International Civil Aviation Organization

WORKING PAPER

A41-WP/320
TE/128
15/8/22
(Information paper)
English only

ASSEMBLY — 41ST SESSION

TECHNICAL COMMISSION

Agenda Item 31: Aviation Safety and Air Navigation Standardization

WAKE ENERGY RETRIEVAL: AN ENVIRONMENTAL OPPORTUNITY FOR AVIATION (AUTOMATED FORMATION FLIGHT)

(Presented by the International Coordinating Council of Aerospace Industries Associations (ICCAIA))

EXECUTIVE SUMMARY

Wake energy retrieval operations in cruise, applied to aeroplanes engaged in international commercial operations, allow significant fuel burn savings and associated CO2 emission reduction without additional ground infrastructure or aeroplane sensors. The principle relies on an aeroplane harvesting a part of the energy from the wake vortex generated by a leading aeroplane, by actually surfing it. The technical solution ensures that the aeroplanes remain safely positioned throughout the "paired" flight.

The technical solution ensures aircraft remain safely positioned at a steady altitude throughout "paired" flight. The technology has shown it can drive at least a 5 per cent reduction in CO2 emissions per flight. This paper describes advances during transatlantic trials conducted by Airbus, proving technical and operational feasibility with engagement of airlines, air navigation services providers (ANSPs) and authorities, and provides a preliminary identification of required Standards and Recommended Practices (SARPs) and related ICAO guidance to support entry into service of the concept within five years. This paper also highlights the need to identify a strategy for further developing provisions through the relevant technical panels.

Strategic Objectives:	This information paper relates to Strategic Objectives: Environmental Protection, Safety, Air Navigation Capacity and Efficiency.
Financial implications:	N/A
References:	A41-WP/127-TE/39: *Wake energy retrieval (Automated formation flight)* Annex 2 — *Rules of the Air* Annex 6 — *Operation of Aircraft* Annex 10 — *Aeronautical Telecommunications* Annex 11 — *Air Traffic Services* Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM) Doc 8168, *Procedures for Air Navigation Services — Aircraft Operations* (PANS–OPS) Doc 9760, *Airworthiness Manual*

1. INTRODUCTION

1.1 Reduction of fuel consumption and consequently of "Greenhouse Gas emissions" (GHG - mainly CO2) and more globally the environmental footprint of the aviation sector is a key challenge for commercial aviation for the next decades. Significant technical progress has already been made for fuel efficiency during the last decades.

1.2 Wake energy retrieval operations in cruise applied to aeroplanes engaged in international commercial operations is one of the most promising complementary ways to reduce fuel burn. This paper provides elements on progress and achievements since the ICAO 40th Assembly and proposes a strategy to address the required provisions for wake energy retrieval operations.

1.3 As the "formation flight" name generated frequent confusion with "close proximity" military operations, it was decided to rename the program as "wake energy retrieval".

2. DISCUSSION

2.1 The value of wake energy retrieval is linked to the local fuel savings obtained for the follower aircraft while surfing the vortex. The principle relies on harvesting a part of the energy from the wake vortex generated by a leading aircraft, by actually surfing it. Whilst wake turbulence is commonly considered as a threat for commercial aeroplanes, this concept aims at taking benefit from the energy contained in trailing vortices, without compromising safety (which is paramount). Thus, positioning a trailing aircraft in a right way in the area where the vortex pushes air upward enables the trailing aircraft to save fuel.

2.2 At aircraft level, airborne functions are developed to automatically position and maintain the trailing aircraft in the optimum position near the vortex generated by a lead aircraft, while guaranteeing protection with regard to wake vortex encounters and mid-air collision risks.

2.3 Many workshops have been carried out with operational partners, ANSPs and supportive airlines to prepare the test campaigns. A Concept of Operations (CONOPS) has been initiated and is available at: https://www.airbus.com/en/innovation/disruptive-concepts/biomimicry/fellofly.

3. DEMONSTRATION FLIGHTS

3.1 In July 2020, a first flight test campaign validated all elements of the concept (vortex position estimator, automated capture and tracking functions through a dedicated aircraft system).

3.2 In March 2021, a second flight test campaign confirmed fuel and emissions reductions in line with models. In addition, airborne functions for automated vortex capture and tracking were tested at different altitudes and separations.

3.3 In September 2021, for the first time, a pair in formation flew in General Air Traffic conditions, with French (Brest) and UK (Prestwick) Air Traffic Control. Based on CONOPS and ATM Safety assessment work, NATS and DSNA coordinated with their National Authorities (DSAC and UK CAA) to provide the necessary authorizations. Safety studies were performed to manage Wake Energy Retrieval operations in General Air Traffic conditions with legacy tools.

3.4 A specific VHF frequency was allocated by French and UK frequency management authorities for the necessary coordination between crews. Standard ATC communication was used.

3.5 A dedicated phraseology was defined and shared with involved Airbus Pilots, DSNA, NATS, NAVCANADA and IAA Air Traffic Controllers. Rendezvous and split procedures were experienced in both Brest domestic and Shanwick oceanic airspaces. The pair crossed the border between Brest and Shanwick airspaces in formation under the coordination of French DSNA and NATS Prestwick Air Traffic Controllers. Oceanic Clearances have been integrated into the process.

