International Civil Aviation Organization

METEOROLOGICAL/AIR TRAFFIC MANAGEMENT (MET/ATM) SEMINAR

Tokyo, Japan, 29 June – 1 July 2015

Agenda Item 3: ATM-tailored meteorological services

WEATHER PHENOMENA AFFECTING AIR TRAFFIC MANAGEMENT OPERATIONS

(Presented by Japan)

SUMMARY

This paper presents characteristics of weather phenomena that have significant influences on air traffic management. It is derived from case studies in Japan, and could be used as a reference for making guidance material on the requirements of meteorological services to support ATM.

1. Introduction

1.1 Since February 2006, Air Traffic Meteorology Center (ATMetC) of Japan Meteorological Agency (JMA) has provided direct and wide-ranged support to Air Traffic Management Center (ATMC) of Japan Civil Aviation Bureau (JCAB), which manages the entire air traffic network within Fukuoka FIR. Since circumstances of major airports have a significant effect on air traffic management, precise and pin-pointed weather observation and forecast around such airports are required. Also, detailed briefing on significant weather and its possible impact on air traffic flow within wide airspace, including major air-routes, are needed at the same time. Forecasters at ATMetC assess whether expected significant weather will affect air traffic management, predict when such significant weather will occur/end, and provide briefings for air traffic flow management officers. ATMC manages air traffic flow for both airports and airspace in Fukuoka FIR with utilizing the information and briefings provided by ATMetC. For further information on the services of ATMetC, please refer to: http://www.icao.int/APAC/Meetings/Pages/2011-metatm-seminar.aspx

2. ATM and Weather

2.1 Accurate information on weather phenomena which affect air traffic flow is necessary for supporting ATM. In particular, the information on weather phenomena which cause the “air traffic disorder”, such as takeoff and landing delays or widened separations, is highly important. There are seven airports selected which plays major roles in air traffic network in Japan as shown in Figure 1. Figure 2 shows the annual number of landings at the top five ranked airports. Figure 3 indicates the number of air traffic flow controls due to significant weather for each major airport in the warm season (from April to September) and the cold season (from October to March) . The most significant weather during the warm season is cumulonimbus (CB) and in the cold season, it is snowfall.

2.2 The number of air traffic flow controls at RJTT (Tokyo Intl. airport) is the largest among the seven major airports. The difference in numbers among these airports depends on the characteristics of significant weather at each airport. For example, since RJTT is the most congested airport in Japan, the frequency of controls is also higher than other airports. RJCC (New Chitose airport) is located in an area where snowfall occurs frequently, so air traffic flow controls were implemented mostly during the cold season.

2.3 Table 1 shows the number of air traffic flow controls at RJTT classified by the causes (weather phenomena). Convective weather like CBs and thunderstorms occurred within and around the approach control area, and lower winds (below 10,000ft), such as strong crosswind, strong low level wind and vertical wind shear, affected air traffic flow control the most.

