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Agenda Item 4: Review of Current ATFM Operations and Problem Areas

THE OPERATION CONCEPT OF NATIONAL TRAFFIC FLOW MANAGEMENT SYSTEM

(Presented by China)

SUMMARY

This paper presents 11 operational concepts in the construction process of National Traffic Flow Management System (NTFM). ATFM in Asia-Pacific region is moving from cognitive consistency, to system interconnection, to network interconnection, and finally to cultural integration. The future of ATFM various States/Administrations will not only gradually converge, but the connections will become increasingly close to form a large ATFM system composed of many subsystems from the perspective of the Asia-Pacific region. Therefore, if a certain degree of consistency can be reached in the concept during the construction stage, it will not only be beneficial to the construction of their own ATFM systems, but also conducive to the overall development of ATFM in Asia-Pacific region. At the same time, this paper also invites all stakeholders to jointly improve the operational concept of ATFM system construction, and welcomes all stakeholders to test the interconnection between systems with NTFM.

1. INTRODUCTION

1.1 In 2024, ATFM in Asia-Pacific region requires not just a CTOT, but a more precise CTOT, a predictive CTOT, a more stable CTOT, a CTOT that meets multiple ATFM measures, and a high-quality CTOT that can efficiently solve ATFM events. After addressing the phase of "availability," ATFM in Asia-Pacific region is moving towards the phase of "quality." The current ATFM in Asia-Pacific region is entering a new stage of high-quality development. ATFM system tools are not a necessary condition for carrying out ATFM work, but with the increase in the complexity of the ATFM operating scenarios and the volume of flights, ATFM system tools can significantly improve the efficiency and quality of ATFM through more efficient solutions.

1.2 It is easy to take detours in the development process of ATFM system tools, such as directly copying advanced ATFM systems without considering local actual conditions; always wanting to achieve goals in one step without experience accumulation; overly pursuing perfect functions but not practical; not having a operation concept that conforms to oneself. The development of ATFM tools should be closely aligned with the development stage of the national civil aviation industry. Different development stages have different requirements for ATFM tools. When the flight volume is relatively small, the importance of system tools to ATFM is relatively low. However, with the increasing complexity of the environment, flight volume, and functional requirements, the role of tools in handling complex ATFM situations will become increasingly important.

1.3 ATFM tools seem to be isolated, and States/Administrations mainly establish their own tools based on their own conditions and inputs, but the actual situation is that ATFM itself is integrating,

and system tools tend to integrate. This integration does not mean that it is necessary to disclose their own technology, but the concept, method, principle, and function implementation will further converge. Some States/Administrations in the Asia-Pacific region are currently building or planning to build their own system tools., but if there is no clear design concept before system construction, later adjustments will face many difficulties, such as a GDP program, whether the sequence of sorting is based on ELDT or EOBT, it seems to be a simple issue, but the choice in the early stage may affect the expansion of later functions.

1.4 Civil aviation in China has gone through four development stages from no ATFM system tools, to scattered ATFM system tools in different regions, to a unified national ATFM system tool, and gradually upgrading ATFM system tools. This is synchronized with ATMB's process from finding ATFM solutions to finding the optimal solutions. In the process of ATFM integration and development in Asia-Pacific region, ATMB is committed to actively exploring the construction and improvement of ATFM support tools with all stakeholders, and jointly enhancing the overall ability of ATFM in Asia-Pacific region by enhancing the support of ATFM system tools.

2. DISCUSSION

ATFM Culture

2.1 ATFM system, as tools supporting ATFM personnel's decision-making, usually need to have a high consistency with the thinking and cognition of ATFM personnel, which is closely related to the local ATFM culture behind the personnel's thinking and cognition. While the concepts and methods of ATFM in different States/Administrations may share a high degree of consistency within the overall framework of ATFM, due to the different understandings and expectations of various stakeholders, discrepancies inevitably arise when these concepts and methods are put into practice. These discrepancies can be largely attributed to the unique ATFM cultures of each State/Administration.

2.2 ATFM culture is not only an environment that supports the ATFM operation, but also a multilateral consensus reached by various stakeholders based on their understanding of ATFM. In the process of traffic management construction, it is usually based on this culture to construct their own traffic management network. This network includes ATFM operating procedures, personnel capabilities, and supporting tools, all of which are closely related to the local ATFM culture. As a physical tool and carrier for carrying out ATFM work, supporting tools are a microcosm of ATFM culture. Therefore, the construction of these tools should be closely aligned with the local actual conditions.

Elastic Network

2.3 The starting point for the construction of NTFM is not only a set of supporting tools, but also the construction of a network linking various ATFM-related information of civil aviation in China. All users are a node in this network. Whether it is centralized operation, distributed operation or remote operation, all actions are not only shared, but also interact. At the same time, the network has strong elasticity and can be corrected in time to achieve the best effect. For example, when a node in the network has difficulties or even improper operation, when this node reduces efficiency, the system will automatically adjust other resources according to the principle of complementarity to ensure the optimality of the entire network.

