International Civil Aviation Organization

INFORMATION PAPER

Tenth Meeting of the Asia/Pacific Meteorological Requirements Working Group (MET/R WG/10)

Virtual Meeting (Online), 24 – 28 May 2021

Agenda Item 5: Coordination between MET and ATM services

ASSESSING THE IMPACT OF CONVECTIVE WEATHER ON AIRPORT DEPARTURE RATE

(Presented by Hong Kong, China)

SUMMARY

This paper presents a study on modelling the impact of significant convective weather on Airport Departure Rate (ADR) at Hong Kong International Airport (HKIA).

1. INTRODUCTION

1.1 Significant convective weather along the departure route could have a notable impact to the Airport Departure Rate (ADR), which could in turn affect the turnaround of aircraft, availability of parking stands and arrival capacity. If the significant convective weather persists for some time, it might even lead to apron full situation. The following sections introduce an algorithm developed by Hong Kong, China to estimate the reduction in ADR arisen from significant convective weather near HKIA. Applicability of the algorithm was evaluated via case review.

2. DISCUSSION

Assessment of convective weather in departure zones

2.1 This study focuses on ADR estimation for Runway 25 of HKIA. Figure 1 shows the departure route of Runway 25 and the associated funnel-shaped departure zone near HKIA for this ADR study. As shown in Figure 1, zone D1 is the foremost zone traversed by an aircraft after take-off. After passing zone D1, the aircraft can go through either zone D2 (primary) or zone D3/D4 depending on the distribution and strengths of the convection.

2.2 Weather radar data every 6 minutes was used to assess the severity of convective weather activities in the above departure zones. The intensity of the convection is given by the radar reflectivity (in dBz) at that location. The convective activity is considered to be more severe if the intensity is higher and covers a larger area. Thus, in this study, 80th-percentile reflectivity (REF80%) of each of

the four departure zones was calculated to represent the severity of convective weather over the respective zones and serve as the basis to assess the impact in terms of the reduction of ADR.

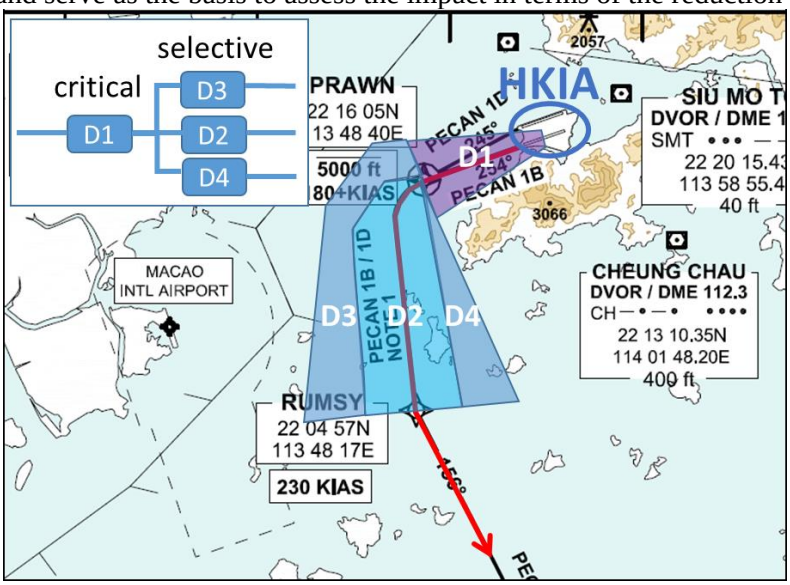

Figure 1: Departure Zones (D1, D2, D3 and D4) for RUNWAY 25 at HKIA

The rules and algorithms

2.3 Nature of the departure queue is different from that for arrivals. While hourly arrivals would depend on decisions of all pilots affected by weather in the terminal area, decision of the first pilot at the departure queue would have a determining effect to hold the movement of the queue, similar to the scenario of "traffic jam on a one-way track". A departure hold during a period would result in a sharp decrease in the ADR, so the ADR drops non-linearly with weather severity in the departure zones.