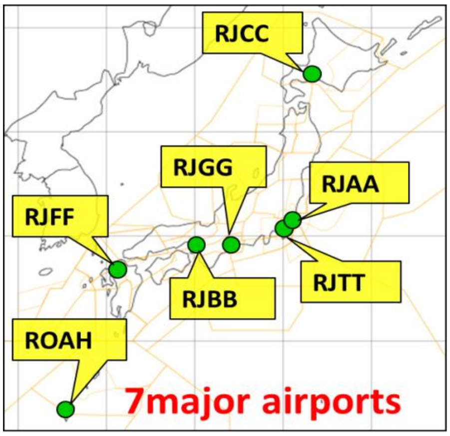


Figure 1. Seven major airports in Japan

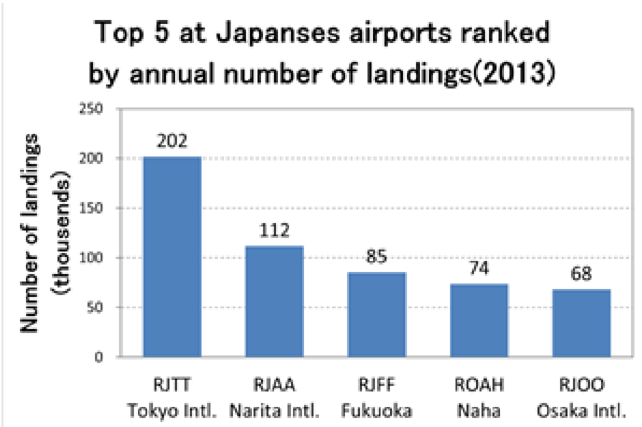
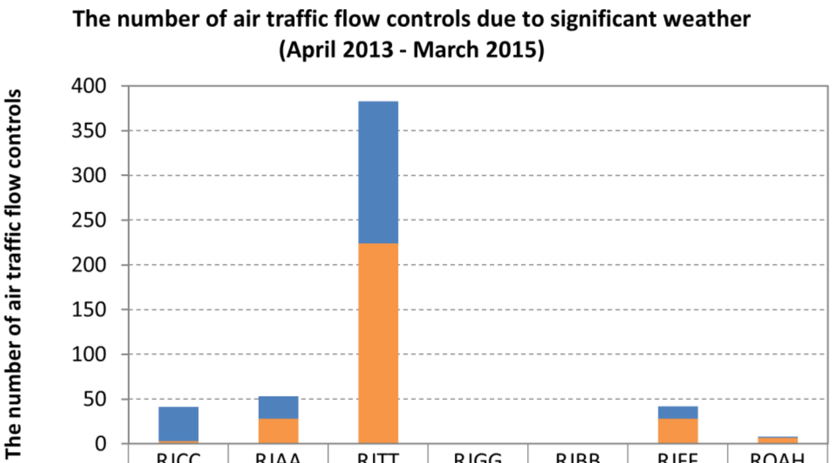


Figure 2. Top 5 at Japanese airports ranked by annual number of landings (2013)



	RJCC	RJAA	RJTT	RJGG	RJBB	RJFF	ROAH
Oct～Mar	38	25	159	1	0	14	1
Apr～Sep	3	28	224	0	1	28	7

Figure 3. The number of air traffic flow controls due to significant weather (April 2013 – March 2015)

Table 1. The number of air traffic flow controls at RJTT classified by the causes (weather phenomena)

Cause		Cold Season (Oct – Mar)	Warm Season (Apr – Sep)	Sum
TS	TS-OHD	4	23	27
	Around the airport	6	28	34
CB	Within the Approach Control Area	29	80	109
	Microburst Alert	2	0	2
	Around the Approach Control Area	42	57	99
Wind	Strong Crosswind	40	29	69
	Strong Low Level Wind	23	6	29
	Vertical Wind Shear (Wind change on approach course)	6	4	10
Snow	Snowfall	5	0	5
	Snow Removal	2	0	2
Others		0	1	1
Sum		159	228	387

3. Cases of significant weather which affected ATM.

3.1 This section shows four actual cases of air traffic flow control at RJTT due to significant weather. Detailed information is provided in the Attachment A.

<u>Case 1 - Strong Crosswinds at the Airport</u>

3.2 Weather conditions close to aircraft operation limitations at airports, such as strong crosswind, may affect ATM at and around the airport.

3.3 Each airline has established the limit values of crosswind speed for each aircraft type depending on the conditions of runway, so as not to let aircraft land and take off under difficult weather condition (See Table A-1 for example). When crosswinds are stronger than these limit values, aircraft approaching the airport have to do G/A, and this may sometimes lead to significant air traffic flow disturbance.

3.4 The case of air traffic flow control due to strong crosswinds on 22 October, 2014 at RJTT is shown in Attachment A-1. In this case, the condition of runway was stated as “NON-GROOVED” due to construction and also “WET” because of rainfall. Therefore, the limit value was relatively lower and the crosswinds exceeded this limit.