2.4 The reason why the ATFM network needs to be elastic is because things that have not happened often have uncertainty. For example, when a flight does not take off at the assigned CTOT, the ATFM expectations cannot be achieved because of the non-compliance of this flight. Therefore, the system can automatically adjust other flights, such as finding available airborne holding capacity to solve this problem. The complementarity of the network is a basic principle of the elastic ATFM network. Since it links all resources within the network, when a problem occurs at one point, the resources of the whole network will be used to supplement it. At the same time, such results will not

only be transmitted to various ATFM participants in real time, such as the airline operation control centers, tower electronic flight strip, etc., but will also be reflected in the system's post-operation analysis module.

Unified ATFM System

2.5 Since 2013, the first generation of formal ATFM system tools in China have been developed by four civil aviation enterprises for the Operation Management Center and eight regional ATFM units. Although this generation of ATFM system tools can cope with the complex ATFM operating environment, however, when the volume of flights in China's civil aviation doubled again in 2017, the scattered and isolated traffic management system faced great challenges in nationwide information interaction, decision synchronization and integrated operation. For this reason, the second generation of ATFM system tools has also entered the design and development stage. In 2020, the official launch of China's unified and unique second-generation ATFM system tools NTFM realized the integrated operation of China's civil aviation ATFM concepts, methods and procedures nationwide.

2.6 Under normal circumstances, for a State/Administration with a large volume of flights and unbalanced development of ATFM capabilities, although many technologies such as System-Wide Information Management (SWIM) can support ATFM information interaction, it has obvious shortcomings in terms of efficiency and cost. Under permissible conditions, a unified ATFM system can not only unify the concepts, methods and procedures within a node, but also improve the overall cognition and ability of ATFM personnel through the platform provided by the system. In the long run, under permissible conditions, for a node, a unified ATFM system not only has a larger space for subsequent upgrades and expansions, but also is more conducive to the adjustment of resources within the system.

2.7 For Asia-Pacific region, establish a unified ATFM system tool is the best option, however as it is difficult to achieve，therefore each State/Administration can learn from each other in the process of constructing ATFM system tools, especially when there are regional guidance materials, the higher the consistency of each State/Administration's ATFM system tools in concepts, methods and procedures, the more conducive to the future interconnection and interoperability of information between systems, improve efficiency and thus more easily form higher consistency decisions. For example, the current ATFM system interconnects information based on FIXM. If some use 4.1 Extension and some use 4.3 version, this not only causes resource waste, but also creates barriers to information interaction. Therefore, even if the conditions for a unified system are not met, efforts should be made to reduce unnecessary differences between systems and increase consistency between systems based on a common ATFM framework.

The concept of Internet of Everything (IOE)

2.8 ATFM can be seen to some extent as a hub for air traffic management information, with all kinds of air traffic events directly or indirectly related to ATFM. Therefore, ATFM is not just limited to ATFM measures themselves, but requires a comprehensive analysis of various types of information to better support ATFM decision-making. For example, with ACDM information, although some views believe it is not information that needs to be interacted with in the field of ATFM, if accurate ACDM information is obtained in the ATFM system tools, it will greatly improve the predictability of ATFM and can correct the accuracy of each node in the network in real time. To obtain richer information resources, ATFM system tools can introduce the concept of Internet of Everything (IoE) to some extent.

2.9 Based on the Internet of Everything (IoE) concept, NTFM has achieved information interconnection, system interconnection, and even operation interconnection. With the construction of the NTFM, civil aviation in China has not only achieved interconnection between ATFM information, but also achieved interaction between various systems, such as A-CDM, A/DMAN, ATC automation

system, tower electronic flight strip, ground surface monitoring radar, etc. It's not only possible to see the merging and opening status of all ATC sectors in the country in real time, but also when NTFM gives suggestions for airborne delays, it will also affect AMAN. Based on the IoE concept, NTFM is interconnected with air traffic control, airlines, airports, and other stakeholders to form a national ATFM information interaction network.

One CTOT Solution (OCS)

2.10 Each ANSP faces different ATFM challenges, and the challenges that need to be overcome from the starting point to the goals that need to be achieved are also different. In Asia-Pacific region, including China, ATFM hotspots are relatively concentrated, and the distribution of busy airspace and simple airspace is very different. Therefore, ATFM in Asia-Pacific region is more concentrated in hotspot areas and hotspot traffic flows, and the concentration of problems and challenges will also lead to the demand for ATFM measures also concentrated in hotspot areas. Therefore, multiple ATFM measures based on hotspot areas and hotspot traffic flows is one of the characteristics of the region.

