# Overview of operational improvements and ICAO's path to net-zero carbon emissions by 2050

**By ICAO Secretariat**

## Introduction

As the global aviation sector faces the pressing challenges of climate change, the International Civil Aviation Organization (ICAO) is supporting States and aviation stakeholders to implement effective mitigation measures. The urgency for immediate action is underscored by the extreme weather events that threaten aviation infrastructure and flight operations. This article explores key operational improvements and air traffic management (ATM) strategies that support ICAO's Long-Term Global Aspirational Goal (LTAG).

## Operational Measures and Their Contributions

In the context of aviation, "operations" can refer to a wide range of activities, such as Air Traffic Management (ATM), Aircraft Operator activities, Airport activities, ground operator activities, flight planning activities, airspace design, network management etc. The Operational Improvements wedge of the ICAO Basket of Measures has many practices that can reduce noise, carbon dioxide ($CO_2$) emissions, fuel consumption, and enhance local air quality.

Operational measures provide an opportunity to improve fuel efficiency across different phases of flight and in turn, reduce the environmental impacts. These include the implementation of innovative new concepts, more efficient flight paths, aircraft weight management, enhanced ground procedures, and the integration of new technologies. Such measures can contribute to reducing $CO_2$ emissions, particularly in the short to medium term, and complement longer-term technological and cleaner energy-based solutions.

During the assessment of contributions from operational improvements reaching net-zero carbon emissions by 2050, the CAEP focused on identifying and analyzing operational measures to reduce $CO_2$ emissions from international aviation. As the basis of the work, CAEP utilized the work already undertaken in the CAEP/11 cycle by WG2 on the environmental assessment of the Global Air Navigation Plan – Navigation Plan – Aviation System Block Upgrades (GANP-ASBU). This data included operational improvements for the years 2028, 2038 and 2050 for Horizontal Flight Efficiency (HFE). This previous analysis, which served as the baseline, had created 53 rule of thumb fuel saving benefits to be expected from the implementation of 31 measures in total.

**TABLE 1:** List of Operational Measures assessed by CAEP.

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| ✓ Remote Tower<br>✓ Enhanced MET information<br>✓ Flexible use of airspace<br>✓ Flex routes<br>✓ Free Route Airspace<br>✓ User Preferred Routings<br>✓ Space-based ADS-B surveillance<br>✓ Datalink En-route<br>✓ Datalink Departure Clearance<br>✓ FF-ICE Planning Service<br>✓ Continuous Descent Operations<br>✓ Continuous Climb Operations<br>✓ PBN STARs<br>✓ PBN SIDs<br>✓ Flight-based Interval management<br>✓ Ground-based Interval Management<br>✓ ATFM | ✓ Short-Term ATFCM Measures<br>✓ Advanced FUA (ATFM / Airspace Management)<br>✓ RNP-AR approaches<br>✓ Airport – Collaborative Decision Making<br>✓ Wake Vortex Re-categorization<br>✓ Time-Based Separation<br>✓ Arrival Manager<br>✓ Extended Arrival Manager<br>✓ Terminal Flight Data Manager<br>✓ Advanced – Surface Movement Guidance and Control System<br>✓ PBN approaches (Radius to Fix)<br>✓ PBN to xLS approaches<br>✓ GBAS CAT I/II/III<br>✓ Multi-segment approaches/ glideslopes |

Together with these measures, CAEP found other innovative measures that should be taken into account and assessed. Table 2 below lists the other measures that were taken into consideration.

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| ✓ Dynamic Sectorization<br>✓ Reduced Extra Fuel On-board<br>✓ Best Practices in Operations Minimizing Weight<br>✓ In-Trail Procedure (ITP)<br>✓ Airline Fuel Management System<br>✓ Optimized Runway Delivery Support tool and Reduced Pair-Wise Weather Dependent Separation between Arrivals<br>✓ Electrical Tug Detachable Aircraft Towing Equipment | ✓ Support for Optimized Separation Delivery and Reduced Pair-Wise Weather Dependent Separation between Departures<br>✓ Formation Flight<br>✓ Geometric Altimetry and RVSM Phase 2<br>✓ Global Air Traffic Flow Management<br>✓ Satellite Based VHF for oceanic/ remote areas<br>✓ APU Shut Down<br>✓ MAINTENANCE - difference between maintenance and modification to aircraft, technology related |

**TABLE 2:** List of additional Operational Measures assessed by CAEP

Figure 1 below shows how CAEP categorized the operational measures into five flight efficiency areas that optimize fuel use and reduce emissions.


