International Civil Aviation Organization

WORKING PAPER

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**English only**

# TWELFTH AIR NAVIGATION CONFERENCE

**Montréal, 19 to 30 November 2012**

**Agenda Item 5: Efficient flight paths – through trajectory-based operations**
**5.3: Increased flexibility and efficiency in descent and departure profiles**

## UTILIZATION OF THE POINT MERGE TECHNIQUE IN STANDARD INSTRUMENT ARRIVAL PROCEDURES (STARs)

(Presented by the Republic of Korea)

**EXECUTIVE SUMMARY**

ICAO provides various information related to the implementation of performance-based navigation (PBN) to improve the efficiency and safety and increase terminal airspace capacity.

This paper addresses the economic and operational benefits of the point merge technique which is one way of implementing RNAV 1/RNP 1 STARs and can be used in conjunction with continuous descent operations (CDO), and suggests the use of the point merge technique when developing RNAV 1/RNP 1 STARs to realize the benefits of it.

**Action**: The Conference is invited to agree to the recommendation in paragraph 3.

## 1. INTRODUCTION

1.1 ICAO introduced and encourages its Member States to implement area navigation (RNAV) 1/required navigation performance (RNP) 1 standard instrument arrival procedures (STARs) and the application of continuous descent operations (CDO) as one of the solutions to increase safety, efficiency and terminal airspace capacity.

1.2 In addition, ICAO is planning to use 4D trajectory-based operations (TBO) based on performance-based navigation (PBN) as a method of future air traffic management (ATM) in the ICAO aviation system block upgrade (ASBU) methodology.

1.3 In line with this, the Republic of Korea established the national PBN implementation plan in December 2009, and has been implementing RNAV 1 STARs and various operational methods to improve safety, efficiency, economics and capacity of terminal airspace.

## 2. DISCUSSION

2.1 In general, STARs are usually designed to provide the shortest transition to the final approach course with information on the expected arrival track to the pilot, which allows planning for the approach to include CDO. However, it was not applicable if the traffic volume exceeded the maximum capacity of the STARs. In this situation, radar vectors were used to accommodate the increased traffic volume while increasing the air traffic controller and pilot's workload as well as reducing the pilot's situational awareness, even when following ATC instructions.

2.2 To overcome the disadvantages of radar vectors and to improve efficiency and effectiveness of terminal airspace, some States in Europe developed the point merge technique in conjunction with RNAV STARs. Also, ICAO provides various forms of STARs which can be used in conjunction with CDO in the *Continuous Descent Operations (CDO) Manual* (Doc 9931) and the point merge technique is one of them.

2.3 Usually, the point merge STARs are designed to absorb delays of the arrival phase on the sequence leg which is an equidistance arc from the merging point. This means the flying distance of STARs will be increased compared to conventional STAR. It results in decreasing fuel efficiency.

2.4 However, once the point merge technique with RNAV 1 STARs is implemented, the downside of existing STARs and radar vectors can be resolved and the following effects will be achieved:

a) increased terminal airspace capacity and facilitation of PBN implementation by providing STARs which accommodate a similar level of traffic volume as radar vectors (related to ASBU performance improvement area (PIA) 1: Airport Operations);

b) improvement in accuracy of aeronautical information including aircraft position, estimated time of arrival (ETA) which is used for SWIM, airport collaborative decision making (CDM) (related to ASBU PIA 2: Globally Interoperable Systems and Data – through globally interoperable systems and data and ASBU PIA 1: Airport Operations);

c) use of CDO and improved fuel efficiency (related to ASBU Module No. B0-05: Improved Flexibility and Efficiency in Descent Profiles (CDO);

d) improvement in aerodrome capacity by providing regular intervals of wake turbulence separation between aircraft (related to ASBU Module N° B0-70: Increased Runway Throughput through Optimized Wake Turbulence Separation);

e) improvement in aviation safety through the reduction of controller-pilot radio communication and enhanced surveillance capability (related to ASBU Module No. B0-85: Air Traffic Situational Awareness (ATSA)); and

f) enhanced expectancy and planning of flight tracks which will be used for 4D trajectory-based operations (related to ASBU PIA 4: Efficient Flight Path - through trajectory-based operations).

2.5 In an attempt to reduce congestion and to improve the aviation safety within terminal airspace, the Republic of Korea has been adjusting arrival tracks using PBN. On this account, STARs with point merge technique has been implemented at Incheon International Airport since 3 May 2012. (See Appendix A).

