Contextual note – PJ.02-01-07 AO-0325[1] "Wake Decay Enhancing Devices" (TRL7) Description Form for Deployment Planning

1. Purpose

This contextual note describes PJ.02-01-07 OI step AO-0325[1] "Wake Decay Enhancing Devices" with a summary of the results stemming from R&D activities contributing to deliver it. It provides (to both those external and internal to the SESAR programme) an overview of AO-0325 (of PJ.02-01-07) in terms of scope, main operational and performance benefits, relevant system impacts and recommends additional activities that should be conducted during the industrialisation phase or as part of deployment.

This contextual note complements the solution Data Pack comprising the SESAR deliverables required for industrialisation and deployment.

2. Improvements in Air Traffic Management (ATM)

PJ.02-01-07 is a technological solution reducing the Wake Turbulence Risk via positioning of decay enhancing devices that accelerate the Wake Vortex Decay in Ground Proximity.

Wake Vortex Decay Enhancing Devices, so-called plate lines, can be installed at any major European airport in order to increase safety by reducing the risk of low-altitude wake encounters. In addition, further capacity gains may be possible in combination with different separation schemes and/or through further optimisation of the wake turbulence separations on final approach.

Plate lines reduce the lifetime of long-lived wake vortices in ground proximity by up to 37%, making wake encounters less likely. Each plate line consists of several upright plates that are installed beyond the ends of runways underneath the approach glide path where the individual plates are oriented in parallel to the runway centreline. While descending, wake vortices interact with the plates generating disturbances that propagate in and against flight direction. These disturbances reduce the lifetime of the long-lived and potentially most hazardous wake vortices.

Within this solution, a live trial activity was used to validate the Wake Decay Enhancing Devices concept.

Relevant Operational Environments

OEs	Sub Operating Environments	Definition
Airport	Very Large Airport	Airports with more than 250k movements per year
	Large Airport	Airports with more or equal than 150k and less or equal than 250k movements per year
	Medium Airport	Airports with more or equal than 40k and less than 150k movements per year

[1] Inside DS23-draft the enabler AIRPORT-08 (used in PJ.02-01-07's TRL6 Contextual Note) is no longer coupled to AO-0325 (as was the case in DS19), but it has been linked to POI-0037-AO. So in this CN of TRL7 for PJ.02-01-07 AO-0325 has been used.

3. Operational Improvement Steps (OIs) & Enablers

Applicable OI Step:

AO-0325 — Reduction of Wake Turbulence Risk considering Acceleration of Wake Vortex Decay in Ground Proximity

Applicable Enablers:

AIRPORT-08 [2] **–** Decay Enhancing Devices;

Applicable Integrated Roadmap Dataset is DS23-draft.

4. Background and Validation Process

Previous work on Wake Vortex Decay Enhancing Devices indicates a reduction of the maximum wake vortex life time by at least 20%, leading to a positive impact on wake encounter rates close to ground and hence creating an associated safety benefit. Wake Vortex Decay Enhancing Devices can be installed at any major European airport in order to increase safety by reducing the number of encounters. In addition, there is potential to achieve runway capacity gains in combination with various minimum aircraft separation schemes.

SESAR2020 Wave 1 Validation:

- **LT10:** Two temporary plate lines were installed at runway 16 of Vienna airport. A measurement campaign was conducted with the objective to quantify the accelerated vortex decay and the related safety gains. A preliminary average reduction of wake vortex lifetime of over 30% was found.

SESAR2020 Wave 2 Validation:

The objective of WP3 in VLD3-SORT was to industrialise the plate line concept into a prototype for permanent installation at airports. To achieve this, five goals need to be met:

- Elaborate a technical plate line design for permanent installation at an airport;
- Receive approval from the authorities for the installation of plate lines at the runway ends;
- Installation of the plate prototype in a suitable environment, e.g. at Vienna airport considering legal, and stakeholders requirements;
- Thorough quantification of the acceleration of wake vortex decay by plate lines considering the effects of individual aircraft types, flight altitudes, and environmental conditions. This analysis shall also provide guidance on the number of required plate lines and their location;
- Assessment of achievable reductions of separation minima for the arrival concepts RECAT-EU and RECAT-EU-PWS following the approaches employed for the respective safety cases. The data is also used to assess the potential benefits for weather dependent separations (RECAT-III).

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5. Results and Performance Achievements

Consolidated Wave 1 Results (EARTH)

The wake decay enhancing method is passive, low-cost, robust, and safe. The installation of the plates increases flight safety and reduces the number of go-arounds. Furthermore, the concept may enable capacity gains via synergies with other measures for the optimization of aircraft separations (e.g. RECAT). The live trial has demonstrated the technical feasibility employing a temporary plate line design complying with ICAO and EASA requirements and approved by the authorities. Alternative designs for permanent installation have been developed.

