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Agenda Item 5: ATM Systems (Modernization, Seamless ATM, CNS, ATFM)

US EXPERIENCE WITH AIR TRAFFIC MANAGEMENT (ATM)

(Presented by United States of America/Federal Aviation Administration)

SUMMARY

This information paper discusses Air Traffic Management (ATM) System, automation platforms, Traffic Management Measures (TMMs), and Collaborative Decision-Making (CDM) processes used by the Federal Aviation Administration (FAA) in the US. The FAA is sharing this information in hopes that its experience and lessons learned will prove valuable to the APAC region and its stakeholders in their effort to establish and strengthen a Regional ATM capability.

1. INTRODUCTION

1.1 The FAA's ATM system is responsible for balancing air traffic demand with system capacity to ensure the most efficient utilization of the National Airspace System (NAS). Within the FAA, Air Traffic Organization (ATO) is responsible for safe, orderly, and expeditious flow of air traffic. ATO applies minimal delays when needed, and through continued analysis, coordination, and dynamic utilization of Traffic Management (TM) Measures (TMM) and programs. Responsibilities for managing air traffic flows are distributed across the following facilities and personnel:

- Air Traffic Control System Command Center (ATCSCC) monitors and manages the flow of air traffic throughout the NAS, producing a safe, orderly, and expeditious flow of traffic while minimizing delays. ATCSCC also maintains the FAA's Operational Information System (OIS) used for centralized information update and sharing with respect to NAS status, international status, severe weather development, Ops plans, national playbook, and current restrictions. [URL: https://nasstatus.faa.gov/]

- Air Route Traffic Control Centers are the ATO's Area Control Centers (ACC) responsible for En Route and Oceanic Operations in 22 facilities across the NAS. For traffic management issues, tower personnel work through the Terminal Radar Approach Control (TRACON), if available, or directly with the overlying ACC, while TRACON personnel generally work through the overlying ACC. ACC personnel coordinate directly with the ATCSCC, who holds the final approval authority for all national traffic management. Certain large TRACONs also work periodically with the ATCSCC in the case of significant constraints.

- Traffic Management Units (TMUs) monitor and balance traffic flows within their areas of responsibility in accordance with TM initiatives and programs. TMUs are established in each ACC and in designated terminal facilities to ensure harmonized resolutions to both local and national challenges in unison with ATCSCC and stakeholders.

1.2 To maintain the integrity of the air traffic system, FAA requires facility traffic management personnel to prioritize use of time-based management tools and aircraft sequencing when evaluating traffic flow management options. Time-based management is a methodology for assigning crossing times at specific points along an aircraft's trajectory; it applies time to mitigate demand-to-capacity imbalances while enhancing efficiency and predictability of the NAS. Time-based management techniques and tools are used as needed; if needed, they could also be used during periods when demand does not exceed capacity. This sustains operational predictability, and regional or national strategic plan. Time-based management utilizes capabilities within Traffic Flow Management System (TFMS), Time Based Flow Management (TBFM), and Terminal Flight Data Manager (TFDM) automation platforms that are designed to achieve a specified interval between aircraft.

1.3 Traffic Management Measures (TMMs) are techniques used to manage demand with capacity in the NAS. These initiatives contribute to the safe and orderly movement of air traffic. Any TMM creates an impact on customers, so it is imperative to consider this impact and implement only those initiatives necessary to maintain system integrity. [See FAA JO7210.3DD for more information]

1.4 Collaborative Decision-Making (CDM) process is a cornerstone of FAA's ATFM. Commenced about 30 years ago, CDM began as an experiment in use of improved data to increase efficiency of GDPs. Prior to the experiment, the FAA relied solely on scheduled flight data to manage GDPs, and did not consider airline, weather, and other operational constraints upstream of the flight to the constrained airport, which led to a poor delivery of GDPs. The successful completion of the experiment led to a new process, infrastructure and agreements between all stakeholders affected by ATFM in the NAS. CDM continues to evolve as new technologies, and global and regional disruptions and challenges appear on the scene.

1.5 Plan, Execute, Review, Train, and Improve (PERTI) is a data-driven philosophy and process that applies to all aspects of ATFM in the FAA, and aims to improve the use and management of NAS resources.

