60th CONFERENCE OF DIRECTORS GENERAL OF CIVIL AVIATION ASIA AND PACIFIC REGIONS

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AGENDA ITEM 4: AIR NAVIGATION

APPLYING DATA ANALYTICS TO ENHANCE EFFICIENCY AND SAFETY

(Presented by Singapore, Thailand and with input from China)

SUMMARY

The Asia Pacific is facing high traffic growth. To support and capture economic opportunities of the growth, there will be a need to enhance or develop new ConOps and applying data analytics to provide insights into areas where more efficiency can be extracted while maintaining high level of safety. This is more so when the current airspace are also required to accommodate new entrants, overcome adverse weather and the need for more sustainable practices. This paper presents the opportunities, challenges and applications of applying data analytics as a critical enabler for proactive risk management and performance-based oversight and for member States to participate in the ICAO Asia Pacific Data Analytics Group to share best practices and solve common problems.

APPLYING DATA ANALYTICS TO ENHANCE EFFICIENCY AND SAFETY

1. INTRODUCTION

1.1 Air traffic volume in Asia Pacific (APAC) is expected to triple over the next 20 years. The advent of drones, air taxis, High-Altitude Operations and commercial space vehicles through controlled airspace would also increase demand on airspace and add operational complexities for air navigation service providers and airlines. Furthermore, the impact of climate change is likely to cause more frequent, severe and unpredictable weather events and patterns to flight routes and air traffic flow. At the same time, the public are likely to expect aviation to adopt sustainable practices. These challenges are complex and require collective effort from member States to find innovative solutions, design new ConOps for the future and/or pervasive adoption of data analytics as a critical enabler for proactive risk management and performance-based oversight.

1.2 ICAO has long supported the collation of safety information for safety monitoring and performance measurement. The aviation ecosystem generates vast amounts of data from flight operations, air traffic management and airport systems. The aviation systems can better harness the availability of these data through a data-driven approach to provide sharper insights to better support policy, investment and operational decision making. Data analytics will help member States take a leap forward by providing powerful means to extract insights, identify patterns and enable timely interventions for both safety and efficiency.

1.3 The data analytics maturity spectrum can be described in 4 levels:

Level	**Description**	**Example**
Descriptive	What happened?	How many safety incidents were there?
Diagnostic	Why did it happen?	What are the attributing factors for these incidents?
Predictive	What might happen?	Can I forecast the conditions for these incidents?
Prescriptive	What should be done?	What can be done to mitigate these conditions and prevent the safety incidents?

Table 1: Data Analytics Maturity Spectrum

1.4 Based on the current understanding, most member States operate at the descriptive and diagnostic level. Moving towards predictive and prescriptive levels requires capability development in areas such as data governance, manpower upskilling and the adoption of new data toolsets.

2. DISCUSSION

2.1 In the APAC region, the Data Analytics Group (DAG) has led the APAC region's transformation towards performance measurement. DAG members have demonstrated strong foundational capabilities in data management, including storage, extraction, transformation, and augmentation. While traditional performance measurement has enabled evidence-based decision-making and early problem detection through trend analysis, the aviation sector now requires more sophisticated analytical approaches to address emerging challenges.

2.2 Data analytics is the systematic process of collecting, processing and analysing data to extract meaningful insights, identify patterns and support informed decision-making. When coupled with performance measurement, it provides member States a means to detect problems, identify the causal factors and derive mitigations. For example, member States can use analytics to reduce en-route delays by identifying congestion patterns, adjust staffing and resource allocation based on traffic forecasts and analyse historical runway incursion data to help identify conditions that increase risk and inform improved procedural or structural changes.

2.3 The application of data analytics has the potential to transform air navigation by enabling smarter, safer and more efficient operations. Member States are encouraged to invest in capabilities that allow for the collection, analysis and use of data to support proactive decision-making. Member states in the APAC region can progress together by utilizing data sharing, upskilling through working on joint projects.

2.4 Despite its benefits, adoption of data analytics remains uneven due to challenges such as data availability and quality issues, risk of misinterpretation and limited analytical capacity in some States.

2.5 The DAG has a group of established performance experts and data analysts. Most of the members have utilised data analytics to enhance operations. For example, China is utilizing forecasted traffic to identify potentially high ATCO workload and flight delays and actively introducing measures such as alternative and temporary flight routes to manage traffic distribution. Details of these projects are included in Annex A. Singapore utilizes a data-driven approach to identify areas of improvement for on-time performance such as enhanced gate allocation policies and turnaround processes. India measures the fuel savings to see the effectiveness of implementing ATFM measures.

2.6 Presently, the DAG is working together to establish a methodology to measure fuel burn and carbon emissions to help member States plot its trajectory towards ICAO Long Term Aspirational Goal (LTAG). The DAG will also be working on developing the methodology for additional time in terminal airspace to understand the operational efficiency in the terminal airspace. The DAG can do more. The recent DAG meeting saw members keen to better capture the economics of significant air traffic growth, and explore the use of business intelligence and data analytics to increase efficiency and manage potential safety risks.

