International Civil Aviation Organization

WORKING PAPER

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TWELFTH AIR NAVIGATION CONFERENCE

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Agenda Item 4: Optimum capacity and efficiency – through global collaborative ATM
4.1: Efficient management of airspace and improved flow performance through collaborative decision-making (CDM)

THE NEED TO DEVELOP A SPECIALIZED, INTEGRATED WAKE VORTEX FLIGHT SAFETY SYSTEM

(Presented by the Russian Federation)

EXECUTIVE SUMMARY

This paper presents a proposal for the development of a specialized, integrated wake vortex flight safety system.

Action: The Conference is invited to note the potential of a WVSS, as described in the working paper and proposes that ICAO further develop a WVSS concept description along with a proposed system architecture with the possibility to be included in the block upgrades e.g. B1-85, B2-85, B1-70 and B2-70.

1. INTRODUCTION

1.1 The aim of increasing the intensity of air traffic requires technologies and procedures to be developed that will make it possible to reduce aircraft separation intervals in all phases of flight, including wake vortex separation minima.

1.2 The ICAO strategy proposed in the aviation system block upgrade (ASBU) to reduce aircraft separation minima under wake vortex safety conditions should ensure an increase in airspace capacity subject to the safety constraints arising in typical air traffic conditions.

1.3 It is possible to ensure wake vortex safety in conditions different from standard ones and to increase the level of flight safety in typical air traffic conditions only by using additional technical systems.

2. BACKGROUND

2.1 One of the tools for increasing airspace capacity in all phases of flight is a revision of the existing ICAO aircraft wake turbulence separation minima and procedures. The improvement of processes, procedures, and standards for mitigating the effects of wake vortices between aircraft is envisioned by ICAO's ASBU Blocks B0, B1, B2 and B3.

2.2 The change in the ICAO wake vortex separation standards introduced into the temporary framework of Block B0 will lead the number of ICAO aircraft wake vortex categories to increase from three to six. In the implementation period for the Block B1 measures, the six categories can be expected to expand to a pair-wise static separation matrix for wake vortex safety (theoretically sixty-four or more pairs based on the type of separation). Meanwhile, the aircraft separation matrix will be calculated for some reasonable combination of worst-case meteorological conditions contributing to the formation of a long-lasting hazardous wake vortex. In Block B2, a pair-wise dynamic aircraft separation matrix for wake vortex safety will be introduced. Meanwhile, the size of the matrix will increase. Separation intervals will be a function not only of aircraft pairs, but also of discrete values pertaining to meteorological conditions (wind direction and speed, turbulence, etc.).

2.3 The primary drawback of the approach outlined above is that the matrix of separation intervals, which is presented as a set of "finished decisions", is calculated for a certain relatively wide, yet limited, range of meteorological conditions in flight. Therefore, even maintaining the prescribed aircraft separation intervals does not guarantee wake vortex safety. For example, in conditions when atmospheric turbulence is close to zero, safe distances may turn out to be significantly greater than those assigned. Meanwhile, it is possible that an aeroplane may enter a hazardous wake vortex area even when ICAO separation standards are observed. The practical experience of operating aircraft in flight only confirms this. We will give several examples.

2.4 On 13 August 2005, an incident involving an Airbus A340-500 occurred within the area of responsibility of the Area Control Centre in Shannon, Ireland. The aeroplane encountered the wake vortex of a Boeing B757-200, and as a result it experienced an extremely strong, uncontrollable roll to 45 degrees accompanied by a loss of 120 m in altitude. According to data from the ground radar, the actual longitudinal separation interval between the aircraft exceeded the required ICAO standard by a factor of two. A similar incident occurred on 10 January 2008 with an Airbus A319-114 aeroplane that experienced a series of rolls from 28 to 55 degrees when encountering the wake vortex of a Boeing B747-400 at a range of 10.7 nautical miles, which exceeded the ICAO minimum horizontal separation more than twice.

