



International Civil Aviation Organization

ICAO **Fourteenth Meeting of the Air Traffic Management Sub-Group (ATM/SG/14) of APANPIRG**

Bangkok, Thailand, 3 – 7 August 2026

Agenda Item 6: ATM Coordination and Implementation

6.1: A-CDM and ATFM

OUTCOMES FROM ATFM & A-CDM/SG/16

(Presented by Secretariat/Chairperson of ATFM & A-CDM/SG)

SUMMARY

This paper presents the outcomes of the Sixteenth Meeting of the Air Traffic Flow Management and Airport Collaborative Decision-Making Steering Group (ATFM & ACDM/SG/16) and sub-regional cross border ATFM programs.

1. INTRODUCTION

1.1 The Sixteenth Meeting of Air Traffic Flow Management and Airport Collaborative Decision-Making Steering Group (ATFM & A-CDM/SG/16) was held in Bangkok, Thailand, from 06 to 10 April 2026. The Meeting included a joint plenary session with the Fifteenth Meeting of Meteorological Requirements Working Group (MET/R WG/15).

1.2 There were 22 working papers, seven information papers, 16 presentations and one flimsy considered by the meeting. The meeting papers, presentation and report are available on the ATM/SG/16 meeting webpage: [APAC Meetings | International Civil Aviation Organization](#).

1.3 The meeting agreed the following Draft Conclusions:

- a) **Draft Conclusion ATFM & A-CDM/SG/16-1:** Adoption of Asia/Pacific Regional Guidance for Assessment of Airport Capacity and Airspace Capacity; and
- b) **Draft Conclusion ATFM & A-CDM/SG/16-3:** Adoption of ATFM FIXM Message Data Attributes and Associated Message Templates Based on FIXM Version 4.3 as Asia/Pacific Regional Standard.

1.4 The meeting agreed to the following Conclusions:

- a) **Conclusion ATFM & A-CDM/SG/16-1:** Adoption of a revised *Asia/Pacific ATFM Daily Plan (ADP) Exchange Procedure*

2. DISCUSSION

Presentation on ATFM New Provisions

2.1 Mr. Elie El Khoury, Regional Office Coordinator, Air Navigation Bureau, ICAO HQ presented “ATFM New Provisions” to provide updates on the proposed. new ICAO provisions on ATFM, including amendments to ICAO Annex 11, PANS-ATM (Doc 4444), and updates to the guidance material in ICAO *Manual on Collaborative ATFM* (Doc 9971).

2.2 It was highlighted that ATFM had been elevated from a conditional measure to a mandatory service supporting air traffic service. Under the new Standards in ICAO Annex 11, States/Administrations were required to establish and to provide ATFM services for all controlled airspace and designated aerodromes, either individually or collaboratively. Key requirements included the establishment of ATFM units with defined areas of responsibility, designation of Flow Management Positions (FMPs), coordination between ATFM units, and formal determination and declaration of air traffic control (ATC) capacity in the form of strategic capacity and operational capacity.

2.3 A major element of the new provisions was the formalization of ATFM operations across four phases (strategic, pre-tactical, tactical, and post-operations) supported by structured information exchange among ATFM stakeholders. The provisions would also strengthen the requirements for capacity management, ATFM planning, coordination mechanisms, and progressive integration with flight and flow information for a collaborative environment (FF-ICE) and system-wide information management (SWIM) concepts.

2.4 It was emphasized that ATFM being a key enabler of safety, efficiency, cost-effectiveness, and environmental sustainability, particularly in managing disruptions, contingency situations, and recovery operations. The revised provisions set goals to ensure globally consistent application of ATFM measures and to support enhanced cross-border, intra-regional, and inter-regional collaboration, with a long-term vision of an “ATFM Network of Networks.”

2.5 The Meeting noted that the consultation process for the proposed amendments was in progress, with final review by the ICAO Air Navigation Commission scheduled for June 2026.

Regional ATFM Implementation Status

2.6 ICAO provided a summary of the ATFM implementation status of APAC Administrations, reported against the performance objectives of the *Regional Framework for Collaborative ATFM*. Annual implementation status reports for 2026 were received from 22 APAC Administrations:

Australia, Bangladesh, Bhutan, Cambodia, China, Hong Kong China, Macao China, Fiji, India, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Singapore, Sri Lanka, and Thailand.

Note: Republic of Korea and Viet Nam provided the implementation update after the working paper was prepared. Hence its implementation was not available in the working paper but was included in the Meeting report.

2.7 Based on reports received, States were assessed as having Robust (90-100%), Marginal (70-89%) or Incomplete (0-69%) implementation. Australia, China, Hong Kong China, Singapore, Thailand and United States were assessed as having “Robust” implementation.

2.8 **Figure 1** summarized the implementation status for Part A (Administrations that were expected, or intend, to implement and distribute cross-border ATFM measures).

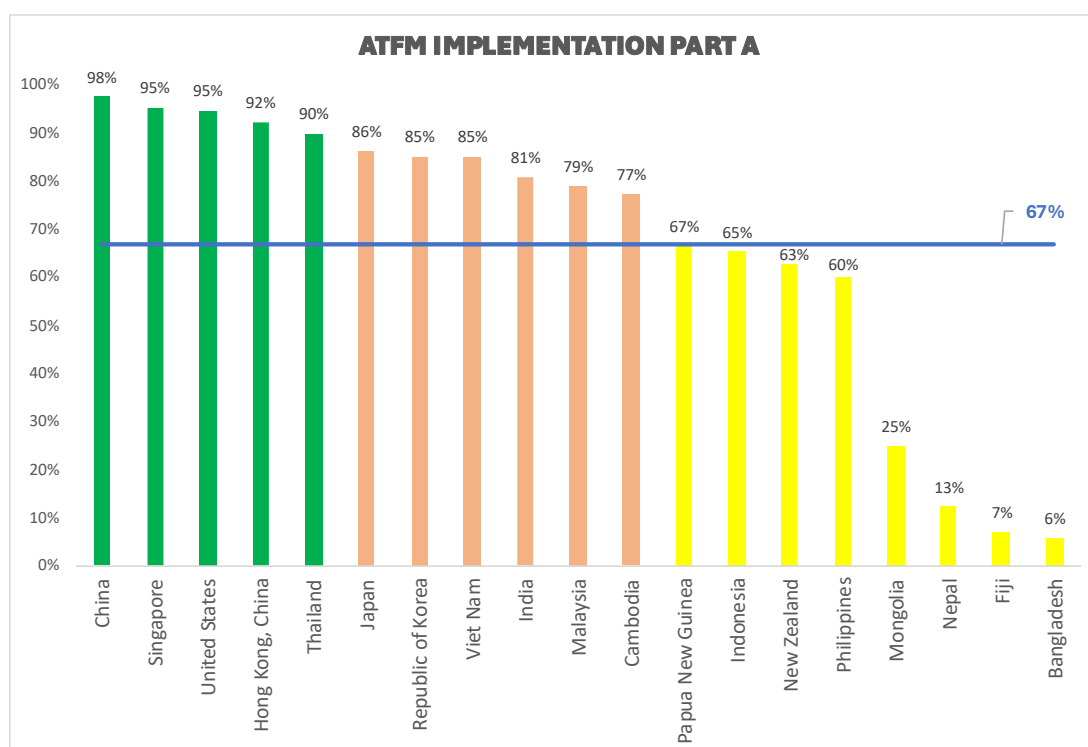


Figure 1. ATFM Implementation Status – Part A

2.9 **Figure 2** summarized the implementation status for Part B (Administrations that were not expected to implement and distribute cross-border ATFM measures).

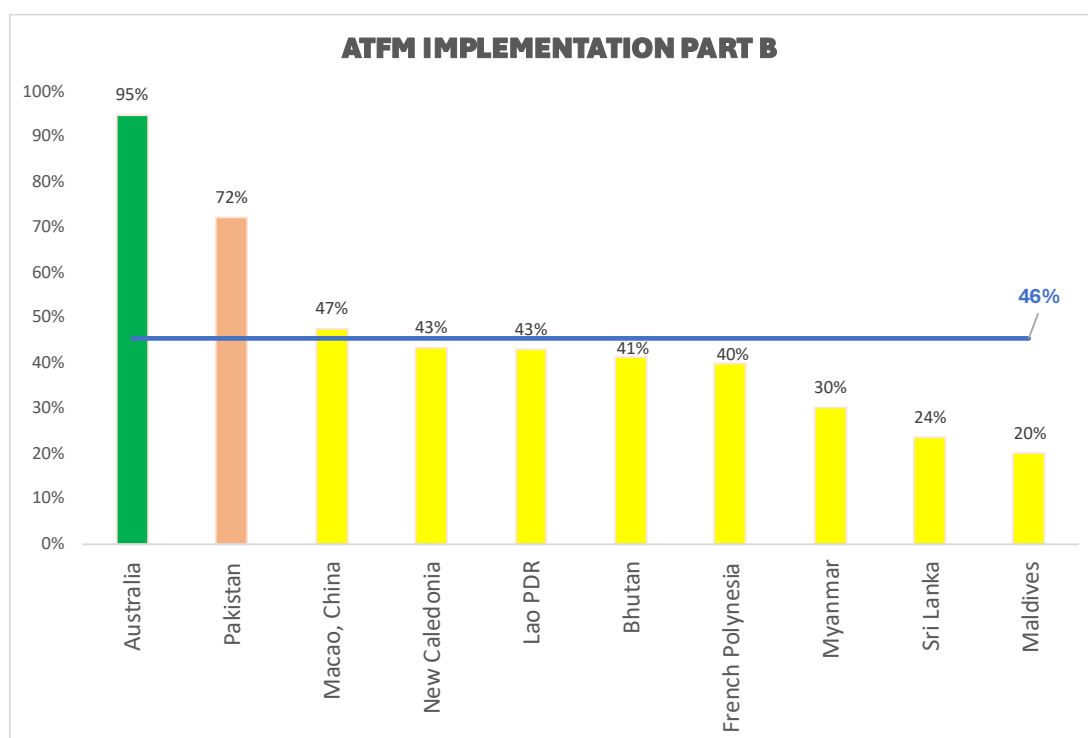


Figure 2. ATFM Implementation Status – Part B

2.10 The Regional ATFM Monitoring and Reporting Form was available on the ICAO Asia/Pacific Regional Office eDocuments webpage at: <https://www.icao.int/APAC/apac-electronic-documents#tabs-2>

BOBCAT ATFM Operational Updates

2.11 Thailand presented the post-operations analysis of the Bay of Bengal Cooperative ATFM (BOBCAT) operations which was resumed since 4 September 2025. The analysis covered traffic demand and delay impact assessment, ATFM [Calculated Take-Off Time (CTOT)] compliance and effectiveness analysis based on achievable flight levels by BOBCAT traffic for the period of 4 September 2025 to 28 February 2026.

2.12 Updated information on the BOBCAT operation is provided in a separate Information paper (i.e. **ATM/SG/14 IP/11**) by Thailand.

NARAHG Updates

2.13 NARAHG presented a new cross-border ATFM coordination method that jointly trialled by China and Republic of Korea under the NARAHG framework. The concept unitized CTO at boundary waypoints allowing for “0-VOICE” operations where no manual voice communication be required between coordination units. The downstream unit would define a set of operational parameters including Trailing intervals, Waypoint Tolerances and Minimum Intervals to govern traffic flow.

2.14 Under this model, the upstream unit was granted the autonomy to manage its own departure sequence and adjust traffic queues independently, provided concerned flights be predicted to meet the constraints. Automated alerts would only be triggered if a potential infringement of the minimum interval being detected. This approach significantly reduced the coordination burden on controllers and tactical ATC intervention, as demonstrated by the positive endorsement from Shanghai ACC.

2.15 NARAHG expressed that the second phase of trials was planned to enhance CTO accuracy by requesting flight crews to enter the assigned CTOs into the onboard FMS. This phase aimed to narrow the waypoint tolerance towards ± 1 minute. NARAHG emphasised such efforts would support the region’s long-term transition towards Trajectory-Based Operations (TBO) as envisioned in the ICAO Global Air Navigation Plan (GANP).

2.16 The Meeting also discussed the potential challenges and difficulties for flight crews to enter and comply with the CTO especially when there were multiple CTO constraints along the flight route.

Progress Update from the Asia-Pacific Cross-Border Multi-Nodal ATFM Collaboration (AMNAC)

2.17 The Meeting was presented with the updates from AMNAC covering the network post operations analysis for March 2025 – February 2026, an agreed CTOT compliance performance target, updates to the Common Operating Procedure (COP), adoption of harmonized REGUL and REGCAUSE nomenclatures, modification of the ATFM Daily Plan (ADP) exchange procedure, and progress of the trial of ATFM information exchange via SWIM.

2.18 Network post-operations analysis showed that Ground Delay Programs (GDPs) were used consistently among Level 3 ANSPs to balance demand and capacity. Of flights subjected to CTOTs, 77% departed from Level 2 or Level 3 aerodromes. CTOT compliance varied: 71% for departures from aerodromes of Level 3 departures ANSPs and 60% for departures from aerodromes of Level 2 departures ANSPs, with CAAP (the Philippines) demonstrating notably high compliance at 86%. Recognizing the need for improvement, AMNAC/25 agreed to monitor CTOT compliance against an initial 80% performance target, referencing both regional experience and benchmarks from the European Union and United States. Performance against this target would form the monitoring baseline for AMNAC in the coming year and may serve as the foundation for recommending region-wide CTOT compliance performance expectations in the future.

2.19 AMNAC continued work on the standardization of ADP data formats, supporting future SWIM-based digital exchange. The AMNAC Core Team revised the *Asia/Pacific ADP Exchange Procedure* to include a new ADP template and updated contact lists.

2.20 The Meeting was informed that the update process of AFTN/AMHS ICD for ATFM had been taken up by ICAO Secretariat with the ICD expected to be presented to ACSICG/13 (April 2026) and proposed to CNS SG/30 (July 2026) for endorsement and noted the proposal for using REGUL and REGCAUSE as part of AMNAC ICD in the interim.

2.21 The updates of AFTN/AMHS ICD for ATFM were presented to ACSICG/13 which noted that the ICD comprised of both operational logic and technical specifications, including interface protocols and message syntax. The ACSICG Co-Chairs recommended that changes on the operational content of such regional ATM deliverables should be reviewed and endorsed through ATM SG to ensure appropriate governance, ownership, and accountability.

2.22 CNS SG/30 Meeting deliberated on the views expressed by the ACSICG Secretary, the ATFM & A-CDM SG Secretary, and the Co-Chairs of both groups. Taking into account the discussions and the respective responsibilities of the groups, the Meeting suggested that ownership of the AFTN/ATFM ICD for ATFM be shared jointly between ATM SG and CNS SG. Under this arrangement, ATM SG, with support from ATFM & A-CDM SG, would be responsible for reviewing and endorsing the operational aspects of the document, while CNS SG, with support from ACSICG, would be responsible for reviewing and adopting its technical and communications-related components. Accordingly, CNS SG/30 adopted the following draft conclusion (reference to **ATM/SG/14 WP/14** para 2.10 – 2.16):

Draft Conclusion CNS SG/30/02 (ACSICG/13/02) – AFTN/AMHS-based Interface Control Document for ATFM (ICD) be jointly owned by ATM SG and CNS SG

2.23 ATM/SG/14 meeting is invited to consider the following Conclusion:

Conclusion ATM/SG/14-X: Uploading of Asia/Pacific AFTN/AMHS Interface Control Document

That, the AFTN/AMHS-based Interface Control Document for ATFM (ICD) used by APAC States/Administrations to implement cross-border ATFM communications at Appendix X to the report be uploaded to the ICAO Asia/Pacific Regional APAC Office website eDocuments webpage, for guidance and reference, by Asia/Pacific APAC States/Administrations.