2.6 According to the results of analysis on the initial phase of the point merge technique implementation, the average flight distance was decreased by 2.3 per cent while average flying time was increased by 1.1 per cent caused by speed control for spacing. However, variance related to flight distance and flying time was decreased by 35.6 per cent and 42.4 per cent respectively, which increases the predictability of aircraft position. (See Appendix B).

2.7 As for the vertical profiles of aircraft, it significantly showed that the aircraft following STARs with the point merge technique descend from higher altitude compared to conventional procedures including radar vectors. This means that the point merge procedures enabled aircraft to descend continuously from the higher altitude. Based on the observed results, new procedures can save fuel consumption by 16 per cent compared to the old procedures.

2.8 In terms of the workloads of air traffic controllers, it was analyzed that new procedures reduced average communication time per aircraft and average communication frequency per aircraft by 36.6 per cent and 10.0 per cent respectively. These results mean that air traffic controllers could concentrate on the traffic monitoring, and could provide the pilot with more information which is useful for situation awareness and improve quality of air traffic services.

2.9 Finally, the result shows that there was no significant difference between radar vectors and the point merge technique on the airspace capacity. However, capacity improvement is expected if the arrival management tool is added to the point merge technique. (See Appendix C).

2.10 Although this study showed preliminary analysis results on the effect of the point merge technique, the Republic of Korea is anticipating more outcomes when the point merge technique is settled down and supported by arrival management tools, and is planning to expand it to other terminal areas within the Incheon FIR.

## 3. CONCLUSION

3.1 Implementation of the point merge technique enables operation in terminal airspace in safer and more efficient ways, and if CDO and arrival management tools are applied together with the point merge technique, advantages like cost savings, less carbon dioxide emission, and increased airspace capacity are expected. Although this study showed preliminary analysis results on the effect of the point merge technique, the Republic of Korea is anticipating more outcomes when the point merge technique has settled down and is supported by arrival management tools, and is planning to expand it to other terminal areas within the Incheon FIR. The Conference is invited to agree to the following recommendation:

**Recommendation 5/x – Utilization of the point merge technique in standard instrument arrival procedures (STARs)**

That the Conference:

a) note the information provided in this paper;

b) encourage Member States to use point merge technique when developing RNAV 1/RNP 1 STARs recognizing the economic and operational benefits of it; and

c) request ICAO to review the inclusion of point merge technique as a separate ASBU module.

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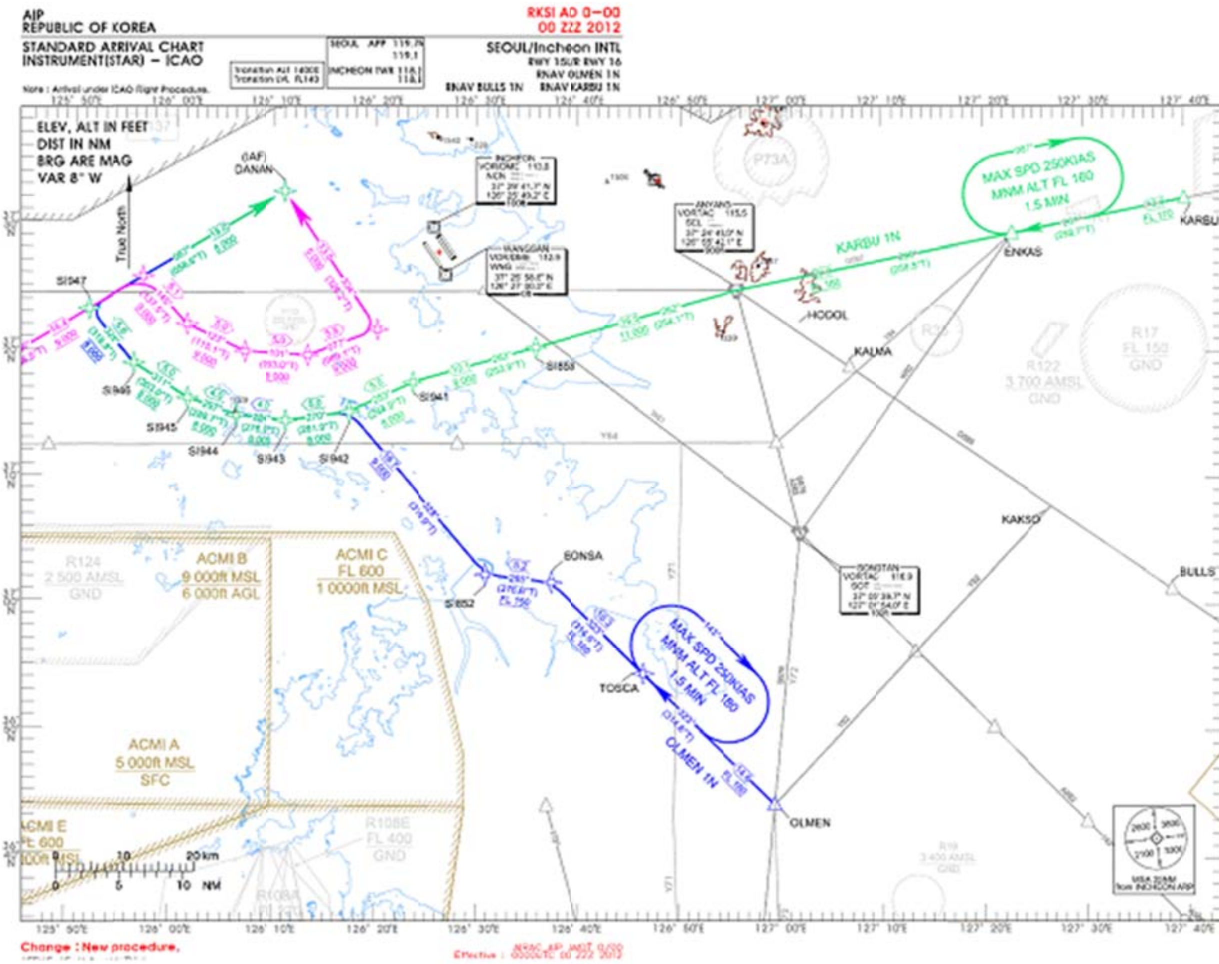
# APPENDIX A