2. DISCUSSION

Automation Systems Supporting Air Traffic Flow Management (ATFM) and Airport-Collaborative Decision-Making (A-CDM)

2.1 TFMS is an automation platform used for managing demand-to-capacity imbalances in the National Airspace System (NAS). TFMS ingests flight operator schedules, flight plans and other data supplied by flight operators, and aggregates and updates demand predictions to be shared with stakeholders. The ATCSCC uses this information to continuously plan and adjust the collaborative ATFM plan. TFMS is used to:

- Visualize active and proposed flights on a map;
- Overlay weather on the map;
- Create demand predictions for airspace and airports;
- Provide common situational awareness of current and forecasted weather impacts, SAA or other constraints;
- Support development of strategic TMMs to manage demand-capacity imbalances;
- Implement Ground Stops, Ground Delay and Airspace Flow Programs;
- Create and publish Required Routes in response to weather, equipment outage, flow saturation, military activity and space operations;

- Publish advisories for major TMMs, which are sent to all TMUs as well as Nav Canada and CDM flight operators, and are also published on a public website; and
- Log ATFM action and measures, which allows all TMUs to coordinate electronically.

2.2 TBFM is an Arrival Manager (AMAN) automation platform used for scheduling and metering aircraft through congested NAS Resources. TBFM is used to:

- Help manage air traffic flows by creating integrated time-based schedules through constraint points, and by providing tools for smooth merging and sequencing of aircraft;
- Apply additional spacing through constraint points in the NAS based on current and predicted traffic demand, aircraft trajectory and performance, winds, etc.; and
- Manage and coordinate anticipated delays through constraint points in the NAS.

2.3 TFDM is a Departure Manager (DMAN) automation platform for airport surface operations management and includes electronic flight strips. Full TFDM capabilities are expected to become operational in 2025, and used to:

- Automatically update controller displays with the latest flight data delivered through improved Electronic Flight Data (EFD) exchange and Electronic Flight Strips (EFS);
- Enable Surface and Airport CDM (A-CDM) by providing real-time management of departures as well as management of aircraft movement on airport surface; and
- Complete the integration with TBFM and TFMS to expand information exchange and enable integrated decision-support for cohesive surface and airborne traffic flow management.

<u>Automation Systems Supporting Air Traffic Control (ATC) Safety and Separation Management</u>

2.4 En Route Automation Modernization (ERAM) is an ATC automation system the FAA uses at its high altitude ACCs to process flight and surveillance data, provide CPDLC communications, and generate display data for aircraft position and weather to air traffic controllers. ERAM provides core functionality for air traffic controllers; in addition to processing data from multiple radars, ERAM also supports satellite-based systems such as Automatic Dependent Surveillance-Broadcast (ADS-B) and Controller Pilot Data Link Communications (CPDLC). Operational at 20 high-altitude ACCs, the system allows controllers to share and coordinate information seamlessly between centers, and enables automatic transitions between sectors and centers, even when planes divert from their planned course.

2.5 Standard Terminal Automation Replacement System (STARS) is an ATC automation system used by air traffic controllers at terminal facilities in the airspace immediately surrounding major airports. STARS displays aircraft position and weather for air traffic controllers at more than 255 radar control facilities and hundreds of airport control towers. These services include separation and sequencing of air traffic, conflict and terrain avoidance alerts, weather advisories, and radar vectoring for departing and arriving traffic. STARS gives controllers a complete, precise picture of the airspace, enabling them to manage aircraft they are tracking with radar or the satellite-based Automatic Dependent Surveillance- Broadcast (ADS-B).

2.6 Advanced Technologies and Oceanic Procedures (ATOP) is an Air Traffic Control (ATC) System deployed in designated en route and oceanic airspace. ATOP includes both surveillance and flight data processing, which provides the controllers with automated decision support tools to establish, monitor, and maintain separation between aircraft, and aircraft to airspace and terrain. ATOP capabilities include:

- Ingesting and processing surveillance data from multiple systems, including Micro En Route Automated Radar Tracking System (mEARTS), Automatic Dependent Surveillance − Addressable (ADS−A), Automatic Dependent Surveillance − Contract (ADS−C), and Automatic Dependent Surveillance − Broadcast (ADS−B);
- Conflict Prediction and Reporting for conflict probe;
- CPDLC;
- ATC Interfacility Data Communications (AIDC);
- Decision Support Tools used primarily for situation awareness; and
- Electronic Flight Data including Electronic Flight Strips.

2.7 mEARTS is an ATC automated radar and radar beacon tracking system capable of employing both short-range (ASR) and long-range (ARSR) radars. Planned to be replaced by ERAM in early 2029, this microcomputer-driven system is currently used only at the Anchorage, Alaska ACC and Center Radar Approach Control (CERAPs) environments to provide improved tracking, continuous data recording, and use of full digital radar displays.