Analysis of CTO Trial in Fukuoka FIR

2.24 Japan presented the update on the CTO trial conducted within Fukuoka FIR, analyzing approximately 2,800 flights. The trial aimed to evaluate the operational performance, time accuracy, and cancellation factors of CTO as an ATFM measure. The analysis highlighted how operational conditions, including weather and traffic situations, influence the effectiveness of these measures in balancing demand and capacity. **Figure 3** illustrates the scope of the trial.

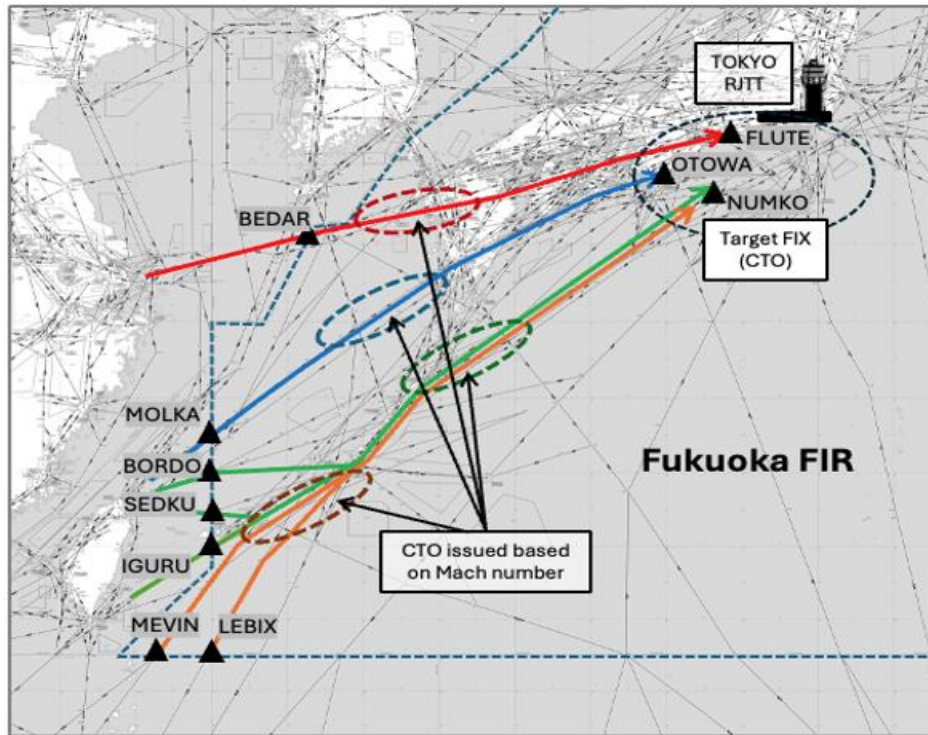


Figure 3. CTO Target Fixes in Fukuoka FIR

2.25 Flights with assigned CTO were expected to achieve a window of ± 3 minutes. Out of 2808 flights analyzed, 1897 CTO assignments were complied with, while 911 assignments were cancelled. The analysis indicated that weather avoidance, tactical ATC intervention for separation and altitude constraints were the major contributing factors towards CTO cancellations.

2.26 The trial observed variations in ETA prediction accuracy with reference to different operational conditions. The ETA prediction errors were also evaluated against different time horizons indicating the presence of adjacent FIR data would improve predictability.

2.27 The trial also identified a gap between assigned CTOs and actual times over the designated waypoints. These discrepancies were often linked to tactical ATC operations and the specific structure of traffic flows within the sectors. The findings indicate that while CTO is a useful tool, its accuracy is highly dependent on the level of coordination between ATFM planning and real-time tactical ATC interventions.

Progress Update on ATFM Activities in India

2.28 India presented their progress update on various ATFM activities undertaken by India since ATM/SG/15.

2.29 India reported on the significant improvements observed following the harmonization of ATS procedures with the provision of ATFM. CTOT compliance increased from 77% in 2023 to 85% in 2024 and further to 97% in 2025. In 2025, 513 ATFM measures were applied, air delay reduction of 248,470 minutes (~4,141 hours), fuel savings of 15,650.288 tons, and CO₂ reduction of 49,454.911 tons were recorded. India also amended its ATFM Unit AFTN address to VIDPZDZX effective 30 October 2025.

2.30 Chairperson of ATFM & A-CDM/SG informed the Meeting on the update process of the ATM Operations Panel (ATMOPSP) consideration of proposal from India on inclusion ATFM-related phraseologies into ICAO Doc 4444. It is expected that the ATFM phraseology may not be included in the ATFM PfA planned to be applicable in 2030. Nevertheless, ATMOPSP ATFM Working Group expects to continue its work on ATFM phraseology for the next batch of updates, while also considering communications of other ATFM measures between ATCOs and pilots.

2.31 The Meeting appreciated India's efforts on improving CTOT compliance. India informed that they would share the updated Standard Taxi-in and Standard Taxi-out for India airports with the Bangkok ATFMU for BOBCAT operations.

Streamlining Regional ATFM Collaborative Decision-Making Platform

2.32 The Meeting was presented the proposal to streamline regional ATFM CDM platforms by consolidating the APAC Bi-Weekly ATFM Web Conference and the Traffic Flow Coordination Call (TFCC) into a single unified platform to enhance operational efficiency and improving resource management in the region.

2.33 The Meeting supported the proposal of harmonizing the different coordination mechanisms in the region. It was expressed that APAC States/Administrations interested in joining the TFCC calls could approach China, Hong Kong China or Singapore POCs listed in WP-4a-07 Annex B Appendix A.

2.34 The Meeting observed the conduct of TFCC on 9 April 2026. Subsequently, the expansion of the TFCC into APAC TFCC was scheduled for 1 June 2026.

MET/ATM Joint Plenary Session

2.35 The MET/ATM Joint Plenary Session was organized on the morning of 8 April 2026. A total of 6 papers were presented during the plenary session.

2.36 The joint plenary agreed to conduct a MET/ATM Seminar in 2027 with the seminar objectives, content, format and agenda to be developed by a small joint task group composing of both MET/R WG and ATFM & A-CDM/SG members.

2.37 Realizing the role of impact-based MET information to support ATM decision making, the joint plenary noted that MET/R WG/15 adopted a decision to update the *Regional Guidance for Tailored Meteorological Information and Services to Support ATM Operations* with the draft guidance to be finalized by 1 June 2026 for approval at the MET SG/30.

Asia/Pacific Regional Guidance Document for Airport and Airspace Capacity Assessment.

2.38 The Meeting was presented with the draft *Regional Guidance Document for Airport and Airspace Capacity Assessment*, developed following the ICAO APAC Airport and Airspace Capacity Assessment Workshop held in Yogyakarta, Indonesia, in June 2025. The document is provided as **Appendix A** to this paper.

2.39 The guidance provided a brief description of airport capacity assessment processes along with airspace capacity assessment processes, including practical examples and appendices illustrating models that could support States/Administrations in evaluating capacity. Its purpose was to assist ATM planners in developing plans to improve capacity in order to meet current and future system demand across the Asia/Pacific region.

2.40 The Meeting agreed to the following Draft Conclusion to adopt the *Asia/Pacific Regional Guidance for Assessment of Airport and Airspace Capacity*. ATM/SG is invited to consider the following Conclusion:

Conclusion ATM/SG/14-X: Adoption of Asia/Pacific Regional Guidance for Assessment of Airport Capacity and Airspace Capacity.

That, the Asia/Pacific Regional Guidance for Assessment of Airport and Airspace Capacity at Appendix X to the report be adopted and uploaded to the ICAO APAC Office eDocuments webpage, for guidance and reference, by APAC States/Administrations in conducting airport and airspace capacity assessments in accordance with the provision of the Regional Framework for Collaborative ATFM.

Status on Regional Monitoring and Reporting Scheme for A-CDM Implementation

2.41 ATFM/IR/SWG provided a summary of the *Regional Monitoring and Reporting Scheme for the Asia/Pacific A-CDM Implementation*. Annual implementation reports for 2026 were received from 21 APAC States/Administrations covering 87 airports in the region.

Australia, Bangladesh, Cambodia, China, Hong Kong China, Macao China, Fiji, India, Japan, Malaysia, Mongolia, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand and Viet Nam

2.42 All reported aerodromes were international aerodromes, of which 82% (71) were reported as high-density international aerodromes. All reported high-density international aerodromes had A-CDM planned or implemented.

2.43 More than 85% (67) of reported high-density international aerodromes indicated A-CDM in Operation and Monitoring Phase. The rest of the reported high-density international aerodromes indicated either A-CDM in Implementation Phase or Initiation Phase to implement A-CDM.

2.44 Out of the 67 aerodromes (including both high density and other international aerodromes) that A-CDM in Operation and Monitoring Phase, 63 of them have implemented all eight required A-CDM Milestones. The reasons for not implementing all required Milestones include information sharing platform not available or respective ATM systems being unable to capture the required Milestone event.

Operational Efficiency Promotion by Support from A-CDM in China

2.45 The Meeting was presented with the current status, key achievement and the proposed actions regarding the implementation of A-CDM in China under the collaboration between the Civil Aviation Administration of China (CAAC) and IATA.

2.46 The deployment of A-CDM at major airports (those with over 10 million annual passengers) had led to a 5–10% increase in the national average flight delivery rate. Target Off-Block Time (TOBT) prediction accuracy had surpassed 95%, while the national average on-time performance remained robust at 85.66% between 2017 and 2025.

2.47 China expressed that the success if A-CDM implementation was attributed to sufficient investment support from stakeholders; supporting role of regulatory body; effective interoperability between individual A-CDM and National Traffic Flow Management; and the establishment of the operations management committee responsible for the performance review of stakeholders.

2.48 China implemented a comprehensive 45-milestone model that covers all operational entities. This exceeded the 16-milestone model commonly used in Europe and ensured that over 80% of operational data be collected automatically. This broader scope provided enhanced visibility and traceability across the entire A-CDM process, allowing airports to design additional milestones tailored to their specific local requirements.

Progress of the ATFM Concept Design Ad-Hoc Group

2.49 The Meeting was presented with the progress from the ATFM Concept Design Ad-Hoc Group which was established following the ATM/SG/15 in 2025 with primary mandate to review and propose a revised regional ATFM Concept of Operations (CONOPS) that would address from near-term operational challenges to long-term vision for the Asia/Pacific region.

2.50 The Ad-Hoc Group is comprised of 36 representatives and 10 observers from 11 States/Administrations and three international organizations. Mr. Sugoon Fucharoen from Thailand and Mr. Yan Xiaoyu from China were the co-rapporteurs to coordinate the work of the Ad-Hoc Group.

2.51 The Ad-Hoc Group established structured working arrangements including scheduled virtual monthly meetings, well defined working areas and groups, and a dedicated SharePoint workspace on top of email for information sharing. In-person meetings could would be arranged on needed basis.

2.52 The following deliverables were expected for submission at ATM & A-CDM/SG/17 in 2027:

- a) draft revised *Asia/Pacific Regional ATFM Concept of Operations* document; and
- b) principles guiding the amendment of the *Asia/Pacific Regional Framework for Collaborative ATFM* based on the revised *Asia/Pacific Regional ATFM Concept of Operations*.

2.53 The Ad-Hoc Group anticipated to have one or two in-person meetings during Phase 2 to facilitate effective brainstorming and discussion in concept development. through the in-person meeting One such meeting would be conducted alongside the ATM & A-CDM/SG/16 while another is scheduled during 26 – 30 October 2026. Progress updates would be shared with the Chairperson of the ATM & A-CDM/SG and be reported to relevant regional forums when needed to ensure the deliverables would remain aligned with broader regional air navigation objectives.

Enhancing Regional ATFM Coordination through Regional Collaborative Operational Mechanism (RECOM)

2.54 The Meeting was presented with the RECOM voluntary initiatives by AAC intended to enhance coordination among existing sub regional ATFM mechanisms by outlining the operational rationale, structural concept, ongoing implementation, and future integration of regional collaborative arrangements.

2.55 Despite the significant progress in implementing cross-border ATFM operations through several sub-regional collaborative mechanisms, the scale and complexity of traffic flows in the region had evolved to the extent that enhanced cross-sub-regional situational awareness and coordination would become more salient.

2.56 It was highlighted that while sub-regional mechanisms remained effective, the number of ATFM-related coordination meetings had increased and lead to duplicative efforts with increased coordination burden. It was suggested that an open, inclusive, operationally focused platform—RECOM—could streamline coordination without altering governance arrangements or infringing on States/Administrations’ responsibilities. RECOM was emphasized as a distributed, multi-nodal, non-centralized mechanism that respects States’ decision-making authority

2.57 While the meeting expressed interest in participating in developments that could cultivate ATFM information sharing initiatives, the meeting sought clarification on the methodologies to operationalize and materialize the RECOM concept into implementation, while emphasizing the importance of streamlining efforts to avoid resource burdens associated with participation in multiple parallel initiatives. In addition, no clarification was provided in respect to independence of TFCC (para 2.32 – 2.34) in relation to RECOM. The presenters clarified that the RECOM initiative was an ANSP-level cooperation mechanism, aiming to promote integrated ATFM operations across the APAC region. In addition, RECOM could offer to bridge various cross-border ATFM initiatives in the region and could foster more coordinated and efficient ATFM operations across the region.

2.58 The meeting noted that RECOM would explore opportunities to enhance and streamline regional coordination, starting with enhancing common situational awareness and consolidating ATFM coordination meetings as initial steps. From a regional perspective, this consolidation effort could support more efficient use of resources and strengthen alignment among stakeholders. RECOM would enable participants to come together to discuss and explore ATFM solutions for the APAC region.

2.59 Further information is provided in a separate Information Paper (i.e. **ATM/SG/14 IP/10**) by China to this meeting.

Need for A-CDM Performance Reporting

2.60 Recognizing the lack of performance reporting to measure the effectiveness and benefits of A-CDM system for ANSPs, CANSO presented to the Meeting on the A-CDM Performance Framework to support A-CDM performance-based steering, reporting, and publication in Asia/Pacific.

2.61 By creating a common A-CDM performance framework with international reporting and publications, performance monitoring and reporting gaps could be overcome, and such framework would also complement existing industry performance frameworks that apply to airport operational efficiency.

2.62 The A-CDM Performance Framework was expected to enhance ATFM ground delay compliance, flight plan adherence, and overall ATM efficiency, while increasing data-driven performance publications that foster harmonization and innovation, and would serve as a key enabler for FF-ICE, TBO, and future ATFM developments through improved predictability of pushback and take-off times.

2.63 The Meeting noted CANSO had proposed forming a Joint Task Force with ACI and IATA to finalize the A-CDM Performance Framework and to establish a performance-assessment mechanism, while encouraging States/Administrations and their ANSPs to support early validation of the draft Framework and ICAO to consider its use for regional A-CDM implementation and monitoring

Proposal to Amend Asia/Pacific ATFM Daily Plan Exchange Procedure

2.64 The Meeting was presented with the proposal to update the Asia/Pacific ATFM Daily Plan (ADP) Exchange Procedure, incorporating the new ADP template presented during ATM/SG/15 and an updated contact information list for ADP exchange.

2.65 The revised draft *Asia/Pacific ATFM Daily Plan (ADP) Exchange Procedure Version 1.0* including the revised template, updated contact list, and editorial amendments were presented to the meeting. The meeting agreed to the following Conclusion:

Conclusion ATFM & A-CDM/SG/16-2: Adoption of a revised Asia/Pacific ATFM Daily Plan (ADP) Exchange Procedure

That, noting the importance of effective procedure for ATFM Daily Plan (ADP) exchange in the regional ATFM network, the revised Asia/Pacific ATFM Daily Plan (ADP) Exchange Procedure be adopted as a “version 1.0” and, together with a separate Asia/Pacific ADP Exchange Operational Contact List, be uploaded to the ICAO Asia/Pacific Regional Office eDocuments webpage, replacing the current working draft version.