<u>Case 2 - CBs Within the Approach Control Area</u>

3.5 CB existing on final approach course or standard instrument arrival (STAR) affects ATM. As aircraft in their final approach cannot change routes significantly in order to avoid the CB (even if the CB is small), air traffic flow controls, such as restrictions on entering into the approach control areas, must be implemented. (See MET/ATM Seminar 2013 IP/6 about the impacts of CBs on ATM.) This may result in significant congestions and/or delays for entire air traffic across the nation.

3.6 The case of 13 September, 2014 is shown in Attachment A-2. In this case, CBs coming near Final Approach Fix of RJTT affected air traffic flow.

Case 3 - CBs Around the Approach Control Area

3.7 Significant weather around the congested airport affects air traffic flow even if such weather conditions do not occur at the airport itself. For example, when CBs exist around congested airport, more and more aircraft head to particular airspace or sector than usual in order to avoid the CBs, and controllers become less able to handle those increased number of flights in the airspace. Therefore, air traffic flow controls would possibly be implemented for aircraft approaching the airport.

3.8 The case of 1 September, 2014 is shown in Attachment A-3. In this case, CBs moved around the approach control area of RJTT affected air traffic flow.

Case 4 - Vertical Wind Change Around the Airport

3.9 Recently operational experience in ATMetC found the fact that great differences in wind speed/directions in a flight path within an approach control area could result in air traffic flow controls. For example, when strong tailwinds (more than 50kt) blow at an altitude of 10000ft (which is normal altitude that an aircraft enters in approach control area) whereas headwind blows near touch-down zone, separations between aircraft become narrower during their final approach. As air traffic controllers have to maintain consistent separations, the controllers would have to allow less aircraft land the airport. As a result, air traffic capacity decreases aircraft and finally air traffic flow controls are implemented.

3.10 The case of 21 April, 2014 at RJTT is shown in Attachment A-4.

4. Conclusion

4.1 Through four case studies of air traffic flow controls mainly caused by significant weather conditions at RJTT, described in Section 3, the following knowledge on what types of weather phenomena affect ATM at congested airports can be derived;

1. Weather conditions related to operation limitations, such as crosswind limitation
2. CBs existing in a flight path within an approach control area (even if they are small-scale)
3. CBs existing in a flight path around an approach control area
4. Great differences in wind speed and direction in a flight path within an approach control area. This makes it difficult for controllers to maintain appropriate separations in the approach control area

4.2 From ATMetC's 10-years operational experience on the MET support to ATM, it is suggested that both ATM officers and MET forecasters should pay attention to the occurrence of the weather phenomena listed above in a collaborative manner. And for MET forecasters, it will be important to provide precise and accurate weather information and detailed weather briefings on such phenomena and possible impact, in order to meet requirements from ATM officers and maintain safe and smooth air traffic flow as much as possible.

5. Action by the Meeting

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

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Attachment A

1. Strong crosswinds at Tokyo Int'l airport (RJTT) (22 October 2014)

Figure A-1. shows wind and weather (types of precipitation) in the morning of the 22nd at RJTT. Rain showers were observed from morning. From 00UTC, north east winds were getting stronger and the wind speed occasionally reached about 20kt.

Figure A-2. indicates the position and number of each runway at RJTT. North east winds are crosswinds for two runways (RWY34L/16R, RWY34R/16L). From 00 to 01UTC, crosswinds became stronger for the runways (the RWY34L and RWY34R were used at that time) and their conditions were "WET".

Examples of crosswinds limitations for major aircraft types are shown in Table A-1. When the condition of a runway becomes worse, the criteria for crosswind speeds decrease. Usually, the limit is 25kt in "WET" condition. However, as the condition of RWY34R/16L was "NON-GROOVED" on that day due to construction, the limit became 20kt for many aircraft approaching the airport. Therefore, around 00UTC two aircraft did G/A and many aircraft requested to land RWY34L, not RWY34R. As a result, capacity limit of RWY34L exceeded and air traffic controllers began to halt takeoff clearance for aircraft which assumed RJTT as the destination (Ground Stop) at around 0140UTC.