Traffic Management Measures (TMMs)

2.8 *Altitude* as a TMM is used to separate different flows of traffic or aircraft flying in close proximity to each other. These measures aim to increase throughput and reduce delays by increasing use of available altitudes. There are three main types of Altitude TMMs used in the NAS:

- *Tunneling* are altitude restrictions applicable to arrivals that require aircraft to descend prior to the normal descent point to avoid airspace or traffic constraints. Tunneling may apply to the final segment of the flight or to the entire flight.
- *Capping* are altitude restrictions applicable to departures that require aircraft to climb and remain below their requested altitude until they are clear of a particular airspace. Also known as the Escape Routes, Capping may apply to the initial segment of the flight or to the entire flight.
- *Low Altitude Arrival/Departure Routing (LAADR)* is a special set of routings with altitude expectations for use in times of capacity constraints in the NAS that requires a written agreement with the customers prior to implementing. LAADR may apply to the departure or the arrival phase of flight.

2.9 *Miles-in-trail (MIT)* restriction refers to longitudinal separations in nautical miles between successive aircraft that meet specific criteria relating to their origin or destination airports, or fixes, altitudes, sectors, or routes along their way from origin to destination. MITs are used to apportion traffic into manageable flows, as well as to provide space for additional traffic (merging or departing) to enter the flow of traffic as well as in situations when additional spacing is needed for safe aircraft deviation around weather.

2.10 *Minutes-in-trail (MINIT)* restriction refers to longitudinal separations in minutes between successive aircraft that meet specific criteria similar to those for MITs. MINIT restrictions are normally used in a non-radar environment or when transitioning to or from a non-radar environment.

2.11 *Fix balancing* is used to assign an aircraft a fix other than in the filed flight plan in the arrival or departure phase of flight to equitably distribute demand.

2.12 *Airborne holding* as a TMM is typically used when the weather or congestion conditions are expected to be short-lasting and only where the operating environment can safely accommodate it;

holding ensures aircraft are available to fill the capacity at the airport.

2.13 *Departure Sequencing Program (DSP)* assigns a departure time to achieve a constant flow of traffic over a common point. Normally, this involves merging departures from multiple airports through a common point.

2.14 *TFMS Programs* include:

- *Ground delay program (GDP)* is administered by the ATCSCC to hold aircraft on the ground prior to take-off to manage capacity-to-demand imbalance at a specific destination. Through assignment of arrivals slots and Controlled Time of Takeoff (CTOT), the program is used to limit congestion and airborne holding at the impacted location. Users are permitted to exchange and substitute arrival slots for their flights congruent with CDM agreements concerning substitutions. Departure-specific CTOT is calculated based on the estimated time en route and the availability of the arrival slot, and can be modified through a coordination the ATCSCC. Due to its importance for ensuring accurate delivery of aircraft to the impacted location, compliance to CTOT is evaluated and reported by airport. The FAA and the CDM community are committed to improving CTOT compliance; in 2023, a compliance rate of 80% or better has been achieved for over 59,000 flights that had a CTOT.

- *Airspace flow program (AFP)* assigns specific crossing slots and corresponding CTOTs to manage capacity-to-demand for a specific flow constrained area (FCA)—a segment of airspace with limited capacity. AFPs may be applied to all aircraft departing airports in the contiguous United States and from select Canadian airports. Aircraft that have been assigned a CTOT in an AFP should not be subject to additional delay. Exceptions to this policy are MITs and departure/en route spacing initiatives that have been approved by the ATCSCC. It is important for aircraft to depart as close as possible to the CTOT to ensure accurate delivery of aircraft to the impacted area.

- *Collaborative trajectory options program (CTOP)* is a method of managing demand through constrained airspace that leverages the use of one or more FCAs while considering customer preference with regard to both route and delay as defined in a Trajectory Options Set (TOS). Using algorithms that compare capacity and demand, the CTOP will look at each trajectory option and determine the amount of ground delay that would need to be associated with that option (including zero-delays). CTOP will then assign the most preferred trajectory available. Customers must file flight plans in accordance with the TOS option assigned. Customers may manage their flights through the use of the TOS or through the substitution of flights.

- *Ground Stop (GS)* is a process that requires aircraft that meet specific criteria to remain on the ground; the criteria may be airport, airspace, or equipment specific. They are typically issued in severely reduced capacity situations to preclude gridlocks. GSs normally occur with little or no warning and override all other traffic management initiatives. Aircraft must not be released from a GS without the approval of the originator of the GS. Since GSs are one of the most restrictive methods of traffic management, alternative initiatives must be explored and implemented whenever possible and as appropriate.