2.66 The revised *Asia/Pacific ATFM Daily Plan (ADP) Exchange Procedure Version 1.0* and the Asia/Pacific ADP Exchange Operational Contact List have been uploaded to the ICAO APAC Office eDocuments Webpage.

Guidance Material to Assist APANPIRG Subsidiary Groups in Reviewing and Updating the List of APAC Common SWIM Information Services

2.67 The Meeting recalled that ***Decision APANPIRG/36/11*** adopted the *First Version of the Business Functionality for APAC Common SWIM Information Services* and requested APANPIRG Subsidiary Groups to review the document for the development of the *Second Version of the APAC Common SWIM Information Services* document, through the provision of Guidance Material.

2.68 APANPIRG contributory bodies were invited to assess whether existing entries combine multiple business functions and, if so, to consider splitting them into more detailed and focused information services. A working draft of the Second Version had been developed, and groups were requested to submit updates using “track changes” for consolidation at SWIM TF/11 (26 – 29 May 2026).

2.69 The Meeting noted the two potential future enhancements identified by SWIM TF: the introduction of an “applicability” field (e.g., region-wide vs. local need as needed by subset of States) and the addition of desired implementation timeframes (immediate, medium-term, long-term). It also recommended that Subsidiary Groups review the document regularly at each meeting, and to provide updates to SWIM TF as necessary to maintain the currency of the list relevant to their information domain.

2.70 The Meeting noted that Appendix B of the working paper identified four ATFM related SWIM Information Services; however, only two services, namely the Flight Specific ATFM Measure Service and the ATFM/A CDM Integration Service—had been included in the first published edition. It was highlighted that the remaining two services—the ADP Distribution Service and the Flow Specific ATFM Measure Service—had been previously discussed but were not included due to unresolved issues related to information exchange models and data formats (e.g. FIXM vs Flow Information Exchange Model – FLXM). The Meeting encouraged further review of these two services, considering any progress since the previous SWIM TF discussions, and invited feedback on their potential inclusion in the next revision.

2.71 The Meeting noted that, while a reference document for the ADP Distribution Service was made available following the elevation of the Asia-Pacific ADP exchange procedure, the digital data format and the appropriate information exchange model for ADP remained under development. The Flow-Specific ATFM Measure Service was similarly recognized as less mature, given the absence of harmonized, region-wide operational application and potential network impacts. It was agreed that further operational and technical development would be required before detailed operational use cases

could be developed to support identification of MEP. It was also discussed that the priority of ADP Distribution Service and Flow-Specific ATFM Measure Service could be reviewed by the ATFM & A-CDM SG, and that its feedback could be provided to SWIM TF/11. More information is provided in the Working Paper 14 “Outcomes of CNS SG-30 (para 2.59 to 2.62)” by ICAO Secretariat.

ATFM FIXM Message Data Attributes and Associated Message Templates Based on FIXM Version 4.3 as Asia/Pacific Regional Standard

2.72 The Meeting was presented with the work on identification, mapping, and development of ATFM FIXM message data attributes and associated message templates based on FIXM version 4.3, to support cross-border ATFM operations, A-CDM, ATFM/A-CDM integration, and traffic synchronization in a SWIM environment in the Asia/Pacific region.

2.73 It was recalled that the Asia/Pacific Regional Framework for Collaborative ATFM identified FIXM 4.2 or later as the agreed information exchange model, and that ICAO ATM/RPP recommended FIXM 4.3 for FF-ICE/R1 services. FIXM 4.3 was endorsed at ATFM/SG/14 and ATM/SG/12, with APANPIRG/35 formalizing its adoption. Successive regional FIXM extensions, developed jointly by ATFM SG and SWIM TF, were adopted through Conclusion APANPIRG/36/12 to support harmonized implementation across the region.

2.74 The Meeting agreed to the adoption of the identified ATFM FIXM messages data attributes, mapping, and the associated message templates, based on FIXM version 4.3, as regional standard templates effective Q1/2027.

2.75 Subsequently, the updates were presented to SWIM TF/11 meeting and CNS SG/30 meeting for consideration. CNS SG/30 endorsed the Draft Conclusion for adoption by APANPIRG/37. More information is provided in the **ATM/SG/14 WP/14** “Outcomes of CNS SG-30 (para 2.56)” by ICAO Secretariat

Asia/Pacific Regional Flight and Flow Information for A Collaborative Environment (FF-ICE) Release 1 Implementation Plan

2.76 The Meeting was presented with the draft *APAC Regional FF-ICE Release 1 (FF-ICE/R1) Implementation Plan* developed by the ICAO APAC FF-ICE Ad Hoc Group. The Plan detailed the operational and technical requirements for regional FF-ICE/R1 services implementation, as well as the identified and recommended areas of harmonization for the APAC region to ensure regional interoperability and consistent handling of operational conditions.

2.77 The Meeting was briefed on the interpretation and expected eAU actions for the Filing Status values as in Table below. It was emphasized that the Filing Status would reflect the operational acceptability only and would not constitute ATC clearance.

Table 1. FF-ICE Filing Status Interpretation and Expected eAU Action

Filing Status	Interpretation	Expected eAU Action
ACCEPTABLE	The flight plan complies with operational requirements. Any constraints identified can be accommodated without flight plan modifications.	No immediate action or update required. Note any provided constraints for awareness. Prepare for possible tactical clearances reflecting identified constraints.

Filing Status	Interpretation	Expected eAU Action
NOT ACCEPTABLE	The flight plan does not comply with operational requirements and requires modification.	Submit Flight Plan Update to address non-compliance. If close to EOBT, the operator may be unable to update their flight plan in time using FF-ICE/R1 processes. In these cases, the operator may update their flight plan as needed through tactical coordination with ATC. <i>Note: if departure eASP provides a “Not Acceptable” Filing Status, eAU can expect refusal to start-up clearance if non-compliance requires flight plan modification (e.g. aerodrome closure). This does not apply to “Not Acceptable” status received from downstream eASPs.</i>
PENDING	Flight plan evaluation has not yet been performed.	Await subsequent Filing Status update. Monitor Expected Evaluation Time if provided.

2.78 With a substantive discussion, the Meeting acknowledged that while ATFM was not a prerequisite for FF-ICE/R1, and FF-ICE could be implemented independently prior to 2030 when ATFM services were not yet mandatory. However, ATFM would be the key enabling requirement for subsequent FF-ICE/R2 and beyond. It emphasized the importance of considering the applicable timeframes and evolving operational environment when interpreting these relationships.

2.79 Further updates on the subject are presented in Working Paper 22

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information contained in this paper; and
- b) note the progress of:
 - i) AMNAC; and
 - ii) NARAHG;
- c) note the continued slow regional progress in implementation of the performance expectations of the Regional Framework for Collaborative ATFM;
- d) note the regional progress in implementation of Airport Collaborative Decision Making;
- e) discuss and agree to **Conclusion ATM/SG/14-X: Uploading of revised AFTN/AMHS ICD to ICAO APAC eDocuments website;**
- f) discuss and agree to **Conclusion ATM/SG/14-X: Adoption of Asia/Pacific Regional Guidance for Assessment of Airport Capacity and Airspace Capacity;** and
- g) discuss any relevant matters as appropriate.

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Conclusion ATM/SG/14-X: Adoption of Asia/Pacific Regional Guidance for Assessment of Airport Capacity and Airspace Capacity	
What: That, the Asia/Pacific Regional Guidance for Assessment of Airport and Airspace Capacity at Appendix X to the report be adopted and uploaded to the ICAO APAC Office eDocuments webpage, for guidance and reference, by APAC States/Administrations in conducting airport and airspace capacity assessments in accordance with the provision of the <i>Regional Framework for Collaborative ATFM</i> .	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To provide guidance for conducting airport and airspace capacity assessment and to improve understanding of the processes by cataloging the best practices and models as adopted by Asia/Pacific States/Administrations.	Follow-up: ☐ Required from States
When: 7-Aug-26	Status: Draft to be adopted by Subgroup
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:	

Conclusion ATM/SG/14-X: Uploading the revised AFTN/AMHS-based Interface Control Document	
What: <i>That, the revised AFTN/AMHS-based Interface Control Document for ATFM (ICD) used by APAC States/Administrations to implement cross-border ATFM communications at Appendix X to the report be uploaded to the ICAO Asia/Pacific Regional APAC Office website eDocuments webpage, for guidance and reference, by Asia/Pacific APAC States/Administrations</i>	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To enhance ATFM post-operations analysis and to improve regional interoperability by broadening the technical applicability of the ICD to conform with system requirements of all Asia/Pacific States/Administrations.	Follow-up: ☐ Required from States
When: 7-Aug-26	Status: Draft to be adopted by Subgroup
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:	

INTERNATIONAL CIVIL AVIATION ORGANIZATION



**ASIA/PACIFIC REGIONAL GUIDANCE
FOR ASSESSMENT OF
AIRPORT CAPACITY AND AIRSPACE CAPACITY**

Version 1.0, APRIL 2026

This Guidance Document was developed by the Asia/Pacific Air Traffic Flow Management & Airport Collaborative Decision Making Steering Group (ATFM & A-CDM/SG)

Adopted by XXX Meeting of ATM Sub-Group of APANPIRG and published by the ICAO Asia and Pacific Office, Bangkok

RECORD OF AMENDMENTS AND CORRIGENDA

Amendments / Corrigendum			
No	Amendment/Corrigendum	Date of Issue	Subject Matter

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Chapter 1 - Introduction

1.1 Purpose and overview of the guidance

1.1.1 This guidance aims to enhance States' understanding of recommended methodologies to assess airport and ATC sector capacity, within Asia/Pacific (APAC) region. The purpose of this document is to assist ATM planners to develop plans, where necessary, to improve such capacity in order to meet present or future demands of the system. Although the document is aimed at Asia/Pacific region, the concept, application and guidance presented herein is globally applicable.

Note: In this document the terms “airport and/or aerodrome” refer to “controlled aerodrome”.

1.1.2 The guidance captures most of the necessary processes from preparatory to implementation phases. Information in this guidance can be used to facilitate further improvement in ATM Services by the States.

1.1.3 A stepwise (process-wise) structure of the guidance is expected to allow each State to refer to chapters, sections or subsections useful for the commencement, implementation or improvement of its capacity assessment process to support effective ATM.

1.1.4 This Guidance is intended to be referred to by the ATM community to ensure common understanding for the implementation and/or enhancement of capacity assessment process.

1.2 Development of Regional Guidance Document

1.2.1 ICAO APAC Air Traffic Flow Management Steering Group (ATFM/SG) 13th meeting, held in September 2022 in Bangkok, noted that assessment of Airport and Airspace capacity is an essential initial step towards ATFM implementation. However, the detailed explanation for carrying out Airport and Airspace Capacity assessment has not yet been specified in Annex 11. The meeting also noted that specific regional guidance material is necessary to assist States in developing and implementing airport and airspace capacity assessment to support effective ATM and agreed to conduct a workshop as a way towards developing the regional guidance material.

1.2.2 ICAO conducted a workshop on Airport and Airspace Capacity Assessment in June 2025 in Yogyakarta, Indonesia.

1.2.3 A draft regional guidance document for conducting airport and airspace capacity assessment to support ATM operations was presented during the workshop. The draft document was circulated to ATFM points of Contact (POC) of APAC States and administrations in October 2025 for further development and a final draft presented to APAC ATFM & A-CDM/SG in April 2026 for approval.

1.3 Process towards implementation

Preparatory Phase- Need for Capacity Assessment

1.3.1 Regular assessment of historical air traffic statistics at major airports provides an overview of air traffic demand. Flight delays are is-usually the best source for identifying capacity shortfalls. The departure and arrival delay as well as punctuality statistics obtained from the different sources (airspace users, airports, ANSPs), and compiled together, are among the best sources for identification of capacity imbalances and shortcomings. When it is noted that air traffic demand consistently exceeds the available airport and airspace capacity, the ATM planners should initiate a comprehensive capacity assessment process to identify bottlenecks, either for an airport or for airspace or for both. ~~for identifying bottlenecks.~~ Other triggers for capacity assessment could be expected growth of the traffic, or due to change in ATM resource airport infrastructure, procedures or change in the traffic mix, etc.

1.3.2 Doc 9971 in Appendix II-D recommends that an annual capacity planning and assessment process, as well as a cyclical process that identifies and quantifies the capacity requirements for the short- and medium-term, should be put in place.

1.3.3 Asia Pacific Seamless ANS Plan V4.0 also recommends that regular airport capacity analysis (Para 7.1 c) and ATC Sector capacity assessment (Para 7.40) should be conducted.

Stakeholders' consultation-

1.3.4 Airport and Airspace Capacity assessment is a collaborative process involving all the stakeholders of the aviation system such as airport operators, ANSPs, Airspace users, military authorities, ground handling agencies, security agencies etc. The capacity assessment process will involve the stakeholders concerned at many stages. For example, airport capacity assessment is not restricted only to the runway capacity, but also considers the combined system: runways, taxiways, aprons and terminals. Hence the involvement of all stakeholders in the process is essential.

1.3.5 The following is an extract from Doc 9971 on establishing an Airport ~~Aerodrome~~ Arrival Rate (AAR) process at an airport. It shows the collaborative process.

Note: For example, to establish an AAR Process;

- *Identify the organization responsible for the establishment and implementation of AARs at the selected airports*

NOTE: It is recommended that you establish a small working group of stakeholders that will have input into the AAR value. For example, ATCOs, supervisors, airport authority, a major airline.

- *Establish optimum AARs for the airport identified; and*
- *Review and validate the airport primary runway configurations and associated AARs at least once each year*

--Doc 9971, Appendix II-B, 2

Past events and Case Studies-

1.3.6 ATM Planners can draw upon the lessons learned from organizing large scale events such as air shows, military exercises, long duration airport maintenance work, major upgradation of crucial CNS facilities etc., which resulted in large scale air traffic disruptions and rescheduling. Such events provide valuable ~~steps~~ information for demand and capacity balancing process. Post operation analysis after the event will also indicate the accuracy of capacity and demand estimation. Such analysis will help in refining the capacity assessment process.

Data Collection Phase-

1.3.7 ATM Planners will need to carefully consider the data required for capacity assessment process. The type, extent and accuracy of data will determine the quality of the capacity assessment process. The following is an indicative list of data which may be considered for the airport capacity assessment process.

Data	Type of data/Time period	Units
Traffic	Monthly, daily, hourly	Average/distribution
Traffic mix	Type of aircraft, Operator share, Patterns (AA/DD, ADA...)	Average/distribution

Data	Type of data/Time period	Units
Runway use	Hours Hourly, Daily, Monthly	Average/distribution
Arrival Throughput	Hourly/30'/15'	Average/distribution
Departure throughput	Hourly/30'/15'	Average/distribution
Max observed throughput in peak	Hourly/ Daily	Average
Runway Occupancy Time(ROT)- Arrival	Per aircraft, runway and exit point	Average/distribution/median
ROT-Departure	Per aircraft, runway and entry point	Average/distribution/median
Separation on final approach	Distance or Time	Average
Separation Minima (Terminal airspace)	Distance	Average

Table 1- List of Data Considered for Airport Capacity Assessment Process

Chapter 2 - Understanding Capacity

2.1 What is Capacity?

2.1.1 Annex 11 to the ICAO Convention defines “declared capacity” as the measure of the ability of the ATC system or any of its subsystems or operating positions to provide service to aircraft during normal activities. It is expressed as the number of aircraft entering a specific portion of airspace in each period of time, taking due account of weather, ATC unit configuration, available staff and equipment, and any other factors that may affect the workload of the controller responsible for the airspace.