2.4 The non-linear ADR reduction factors used in this study against weather severity, as represented by 80th-percentile of radar reflectively within a particular zone (D1/D2/D3/D4), is shown in Figure 2. Two relationships of ADR reduction factors were constructed, one with more significant ADR reduction for "more severe" scenarios and another one with less reduction for "less severe" scenarios. A departure zone is considered under a "more severe" scenario is in this study if 95th-percentile of radar reflectively (REF95%) in the zone exceed or equal to 41dBz.

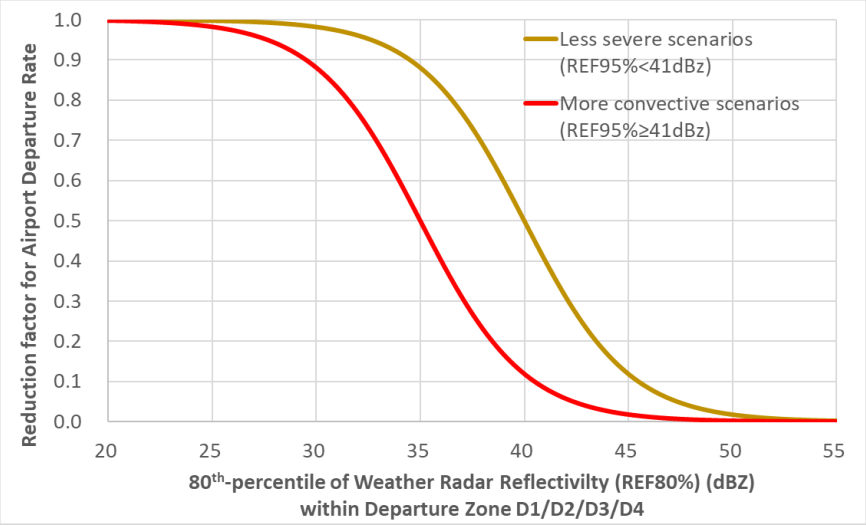

Figure 2: ADR reduction factors for less severe (light brown) and more severe (red) scenarios.

2.5 Normal ADR of HKIA is about 34 departures per hour in daytime. To tie in with the 6-minute update rate of weather radar data, the reference number of departures every 6 minutes is taken which is 34/10 = 3.4 and the estimated number of departures within the four zones in 6 minutes is as follows:

Estimated number of departures in a zone
= (reference number of departures) x (ADR reduction factor based on REF80%)

2.6 Since all flights go through zone D1 while zone D2/3/4 is selective as illustrated in Figure 1, the overall estimated departure number in 6 minutes is determined as the smaller number of the following to reflect the blockage due to weather in zone D2/3/4:

- number of departures in zone D1
- the highest number of departures in zone D2/D3/D4

An 18-minute reaction time is added in counting the estimated number of departures to cater for the observed delay in ADR response.

Case review

2.7 The above algorithm for estimating ADR was evaluated using past cases with results given in the Appendix. In Case 1, convective weather affected HKIA on 4 June 2019, significant convection in zone D1 induced blockage and sharp decrease in actual ADR since 17:00 (local time) and the actual ADR started to resume from 18:00 onwards. The algorithm for estimating ADR could generally capture the timing of the ADR change and the minimum ADR of around 5 departures in the episode.

2.8 In Case 2 on 11 June 2019, significant convection started to affect zone D1 around 17:00 but the intense echoes moved away from the departure zones faster than that in Case 1, resulting in a less reduction in ADR which could also be captured by the algorithm for ADR estimation. The grey line in the ADR time series shows the ADR estimation without applying ADR reduction factor for "less severe" scenario, which deviated from the actual ADR during 18:30-20:00. This case shows that the broad coverage of around 35dBz had little impact on ADR. This was also the motivation for introducing two reduction factors (Figure 2) in the algorithm, which could capture better the actual ADR (green line in ADR time series).

2.9 In Case 3 on 20 April 2019, the algorithm captured significant drop of actual ADR during 14:00-15:30 due to impact of the broad band of intense convection on the departure zones. However, it was noticed that actual ADR was held at about 20 for around 2 hours even after the convection had departed, which might be caused by blocking effects outside the departure zone D1-D4 (such as the echo to the south) and other non-weather factors.