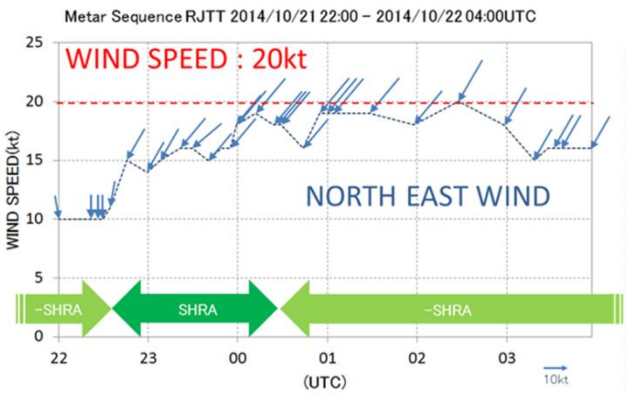

Figure A-1.
Wind and type of precipitation at RJTT

Blue broken line: actual wind speed
Blue arrow: actual wind direction

Figure A-2. The positions and numbers of runways at RJTT

Table A-1. Examples of cross wind speed limitations for major aircraft types

	limitations (kt)	
Condition of Runway	Airline A Aircraft-Type-I	Airline B Aircraft-Type-II
DRY	33	25
WET (GROOVED)	25	25
WET (NON-GROOVED)	20	20
WATER	10	10

2. CBs within the approach control area of RJTT (13 September 2014)

Figure A-3. shows the intensity of radar echo at 0400UTC on 13th. The CBs generated around PQD moved north and stayed around ARLON and CREAM (both are located around Final Approach Fix) from 0330 to 0500UTC.

Figure A-4. indicates the standard approach routes to RJTT. Red line (hereinafter "RJTTS") is the route for aircraft approaching from south, and blue line (hereinafter "RJTTN") is the one for aircraft approaching from north. When the weather is fine, RJTTS passes through KAIHO and leads to RWY34L, and RJTTN passes through CACAO and leads to RWY34R. When the weather is not fine, RJTTS leads to RWY34L by way of ARLON and RJTTN leads to RWY34R by way of CREAM.

In this case, the weather was not fine, the aircraft approaching from both south and north could not pass over between ARLON and CREAM to avoid the CBs and approached from KAIHO. The aircraft which avoided the CBs and headed to KAIHO are shown in Figure A-5 (indicated by red arrows). As the approach route leads to RWY34L, only RWY34L was used for all aircraft approaching to RJTT. As a result, holding occurred over XAC (indicated by yellow allow in Figure A-5) and TLD (blue arrow).

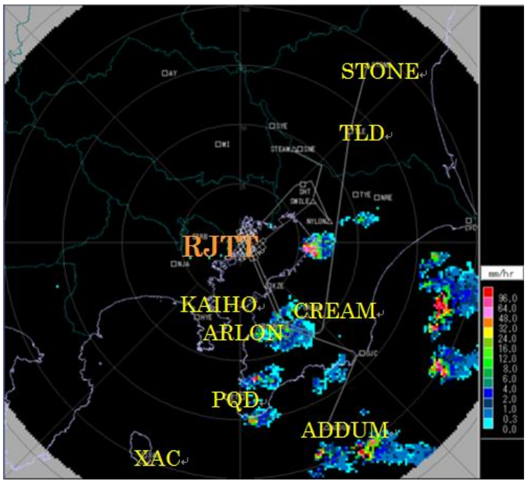

Figure A-3. Radar echo intensity and reporting points around RJTT (04UTC, 13th)

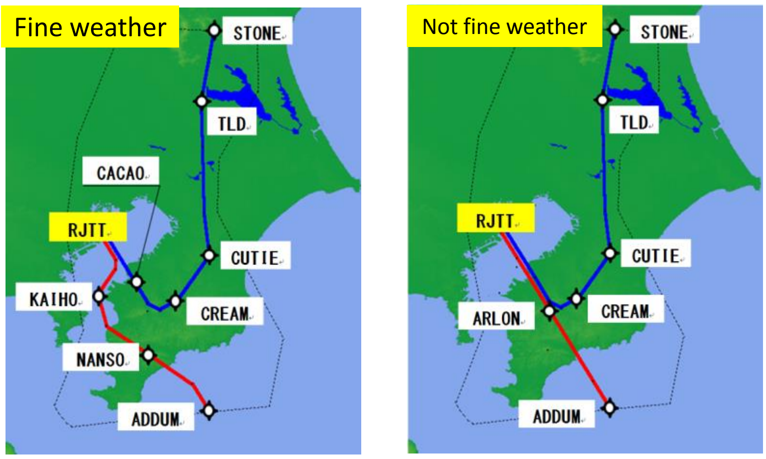

Figure A-4. Example of usual approach route for RJTT
(left: fine weather right: not fine weather)