2.1.2 Additionally, Document 4444, ATM, Procedures for Air Navigation Services, in paragraph 3.1.4.1 of Chapter 3, establishes that the appropriate ATS authority should periodically review ATS capacity in relation to traffic demand; and should provide for flexible use of airspace to improve operational efficiency and increase capacity.

2.1.3 Next, paragraph 3.1.4.2 states that, in the event that traffic demand regularly exceeds ATC capacity, resulting in continuous and frequent traffic delays, or it becomes apparent that traffic demand forecasts will exceed capacity values, the appropriate ATS authority should, to the extent possible, take steps to maximize the use of existing system capacity; and develop plans to increase capacity in order to meet current or foreseen demand.

2.1.4 The following is an extract from draft proposal of ATMOPS Panel. It shows how the definition of CAPACITY is evolving to recognize the relationship with time.

- **Strategic capacity.** *A measurement of the ability of the ATC unit to provide safe, orderly and efficient service to aircraft during normal circumstances expressed as the number of aircraft entering a specified controlled airspace or operating at a specific aerodrome in a given period of time. Strategic capacity is often referred to or considered as ~~Planned~~ Declared Capacity.*

Note: Declared capacity' and 'Strategic capacity' are equivalent terms and have been used interchangeably in this document.

- **Operational capacity.** *A dynamic, time-specific capacity value derived from strategic capacity, to be updated as required and used in ATFM pre-tactical planning and ATFM tactical operations.*

2.1.5 Strategic capacities are primarily used for multi-year and investment planning. Declared, expected (or Operational) capacities are used in strategic, pre-tactical and tactical traffic flow management as well as for measuring and monitoring service delivery and efficiency. In contrast to normal circumstances considered for Strategic capacity evaluation, Operational capacity accounts for evolving operating conditions on the day-of operation.

2.1.6 Some ANSPs may prefer not to declare capacities in advance based on normal operating circumstances, instead establishing these capacities daily based on known/current operational factors. Establishing capacities at different planning horizons provides an important reference for understanding the total system performance under normal operating conditions and provides a basis to work from when determining the impact of operational factors limiting capacity. These factors include – but are not limited to – Air Traffic Control Office (ATCO) availability and workload.

2.2 Importance of Capacity and Demand Assessment

2.2.1 Annex 11 in paragraph 3.7.5.1, establishes that air traffic flow management (ATFM) will be implemented in airspaces where air traffic demand at times exceeds, or is expected to exceed, the

declared capacity of the air traffic control services concerned, and paragraph 3.7.5.2 contains a Recommendation to implement ATFM through regional air navigation agreements or, if appropriate, through multilateral agreements, and that such agreements must make provision for common procedures and methods for determining capacity.

2.2.2 The purpose of ATFM is to achieve a balance between air traffic demand and system capacity to ensure an optimum and efficient use of system airspace. This is achieved by balancing expected/forecasted demand and the capacity declared by the appropriate air traffic service providers in order to accommodate a maximum number of flights under a gate-to-gate concept.

2.2.3 In order to achieve demand-capacity balance in long-term, strategic horizon, it is necessary to know the current and expected demand, to establish a capacity baseline using an analytical calculation, to analyze the impact that expected demand will have on existing capacity, to identify the limitations of, and possible improvements to, the current system based on a cost/benefit analysis thereof, to set priorities, and to develop a capacity management improvement plan.

2.2.4 Knowledge of the capacity of air traffic sectors or ATC operating positions is necessary for two main reasons. The first is that, for long-term planning, it is necessary to anticipate efficiently any shortfall of future capacity, as inferred from traffic forecasts. The second reason is that if there is already a shortfall in capacity that calls for flow control, it must be known in order to restrict traffic without overloading the system or excessively affecting operators, or to implement best practices on operational performance.

2.2.5 There are many methods for calculating capacity and, as readily noted from the different models described in this document, air traffic controller workload is a significant parameter in these models. Therefore, a better knowledge of workload factors and their implications will provide for a more suitable operational adjustment of the services provided to meet the demand.

2.2.6 DOC 9971 in Appendix II-D note that:

The overriding objective is to develop a capacity assessment process that contributes to the requirement to:

“provide sufficient capacity to accommodate the demand in typical busy hour periods without imposing significant operational, economic or environmental penalties under normal circumstances.”

2.3 Key Performance Indicators for Measurement of Capacity

2.3.1 The Global Air Navigation Plan (Doc 9750) notes the following Key Performance Indicators (KPIs) for measuring airport and airspace capacity.

KPI09 Airport Peak Capacity

Definition:

The highest number of operations an airport can accept in a one-hour time frame (also called declared capacity). Can be computed for arrivals, departures or arrivals + departures combined.

Measurement Units:

- Number of departures per hour,
- Number of landings per hour,
- Number of (departures + landings) per hour

Operations Measured:

The capacity declaration of an airport.

Variants: • Variant A: Airport peak arrival capacity • Variant D: Airport peak departure capacity • Variant AD: Airport peak movement capacity (departures + arrivals)
Objects Characterized: • The KPI is computed for individual airports.
Utility of the KPI: This KPI indicates the highest number of operations that an airport will can accept, using the most favorable runway configuration under optimum operational conditions. The runways may or may not be the most constraining factor for airport capacity: at some airports the most constraining factor may be the terminal airspace, the taxiways, the number of gates, passenger handling capacity etc. The KPI is typically used for scheduling and ATFM purposes, and to develop capacity investment plans.

KPI06 En-Route Airspace Capacity

Definition: The maximum volume of traffic an airspace volume will can safely accept under normal conditions in a given time period.
Measurement Units: • Variant 1: Movements/hr • Variant 2: Number of aircraft (occupancy count)
Operations Measured: • The nominal capability of an ANSP to deliver ATM services to IFR traffic in a given volume of en-route airspace, as seen at a given planning horizon.
Different Type of capacity for each horizon: • Planned capacity: expected values one or more years ahead for planning and investment purposes • Declared capacity: values used during the strategic and pre-tactical ATFM processes • Expected capacity: values as finalised at the end of the pre-tactical process • • Actual capacity: values as actually used on the day of operation during tactical ATFM and ATC.
Variants: • Variant 1: airspace throughput (entry flow rate) • Variant 2: airspace occupancy count
Objects Characterized: • The KPI is typically used at the level of individual sectors (sector capacity) or en-route facilities (ACC capacity).
Utility of the KPI: The KPI measures an upper bound on the allowable throughput or occupancy count of an en-route facility or sector.

Chapter 3 - Airport Capacity Assessment

3.1 Introduction

3.1.1 Airport Capacity Assessment is a crucial process for understanding an airport's ability to handle a specific volume of aircraft and passenger traffic within a given timeframe while maintaining desired levels of service. It involves evaluating the capabilities of various airport components, identifying bottlenecks, and providing insights for future planning and development.

Definition: *Airport capacity refers to the maximum throughput that an airport system or its individual components (runways, taxiways, terminals, airspace, etc.) can accommodate over a specific period (e.g., hourly, annually) without causing unacceptable delays.*

This document defines airport capacity as the maximum number of airport operations in a given aerodrome under specified conditions (e.g., aerodrome layout, aircraft mix, weather conditions, facilities, aircraft parking, etc.), taking into account all take-off and landing operations during a specified period of time (hour, day, month, year, season).

3.1.2 Many different parameters are used for measuring airport and airspace capacity. Consequently, care must be taken when defining the scope of each capacity in order to better understand the indicators to be used for assessing each capacity. The scope of airport capacity can cover airside or landside, however primary KPIs will be different (airside typically focuses on air traffic movements, while landside on passenger counts. Both will contribute to the overall airport capacity) however most of the information presented in this document focuses on the airside aspects.

3.1.3 Airport airside capacity is driven by capabilities and bottlenecks along the arrival and departure trajectories, from TMA, Runway, surface and apron. These should be separately analyzed, to determine the capacity for each segment/area and identify the most constraining one, and act on these.

3.1.4 In some cases, the physical capacity of the aircraft parking area—defined by the number of aircraft it can accommodate—may be lower than the estimated runway capacity for the same aerodrome. In such instances, the apron becomes the actual limiting factor for airport operations.

3.1.5 When all applicable requirements are duly met, service capacity is 100%. This capacity is reduced when such requirements have operational limitations; the greater the constraint in resources, the lower the service capacity. But the declaration of an operational capacity lower than the strategic capacity may also be considered in order to manage contingencies or uncertainties.

3.2 Importance of Airport Capacity Assessment:

- Identifying current and future limitations: Pinpointing areas of congestion and potential bottlenecks.
- Supporting strategic planning: Informing decisions about infrastructure development, operational improvements, and resource allocation.
- Maintaining service quality: Ensuring acceptable levels of service for passengers and airlines by minimizing delays and congestion.
- Optimizing efficiency: Maximizing the utilization of existing infrastructure.
- Stakeholder communication: Providing data for discussions with airlines, air traffic control, and the community.

3.3 Factors to be considered for assessment of Airport Capacity

Numerous factors affect an airport's capacity, including:

- Airfield Characteristics: Number of runways, the runway and runway rapid exit taxiways (RETs) configuration, Runway length, and separation of runways; layout of taxiways; number of aprons and parking stands.
- Airspace Management: Design and complexity of airspace, air traffic control procedures and equipment and technology.
- Applicable separation and spacing minima (e.g., wake, surveillance, arrival spacing), separation delivery accuracy, runway occupancy time.
- Meteorological Conditions: Visibility, wind, and other weather phenomena.
- Aircraft Mix: Types and performance characteristics of aircraft using the airport.
- Operational Procedures: Efficiency of takeoff and landing procedures, ground handling, and gate parking stand utilization.
- Terminal Building Infrastructure: Size and layout of terminals, number of gates, check-in counters, security checkpoints, and baggage handling systems.
- Passengers' profiles (or mix): travel purpose (business vs. leisure), group type (families, PRMs, short connectors), and nationality or visa status.

3.4 Methodologies

Calculating and Expressing Airport Capacity - Contributing Factors

3.4.1 Normally defined as the total number of movements, i.e. arrivals and departures, that the aerodrome can handle during the given period.

- Capacity values are calculated for each aerodrome runway configuration and for the anticipated range of weather conditions, i.e., visual meteorological conditions, instrument meteorological conditions, and low visibility conditions
- Often infrastructure-related, as opposed to ATCO workload-related, airport capacity is easier to calculate using mathematical models.
- Nonetheless, the ATCO workload element, e.g., the need for the ATCO to coordinate departures with the adjoining unit, remains important and should be assessed during the calculation of airport capacity

3.4.2 Methodologies for Assessment: Various qualitative and quantitative methods are employed to assess airport capacity. These can range from relatively simple analytical models to complex simulation tools. Some common approaches include:

- Analytical tools use mathematical formulas to estimate capacity based on factors like runway occupancy time, separation standards, and aircraft mix (e.g., FAA's Airfield Capacity Model (ACM))-ACM is a widely recognized analytical tool used to calculate the runway capacity of an airport. It considers factors such as runway configuration, aircraft mix, weather conditions (VMC/IMC), and operational procedures. The model estimates capacity by analyzing the time intervals between successive aircraft operations. The FAA has upgraded this model over time to incorporate more features and improve accuracy.
- Mathematical models use formulas based on queuing theory and statistical analysis to estimate capacity. They consider factors like runway occupancy times and separation

requirements. These models can provide quick assessments but might oversimplify complex airport operations.

- Employing computer simulations to model aircraft and passenger flows under different scenarios and analyze their impact on capacity and delays.
 - ✓ Runway Capacity Analyzer: This tool employs Monte Carlo simulation to account for uncertainties in input parameters and provides probabilistic estimates of runway throughput. It can optimize flight sequences and analyze the impact of factors like fleet mix and required aircraft separation. This is the methodology used by EUROCONTROL when performing Airport Capacity Assessment, described in Appendix B.
 - ✓ Discrete Event Simulation Models: These models simulate individual aircraft movements on the ground (taxiways, runways, gates) and in the airspace as discrete events occurring over time. They can provide a detailed analysis of airport operations, including delays and bottlenecks, under various scenarios. They may also incorporate a 3D modeling capability.
- Analyzing historical operational data (e.g., arrival and departure rates, delays) to understand current capacity and identify constraints.

Note: It is fundamental that the use of models have their baseline operations calibrated against real-life operations and data. Often models are simplified value or approximations, also for critical parameters influencing capacity, for example on runway capacity, which could lead to over-estimated or under-estimated capacity, while there is observed variability in operations, such as aircraft landing speed, or achieved separation at runway threshold, runway occupancy time or runway exit usage. This has a direct effect on the arrival or departure throughput/capacity. The model parametrization should reflect the observed variability in operations, such as aircraft landing speed, or achieved separation at runway threshold, or runway occupancy time, usage of runway exits, accounting for the actual observed average but also the distribution spread around.

3.4.3 Key considerations when using models to assess Airport Capacity

- Data Accuracy: The accuracy of the model outputs heavily depends on the quality and granularity of the input data (e.g., traffic schedules, aircraft characteristics, operational procedures).
- Model Scope: Different models have varying scopes. Some focus primarily on runway capacity, while others can model the entire airport system, including terminals and landside operations.
- Level of Detail: The choice of model depends on the required level of detail and the complexity of the airport and the analysis being conducted.

Assumptions and Limitations:

It is crucial to understand the underlying assumptions and limitations of each model to interpret the results correctly. Analytical models often rely on simplifying assumptions, while simulation models can be computationally intensive and require careful calibration and validation.

3.4.4 In practice, a combination of different models and analysis techniques is often used to provide a comprehensive assessment of airport capacity. The FAA also provides guidelines and methodologies for conducting airport capacity analyses in its Advisory Circulars.

3.5 Measures for Enhancement of Airport capacity

3.5.1 Airport capacity enhancement is a multi-faceted challenge, requiring a comprehensive approach that addresses various components of the airport ecosystem. It is important to differentiate between measures for improving airport capacity (new runways, new gates, wake RECAT, new procedures that reduce spacing between aircraft, etc.) and improving throughput or the use of existing capacity (A-CDM, etc).

3.5.2 Measures can be broadly categorized into infrastructure expansion, technological integration, and operational efficiency improvements. The following figure is a (indicative) list of airport capacity enhancement measures.

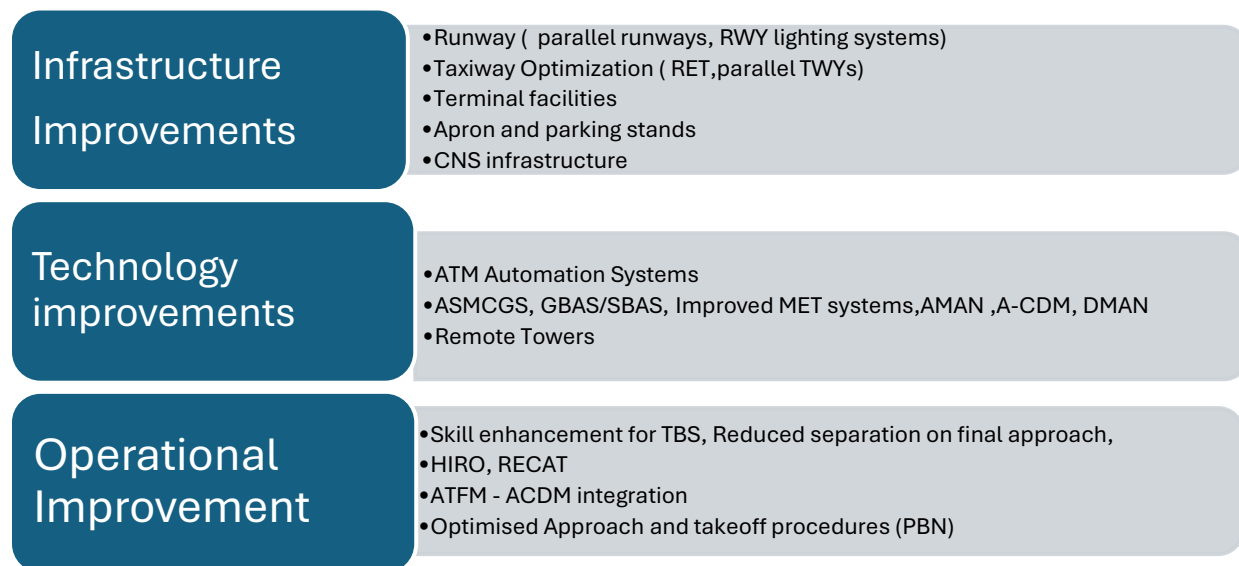


Figure 1- Airport Capacity Enhancement Measures

3.5.3 The primary factor driving the maximum arrival or departure throughput is linked to the arrival or departure separation attained, which itself is dependent on separation or spacing minima established and the delivery performance to these minima. The separation and spacing constraint are in turn linked to surveillance needs, and wake turbulence and runway occupancy of preceding traffic. Optimization can then come from enhancement to separation minima or to the ATC capabilities to deliver traffic closer to the minima, reducing unnecessary buffers.