**FIGURE 1:** Categories of operational measures.

Following categorization, CAEP generated the description of three different scenarios and created "Rules of Thumb" for each individual operational measure and updated the baseline that had previously been established in CAEP. There were three scenarios suggested: aggressive, medium, and conservative. These scenarios were constructed according to different rates at which the five above categories of measures were assumed to be implemented.

Based on that it has been found that Operational Improvements could reduce $CO_2$ emissions by up to 11% by 2050, under the most aggressive scenario.

Resul of three scenarios:

- Conservative: Low action, 5% reduction by 2050.
- Medium: Moderate action, 8% reduction by 2050.
- Aggressive: High action, 11% reduction by 2050.

## ICAO Tracker Tools on Operations

Since the LTAG of net-zero carbon emissions by 2050 was adopted, ICAO has been maintaining a close eye on developments around the world that could help lower $CO_2$ emissions. Air operations, ground operations, green infrastructure, and latest news are the four categories in which the Operations Tracker gathers news from across the globe.

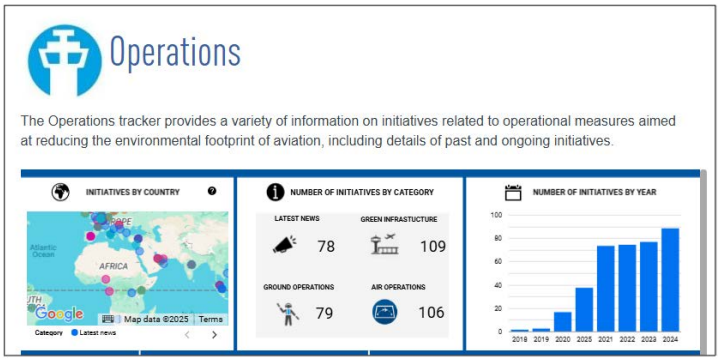


**FIGURE 2:** ICAO Operations tracker.

*Note: This is based on information that the Secretariat is able to obtain from publicly available sources and news sources. It is possible to submit supplementary initiatives to the ICAO Secretariat.*

## Implementation of Operational Concepts Through the Global Air Navigation Plan (GANP)

ICAO's Global Air Navigation Plan (GANP) serves as the framework for harmonized implementation of operational improvements worldwide. The GANP aims to support the development of a global air navigation system that is adaptable, safe, secure, sustainable, and efficient. The Aviation System Block Upgrade (ASBU) framework serves as a programmatic approach, enabling Member States to enhance their air navigation capacities based on specific operational needs.

In the CAEP/11 cycle ICAO's Committee on Aviation Environmental Protection (CAEP) has assessed ASBU modules for their fuel and emissions reduction potential. In the next 3 years, CAEP will continue reviewing the ASBU framework in addition to the other aspects of "Operations" (including flight planning, network operations and airspace design) to assess additional operational elements and provide insights into potential fuel savings. This systematic approach aligns closely with LTAG objectives, ensuring effective integration of operational concepts into the broader strategy for achieving net-zero carbon emissions by 2050.

## Considerations for Implementation

Leading airlines, airports, air navigation service providers and other aviation stakeholders are already integrating operational practices into standard operations, demonstrating the feasibility of broader adoption; key steps include:

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| **Establishing governance structures to oversee implementation and monitor progress** | **Integrating sustainability objectives into corporate planning cycles** |
| **Regional coordination to harmonise approaches and avoid fragmentation** | **Setting clear milestones and performance indicators** |

## Conclusion

In order to achieve net-zero carbon emissions by 2050, the aviation sector should immediately start implementing operational measures. With the implementation of these measures, airlines can more effectively manage the growing demand for travel by optimizing the use of airspace and airport capacity. Increased resilience and flexibility could enable the system to adapt to fluctuating weather patterns and aviation traffic volumes. In addition to that, operational measures implemented on board and on ground can also contribute to reducing $CO_2$ emissions and complement the achievement of LTAG.

Reaching net-zero carbon emissions by 2050 will require comprehensive efforts across all facets of aviation. The examples outlined in this article represent just a subset of the available operational improvements and air traffic management strategies that can contribute to emissions reductions. With continued innovation, investment, and collaboration, the aviation sector can align its growth with global climate objectives and support a more sustainable future.