3.6 In November 2021, a round-trip demonstration flight trial in GAT, was performed from Toulouse (LFBO) to Montreal (CYUL), across the North Atlantic airspace, using the same Airbus Flight Test A359 MSN1 as Leader A/C and A35K MSN59 as Follower A/C was performed and operated by Airbus Flight Test Crews with ATC support. ANSPs directly involved in this flight trial were: French DSNA, UK NATS, NAVCANADA, and Irish IAA. The North Atlantic ICAO Procedures and Operations Group (ICAO NAT POG) has supported the trials over the North Atlantic, in coordination with the NAT IMG.

3.7 These two first transatlantic flights of a pair of aircraft, one surfing the vortex of the other, have been considered a real success. At least 2 tons of fuel (around 6 Tons of CO^2) was saved during each flight. Five per cent fuel saving efficiency has been confirmed.

3.8 Flight crew underlined the very good cooperation with all ATC centres who all supported the success of the mission with defined CONOPS and phraseology to perform rendezvous, transfer of separation responsibility to the pair, monitoring, and split. MSN01, the leader, flew in managed modes at M0.85 and 1.2NM ahead of the follower.

3.9 In both flights, data communication between Aircrafts was ensured through "ADS-B" like data protocol, therefore using a standardised short-range data communication means.

3.10 From the observers that were onboard to witness the flight, very good feedback was received on:

a) comfort when harvesting the vortex, at every seat position of the aircraft: Nose/Mid/Tail section;

b) efficiency of the implemented functions to automatically reach and fly rendezvous, vortex free, and optimum position; and

c) efficiency of the implemented safety nets to keep sufficient margins toward the vortex.

4. TRIALS OUTCOMES

4.1 With around 75 per cent of the flight time in automatic formation flight (in OPTI mode, refer to CONOPS in https://www.airbus.com/en/innovation/disruptive-concepts/biomimicry/fellofly), and a total of 11h20 (round-trip) of automatic positioning, the technical and operational objectives were successfully met and 5 per cent fuel (2 tons of fuel, 6 tons of CO2) savings were confirmed.

4.2 Based on the measured benefits during the transatlantic trials, the environmental potential of wake energy retrieval over the North Atlantic is estimated around 2 million tons of CO_2 or 600.000 tons of fuel per year (2019 traffic basis).

4.3 Trials enable a better understanding of the coming tasks to be addressed:

a) Pilots: wake energy retrieval brings new procedures for rendezvous and split. Cockpit assistance will be provided, together with a specific training;

b) Airlines: pairing decisions within operation centres and dispatchers has to be smoothly integrated; and

c) ANSPs and air traffic controllers: A level of support for wake energy retrieval operations is needed, with integration of a pair configuration within the ATC safety nets.

4.4 This will require support from the regulators and authorities so that this new operational concept can be certified. Standards will need to be established, integrating:

a) geometry of the pair of aircraft (1,2NM longitudinally, FL below the pair to be reserved);

b) transfer of separation responsibility from ATC to the pair; and

c) dedicated communication for the pair coordination.

5. IMPACTED ICAO PROVISIONS

5.1 At this stage, the following SARPs and related guidance have been identified as impacted:

a) Annex 2, Annex 6, Annex 10, Annex 11;

b) PANS ATM, PANS OPS, Airworthiness Manual; and

c) in addition, a dedicated Wake Energy Retrieval manual, supporting the implementation and approval of such an operation, will need to be developed.

5.2 A detailed review will be necessary to confirm the exhaustiveness of section 5.1 list and the necessary updates. This review shall require involvement of experts from at least FLTOPS Panel, ATMOPS Panel and SASP Panel. Other relevant Panels might as well be involved as necessary.

6. CONCLUSION

6.1 These transatlantic trials are a concrete demonstration of collaborative work for designing and qualifying optimised solutions aiming to reduce the environmental impact of aviation.

6.2 Potential savings have been confirmed for over 5 per cent reduction of CO_2 emissions per flight, with relatively limited impacts identified on flight operations.

6.3 A worldwide deployment will be only possible with the support of States and ICAO, in cooperation with industry (airlines, pilots, ANSPs, air traffic controllers).

6.4 It was suggested that a dedicated project team be set up under the NAT SPG, gathering experts from the involved stakeholders with support and under the lead of the industry, to review and propose amendments to current ICAO provisions, and draft a first version of the new Wake Energy Retrieval manual.

6.5 However, the NAT SPG/58 meeting (June 2022) did not support the proposal to establish a NAT project team. The meeting reconfirmed that this work should be done at the global level.

6.6 ICCAIA is therefore requesting the support of the ICAO Assembly in A41-WP/127-TE/39, to develop the provisions that are necessary to enable Wake Energy Retrieval operations, which contributes to ICAO's ambition to achieve the short-term aviation emission reduction targets.

— END —