3.5.4 By strategically combining these measures, airports can significantly enhance their capacity, reduce delays, improve efficiency, and accommodate growing air travel demand. It is crucial to consider the interdependencies between airport and airspace components, as increasing capacity in one area without addressing others can lead to new bottlenecks.

3.5.5 Optimum utilization of airport capacity (NATS example)- To utilize existing airport capacity effectively, NATS takes into consideration the following factors.

1. Sharing information across the airport ensures that all stakeholders—from ground operations to air traffic control—are aligned and responsive to real-time and strategic developments.
2. Making better use of existing resources allows for optimization without the need for major infrastructure investments.
3. Balancing demand through dynamic scheduling and coordination helps prevent bottlenecks and improves flow.

4. Getting your sequence right—whether in aircraft departures, arrivals, or parking stand assignments—can significantly reduce delays and improve throughput; and
5. Being consistently consistent in applying procedures and standards fosters predictability and reliability, which are crucial for maintaining high operational performance.

3.6 Role of Airport Collaborative Decision Making (A-CDM) in Airport Throughput Optimization

3.6.1 If the Airport capacity assessment identifies bottlenecks that will require fundamental infrastructure changes and the Airport has limited opportunities to tackle them, it is worth considering operational optimization to improve the airport throughput. One such optimization may come from improved monitoring of the turnaround process and timely information sharing.

3.6.2 To address the challenges and issues that arise from ineffective data and information exchange between airports and airspace operations, Airport Collaborative Decision Making (A-CDM) has been developed. A-CDM supports both normal and disrupted operations with the aim of increasing the efficiency of airport operations and improving the performance of the overall ATM network, by:

- Reducing delays
- Improving predictability
- Optimizing the use of resources

3.6.3 Another advantage of improving the efficiency of the operation is that aircraft spend less time taxiing and standing with engines running in queues for departure. This is good for the operators and environment as less fuel is burnt.

3.6.4 Airport Collaborative Decision Making (A-CDM) plays a crucial role in enhancing the use of airport capacity by fostering a shared understanding and optimizing operational processes among all stakeholders. It moves beyond traditional, siloed approaches to overall airport capacity management by promoting real-time information exchange and coordinated decision-making.

3.6.5 A-CDM primarily focusses on airport throughput optimization and may support identification of factors useful in airport capacity assessment by:

- Enhanced Situational Awareness: A-CDM provides a common operational picture (COP) for all stakeholders, including airlines, air traffic control (ATC), ground handlers, and airport authorities. This shared view of real-time data on aircraft movements, parking stand availability, baggage handling, and passenger flows allows for a more accurate and dynamic assessment of current and projected capacity.
- Improved Predictability and Planning: By integrating data from various sources, A-CDM enables better prediction of potential bottlenecks and capacity constraints. This allows stakeholders to proactively adjust their plans, such as optimizing departure sequences, managing gate assignments, and allocating ground resources more efficiently, thereby maximizing existing infrastructure capacity.
- Optimized Resource Utilization: A-CDM facilitates the efficient allocation of critical airport resources like runways, taxiways, gates, stands, and ground support equipment. Through collaborative planning and real-time adjustments, it helps ensure that these resources are utilized to their fullest potential, reducing idle times and improving throughput.
- Reduced Delays and Congestion: By enabling quicker and more informed decisions, A-CDM helps mitigate the impact of disruptive events (e.g., adverse weather, technical issues) on airport operations. This leads to fewer delays, reduced taxi times, and less congestion.

on the airfield and in the terminals, effectively increasing the operational capacity of the airport.

- Decision Making supported by data: A-CDM relies heavily on common operational picture, however supported by associated data support analytics to identify trends, predict future states, and evaluate the impact of different operational choices. This data-driven support provides a more robust foundation for capacity assessment, allowing airports to make more tailored and flexible decisions about infrastructure investments, operational procedures, also in the long planning horizon.
- Stakeholder Collaboration: At its core, A-CDM is about collaboration. It establishes formal and informal mechanisms for stakeholders to communicate, share information, and jointly resolve issues related to capacity and efficiency. This collective intelligence leads to more effective solutions than any single entity could achieve alone.

3.6.6 In summary, A-CDM transforms static, reactive airport process into a dynamic, proactive, and collaborative endeavor. By leveraging turnaround monitoring, sharing real-time information, fostering common understanding, and optimizing resource allocation, it helps airports unlock and increase utilization of their capacity, improve operational efficiency, and enhance the overall passenger experience.

3.7 KPIs for Airport Performance Assessment

3.7.1 GANP describes the following KPIs for Airport Operational Performance Assessment. These KPIs indicate the operational capacity of the airport and infrastructure bottlenecks.

Total ATM (Departure, Arrival, Total)

- i. Peak Capacity and throughput
- ii. Taxi-In time
- iii. Taxi-Out Time
- iv. Arrival and Departure Punctuality

3.7.2 In addition, the data analysis should also provide metrics such as

- ROT-Arr
- ROT-Dep
- Stand Occupancy time

3.8 Conclusion

3.8.1 In conclusion, Airport Capacity Assessment is a multifaceted process that provides essential information for the efficient operation, planning, and development of airports. By understanding the factors that influence capacity and utilizing appropriate assessment methodologies, airports can proactively address congestion, optimize infrastructure use, and enhance the overall passenger experience.

Chapter 4 - Airspace (Sector) Capacity Assessment

4.1 Introduction

4.1.1 Airspace sector capacity assessment is the process of determining the maximum number of aircraft that an air traffic control (ATC) sector can safely and efficiently handle within a specific period while maintaining an acceptable level of controller workload. It's a critical element of air traffic flow and capacity management (ATFM), ensuring a balance between traffic demand and the ability for ATC to safely handle the traffic in a volume of the airspace to accommodate it.

***Definition:** Airspace sector capacity represents the maximum throughput of aircraft that can enter and transit a defined volume of airspace managed by a specific ATC unit or sector over a given time (usually hourly or within a 15-minute interval). This capacity is constrained by the controller's ability to safely and effectively manage the traffic.*

4.1.2 Airspace sector capacity is not unlimited, but it can be more or less optimized depending on many factors, such as airspace sector design and flexibility; ATC system capacity; number of sectors and their complexity; segregated airspace; availability, training, and response capability of personnel; available CNS infrastructure; degree of automation; complexity of traffic flows in volume of airspace and the equipage and type of aircraft in the fleet.

4.1.3 Airspace Capacity & Separation Standards

- Airspace capacity is directly related to the applicable separation standard.
- The smaller the separation standard, the more aircraft fit in an airspace volume (sector) CNS infrastructure improvements improve the accuracy of information about aircraft position and movements, resulting in lower separation standard; for instance, PBCS separations in oceanic airspace.

4.1.4 When analyzing airspace capacity, the document focuses on ATC sector capacity and, in this sense, highlights some concepts that must be taken into account as indicators to calculate the ATC sector capacity, such as workload, the importance of observable and non-observable tasks performed by air traffic controllers. The document describes some models used to measure and assess the parameters employed to determine capacity to meet air traffic demand.

4.1.5 While the document mostly focusses on Terminal Area (TMA) and En-route Area Control (ACC) operations, it is important to distinguish that workload dynamics in these environments differ significantly from other air traffic control (ATC) sectors encompassing uncontrolled airspace. Although TMAs and ACCs manage higher volumes of passengers and aircraft, sectors with uncontrolled airspace face unique complexities, specifically the provision of Flight Information Services (FIS), combined areas of controlled and uncontrolled airspace, larger geographic coverage, and a higher density of operational aerodromes where aircraft and passenger movement data is recorded.

4.1.6 Additionally, the provision of air traffic services within uncontrolled airspace often results in periods of acute workload intensity that are less predictable than those in terminal areas. In APAC region, there are many such areas, which present unique mixed airspace challenges. However, this document specifically does not address capacity measurement of uncontrolled aerodrome and airspace operations.

4.2 Calculating and Expressing Airspace Capacity (Annex 11)

4.2.1 The strategic capacity of controlled airspace and designated aerodromes is to be determined on a seasonal or annual basis and periodically reviewed and updated to account for changing circumstances, such as a new runway being commissioned, new automation systems being implemented, or a new separation standard being introduced or changes to ATC procedures.

4.2.2 The operational capacity is initially set by referencing the strategic capacity as a baseline value, and re-calculated iteratively to account for dynamic, short-term, time-specific changes in factors affecting operating conditions and ATCO workload.

4.2.3 There is no universal rule for calculating capacity because it can be affected by many variables and other considerations

- Depending on the local regulatory environment, the State, appropriate ATS authority, ATC unit, and/or ATFM unit decide how to calculate capacity.
- Methods range from observation-based basic models to highly sophisticated mathematical models.
- Typically, capacity assessment is normally done by using detailed analysis by specialist ATFM personnel, input from ATCOs and other operational ATS staff (e.g., planner and flow ATCOs, assistants and supervisors), review of safety information regarding high ATCO workload, and real-time observations.
- Due consideration should be given to the methods employed by neighboring States and within the region to ensure consistency in the methods that consider the same traffic flows.
- Multilateral agreements may be established for sharing are great tools for ensuring consistency in capacity calculation methodologies to ensure consistency.

4.3 Importance: Accurate capacity assessment is essential for:

- Ensuring safety: Preventing sector overload and maintaining adequate separation between aircraft.
- Optimizing airspace utilization: Maximizing the efficiency of the airspace by accommodating the highest possible traffic volume without compromising safety.
- Minimizing delays: Proactively identifying potential bottlenecks and implementing ATFCM measures to mitigate congestion.
- Supporting ATC planning: Informing decisions about sector design, staffing levels, and the implementation of new procedures and technologies.
- Facilitating coordination: Providing a common understanding of airspace limitations for all stakeholders, including ATC units, airlines, and airport operators.

4.4 Factors to be considered

4.4.1 Factors Influencing Sector Capacity: As illustrated in Figure 2, several factors impact the capacity of an airspace sector:

- Airspace Complexity: The size, shape, vertical limits, presence of Prohibited, Restricted and Danger Areas and route structure within the sector. Complex airspace with numerous crossing routes or altitude changes typically has lower capacity, as does the temporary designation of airspace for special activities or events.
- Traffic Characteristics: The volume, type (aircraft mix), speed, and direction of traffic flows. Predictable and uniform flows allow for higher capacity.
- ATC Procedures: The complexity and efficiency of separation standards, coordination requirements with adjacent sectors, coordination mechanism with Military Units and the use of standard routings.
- ATC Tools and Technology: The availability and sophistication of surveillance systems, automation tools, and communication systems. Advanced tools can enhance a controller's situational awareness and workload management, potentially increasing capacity.

- **Controller Workload:** The number and complexity of tasks required to manage traffic within the sector, including communication, coordination, conflict detection and resolution, and data management. An acceptable level of workload is a primary constraint on capacity.
- **Meteorological Conditions:** Adverse weather (e.g., thunderstorms, turbulence) can increase controller workload due to required deviations, special procedures and increased communication, thus reducing capacity.
- **Sector Configuration:** Changes in sector boundaries or the opening/closing of sub-sectors can dynamically affect capacity.

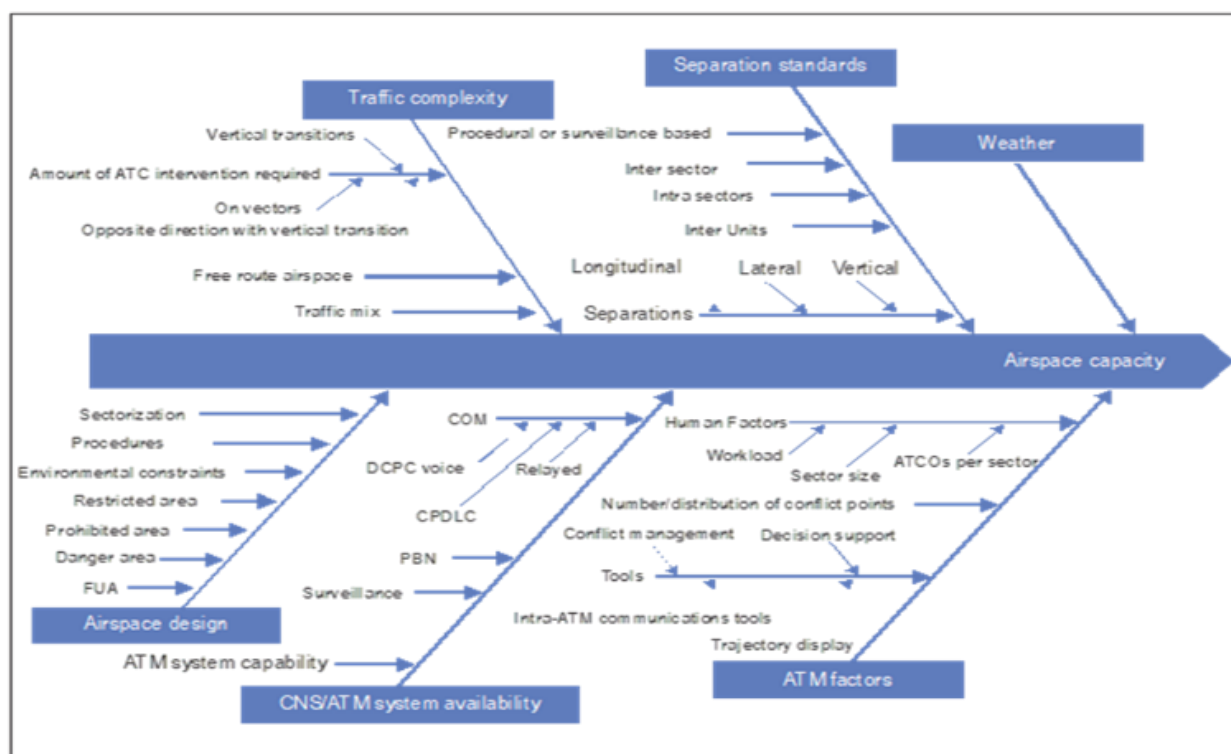


Figure 2- Factors Affecting Airspace (Sector) Capacity (Doc 9971)

4.5 Methodologies

4.5.1 The capacity for a portion of airspace is normally expressed as

- An entry count monitoring value—the maximum number of aircraft which may enter the airspace in a given period of time, normally one hour, or.
- An occupancy count monitoring value — the number of aircraft which may simultaneously operate within the portion of airspace over a specific time period, normally one minute, and the average number of aircraft expected to be maintained over a longer elapsed period e.g., 10 minutes.

In some cases, instantaneous or short duration occupancy counts can be used to complement entry counts.

- This allows for more granular analysis to mitigate and temporarily accept higher traffic demand values that exceed the entry counts monitoring value.
- Such occupancy count capacities require accurate and frequent ATC movement messages and ATS surveillance system data updates to the ATFM service system.

