to note the information contained in this paper.

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APPENDIX

METEOROLOGICAL SERVICES TO ATM (MSTA) FUNCTIONAL DISPLAYS

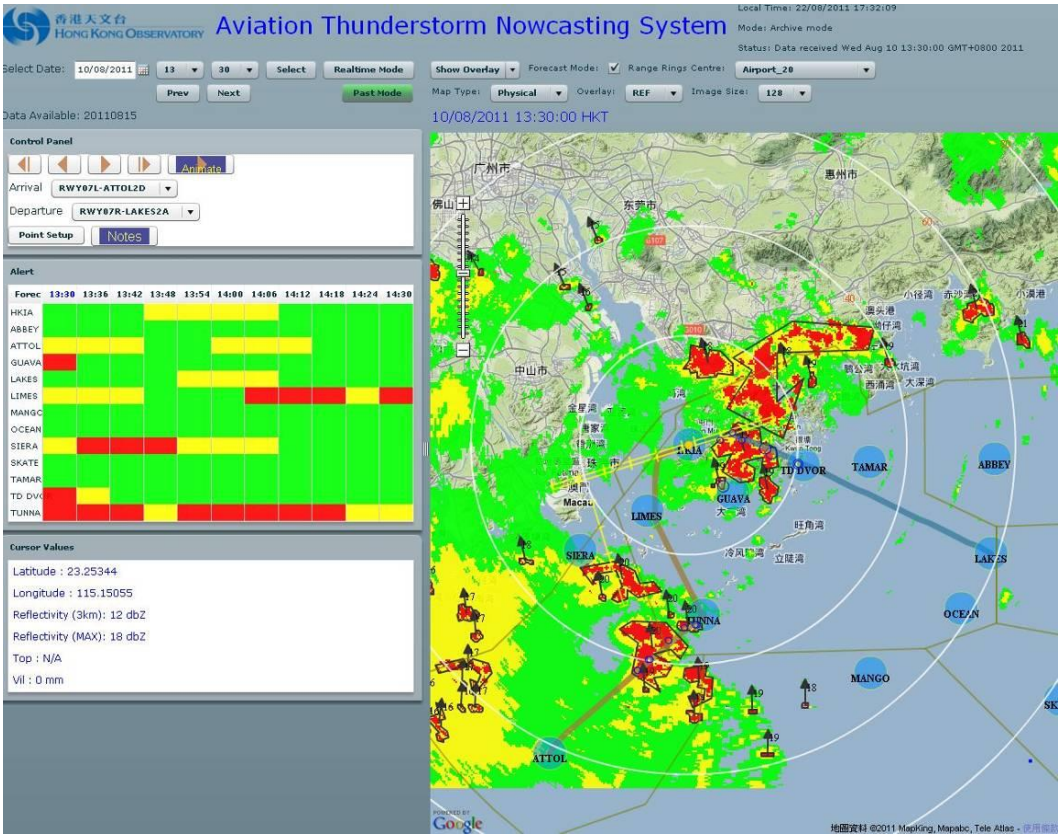

Figure 1. The display panel of the Aviation Thunderstorm Nowcasting System (ATNS)

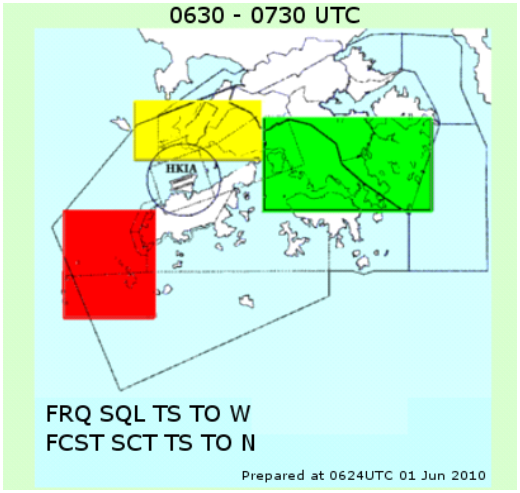

Figure 2. 1-hr convection nowcast for arrival/departure corridors

In this example, the box to the West has changed to Red, indicating that intense convection is affecting or to affect the arrival (departure) area for runway 07(25). The box to the North has changed to Amber, indicating that less intense convection is affecting or to affect the miss-approach area for the northern runway (07L/25R). The box to the East remains in Green, suggesting that no significant convection will affect the arrival (departure) corridor for runway 25(07).