Red solid line: the route for aircraft approaching from south (RJTTS)
Blue solid line: the route for aircraft approaching from north (RJTTN)

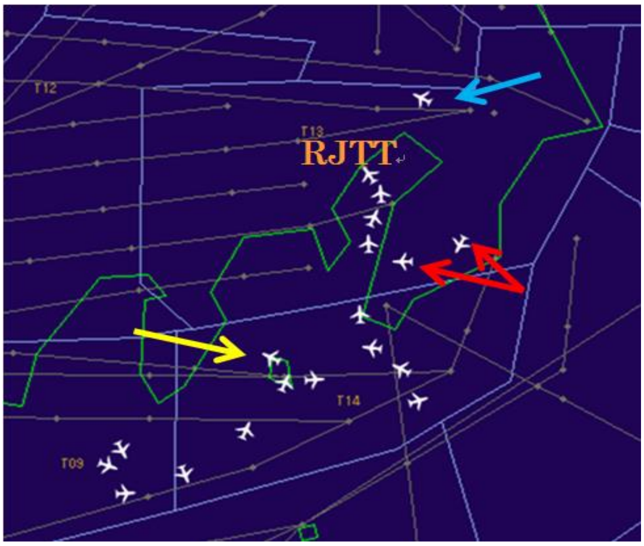

Figure A-5. Aircraft at 04UTC 13th
Red arrow: the aircraft using "RJTTN" move toward KAIHO to avoid CREAM
Blue arrow: the aircraft holding over TLD
Yellow arrow: the aircraft holding over XAC

3. CBs within the airspace around the approach control area (1 September 2014)

Figure A-6 shows the radar echo intensity and positions of aircraft at 1030, 1100, 1130 UTC on 1st. CBs existed south of XAC and expanded rapidly toward east of the approach control area. Usually, the aircraft approaching to RJTT from west or south use route Y21 , Y23 or Y71 to enter sector T14 (Figure A-7), pass over ADDUM and then go into the Tokyo approach control area. CBs were blocking these routes at the time.

At 1030UTC, as the CBs spread to sector T14 and active thunderstorm occurred south of XAC, aircraft began to take a detour to avoid the CBs. At 1100UTC, as the CBs spread into a wider area from XAC to ADDUM and it became difficult for aircraft to approach via ADDUM, aircraft used routes which are north of the usual ones to enter the Tokyo approach control area. At 1130UTC, as the CBs spread northward, aircraft could not approach RJTT, and many of them were in holding patterns in the airspace around the airport.

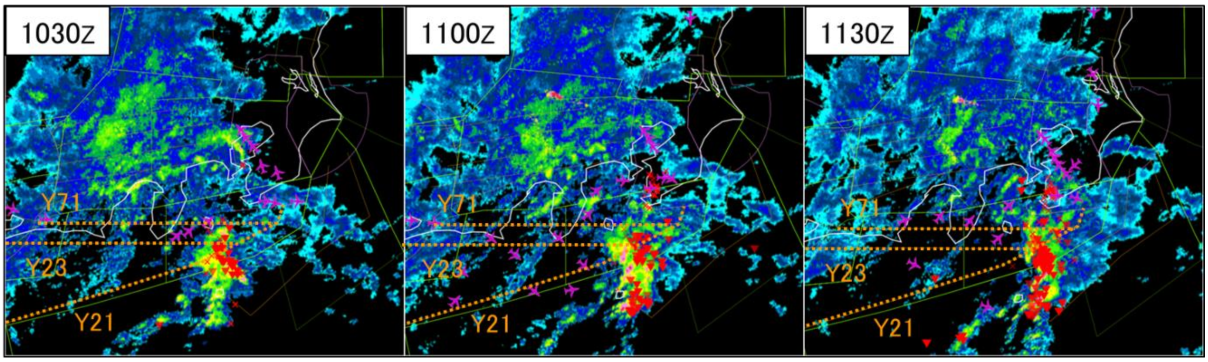

Figure A-6. Radar echo intensity, the positions of aircrafts and thunderstorm (1030, 1100, 1130UTC 1st September)