- Occupancy counts should be made available in advance of the flight entry into the given airspace and on a frequent basis.

Evaluation Models

4.5.2 Airspace sector capacity assessment models are tools and methodologies used to determine the maximum number of aircraft that an air traffic control (ATC) sector can safely and efficiently handle within a given period. These models help in understanding sector limitations, optimizing airspace utilization, and mitigating potential congestion and delays.

Methodologies for Assessment:

4.5.3 Various methods are employed to assess airspace sector capacity, ranging from simple estimations to complex simulations:

i. Mathematical occupancy and complexity models –

These models use mathematical formulas and queuing theory principles to estimate capacity based on parameters like aircraft arrival rates, sector transit times, and controller task load. They can provide quick estimations but may simplify the complexities of real-world ATC operations.

These are relatively simple methods that define capacity based on the maximum number of aircraft allowed to enter a sector within a specific timeframe (entry count) or the maximum number of aircraft permitted to be within the sector at any given time (occupancy count). These models often incorporate buffer mechanisms and adjustments based on factors like sector size and complexity.

ii. Simulations Models: These are more complex models that use computer simulations to represent air traffic flow and controller actions within a sector.

- a. Fast-Time Simulation (FTS): Tools like runway Simulator and customized versions of RAMS Plus (used in CAPAN methodology) fall into this category.
- b. Real-Time Simulation: These involve human-in-the-loop simulations with controllers interacting with simulated traffic to assess workload and capacity under realistic conditions.
- c. Data-Driven Models using historical data: These approaches analyze historical operational data (e.g., traffic counts, delays, controller inputs) to identify patterns and statistically estimate sector capacity based on observed performance under varying traffic levels.

iii. ATCO workload assessment models- Considers average execution times of definable and measurable tasks that contribute to ATCO workload.

Air Traffic Controller (ATCO) Workload

4.5.4 ATCO workload is the key driver of airspace capacity in high -density/high-complexity traffic areas

- i. Operational experience suggests that a safer measure of capacity is based on ATCO's physical and mental work to ensure safe separation and control of traffic
- ii. Capacity is often defined as the traffic volume that results in a controller workload reaching a predetermined acceptable threshold (e.g., 70-80% of available time), leaving a buffer for unexpected events or continuous actions which cannot be related to a specific task

- iii. ATS authorities commonly use simulation techniques to model ATCO workload for estimation of airspace capacity; this allows greater flexibility in capacity estimation and ensuring impact assessment of wider ranges of capacity improvement proposals

4.5.5 While ATCO workload definition and evaluation methods vary, they aim to establish the relationship between aircraft numbers (entering or occupying a sector) and the resulting controller workload over a given time period.'

- a) According to scientific literature, methods for measuring ATCO workload are usually categorized as subjective and objective.
- b) Several workload measurement methods of different states of maturity are currently known and used in the simulation, such as: Self-Assessment Techniques, Workload assessment questionnaires, Third Person-Assessment Techniques, Primary/Secondary Task Performance, Technical measurements of any kind.

4.5.6 Below are the evaluation methodologies based on ATCO workload:

Operational Experience ○ Investigate how much traffic a particular volume of airspace can handle, followed by interviews to ascertain the ATCOs' perception of traffic load. ○ Limited ability to determine capacity for a future ATC setting.
Fast Time Simulations (FTS) ○ These models are based on evaluating the time required by controllers to perform all necessary tasks associated with managing air traffic within a sector. ○ Tasks are often categorized (e.g., communication, coordination, conflict detection, flight data management), and time weights are assigned to each. ○ Often described as calculating task-load rather than workload, FTS do not aggregate the functional relationship between the traffic numbers, airspace sector factors and ATCO workload; as such, they lack ATCO judgement, experience and way of thinking. ○ This can be mitigated by involving active ATC staff in an iterative process of simulation refinement through rigorous data analysis
Real Time Simulations (RTS) ○ RTS involves ATCOs, pilots, and a model of an ATC system to create the full operational environment. ○ While realistically capturing the human element, they are often costlier and require additional infrastructure along with longer simulation time and training of personnel.

4.5.7 Benefits and Limitations:

- Entry/Occupancy Count: Simple to implement but may not accurately reflect controller workload or airspace complexity.
- Frequency Occupancy: Focuses on a key controller task but might not capture other workload drivers.

- Controller Workload: Provides a direct measure of the limiting factor but requires detailed task analysis and can be subjective.
- Simulation Models: Offer high fidelity and can model complex interactions but are data-intensive and require significant computational resources and expertise.
- Mathematical/Analytical Models: Useful for initial estimations and theoretical studies but often rely on simplifying assumptions.
- Empirical Models: Based on real-world operations but are limited by the availability and quality of historical data and may not predict well under new conditions.

4.5.8 The choice of model depends on the specific objectives of the capacity assessment, the availability of data and resources, and the complexity of the airspace and traffic environment being analyzed. Often, a combination of different models and techniques can provide a more comprehensive and robust understanding of airspace sector capacity.

4.5.9 The following systems are sources of data to support the capacity assessment:

- ATC Automation system (Flight Data Processing System (FDPS), AFTN/AMHS flight plan data)
- Billing System (used for Route and Terminal navigation charges)
- ATFM system
- A-CDM/ AOCC (Airport operations) system
- Surveillance system data (archive)

4.6 Measures for Enhancement of airspace capacity

4.6.1 Enhancing airspace sector capacity is critical for managing growing air traffic volumes, reducing delays, and improving overall air navigation efficiency. This involves a combination of strategic airspace design, advanced technology, and optimized operational procedures.

4.6.2 The following figure provides a broad view of various measures that can be implemented to enhance airspace sector capacity.

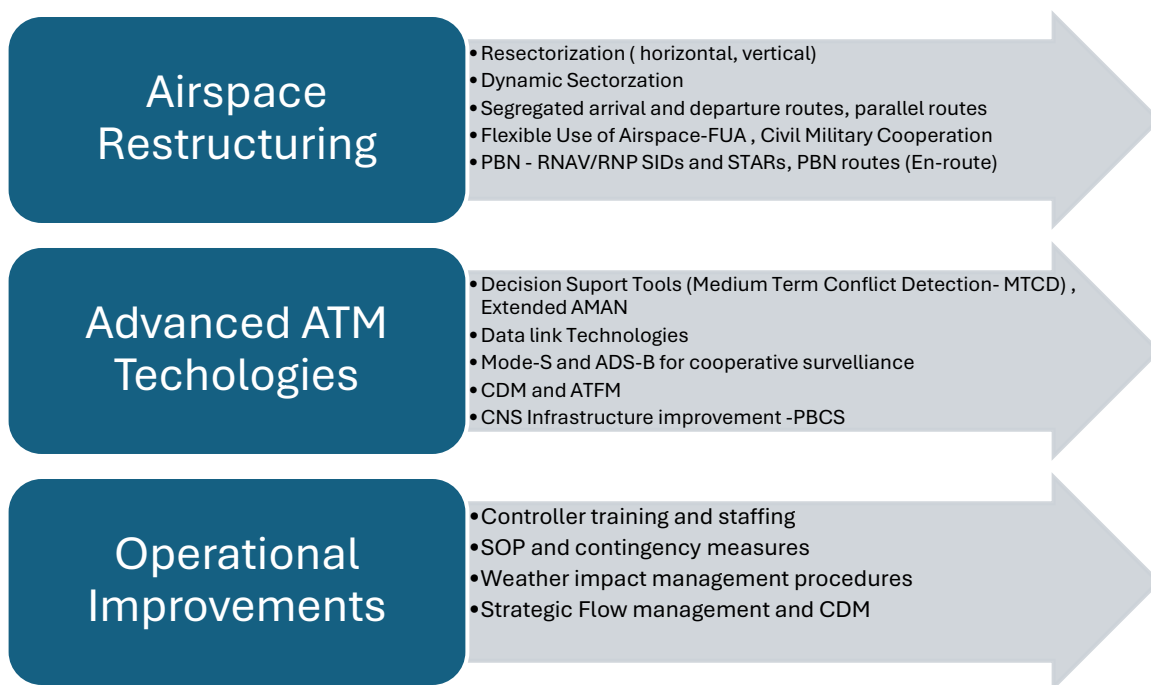


Figure 3- Airspace Sector Capacity Enhancement Measures

4.6.3 By integrating these measures, air navigation service providers can significantly enhance airspace sector capacity, leading to fewer delays, more direct routes, reduced fuel consumption, and improved environmental performance.

4.6.4 In summary, airspace sector capacity assessment is a vital process for ensuring the safe and efficient management of air traffic. By considering the various influencing factors and employing appropriate assessment methodologies, ATC authorities can effectively determine the operational limits of their airspace and implement strategies to optimize its use while maintaining acceptable levels of safety and service.

References

- ICAO Annex 11, Air Traffic Services.
- ICAO Doc. 4444- Air Traffic Management 15th. Edition.
- ICAO Doc. 9426, Air Traffic Service Planning Manual.
- ICAO Doc 9971, Manual on Collaborative Air Traffic Flow Management
- ICAO Global Air Navigation Plan ([ICAO GANP Portal](#))
- ICAO APAC Seamless ANS Plan V4.0
- ICAO APAC Framework for collaborative ATFM

Appendix A – Airport Capacity Assessment

A-1 Determining Airport Arrival Rate (AAR)

Airport Arrival Rate (AAR) is a dynamic parameter specifying the number of arrival aircraft that an airport, in conjunction with

- terminal airspace,
- ramp space,
- parking space, and
- terminal facilities,

can accept under specific conditions during any consecutive 60-minute period.

--Doc 9971, Appendix II-B, 1.1

Determining the Airport Arrival Rate (Doc 9971, Appendix II-B)

Definitions

- Airport arrival rate (AAR) — a dynamic parameter specifying the number of arrival aircraft that an aerodrome, in conjunction with terminal airspace, ramp space, parking space, and terminal facilities, can accept under specific conditions during any consecutive 60-minute period.
- Aerodrome primary runway configuration— an aerodrome configuration that handles three percent or more of the annual operations.

Administrative Considerations

- Identify the organization responsible for the establishment and implementation of AARs at selected aerodromes;
- Establish optimal AARs for the aerodromes identified; and
- Review and validate the aerodrome primary runway configurations and associated AARs at least once each year.

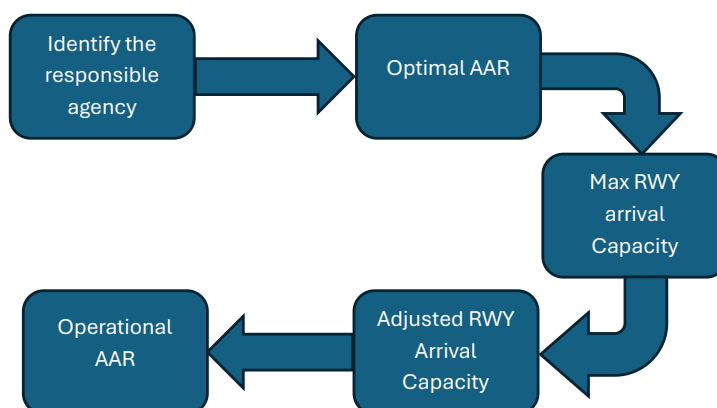


Figure APP.A- 1 Simplified Methodology for Establishing AARs¹

¹ Scientific process developed by the FAA as in FAA Order JO 7210.3EE, Facility Operation and Administration, Chapter 10, Section 7

Optimal AAR

Calculate optimal AAR—the strategic capacity of a runway configuration—for the following meteorological conditions:

- visual meteorological conditions (VMC): meteorological conditions allow vectoring for visual approaches;
- marginal VMC: meteorological conditions do not allow vectoring for visual approaches, but visual separation on final is possible;
- instrument meteorological conditions (IMC): visual approaches and visual separation on final are not possible; and
- low IMC: meteorological conditions dictate Category II or III operations.

Maximum runway arrival capacity

Calculate the maximum runway arrival capacity as follows:

- Determine the average ground speed over the runway threshold and the spacing interval between successive arrivals accounting for required minima and separation delivery accuracy;
- Divide the ground speed by the spacing interval to determine the optimum AAR; and
- Round down to the next whole number, or refer to ICAO Doc 9971, Table II-App B-1.

Adjusted runway arrival capacity

Identify any conditions that may adjust the runway arrival capacity, including:

- intersecting arrival and departure runways;
- lateral distance between arrival runways;
- dual use runways — runways that share arrivals and departures;
- land and hold short operations;
- availability of high-speed taxiways;
- airspace limitations and constraints;
- procedural limitations (noise abatement, missed approach procedures);
- taxiway layouts; and
- meteorological conditions.

Determine the adjusted runway arrival capacity using the previous factors listed for each runway used in an aerodrome configuration:

- add the adjusted runway arrival capacity values for all runways used in an aerodrome configuration to determine the optimal AAR for that airport configuration.

Operational AAR

Calculate the operational AAR by accounting for real-time factors that require dynamic adjustments to the optimal AAR.

- aircraft type and fleet mix on final;
- runway conditions;
- runway/taxiway construction;

- equipment outages;
- approach control constraints; and
- wind (speed & direction).

Operational AAR = Optimal AAR - Adjustment Factors

A-2 Airport Capacity Assessment Process

Example of Airport Capacity Assessment Process by EUROCONTROL Network Manager

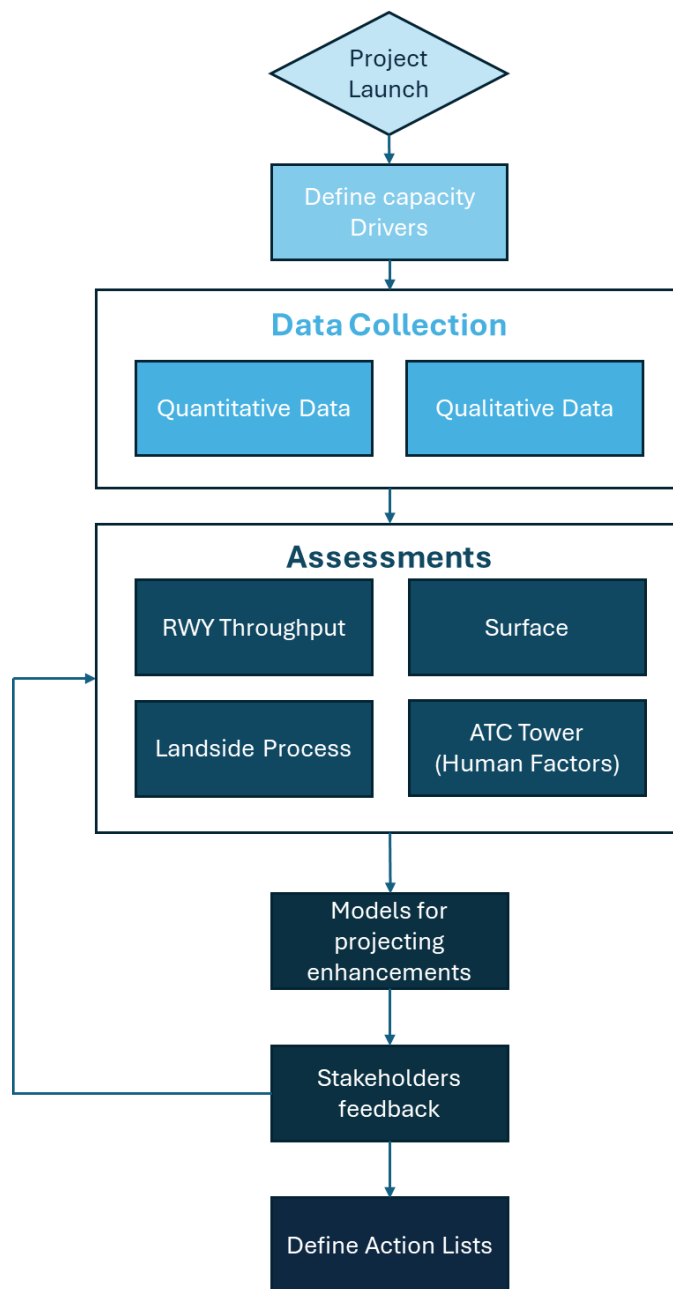


Figure APP.A- 2 Simplified Flow Chart on Methodology for Airport Capacity Assessment by EUROCONTROL

The explanation of the steps is as follows

- 1) Launch of Airport capacity assessment
- 2) Define the capacity drivers, by identifying the current operation status, collecting inputs from all Stakeholders on:
 - a. Terminal
 - b. Apron

- c. Surface
 - d. Runway
 - e. TMA
- 3) Collect Quantitative data based on Traffic and Passenger data
 - 4) Collect Qualitative data based on OPS feedback and Stakeholders survey
 - 5) Perform a RWY throughput assessment
 - 6) Perform a Surface assessment
 - 7) Perform a Landside process assessment if considered as relevant for the assessment
 - 8) Perform an ATC Tower (Human Factors) assessment if considered as relevant for the assessment
 - 9) Use models for projecting Airport capacity enhancements effect on runway throughput and develop scenarios
 - 10) Present result to stakeholders (e.g. in forms of recommendations) and obtain feedback
 - 11) Define action list and ensure regular follow-ups on implementation.
-

Appendix B – Airspace Sector Capacity Assessment

B-1 FAA sector capacity assessment model

Simple methodology for determining sector capacity developed by the FAA assumes that the sectors under consideration work best when they handle:

- no more than 25 aircraft during any 15-minute period; and
- no more than 18 aircraft during any one-minute period.