The measurements with the temporary plate line design have demonstrated that the concept works well physically. The performance of the plate lines is measured in terms of reduced lifetime of the long-lived vortices. Preliminary analysis indicated that the lifetime of the long-lived wake vortices in the flight corridor under calm wind conditions can be reduced by the installation of plate lines by about 30%.

Consolidated Wave 2 Results (VLD3-SORT)

The thorough analysis of over 1000 wake vortex evolutions measured at Vienna airport indicates that the plate lines reduce the lifetimes of the vortices in a safety corridor along the final approach in ground proximity from 22% for aircraft of the Medium weight class up to 37% for Heavies. This corresponds to a reduction of vortex circulation by about 50% for the most relevant ICAO separation (Medium behind Heavy).

Even though plate lines are only effective close to the ground, they still support a potential reduction of the separation further up on the glideslope. When using RECAT-EU as reference, substantial benefits can only be gained for some – albeit relevant – aircraft category combinations. When using RECAT-EU-PWS as reference, for most aircraft pairings benefits of about 0.5 NM (15%) separation reduction seem to be possible when using plate lines. In the near term the RECAT-EU scheme or the RECAT-EU-PWS scheme together with the installation of plate lines may advance both simultaneously, runway throughput for arrivals and safety in terms of wake vortex encounter risks.

The technical plate design was developed very systematically from 15 initial draft designs in an intense exchange with experts leading to a design which is now ready for installation at busy airports. This includes the documentation needed for the required authority approval. One prototype plate has been installed near Vienna airport and another one on DLR premises in Oberpfaffenhofen.

6. Recommendations and Additional Activities

An exchange with a number of European airports and the respective ANSPs made clear that mere safety gains consisting of a reduction of wake vortex encounters in ground proximity and resulting go-arounds (use case I) do not yet justify an investment in the installation of a plate line, as the current situation is considered sufficiently safe. However, for congested airports it would be attractive to install a plate line provided that the landing capacity could be increased.

Nevertheless, already now opportunities appear for plate line installation for some airport specific situations. For example, the airport Leipzig/Halle showed interest to install a plate line in order to use the RECAT-EU scheme also for the more heavy leaders of the DHL cargo aircraft fleet. Airport Frankfurt showed interest to employ a plate line to operate the take-off runway 18 without obeying wake vortex separations for landings on the runway 07R.

In the near term, the RECAT-EU scheme or the RECAT-EU-PWS scheme together with the installation of plate lines may advance both simultaneously, runway throughput for arrivals and safety in terms of the wake vortex encounter risks (use case II). Even larger capacity gains could be achieved by exploiting the accelerated wake vortex decay following the rationale of the RECAT-EU and RECAT-EU-PWS schemes (use case III), or by eliminating the dependency of the REDSEP scheme on headwind conditions (use case IV), or by extending the operation times of wake vortex advisory systems for dynamic pairwise separations (RECAT-III, use case V). Plate line use cases III to V require the preparation and approval of the respective safety cases either by national authorities or EASA. For this the underlying concepts need further development which in turn requires to fill gaps of missing wake vortex data either by new measurements and/or by processing the Vienna wake vortex lidar data base with methods of artificial intelligence. Further, implications on the glide path need to be considered in an appropriate way.

7. Actors Impacted by the SESAR Solution

The following actors are impacted by AO-0325:

- Air Traffic Controllers;
- Flight Crew;
- ANSPs;
- Airlines /airspace Users;
- Airport Operators;
- Regulatory Authorities.

8. Impact on Aircraft System

Plate-Lines have no influence on existing aircraft systems.

9. Impact on Ground Systems

Plate lines are installed beyond the runway ends and are electromagnetically compatible with the instrument landing system. Due to the plate line placement, guidance lighting visibility is maintained.

10. Regulatory Framework Considerations

Plate Lines were classified as air traffic control system. They comply with the requirements set forth by ICAO regarding obstacle clearance, stability, and frangibility. A safety assessment was conducted by the EASA Safety- & Compliance Management of Vienna Int. Airport assuring that the plate lines comply with the relevant standards and regulations. The new plate design for permanent installation complies with these requirements and was approved by external experts.

11. Standardisation Framework Considerations

N/A

12. Solution Data pack

The VLD3-W2-SORT Data Pack includes the following documents:

- D1.1 – SESAR VLD3-W2-SORT DEMO Plan – Part I, Edition 00.04.00, 9th June 2023.
- D1.4 – SESAR VLD3-W2-SORT DEMO Report – Parts I, II, V, Edition 00.03.00, 24th May 2023.
- D3.1 – SESAR VLD3-W2-SORT Availability Note, 14 March 2023.