Dotted orange line: air routes ▼: cloud to ground lightning

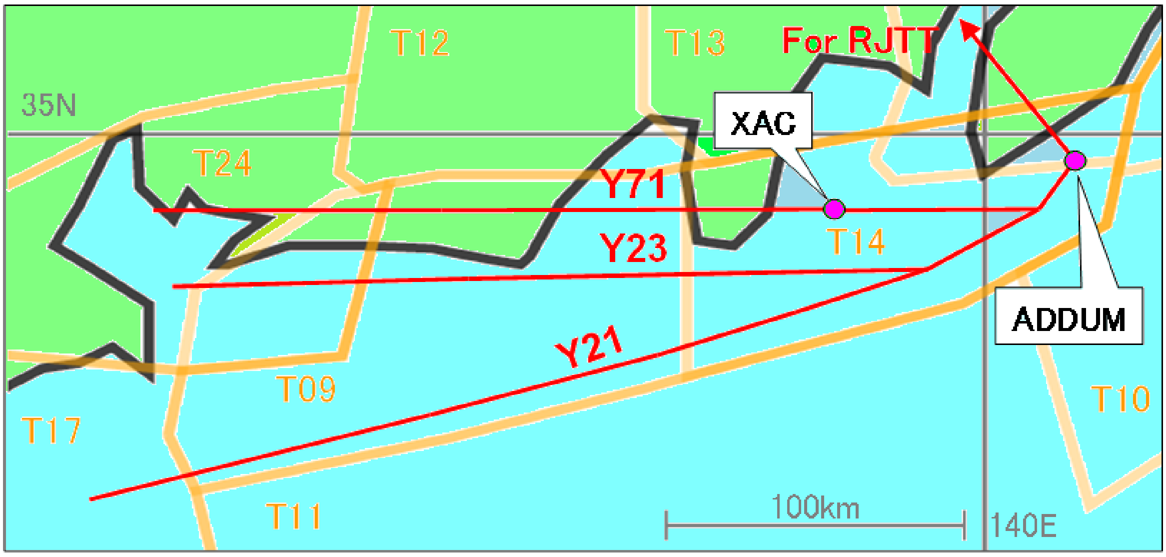

Figure A-7. The control sectors and major air routes which aircrafts approaching to RJTT from west or south usually use.

4. Vertical wind change around RJTT (21 April 2013)

Figure A-8. is a time series - cross section of winds around RJTT. Although approximately 20kt north west winds were observed at RJTT from 21UTC 20th to 04UTC 21st, stronger winds (50 - 60kt) blew from west or south at around 10,000 ft. In this case, aircraft approaching from the south (the right of Figure A-4) had tailwinds at 10,000 ft, but got strong headwinds as they descended. Therefore, even if there had been enough separation when aircraft entered the approach control area, it would become narrower (4NM) than usual (5NM) when the aircraft would reach their final approach (See Figure A-9).

As a result, less aircraft landed than the air traffic controllers had expected, and 11 aircraft were in holding patterns over ADDUM, as were six aircraft over XAC in the early afternoon.