Therefore, each aircraft requires 36 seconds of a controller's work time

$$15 \text{ minutes} \times 60 \text{ seconds} = 900 \text{ seconds}$$

$$900 \text{ seconds} / 25 \text{ aircraft} = 36 \text{ seconds per aircraft}$$

Sector capacity is calculated using the average sector flight time in minutes from 0700 hours to 1900 hours, Monday through Friday, for any 15-minute time period

$$\text{Optimum Sector Capacity} = \frac{60 \times \text{Average Sector Flight Time (min)}}{36 \text{ (seconds)}}$$

Avg Sector Flight Time (minutes)	3	4	5	6	7	8	9	10	11	12+
Optimum Sector Capacity (aircraft count)	5	7	8	10	12	13	15	17	18	18

Table APP.B- 1 Simplified Flying-time-based Method for calculating Sector Capacity²

This simple methodology limits capacity by considering controller workload by assuming that a controller spends 36 seconds providing an ATC service to each flight.

This optimum value needs to be adjusted for applicable factors, such as:

- ATS route structure;
- airspace volume (vertically and laterally);
- complexity;
- climbing and descending traffic;
- terrain and obstacles, if applicable;
- number of adjoining sectors that require interaction; and
- military operations.

The 36-second assumption does not account for dynamic changes in sector traffic complexity characteristics over time and may not be applicable to future capabilities.

Improvements to the simplified method: a workload model that considers the number of aircraft and their interactions with each other, ATC services needed by each aircraft, and the amount of time to provide services:

² ICAO Doc 9971 Manual on Collaborative ATFM, Third Edition, 2018, Appendix II-C, Table II-App C-1

- Estimate the workload associated with imposed task demands by considering the difficulty, number, rate, and complexity of demands;
- Calculate time-on-task workload for the en-route sector radar controller positions based on post-operation logs including sector configurations and
- Model sector tasks and task categories over a period of time to establish more accurate workload estimates for:
 - entry (identify aircraft, establish clearance plan, handoff, flight crew call-in, ack);
 - exit;
 - non-standard (non-radar) arrivals and/or departures;
 - vertical transitions (interim, altitude amendment),
 - scanning;
 - coordination (flash-through or point-out);
 - separation assurance; and
 - delay (vectoring, shortcut, reroute, holding, diversion).

Use industry-standard human performance modeling techniques to identify radar controllers' tasks per sector (or sector combination) and estimate task times:

- Field observations at ACCs
- Human-in-the-loop simulation

Steps for building a workload model:

1. Determine input and output parameters of the workload model:
 - a. Identify tasks performed over a period of time (e.g., Mon-Fri, 0700-1900);
 - b. Record task times and task distributions to execute each task; and
 - c. Sum the task times to estimate of workload for each time period (e.g., rolling 15-minute intervals for 1440 intervals in 24 hours).
2. Set the workload threshold to 90% of the theoretical workload (e.g., 810 sec for a theoretical 15-minute/900 sec interval).
3. Describe the characteristics of traffic complexity for each period.
 - a. Consider three complexity types: cruise, transition (climb/descent), and delay – which may be individual or combined; and.
 - b. For each complexity type, consider if separation-related activity is low or high.
4. Determine the complexity profile that characterizes sector operations over a period of time; for each complexity type:
 - a. Set an alert value according to the highest observed traffic count – hence, less complex sector operations receive higher alert values and more complex sector operations receive lower alert values;
 - b. Express the occurrence of each complexity type as a percentage;
 - c. Calculate the weighted average by multiplying the values from 4a and 4b; and
 - d. The weighted averages are summed together and rounded to determine the monitoring value.

ATC experts can further tune the monitoring value produced by the workload model to:

- a. propose experience-based adjustments; and
- b. account for additional, frequently occurring sector combinations.

The monitoring value of the operational capacity can be dynamically adjusted during periods of reduced efficiency to reflect the ability to provide air traffic services (e.g., meteorological conditions, and temporary degradation of infrastructure). When efficiencies improve, the monitoring value is adjusted back to baseline.

Complexity-type	Avg. complexity type alert value for the sector	Frequency	Weighted average Complexity
Transition with low separation assurance workload	19	41%	7.80
Cruise with low separation assurance workload	22	32.4%	8.13
Delay and transition with low separation assurance workload	21	12.8%	2.70
Delay with low separation assurance workload	18	5.6%	1.00
Transition with high separation assurance workload	18	5.2%	0.90
Delay with high separation assurance workload	17	1.4%	0.20
Cruise with high separation assurance workload	19	0.8%	0.15
Delay with Transition with high separation assurance workload	17	0.5%	0.09
<i>Calculated workload-based monitoring value (capacity)</i>			20

Table APP.B- 2 Sample Case on Calculated Workload-based Monitoring Value

B-2 Brazil sector Capacity Assessment Model

In Brazil, the capacity of ACCs is calculated by observing the capacity of their sectors, which is analytically obtained according to the methodology established in the ICA 100-30, ATC personnel planning (DECEA, 2007).

Calculated capacity value represents the maximum number of aircraft that can be simultaneously controlled by each operational position (ATCO). According to the current model, the controller's workload is the summation of the time spent on each of the following tasks:

- Communications (transmission/reception);
- Manual activities (filling-out strips) and coordination; and
- Traffic planning and distribution.

The Brazilian methodology applies the concept of the controller’s “availability factor” (φ), which is defined as the percentage of time available for the ATCO to plan the aircraft separation procedures. This availability factor is found, usually, between a minimum value of 40% of the ATCO time in a non-surveillance environment, and 60% in a surveillance environment.

The number of aircraft that can be simultaneously controlled by a controller N, within the sector under consideration can be calculated as:

$$N = \frac{\varphi * \delta}{\eta * \tau_m * v_m}$$

Sector capacity is the function of the following factors:

- φ : factor of controller availability, defined as the percentage of time available to plan the aircraft separation procedures;
- δ : average distance flown by aircraft in the sector, which is a function of the ATS route structure within the sector;
- η : number of controller-pilot communications for each aircraft in the sector;
- τ_m : average duration of each controller-pilot communication; and
- v_m : average speed of the aircraft in the sector.

By replacing δ and v_m with the average time flown by aircraft in the sector T , where $T = \frac{\delta}{v_m}$, the number of aircraft that can be simultaneously controlled by a controller N can be calculated as:

$$N = \frac{\varphi * T}{\eta * \tau_m}$$

The values of the factors φ , T , η and τ_m are collected empirically, following the standardized procedures specified by the appropriate ATS authority.

Example for calculating the capacity:

- factor of controller availability: $\varphi = 60\%$
- average flight time spent by the aircraft crossing the sector: $T = 12$ minutes
- number of controller-pilot communications for each aircraft in the sector: $\eta = 6$
- average duration of each controller-pilot communication: $\tau_m = 9$ seconds

$$N = 60\% \cdot 12_{min} \cdot (6 \cdot 9_{sec})^{-1}$$

$$N = 60\% \cdot (12 \cdot 60_{sec}) \cdot (6 \cdot 9_{sec})^{-1}$$

Number of aircraft controlled simultaneously by a single controller

$$N = 8$$

Dynamically changing conditions may necessitate updating sector capacity values to account for significant changes

Data gathering needs to be meaningful to accommodate a reasonable range of operational uncertainties and represent trustworthy values to the ATC unit.

In ideal conditions, data research shall be conducted when there is heavy air traffic activity, for this reason choosing the ideal season is a factor to be considered, once it has a direct influence in final results.

Brazil has calculated the capacities of all sectors, individual and combined. After calculating the initial sector capacity, further adjustment is made to account for the significant air traffic flows, the complexity of each sector, and the capacities of the adjacent sectors.

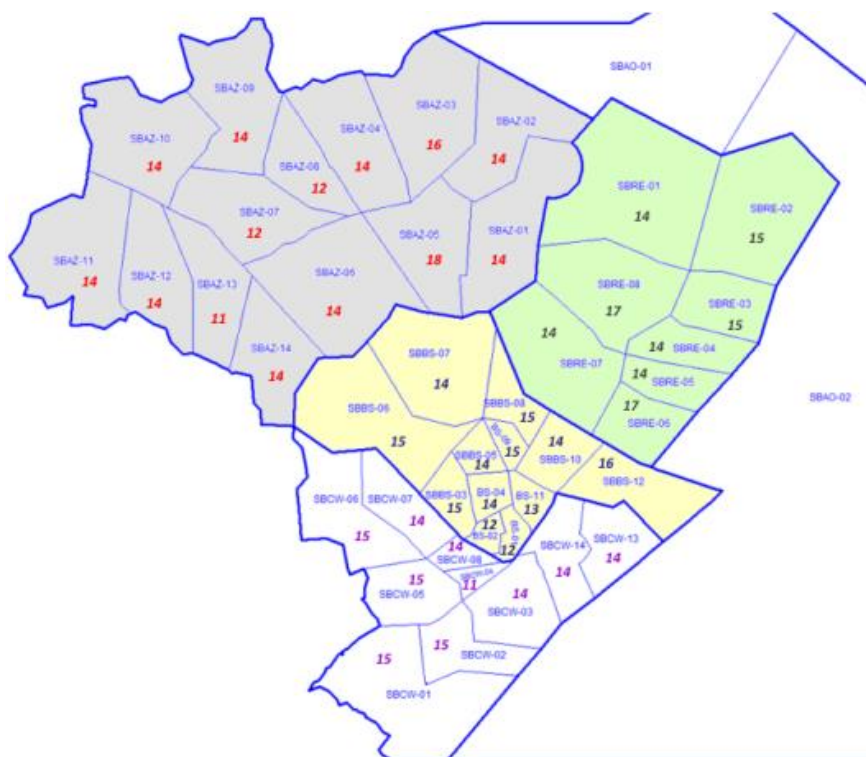


Figure APP.B- 1 Calculated Sector Capacity in Brazil

B-3 Saudi Arabia Capacity Assessment Model

ATC sector capacity calculation is based on the equations to determine the theoretical number of aircraft that can be managed and handled by ATCO. The ATS unit must perform further validation by a group of experts to confirm the calculated sector capacity and consider all possible factors that may impact that capacity.

The number of aircraft that can be controlled simultaneously by a single ATCO (Sector capacity) is calculated as the function of the following factors:

- **ϕ : ATCO Availability factor (expressed as %)**, defined as the percentage of time available for planning aircraft separation procedures;
- **T : Average flight time on the aircraft in the sector** (the unit of time needs to be the same as for τ_m);

- η : **Number of controller-pilot communications for each aircraft in the sector**; and
- τ_m : **Mean duration of each controller-pilot communication** (the unit of time needs to be the same as for T).

A significant data sampling is required to accommodate a reasonable range of operational uncertainties and determine reliable values for the ATC unit.

According to the current model, controller workload is the summation of times spent on:

- Communication (transmission /reception)
- Manual activities (updating of flight progress strip) and coordination
- Traffic planning and distribution

Availability factor, ϕ , is defined as the percentage of time available for the ATCO to plan aircraft separation procedures. Its typical range is between 40% of ATCO time in a non-surveillance environment and 60% of ATCO time in a surveillance environment. It is thus clear that efforts need to focus on increasing the availability factor ϕ .

Studies conducted by experts, who analysed the sampling techniques, show that it is advisable to make at least 25 observations of each parameter for an average controller, during peak traffic, respecting the minimum number of controllers specified by the sampling technique used.

It is essential to collect as many observations from as many controllers as possible in the unit being assessed in order to eliminate extreme values and to minimise any type of trend (e.g., cases of controllers or pilots who are either too slow or too quick in their communications, affecting the arithmetical mean).

B-4: EUROCONTROL Methodology

EUROCONTROL developed the CAPAN (ATC Capacity Analysis) Methodology to calculate ATC sector capacity by assessing controller workload. The methodology ensures a consistent and robust technique to derive ATC controller workload and the associated sector/controller position capacity through an ATC task-based fast-time simulation.

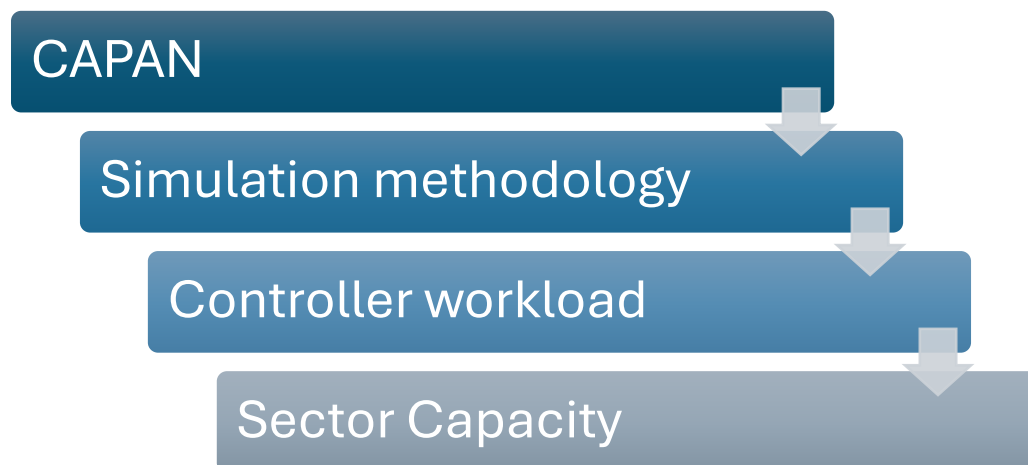


Figure APP.B- 2 Simplified Illustration on CAPAN Methodology

The methodology defines task categories and tasks representing controller actions, conflict detection and resolution mechanisms, a set of rules to mimic controller reasoning, a threshold for average theoretical working time corresponding to sector capacity and a technique, based on regression analysis, to establish the relation between workload and capacity.

The methodology uses a fast-time simulation engine which allows reproducing the ATC environment and follows an iterative process of validation for every assessment case.

Active ATC staff are involved throughout the full process of validation to guarantee simulation scenarios are as realistic as possible. This is fundamental to include the human component into the fast-time simulation, though it makes the process complex and long.

ATC controller workload is calculated by collecting the ATC related tasks generated through an ATC task-based fast-time simulation. The latter reproduces ATC related discrete events which in their turn are used to record tasks representing the actions performed by an ATC controller.