2.11 Conflicting ATFM measures are closely related to ATFM concepts, methods, and tools, but the core reason is how to deal with complex ATFM issues. Although "Prevention" or "Identifying Hotspots" can be used as solutions to Conflicting ATFM measures, but with the further increase in complexity, sacrificing one or more ATFM measures to meet higher priority measures will no longer apply in many scenarios. Therefore, the demand for ATFM in Asia Pacific region will tend to be more inclined to the ability of multiple ATFM measures to be satisfied simultaneously. In other words, there will no longer be conflicts between multiple interacting ATFM measures. ATFM personnel can achieve one CTOT satisfying all ATFM measure constraints by using the One CTOT Solution (OCS) operational concept and corresponding methods, such as the Collaborative Multi-constraint Conversion Program (CMCP).

2.12 Whether to adopt the OCS concept or similar concepts may lead to different architectures of ATFM system tools. Usually, if the supporting tool does not adopt the OCS concept in the early design stage, and then upgrades to the OCS concept after the system is officially used, this will cause many changes in ATFM operation rules and algorithms. Based on the characteristics of civil aviation operations in Asia-Pacific region, OCS would have a wide range of application prospects in the future, and introducing the OCS concept into the ATFM systems of various States/Administrations will be beneficial to handle complex ATFM scenarios.

Seeking a Near-Optimal Solution

2.13 Many ATFM measures are implemented through CTOT, and whether the implementation of measures can achieve the expected effect not only depends on whether the CTOT is well executed, but also depends on whether the CTOT is a high-quality CTOT when it is generated. In Asia-Pacific region, cross-border ATFM often focuses on whether the CTOT is well executed, and the calculation of the CTOT is usually an internal matter of a node. However, the same scenario, the same ATFM measure, if the algorithm or method is different, the calculated CTOT may also be different, which will directly affect whether the ATFM measure can achieve the expected effect.

2.14 The first generation of ATFM system in China adopted the OCS concept in 2013 and realized the goal of a CTOT meeting multiple ATFM measures in actual operation. However, due to the constraints of the cognitive concept, system architecture, core algorithm, and computer calculating power at the time, although the CTOT can meet all constraint requirements, it cannot guarantee that every CTOT is the best CTOT, that is, the optimal solution. Therefore, after more than 10 years of research and upgrade in system architecture and algorithms, the current NTFM can achieve that every CTOT is the near-optimal solution for this ATFM measure.

2.15 The so-called optimal solution is closely related to specific indicators under the overall

goal of ATFM, such as pursuing the smallest average delay, the smallest CTOT variability caused by new measures, and the delay allocation under the need to reach a certain OTP indicator. ATFM personnel will face balance and choice. The system can provide multiple optional solutions for the same ATFM event for personnel, as well as the comparison of each set of solutions on various indicators. Therefore, it is difficult to say which set of solutions is the optimal solution, but if the personnel have clarified the goal they want to achieve, the system can easily provide the optimal solution under this goal.

The Close Relationship between ATFM and ATC

2.16 The relationship between ATFM and ATC in China has evolved from a blurred boundary to a clear one, and then back to blurred. In the early stages of ATFM development in China, ATFM was separated from ATC. Whether in terms of personnel or duty responsibilities, there was some ambiguity in the division of responsibilities with ATC at that time. However, as the tasks of ATFM increased, the division of labor between ATFM and ATC became clearer, and their respective duty responsibilities gradually became clear, and the boundary between their responsibilities also began to clear. However, with the further increase in flight volume and the further complexity of the operating environment, there is a higher demand for improving the efficiency of coordinated operation, which puts new requirements on the integrated operation of ATFM and ATC. Therefore, in the process of NTFM construction, the two are not isolated or opposed, but coordinated, complementary, and integrated. Research has found that when the flight volume reaches a certain level and ATFM develops to a certain stage, the close combination of ATFM and ATC will play a greater overall efficiency and benefit.

2.17 In China, ATFM measures are divided into ATFM measures used by ATFM and used by ATC. It is rare to solve all scenarios through a single ATFM measure, but through a set of measures working together. This may include a combination of ATFM personnel using GDP and air traffic controllers using airborne holding to solve problems together, so the ATFM system needs to consider the application of airborne holding capacity. Not only that, NTFM fully considers the habits and rules of air traffic controllers, which is closely related to the accuracy of upper and low sector traffic prediction, 4D trajectory, capacity, etc.

Support of Modern Technologies

2.18 The development of the civil aviation industry is inseparable from the progress of modern technology, and the same is true for ATFM work. Limited by factors such as system hardware support, processing power, network bandwidth, and intelligence level, China’s first-generation ATFM system cannot fully implement the concept of ATFM operation through system tools. With the progress of modern technology, China’s second-generation ATFM system - NTFM has received substantial support from modern technology. The system’s powerful computing power and intelligence have largely replaced the work of traditional ATFM personnel, shifting the focus of ATFM personnel from formulating ATFM solutions to selecting the better ATFM solutions. Through the system, the better solution can be found and the better CTOT can be generated. The substantial increase in automation level not only improves work efficiency and reduces workload, but more importantly, it can provide ATFM services for stakeholders through better ATFM solutions.