## ARRIVAL PROCEDURES WITH POINT MERGE

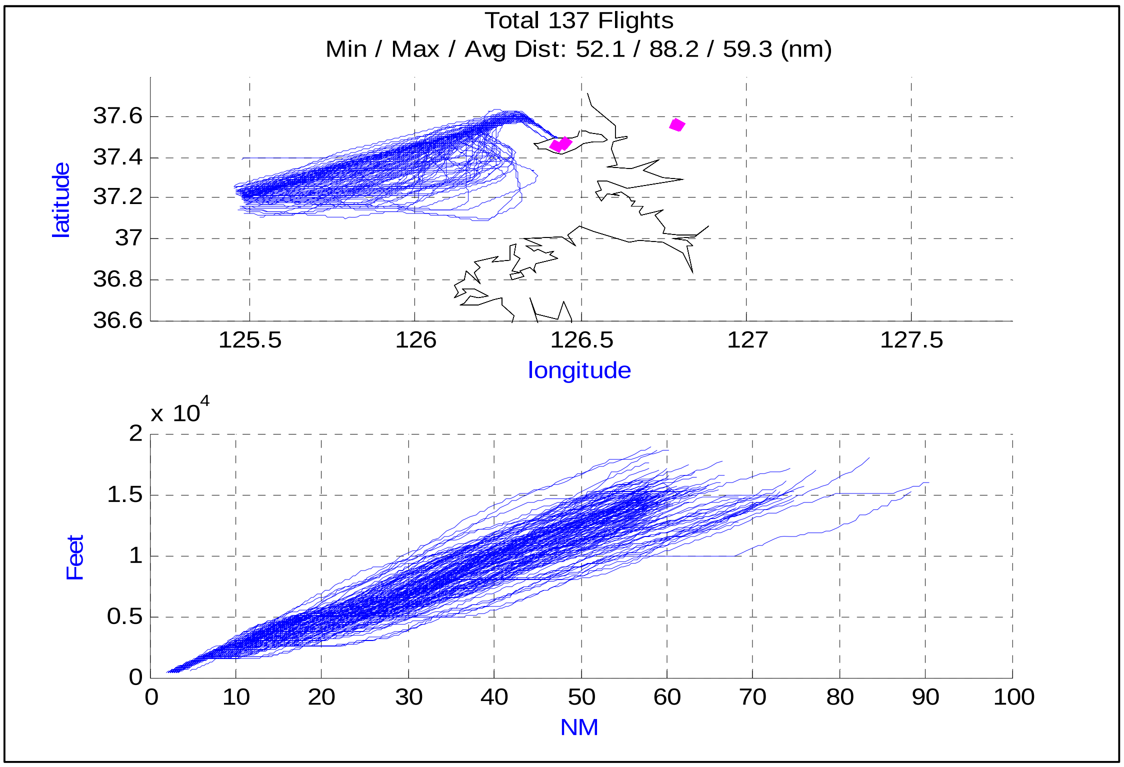


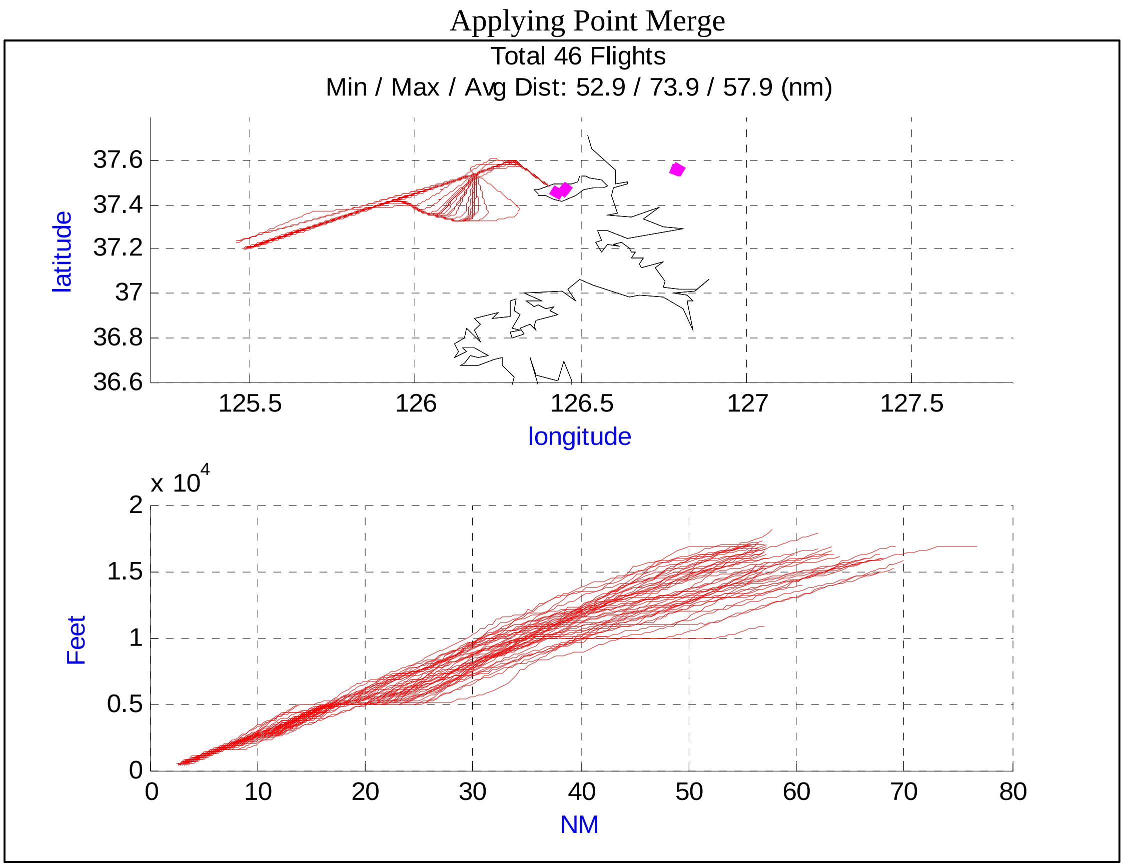
# APPENDIX B

## EFFECTS OF THE POINT MERGE TECHNIQUE

1) Plan view and vertical profile

Applying Radar Vectors





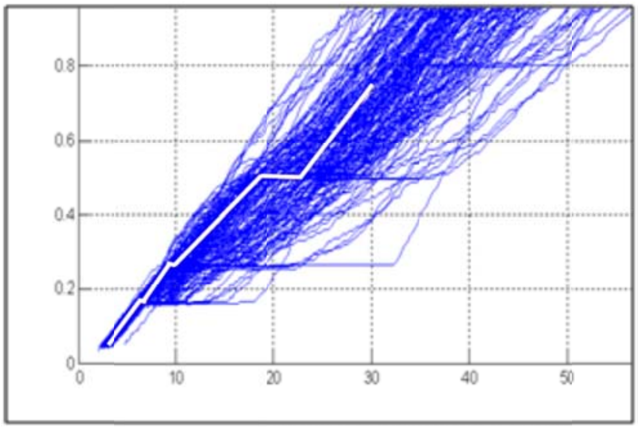

2) Flight Distance and Time

| Flight Distance(NM) | Radar Vectors | Point Merge |
|---|---|---|
| Average | 59.3 | 57.9 |
| Variance | 39.8 | 25.6 |
| Sample Size | 137 | 46 |
| Combined Variance(Sd) | 0.75 | |
| Null Hypothesis | 0.00 | |
| z-Statistics | -1.38 | |
| Alpha | 0.10 | |
| Rejection Region( ∣ z ∣ >) | 1.64 | |