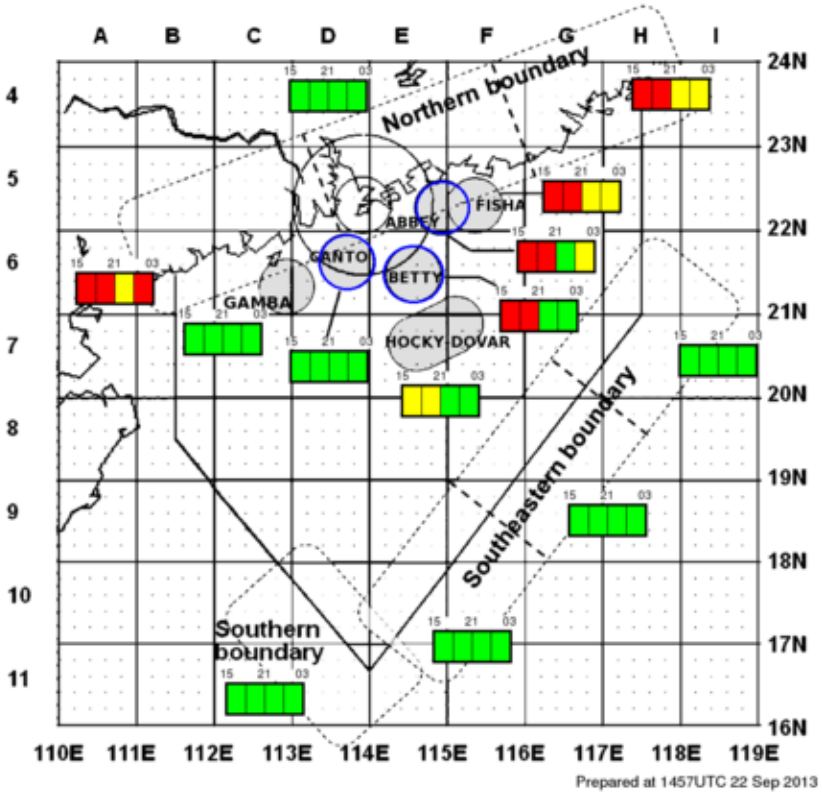

Figure 3. 12-hr significant forecast time series for key ATC areas

Blue circles represent the 3 primary holding areas for arriving aircraft to HKIA in the terminal airspace. The bigger red circle represents the holding patterns with a 20NM radius.

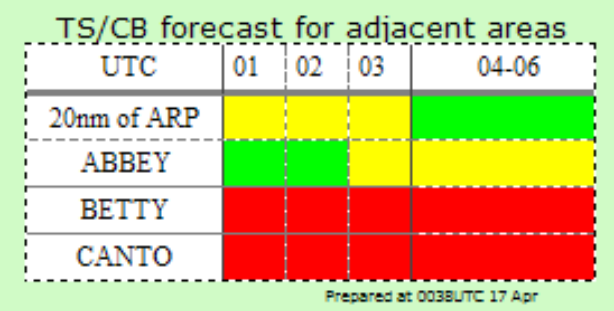

Figure 4. 6-hr convection forecast for the aerodrome area and critical holding areas for entering the HKIA