2.5 The task of ensuring wake vortex safety does not entail merely maintaining the prescribed aircraft separation intervals. It includes, at the very least, the following elements:

a) maintaining prescribed (standard) wake vortex separation intervals;

b) determining the current acceptable wake vortex separation intervals in the existing (actual) flight conditions;

c) providing the crew and ground air traffic control services with information about the standard and current acceptable aircraft separation intervals;

d) obtaining information about the current wake vortex situation from the aircraft and (or) ground ATC units;

e) determining the risk of the aircraft encountering a wake vortex;

f) classifying wake vortices by degree of risk in cases when there are several aircraft generating wake vortices;

g) identifying wake vortex conflicts when aircraft are on intersecting paths or manoeuvring, including when manoeuvring the airplane that is generating the wake vortex; and

h) providing recommendations for resolving potential wake vortex conflicts.

2.6 Wake vortex safety should be ensured not only when an aircraft is flying in a straight line, but also in the event that the leader and follower aeroplanes are manoeuvring. Fulfilling this task requires information about the movement of the airplane generating a wake vortex. The position of its wake vortex (which, in general, is a curved line) in real time must be determined, and then the proper indication and recommendations can be formulated for the crew of the follower airplane.

2.7 The foregoing relates not only to aircraft separation in flight and during manoeuvring en route, but also to aircraft during take-off and landing. Unlike the development of a wake vortex far from the Earth's surface, the dynamic of the wake vortex near the ground is determined by the interaction of a large number of factors: turbulence and the temperature stratification of the atmosphere, the presence of cross-winds, and the viscous/inviscid interaction with the ground. As a result of this, the dynamics of the evolution of hazardous wake areas may be very complex. A viscous interaction of the vortex with a boundary layer of the ground may lead to the generation of secondary vortices or to "hovering" vortices over the runway, and in general, the minimum safe separation intervals established by ICAO for take-off and landing are unsafe. This has been confirmed by a series of disasters involving Yak-40 and Il-76 aeroplanes (Tashkent-Yuzhniy, USSR, 1987), DC-9 and DC-10 aeroplanes (Greater Southwest International Airport, USA, 1972) and others caused by the "hovering" of a wake vortex over the runway. Thus safe aircraft separation minima for random environmental conditions can be determined only through a specialized integrated wake vortex flight safety system in real time, taking into account the prevailing meteorological conditions.

2.8 The task of ensuring vortex flight safety is a problem in which human factors play a major role. This means that it is possible that many irregular situations related to violations of the separation minima could arise when the generation of crew warnings and avoidance recommendations requires taking into account the current spatial locations of the wake vortex and the follower airplane, as well as the dynamic of how those locations are changing. No single system based on calculating only the safe separation intervals is capable of effectively meeting the challenge of wake vortex safety under such conditions. Therefore, to ensure wake vortex safety under such conditions, there needs to be a specialized integrated wake vortex flight safety system.

2.9 The identification and development of warning recommendations to the pilot and ATC service concerning the separation of aircraft and the prevention of entrance into hazardous wake vortex areas are only possible if there is an integrated wake vortex flight safety system capable both of identifying the danger of a wake vortex in any meteorological conditions, given any trajectory of the airplane generating the wake vortex and any spatial location of an aircraft relative to the wake vortex, and of generating warnings concerning the degree of wake vortex danger and issuing recommendations on aircraft separation and how to prevent the aircraft from entering the wake vortex.

2.10 The integrated wake vortex flight safety system is a distributed (i.e. comprising onboard and ground segments) computer system made up of basic and specialized technical systems and air navigation system tools, as well as the aircraft's onboard piloting and navigation equipment. The integrated wake vortex flight safety system is implemented in the form of a hardware/software or software bundle used as a subsystem or special software, as follows:

a) tools for automating airspace use planning and managing air traffic flow (ground segment);

b) air traffic control automation equipment (ground segment);

c) meteorological support equipment (onboard and ground segments);

d) piloting and navigation equipment (onboard segment);

e) radio equipment for navigation, landing and air traffic control (onboard and ground segments); and

f) airborne information system (information display and alarm systems).

3. CONCLUSION

3.1 The Conference is invited to agree to the following recommendation:

Recommendation 4/x – Need for the development of a specialized, integrated wake vortex flight safety system

That the Conference request ICAO to further develop a wake vortex flight safety system concept description along with a proposed system architecture with the possibility to be included in the block upgrades e.g. B1-85, B2-85, B1-70 and B2-70.

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