2.19 Relying on the support of contemporary IT technology, NTFM has achieved the combination of algorithms, computing power, and data. Taking the tactical ATFM algorithm as an example, the implementation of this algorithm benefits from the progress of IT technology so that the algorithm can be implemented in the system. Not only that, civil aviation in China currently has about 17,000 flights per day. The consumption of system computing resources by these flights in the pre-tactical phase is far different from the tactical phase. The calculation trigger mode used in the tactical phase requires the system to have strong computing power. When contemporary technology supports algorithms, computing power, and data at the same time, the NTFM can play a better role.

Deep Data Mining

2.20 Data is one of the important resources of the NTFM. Reasonable and full use of these data can further improve and enhance the capabilities of NTFM. For example, the application of the "similar day" concept in the system has a strong dependence on data accumulation. NTFM can automatically provide dynamic capacity suggestions for ATFM personnel based on the concept of "similar day" through system data mining, but this requires a large amount of accumulated data. The more data, the more accurate the suggested capacity provided. For example, for the prediction of 4D trajectories, although BADA provides a good model, due to different operating environments, 4D trajectories in Asia-Pacific region usually need a large amount of air traffic control operating rules, high-altitude wind information, historical data, etc. to predict more accurate 4D trajectories.

2.21 Although each ATFM event has its own characteristics, if you look at it over a long period, ATFM has a strong regularity. As the running time of ATFM increases, the running data of ATFM is also constantly accumulating. By mining these data, finding out the rules, optimizing methods, providing suggestions, and thus continuously optimizing and improving. Continuing with the 4D trajectory prediction as an example, if a certain airline has a generally longer taxiing time at a certain airport during a certain period in history, then extra taxiing time will also be added when predicting the 4D of this airline. For example, if a certain flight's EET in its FPL report is accurate for a certain segment and not accurate for other segments, then the system will only use this trustworthy segment of EET as a basis for speculation. As the accumulation of data continues to increase, if a ATFM system can dig deeper, study and use these data, the quality of ATFM work will gradually improve.

Cross-Border System Interconnection

2.22 After years of refinement, ATFM in Asia-Pacific region has passed the stage of cognitive consistency. It is currently gradually moving towards the interconnection stage between ATFM systems, and will further move towards deep interconnection of ATFM networks and operating environments, and eventually towards the full integration of ATFM culture. When looking at ATFM from the overall perspective of the Asia-Pacific region, ATFM systems of various States/Administrations are equivalent to a subsystem under the Asia-Pacific large system, and all subsystems are connected to form a complete Asia-Pacific ATFM system. Although there are certain differences in the construction of subsystem tools in various States/Administrations, the network architecture of ATFM system tools in the Asia-Pacific region are becoming increasingly clear.

2.23 NTFM, which integrates a large amount of ATFM information, is not isolated. It is also a part of the ATFM network in Asia-Pacific region and even the world. For this reason, ATMB is also willing to interconnect ATFM information with various States/Administrations in Asia-Pacific region under the relevant framework and standards of ICAO. With the further development of cross-border ATFM collaboration, the interconnection between cross-border systems can not only expand the range of information exchange, but also greatly improve operational efficiency. For this reason, stakeholders are welcome to carry out interconnection tests between ATFM systems with ATMB.

Extensibility

2.24 With the change of ATFM-related business needs and the progress of modern technology, ATFM system tools themselves also face the strong need for continuous upgrading and expansion. ATFM in Asia-Pacific region is currently in the development stage, and it needs a certain period of accumulation and improvement before it can mature, and then the business needs of ATFM will be relatively stable. However, in the face of the development stage, the changes in the needs of ATFM itself will naturally lead to changes in the content supported by the system tools. This is also one of the reasons why ATFM system tools also need to adapt to changes in ATFM needs.

2.25 NTFM also fully considered this demand in the early stage of design. Not only does the

system have strong compatibility, interoperability, and extensibility, for example, as the flight volume increases and the demand for computing power increases, the system's computing power can be directly enhanced by inserting more computing power hardware. Moreover, with the further upgrade of global AI and other auxiliary technologies, ATFM is also continuously researching new technologies to support the NTFM, so that the development of the NTFM keeps pace with the progress of various industries in society.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) jointly research and improve the operation concept of ATFM system tools construction in Asia-Pacific region;

c) suggest strengthening the sharing and guidance of the construction and improvement of ATFM system tools;

d) welcome stakeholders to carry out interconnection tests between systems with NTFM;

e) discuss any relevant matters as appropriate.

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