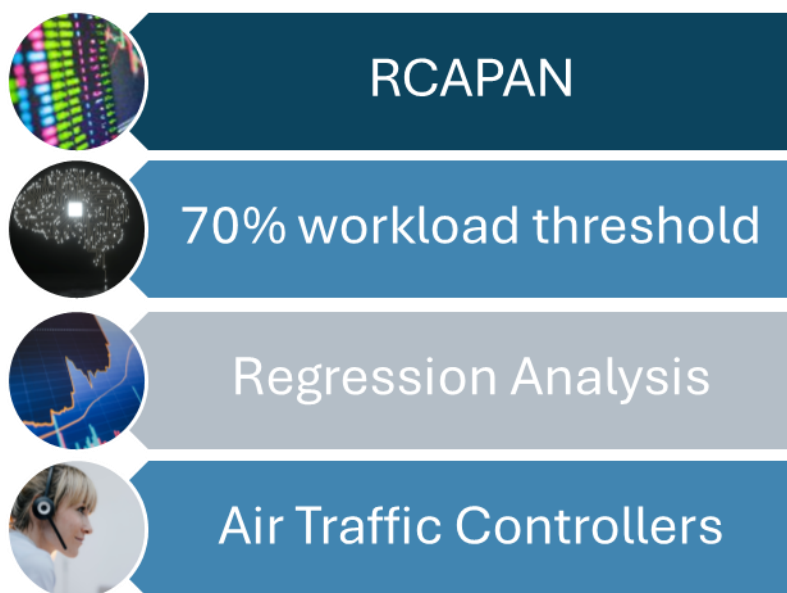


Figure APP.B- 3 CAPAN Main Principles

From a modelling point of view, the profile of a flight through airspace can be used to generate ATC related events, such as sector entry/exit, start of descent, etc.

These ATC events are used to trigger the controller tasks, which are given a specific time weight, representing the average ATC controller effort to perform each specific action.

The sum of all tasks for a certain sector and/or controlling position over a specific period of time, (normally one hour) determines the workload over that period of time.

The relationship between controller workload and the sector entries or occupancy over time is used for analysis of specific periods of the day in the sector, effectively showing the activity happening in the sector over the 24 hours.

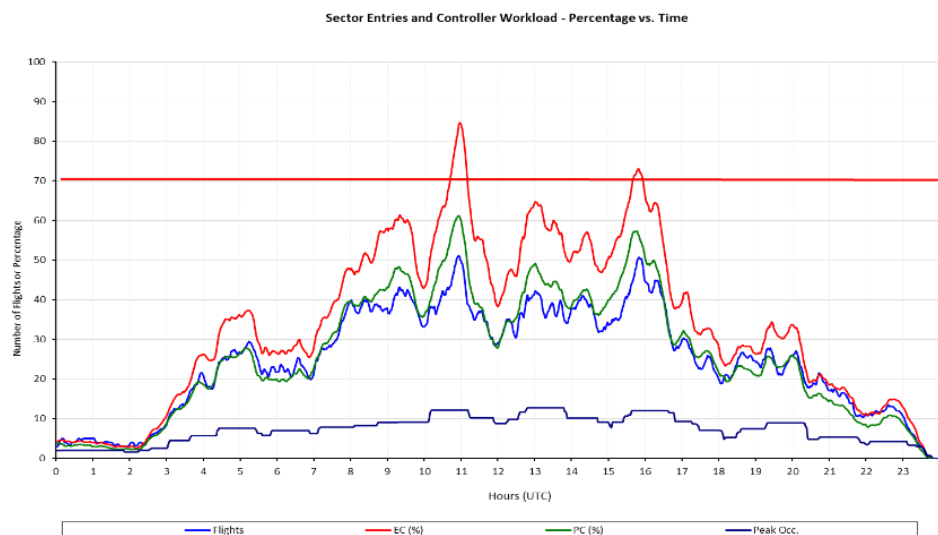


Figure APP.B- 4 Relationship between Sector Entries and Controller Workload

As illustrated in the figure above, the blue curve represents the number of sector entries in a one-hour period, using a sliding window every minute of the day; the green curve represents the corresponding planning controller (PC) workload percentage; the red curve represents the corresponding executive or radar controller (EC) workload percentage. The red line represents the overload threshold of 70% used by CAPAN to identify overloaded working positions.

Simulated workload percentage is often observed to vary with the period of the day, where sector entries can be of a similar number. This represents different complexity of the traffic flows present in this sector at different times of the day and enables a detailed analysis of the sector.

The CAPAN Methodology produces values representing the workload loading in the simulated control positions. Based on the measured workload level, quantitative threshold values and their corresponding qualitative interpretations are defined as follows;

- **Theoretical Sector Capacity** is attained when controller **workload reaches 70%** of the absolute working time, i.e. 42 minutes in an hour
- **30%** represents tasks which cannot be captured by discrete events, e.g. a general monitoring of the radar screen or recuperation time
- 70% threshold has been assessed through a **process of fine-tuning** of the discrete event logic when the first CAPAN studies were carried out together with several Real-Time simulations

Threshold	Interpretation	Recorded Working Time during 1 hour
70 % or above	Overload	42 minutes +
54 % - 69 %	Heavy Load	32 - 41 minutes
30 % - 53 %	Medium Load	18 - 31 minutes
18 % - 29%	Light Load	11 - 17 minutes
0 % - 17 %	Very Light Load	0 - 10 minutes

Table APP.B- 3 CAPAN Workload Thresholds

Capacity results are the average of a series of simulation runs – normally 25 - where the entry times of the flights and the aircraft performances are made to vary, to create different situations in the analysed ATC Sectors. This reduces the possibility that the traffic sample creates a too complex or a not enough complex situation. In the case sectors are not sufficiently loaded, flights can be cloned in a proportional way to create a traffic load sufficient enough to calculate theoretical sector capacities.

The mathematical technique, known as Regression Analysis, is used to evaluate an average theoretical sector capacity over a specific period of time. Sector/controlling position capacity is defined in terms of hourly entry rates as well as occupancy counts.

This Regression Analysis sector capacity value is based on the 24-hour average traffic complexity of the sector.

It should be noted that when the workloads recorded during the 24-hour simulation are light, the capacity by regression analysis may give too high values. In fact, as the traffic demand is low, the behaviour of the sector during difficult periods has not been measured and the function traffic/workload is almost linear. For this capacity calculation a minimum of ten iterations of the traffic sample would normally be used.

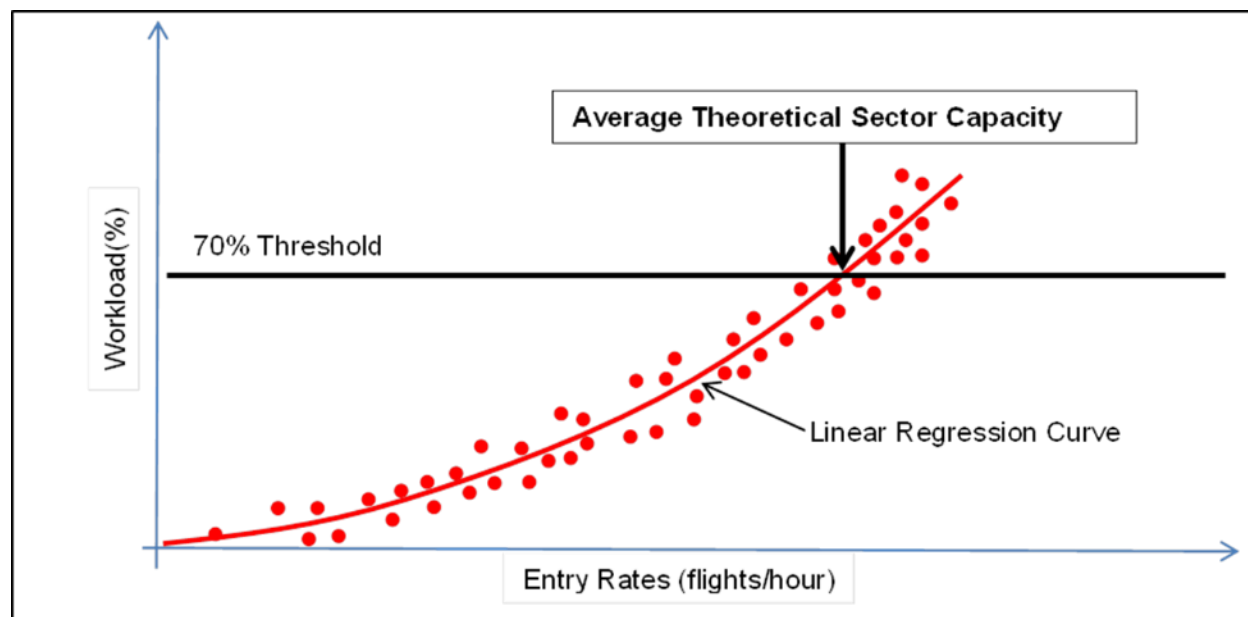


Figure APP.B- 5 Calculation of Regression Capacity

CAPAN Input Data

Traffic Data

Eurocontrol Network Manager's common archive DDR2 provides three types of traffic data:

- Initial demand: the latest flight plan updates.
- Regulated demand: flight plans impacted by flow restrictions.
- Actual demand: flight profiles derived from coordinated position reports.

Samples are selected to represent typical flows in the target area.

The prepared traffic is then iterated multiple times to simulate various scenarios (e.g., entry times, performances).

Airspace Data

Airspace data is directly available in EUROCONTROL Database, it is based on AIRAC Cycle Publication and can be complemented with AIP and tactical information.

Aircraft Performance

Eurocontrol Database BADA (Base of Aircraft Data) provides a range of aircraft type nominal performance tables. They are fundamental for trajectory calculation and totally customizable to local procedures and company policies.

ATC Model

Several parameters are required for fast-time simulation to properly model ATC procedures. CAPAN uses tailored parameters for ACC and TMA environments. Parameters include among others:

- Conflict detection and Resolution parameters
- Sector Manning
- ATC Tasks Several parameters required for fast-time simulation

Standard model for controller tasks for both ACC and TMA environment

Totally Customizable depending on system capabilities, specific procedures, separation minima, etc

Divided into 5 main task categories:

- ✓ Flight Data Management
- ✓ Conflict Search
- ✓ Coordination
- ✓ Standard Radio Telephony
- ✓ Radar
- ✓ Applicable to single/double man operations, multi-sector planner, etc.

Appendix -C – Capacity Assessment Examples from States

Capacity metrics will vary considerably, depending upon many factors such as the COM and SUR capabilities, the presence of terrain, physical attributes of aerodromes and weather. Thus, the expectations outlined for the following States need to be treated with caution, however they form a useful guide as to the sort of capability being achieved with modern systems and appropriately trained controllers.

The arrival rate is obtained as the average ground speed (in kt) divided by the separation (in NM), rounded down to the closest integer.

Table APP.D- 1 provides an indication of potential Aerodrome Airport Arrival Rate (AAR) for a single runway, given aircraft ground speeds and aircraft spacing near the runway threshold.

		Inter-arrival Spacing									
		3NM	3.5NM	4NM	4.5NM	5NM	6NM	7NM	8NM	9NM	10NM
Speed	140kt	46	40	35	31	28	23	20	17	15	14
	130kt	43	37	32	28	26	21	18	16	14	13
	120kt	40	34	30	26	24	20	17	15	13	12

The arrival rate is obtained as the average ground speed (in kt) divided by the separation (in NM), rounded down to the closest integer.

Table APP.D- 1 Potential Runway Arrival Rate³

ATC capacity calculations needed to take into account the volume of airspace of each sector, which varied considerably by State, and factors such as automation, density of traffic and complexity of routes/airspace. The *Manual on Collaborative Air Traffic Flow Management* (ICAO Doc 9971) contained guidelines for ATC sector capacity assessment. **Table APP.D- 2** provides simplified ATC sector calculation guidance from ICAO Doc 9971.

Avg Sector Flight Time (minutes)	3	4	5	6	7	8	9	10	11	12+
Optimum Sector Capacity (aircraft count)	5	7	8	10	12	13	15	17	18	18

Table APP.D- 2 Simplified ATC Sector Capacity Table (no complexity/automation allowance)

Australia, Japan, New Zealand, Singapore, Thailand and the United States of America provided runway and airspace (ATC Sector) capacity data, to indicate potential capacity figures in varying Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC) circumstances.

Australia

Brisbane and Melbourne airport capacity expectations:

- single runway: **48** (24 arrivals - 150 seconds between arrivals, 24 departures, VMC)
- single runway: **40** (20 arrivals - 180 seconds, 20 departures, IMC)

Japan

Airport capacity expectations:

³ Guide for the Application of a Common Methodology to Estimate Airport and ATC Sector Capacity for the SAM Region, Attachment 7: Calculation of the Aerodrome Acceptance Rate used by the FAA

- Narita (dual runways): 56-64
- Haneda (4 runways): 74

New Zealand

Auckland airport capacity expectations:

- single runway: **45** (VMC)
- single runway: **39** (IMC circling)
- single runway: **37** (IMC below circling with missed approach protection for jets)
- single runway: **32** (IMC below circling with missed approach protection)

ATC Sector capacity expectations:

- terminal/low level Category T airspace: **12** aircraft
- en-route Category S airspace: **15** aircraft
- en-route Category R airspace: **15** aircraft

Singapore

Changi airport capacity expectations:

- two parallel/near parallel runways: **72** (IMC)

Thailand

Suvarnabhumi airport capacity expectations:

- single runway: **34** (VMC/IMC)

United States of America

Table APP.D- 3 provides an indication of optimal aerodrome parallel or near parallel arrival rate runway arrival capacity at selected USA aerodromes. It should be noted that multiple runway combinations or whether runways were used for arrivals, departures, or both yielded a number of permutations from the data.

Aerodrome	Runways	IMC	VMC
KATL	5	104	126
KORD	5	84	112
KDFW	5	90	96
KATL	4	92	112
KDEN	4	-	114
KLAX	4	64	80
KORD	4	-	92
KATL	3	76	96
KDEN	3	-	96
KIAD	3	72	100
KATL	2	68	82
KJFK	2	-	58
KSDF	2	40	52
KATL	1	34	42
KSDF	1	20	26
KSFO	1	25	27

Table APP.D- 3 Capacity at Selected United States of America Aerodromes

Average airport arrival capacity expectations (range):

- single runway: IMC average **26** (25-34), VMC average **32** (26-42)
- two parallel/near parallel runways: IMC **55** (40-68), VMC **64** (52-82)
- three parallel/near parallel runways: IMC **74** (72-76), VMC **97** (96-100)
- four parallel/near parallel runways: IMC **78** (64-92), VMC **100** (80-112)
- five parallel/near parallel runways: IMC **92** (84-104), VMC **111** (96-126)

ATC Sector capacity expectations:

- terminal/low level Category T airspace: **12-18** aircraft
- en-route Category S airspace: **16-20** aircraft
- en-route Category R airspace: **17-24** aircraft

Summary

Note: given the unique operation environment and constraints of individual States, these figures are indicative only and do not represent the same expectation across different States in the region.

Table APP.D- 4 summarizes runway and airspace capacity expectations from States, with the greatest capacity achieved in optimum conditions highlighted in bold.

	Parallel or Near Parallel Runway Capacity					ATC Sector Capacity		
	1	2	3	4	5	T	S	R
Australia	40-48							
Japan		56-64		74				
NZ	32-40					12	15	15
Singapore								
Thailand	34							
USA	61	95	150	177	211	12-18	16-20	17-24
ICAO Doc 9971 Simplified Table Comparison						15	18	18

Note: given the unique operation environment and constraints of individual States, these figures are indicative only and do not represent the same expectation across different States in the region.

Table APP.D- 4 Capacity Expectations Summary