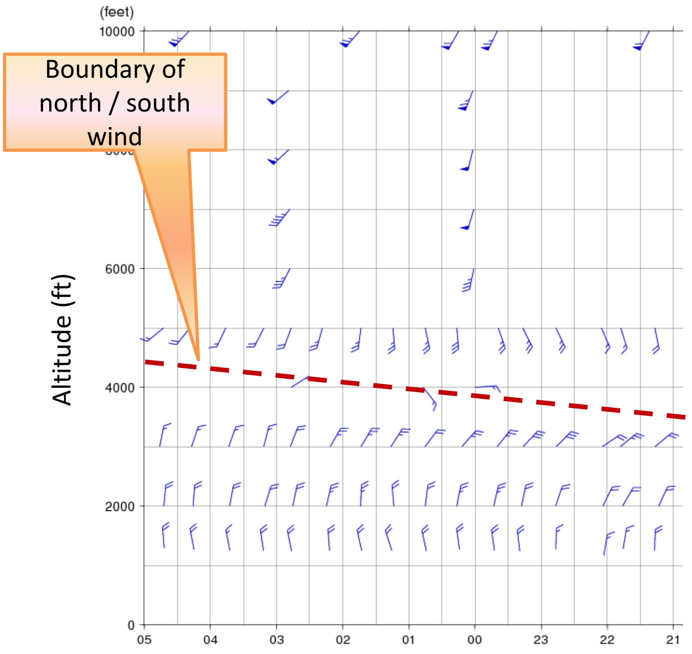

Figure A-8. Time series - cross section of wind around RJTT(21UTC 20th to 06UTC 21st)

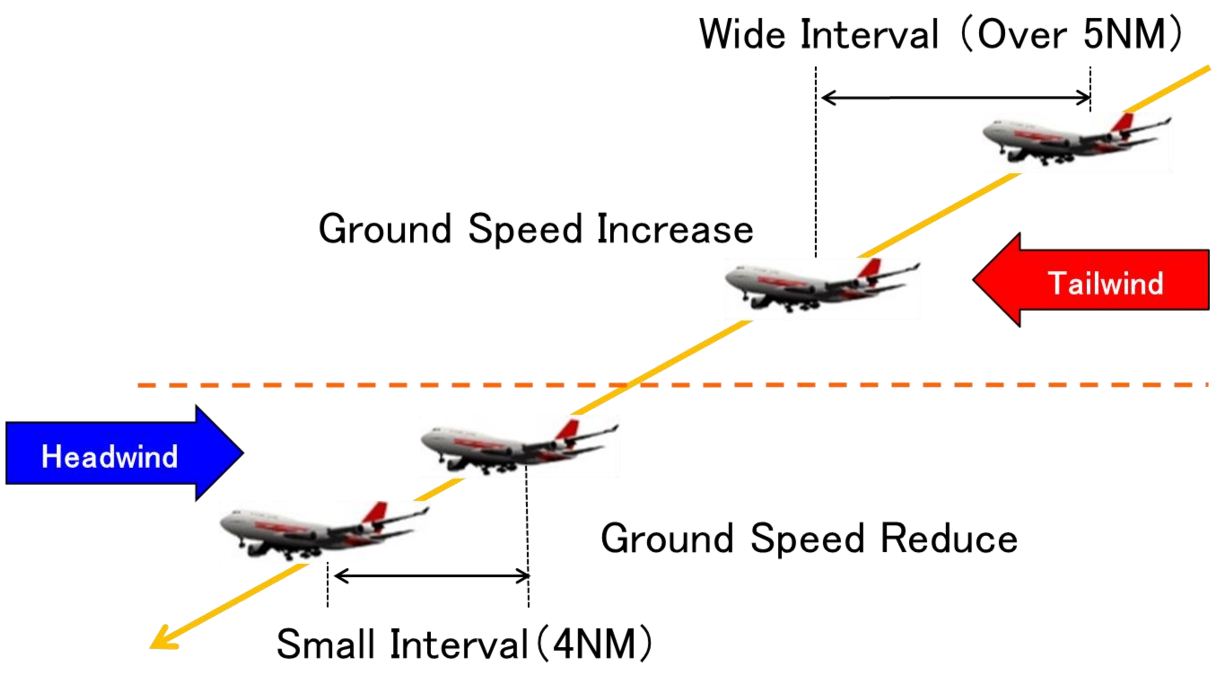

Figure A-9. Model chart of how the separation narrowed due to the vertical wind change