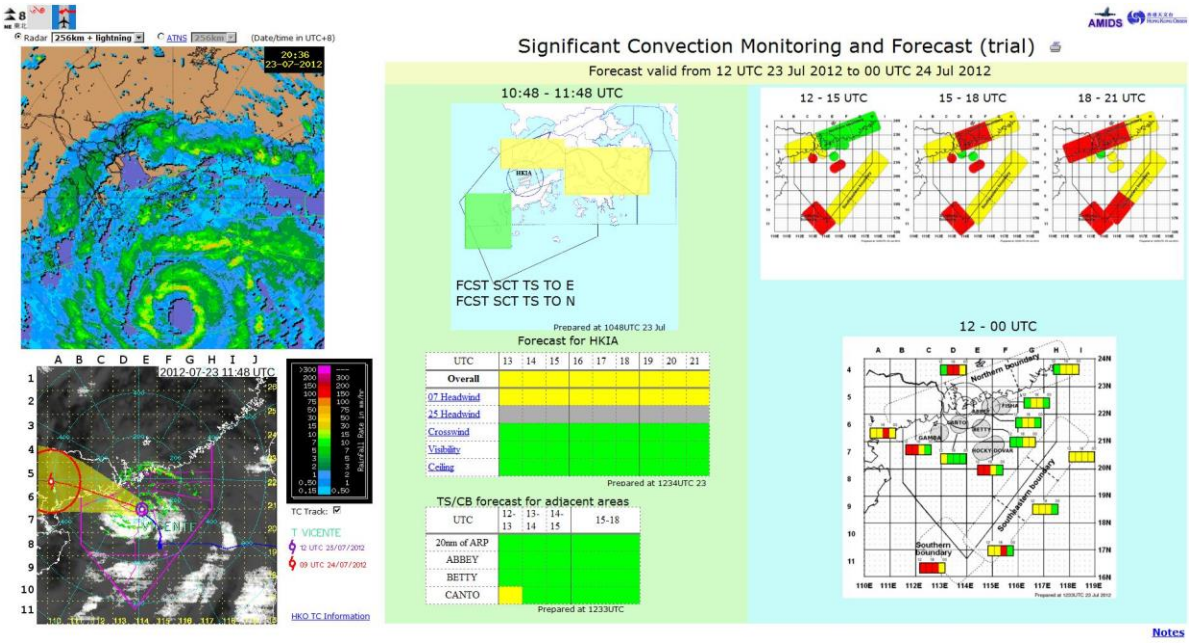

Figure 5. Integrated web display of the significant convection monitoring and forecast suite

The above screen was captured during the passage of Severe Typhoon Vicente in July 2012.

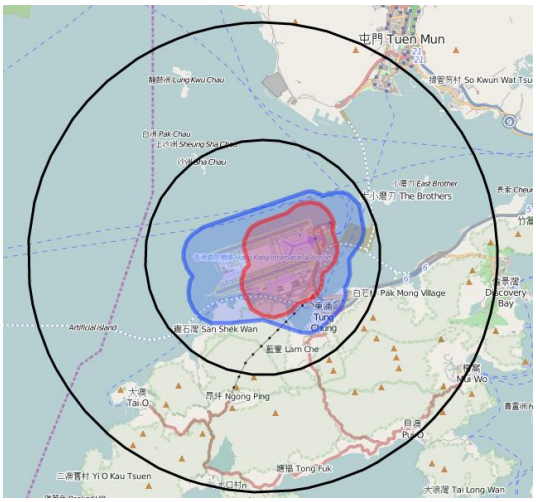

Figure 6. The alert areas of ATLAS

The black circles respectively represent 5 km and 10 km radius from the airport reference point; the red polygon encloses the warning area for the passenger terminal and cargo terminal (Zone A); while the blue polygon outlines the area 1 km from the boundary of the airport island (Zone B by excluding Zone A).

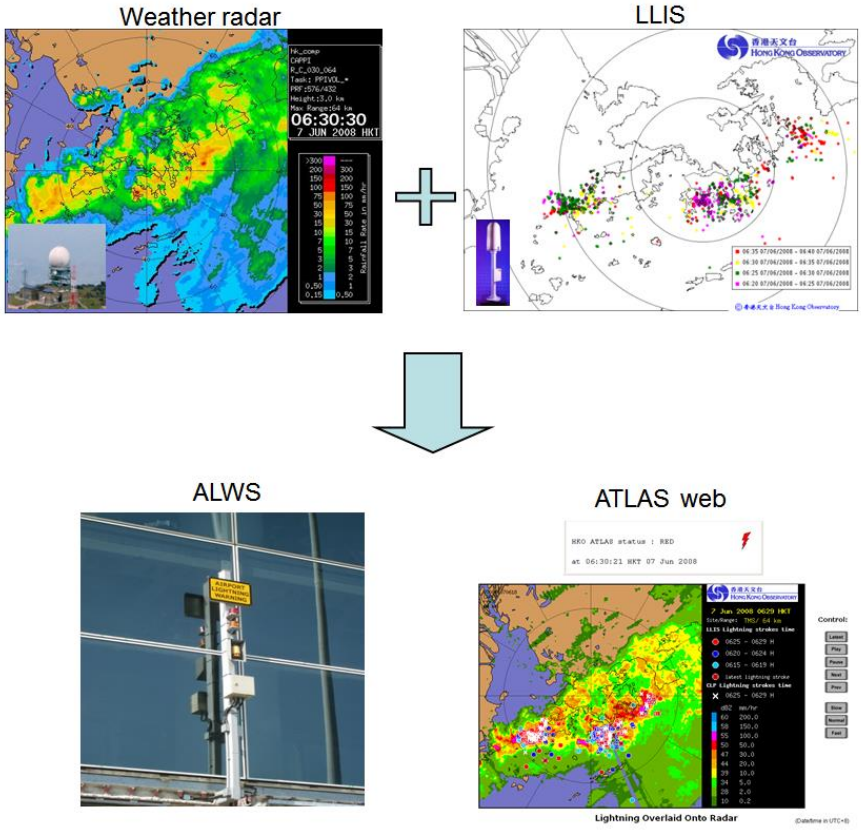

Figure 7. Schematic diagram of ATLAS

ATLAS tracks the movement of radar echoes for predicting the CG lightning strokes and trigger the ALWS to issue AMBER or RED lightning warning for HKIA (bottom figures).

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