The way forward

2.10 As shown in the study cases, ADR changes could largely be explained by significant convection as expressed by the above ADR reduction algorithm. Some other factors such as distribution and structure of the convection, blockage outside the departure zones D1-D4, and other non-weather factors may also affect the ADR such as the long-holding at moderate ADR on 20 April 2019. Relative contribution of these factors in other cases would be a point of further study. Meanwhile, a study on ADR reduction for Runway 07 of HKIA would be conducted.

2.11 A tool showing 2-hour ADR forecast for Runway 25 of HKIA based on actual radar data and nowcasting from an Aviation Thunderstorm Nowcast System (ATNS) was developed and put under evaluation since early 2021.

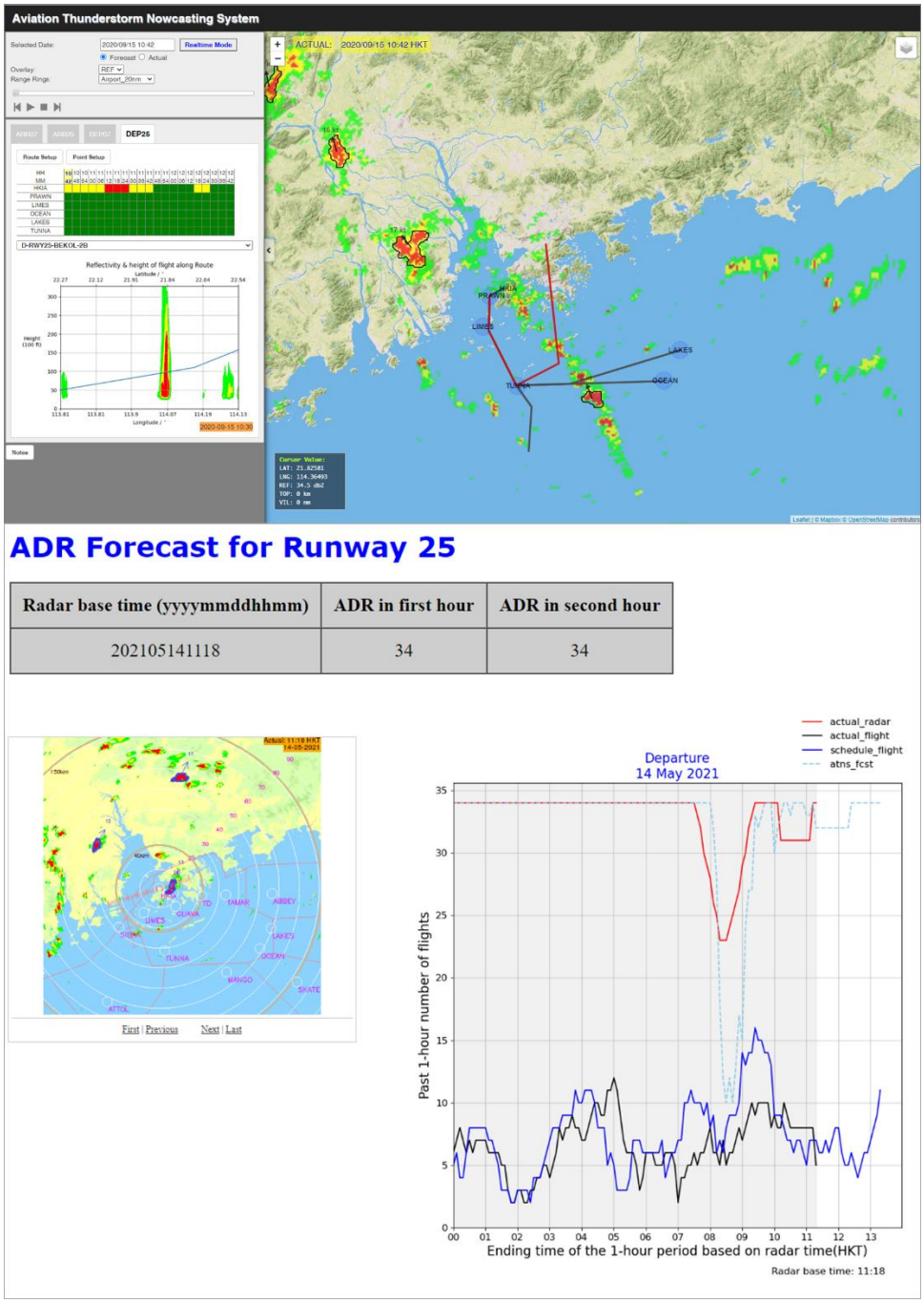

Figure 3: (Upper) Aviation Thunderstorm Nowcast System (ATNS); (Lower) A prototype of ADR forecast tool for HKIA