2.15 *Reroutes* refer to ATC routing advisories that are issued to ensure orderly flows during times with airspace capacity being restricted by congestion, weather, or activation of special use airspace. Reroutes can be selected using several sources, including precoordinated Playbook Routes or developed specifically to meet a specific need. The required route is closely collaborated with the affected ATCCs, and route advisories are issued by ATCSCC and listed on the OIS.

- *Integrated Collaborative Rerouting (ICR)* allows the ATCSCC to identify specific areas that flight operators are encouraged to avoid and TFMS provides lists of flights that enter that area. If enough flight operators do not avoid the area, additional measures will be implemented. This measure is typically used for weather systems in the middle of the NAS.

- *Pre−departure reroute (PDRR)* is a capability within TFMS that enables ATC to quickly amend and execute revised departure clearances to mitigate constraints or balance traffic flows. This capability is especially beneficial during periods of severe weather when departure routes are rapidly opening and closing.

- *Airborne reroute (ABRR)* is a capability within TFMS that is used for tactical reroutes of airborne aircraft. Traffic management coordinators use TFMS route amendment dialog (RAD) to define a set of aircraft−specific reroutes that address a certain traffic flow problem and then electronically transmits them to ERAM for execution by the appropriate sector controllers.

- *TOS* is a message sent to TFMS that specifies route and delay preferences for a flight. While a traditional flight plan contains a single request with a defined route, altitude, and speed, a TOS may contain multiple trajectory options with each one containing a different route, altitude, speed, or minutes of ground delay. Options are ranked in the order of customer preference; in addition to multiple options within a single TOS, each option may also contain start and end times within which each option is acceptable. TOSs are visible to traffic management coordinators for use in PDRR as well as CTOP.

Collaborative Decision-Making (CDM)

2.16 CDM enables proactive collaboration across all of its members based on a common awareness of demand and operating conditions in the NAS. It is supported by an established data infrastructure and interfaces along with agreed-upon procedures and processes for each member to contribute their plans and other relevant information as they become aware of it. While the interfaces have been modernized, data elements expanded and ATFM tools developed and enhanced over time, the underlying concept and its key principles remained the same:

- *Common awareness of demand*: CDM flight operators submit and update their schedules long before filing flight plans, and the FAA aggregates this data into a common view of demand and shares it with the whole CDM community. In addition to Flight Create, Flight Modify (updated airline times), and Flight Cancel messages that have been supported for a long time, CDM now supports an expanded data-set that includes Early Intent messages (including route, attitude and speed), TOS, and the other data elements of A-CDM.

- *Common awareness of operating conditions in the NAS*: the FAA aggregates information about airport construction projects, special events, temporary flight restrictions, equipment outages, weather and other relevant information into a common view of operating conditions, and shares it with the whole CDM community;

- *Dynamic and proactive collaboration*: CDM community participates in the planning process, and each member brings their perspectives, forecasts and operational insights to the discussion, including flight operators, ATCSCC and traffic management coordinators from the FAA field facilities (Enroute and Terminal) who jointly participate in the development of ATFM plans and implementation of ATFM measures. In specific circumstances, primarily winter weather, airport authorities also join the planning webinars; and

- *Continuous and transparent review of events and lessons learned*: with a goal of improving efficiency and effectiveness of ATFM management and coordination, CDM planning and responses to disruptions and capacity-to-demand imbalances in the NAS are continuously scrutinized and discussed with CDM members, and past lessons learned are considered and incorporated into current planning decisions.

2.17 Sub-Teams/projects: As a CDM member, flight operators participate in sub teams and projects to collaboratively work with the FAA to improve systems and develop new concepts and technologies. All teams include Subject Matter Experts from both industry and the FAA. Each team is led by co-leads, one from the FAA and one from industry. The current sub teams include:

- *Flow Evaluation Team (FET)* – Focuses on improving traffic flows using current technologies;
- *Future Concept Team (FCT)* – Focuses on new ATFM technologies;
- *CDM Automation Team (CAT)* – Focuses on algorithms and automation to improve the automation and keep the automation current with changing conditions;
- *Weather Evaluation Team (WET)* – Works on improving forecast tools, incorporating newly developed weather models, and improving tools to evaluate the accuracy of forecasts;
- *Surface Collaboration Team (SCT)* – Advises and assists with the design of the FAA D-MAN and Surface Metering automation. Additionally assists with outreach to all relevant parties for the implementation of D-MAN and Surface Metering;
- *CDM Training Team (CTT)* – As the other sub teams develop training materials, the CTT assembles and formats the training for use both within the FAA and for CDM flight operator refresher training;
- *Stakeholder Engagement Team (SET)* – Focuses on CDM flight operator involvement with the advanced plan and the post operational review. Primarily focuses on flight operator data being incorporated with FAA data to present a comprehensive picture of the operational day. Develops visualization techniques that incorporates both FAA and Flight Operator data for easy understanding and comprehension; and
- *Ad-Hoc Teams* – as conditions warrant, ad-hoc teams are formed to collaborate on efforts that do not fit into the predefined teams.

2.18 Collaboration – In additional to electronic collaboration via OIS, human collaboration follows the following cadence:

- *Strategic* – regular coordination among members to address known constraints, and discuss past management actions, including:
  - *Monthly coordination* though a National Collaborative Forum to share information about upcoming construction projects and their impacts, special events, and new technologies;
  - *Seasonal preparation* primarily occurs at in the spring for severe weather (thunderstorm) season and again in the fall for “Snowbird” season where large numbers of travelers fly south in search of warm weather; and
  - *Annual review* is conducted with operational and delay data for the previous year reviewed and discussed, looking for ways to improve.

- *Pre-Tactical* – Each day at 1830Z, an advanced plan for the next day-of operation is collaborated via webinar with all CDM members, ATFM units, meteorologists and airport authorities, as needed. Supported by the Continuous Planning Portal, an automated website accessible only to the CDM partners, the webinar is used to coordinate operational information that carries through to the tactical plan, including:

- Identification of system constraints and potential TMMs;
- Coordination of critical decision windows for TMM implementation; and
- Publication of the advanced plan for all participants to review and distribute throughout their organizations.

- *Tactical* –On the day-of operation, planning webinars are conducted to coordinate weather, special events, and other unknown developments as they occur, including:
  - *Regular webinars* for the full CDM community: conducted 8 times a day (every two hours) between ATCSCC, Flight Operators, ATFM units, and airport authorities, as needed;
  - *Special webinars* for a subset of CDM community that is affected by a particular TMM: conducted as needed to coordinate, implement and update the details of the TMM between a smaller group of affected operators, along with the traffic coordinators from the ATCSCC, affected ACCs, and neighboring ANSP;
  - *Hotlines* are means for ad hoc coordination; established to deal with developments outside the scope of regular or special webinars, they are typically regional and driven by outages and weather. Hotlines have unique characteristics and procedures; the typical hotlines include those for ATCSCC, ATFM Units ATC units, and Flight Operators for the following regions: New York, DC Metro, Florida, Texas, Chicago.

- *Post Event* – the review of effectiveness of plans and TMM implementation, including delays and other impacts to the NAS and flight operators. Key to understanding and improving CDM and ATFM in the NAS, post-even reviews include:
  - *Daily National System Review*, conducted by the ATCSCC Quality Control office at 1400Z each weekday, reviewing the previous day (or days on weekends and holidays). Flight operators are full participants in the review
  - Monthly Review at the National Collaboration Forum, a look at the previous month in data, always looking for ways to improve both operations and the data so the data can inform the problem and possibly point to solutions
  - *Annual Review* at the National Performance Review in the fall. An in-depth review of the previous 12 months.

PERTI Process

2.19 PERTI is the FAA’s process for addressing system constraints, assessing the effectiveness of the measures implemented to address past constraints, and instituting improvements in future planning and execution efforts through the following steps:

- *Plan* – Consider the best data available at that point in time, with the understanding that plans will change and react to real time developments;
- *Execute* – Follow through on the plan, especially with an eye to the Critical Decision Window so TMMs are not implemented too late to be effective. Timing is key to many things in ATFM. Too early implementation unnecessarily delays flights, potentially into weather leading to diversions and diversion recovery. Late

implementation runs the risk of not properly mitigating a constraint, also leading to poor results and more drastic TMMs than would otherwise have been needed;

- *Review* – Data driven, collaborative review leads to understanding where improvement potential is.
- *Train* – once the Plan, Execute and Review stages are completed, Training of the ways to improve is key to the last step. If timely feedback and training does not occur, to improvement happens; and
- *Improve* – Ultimate goal of the PERTI process is to make systemic, lasting improvements to the ATFM process in the FAA.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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