2.7 In the near term, the DAG has identified on-time performance, and the corresponding delay propagated within the aviation system as a potential project for the group. This project can potentially help member States identify where delays can potentially be absorbed for enhanced on-time performance. DAG is keen to assist member States in their data analytics journey. DAG encourages member States to participate, share best practices, and solve common problems.

3. ACTION BY THE CONFERENCE

3.1 The Conference is invited to:

a) Note the content of the paper;

b) Encourage member States to invest in analytics capabilities and promote data sharing under robust governance framework;

c) Encourage member States to discuss and share their experience in implementing a data-driven approach to efficiency and safety; and

d) Encourage member States to participate in the ICAO Asia Pacific Data Analytics Group to share best practices and solve common problems.

Encl.

Annex A – Applications of Data Analytics

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Annex A – Applications of Data Analytics

Application 1 - Data analytics is used to reduce potential inefficiencies and safety risks

1.1 Excessive concentration of flights on some busy routes during peak hours poses operational inefficiencies and safety risks. These were mainly manifested in increased controller workload and flight delays. To better capture the economics of significant air traffic growth, ANSP would need to explore the use of business intelligence and data analytics to increase efficiency and manage potential safety risks.

1.2 First, the ANSP identified busy route sections/points using business intelligence. Secondly, the ANSP analysed the traffic composition passing through these busy route sections/points, including their origin and destination airports, flight routes, planned and actual departure and arrival times. Corresponding measures including ATFM measures were taken at the strategic and tactical stages to manage the traffic distribution. For example, the departure times, arrival times and the planned routes in the flight plan can be optimized in the strategic stage using simulation techniques.

1.3 Through long-term data monitoring and analysis, for congested route sections/points that cannot be alleviated by demand adjustment, attempts were made to increase capacity by other means such as optimising and adjusting routes, establishing temporary routes, etc. The ANSP tracked and regulated the throughput on the waypoints on its busy routes and managed to reduce safety risks caused by high movements maintaining good punctuality.

Points	Daily average traffic	Hourly peak traffic	Punctuality
VOR（HFE)	1826	155	86.92%
MAMSI	1125	99	85.45%
VOR（SHX)	1052	95	89.95%
MADUK	1036	92	85.79%
DUBAS	1036	82	84.25%
VOR（PLT)	1013	85	81.49%
VADMO	932	76	87.52%
P215	884	79	84.78%
VOR（LLC)	881	81	84.65%
UDUMI	875	76	84.49%
XEBUL	867	78	84.25%
OBDON	867	77	85.89%
TAMIX	860	74	87.15%
VOR（KHN)	840	88	81.63%
P242	833	67	86.81%
P37	821	73	84.26%
P321	807	75	84.36%
ISMED	806	86	83.87%
P206	803	75	84.47%
VOR（FYG）	775	78	87.03%

Table 2: The busy route points and the number of flights passing through in 2024 (China)

Application 2 - Study of flight flow during peak hours at the main coordination airports in China

1.4 China tracked the hourly traffic flow during peak hours (08:00-24:00) at its top 10 airports in 2024, that is, the total number of take-offs and landings within a single hour**.** Through the analysis of the hourly capacity utilization rate of the main time coordination airports, that is, the ratio of hourly traffic flow to the hourly peak capacity of the airports, it was observed that in some main coordination airports of Shenzhen Bao 'an Airport and Shanghai Hongqiao Airport, due to the peak of early departure flights, the hourly capacity utilization rate approached or exceeded 100% for several consecutive hours, while the hourly utilization rate was relatively low in other periods.

Hour	0	1	2	3	4	5	6	7	8	9	10	11
Utilisation	55%	27	21%	20%	19%	20%	40%	78%	84%	88%	88%	98%
Hour	12	13	14	15	16	17	18	19	20	21	22	23
Utilisation	92%	93%	100%	93%	94%	96%	93%	94%	91%	84%	80%	65%

Table 3: Hourly Capacity Utilization for ZGSZ (0-23 hours)

1.5 It was observed that the distribution of hourly capacity utilization at the airport is uneven. The traffic within the terminal airspace increases during peak hours, and the operational efficiency decreases accordingly. The airport's surface support capability is insufficient during peak hours, which will lead to congestion of runways and taxiways, subsequent flights are delayed, and the operational safety risks of the airport surface increased.

1.6 The causes of the uneven traffic distribution were (1) The flight plans are overly concentrated during peak hours. (2) The airport's turnaround capability is insufficient. (3) The placement of taxiways and parking stands were not optimized for high intensity operations.

1.7 To overcome this, some mitigations were identified (1) Making reasonable and efficient flight plans, arranging temporary flights, extra flights, rescheduled flights or cargo flights to the early morning or during the off-peak operation period of passenger flights; (2) Allocate flight that newly applied during the flight season to off-peak hours. (3) Assess the surface operation support capability, optimize runway and taxiway resources, and rationally allocate jetbridges and parking stands to shorten the surface operation time. (4) Enhance the capability for turnaround flights, improve efficiency and reduce subsequent delays.

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