3. ACTION BY THE MEETING

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

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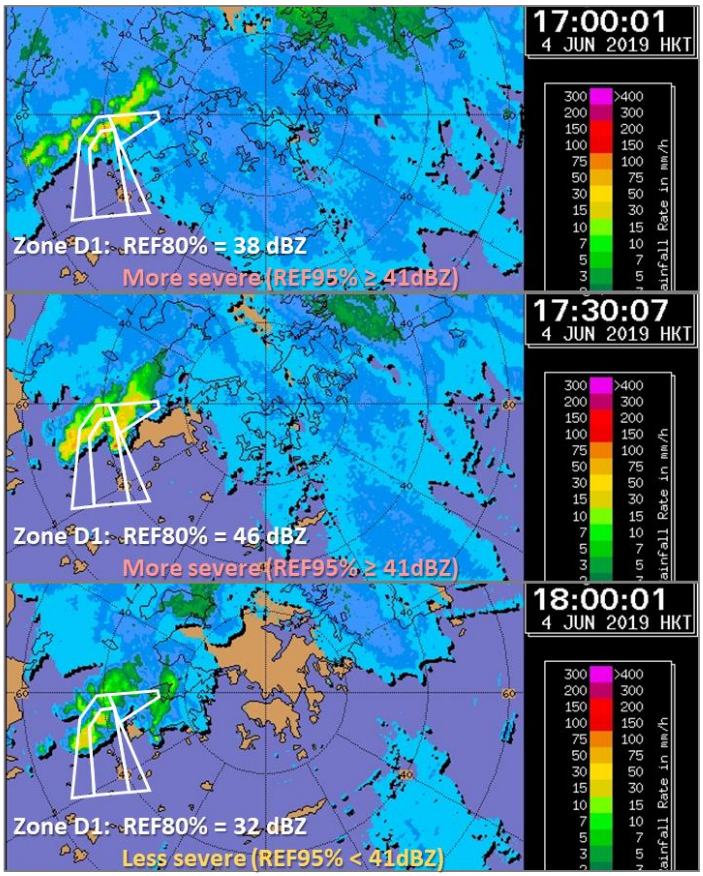
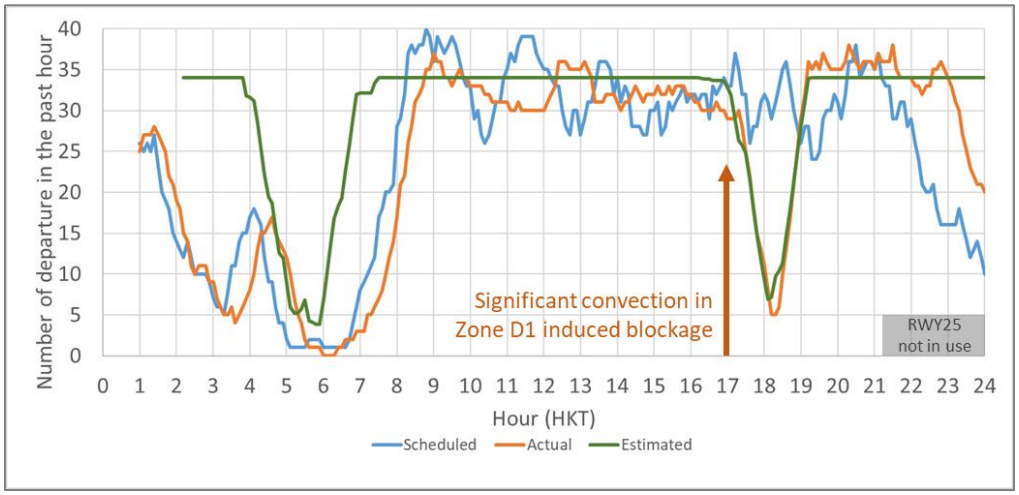
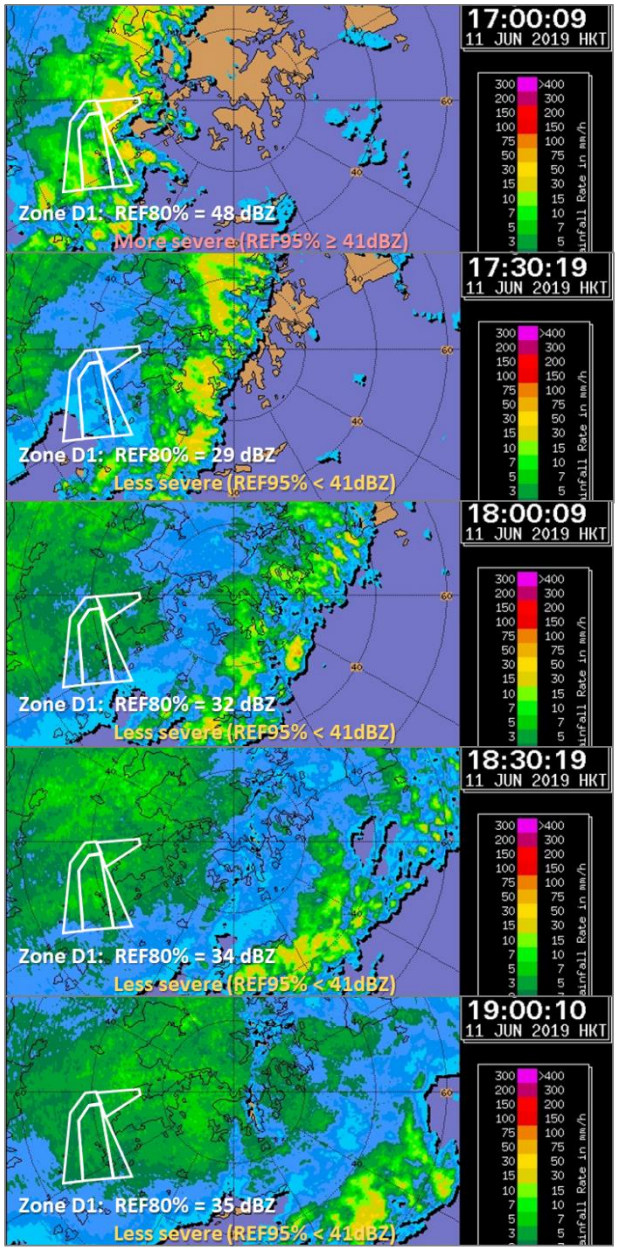
Appendix