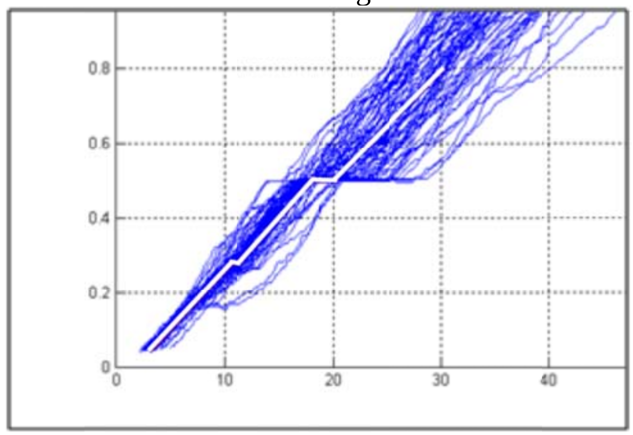
| Flying Time(min) | Radar Vectors | Point Merge |
|---|---|---|
| Average | 14.2 | 14.4 |
| Variance | 3.2 | 1.8 |
| Sample Size | 137 | 46 |
| Combined Variance(Sd) | 0.05 | |
| Null Hypothesis | 0.00 | |
| z-Statistics | 4.90 | |
| Alpha | 0.10 | |
| Rejection Region( ∣ z ∣ >) | 1.64 | |

3) Vertical Profile

Radar Vectors




Point Merge




4) Communication Time and Frequency

| Comm. Time/ Aircraft(sec) | Radar Vectors | Point Merge |
|---|---|---|
| Average | 31.8 | 20.2 |
| Variance | 433.6 | 44.2 |
| Sample Size | 75 | 29 |
| Combined Variance(Sd) | 7.31 | |
| Null Hypothesis | 0.00 | |
| z-Statistics | 1.59 | |
| Alpha | 0.10 | |
| Rejection Region( ∣ z ∣ >) | 1.64 | |

| Comm Freq/ Aircraft(sec) | Radar Vectors | Point Merge |
|---|---|---|
| Average | 8.1 | 7.3 |
| Variance | 15.4 | 7.6 |
| Sample Size | 75 | 29 |
| Combined Variance(Sd) | 0.47 | |
| Null Hypothesis | 0.00 | |
| z-Statistics | 1.73 | |
| Alpha | 0.10 | |
| Rejection Region( ∣ z ∣ >) | 1.64 | |

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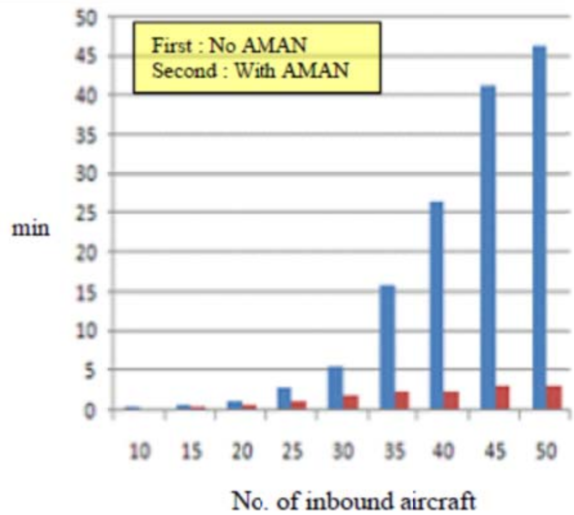
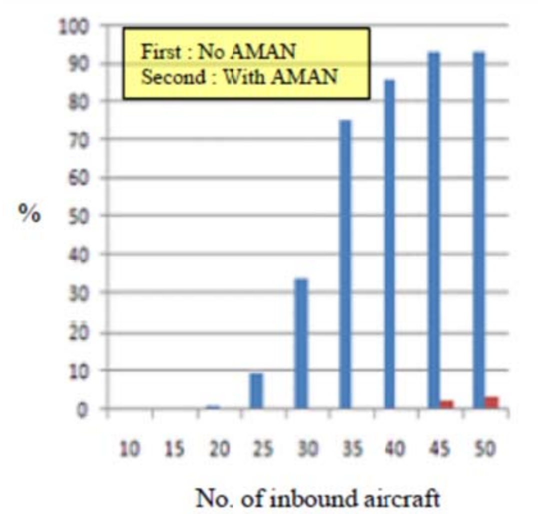
# APPENDIX C

## USE OF ARRIVAL MANAGEMENT SYSTEM (SIMULATION)

Point Merge Sequence Leg Delay Time




Surpassing Ratio of
Point Merge Sequence Leg Capacity

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