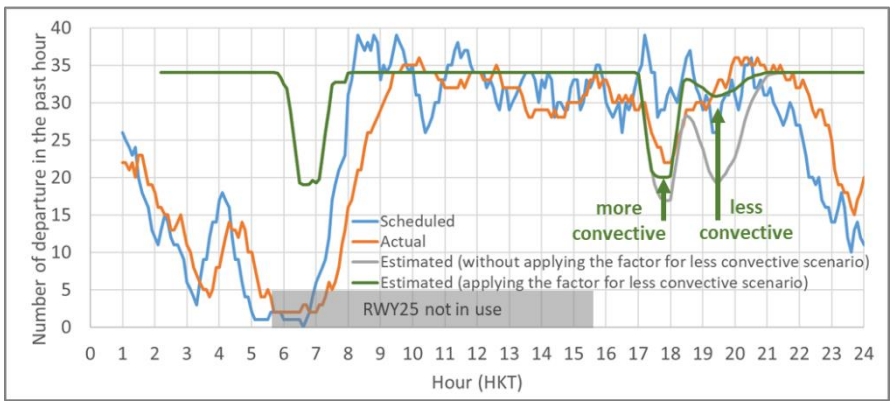
Case 1 - Convective weather affecting HKIA on 4 June 2019. (a) Weather radar images; (b) Comparison of estimated ADR and actual ADR.





Case 2 - Convective weather affecting HKIA on 11 June 2019 (a) Weather radar images; (b) Comparison of estimated ADR and actual ADR.





Case 3 - Convective weather affecting HKIA on 20 April 2019 (a) Weather radar images; (b) Comparison of estimated ADR and actual ADR.