Mitigating Wake Turbulence Risk During Final Approach via Plate Lines

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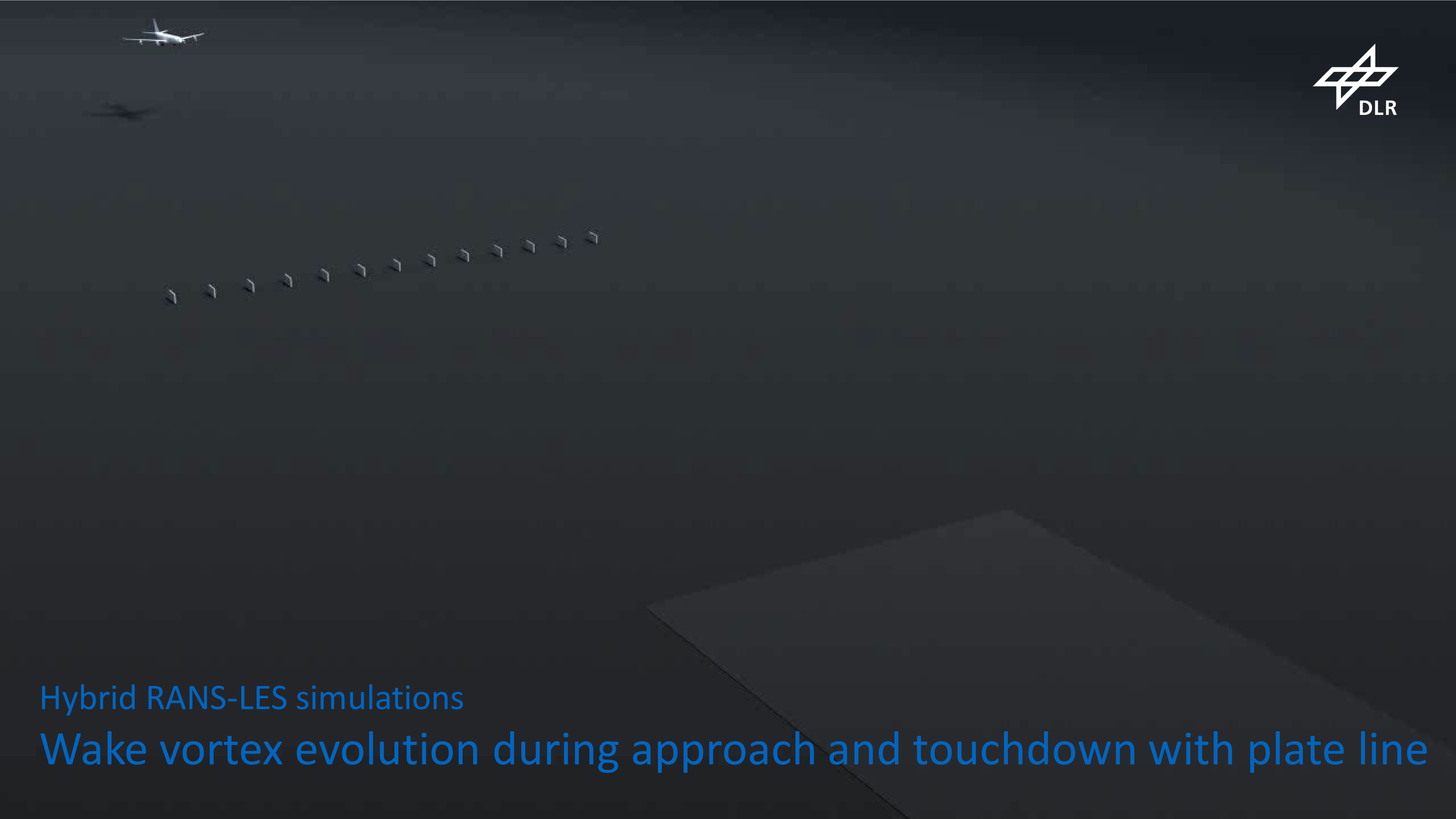


Hybrid RANS-LES simulations

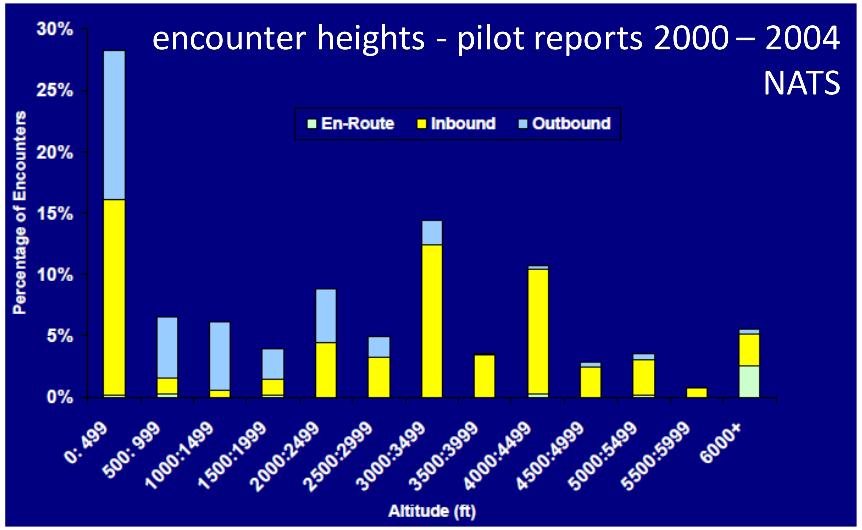
Wake vortex evolution during approach and touchdown with plate line

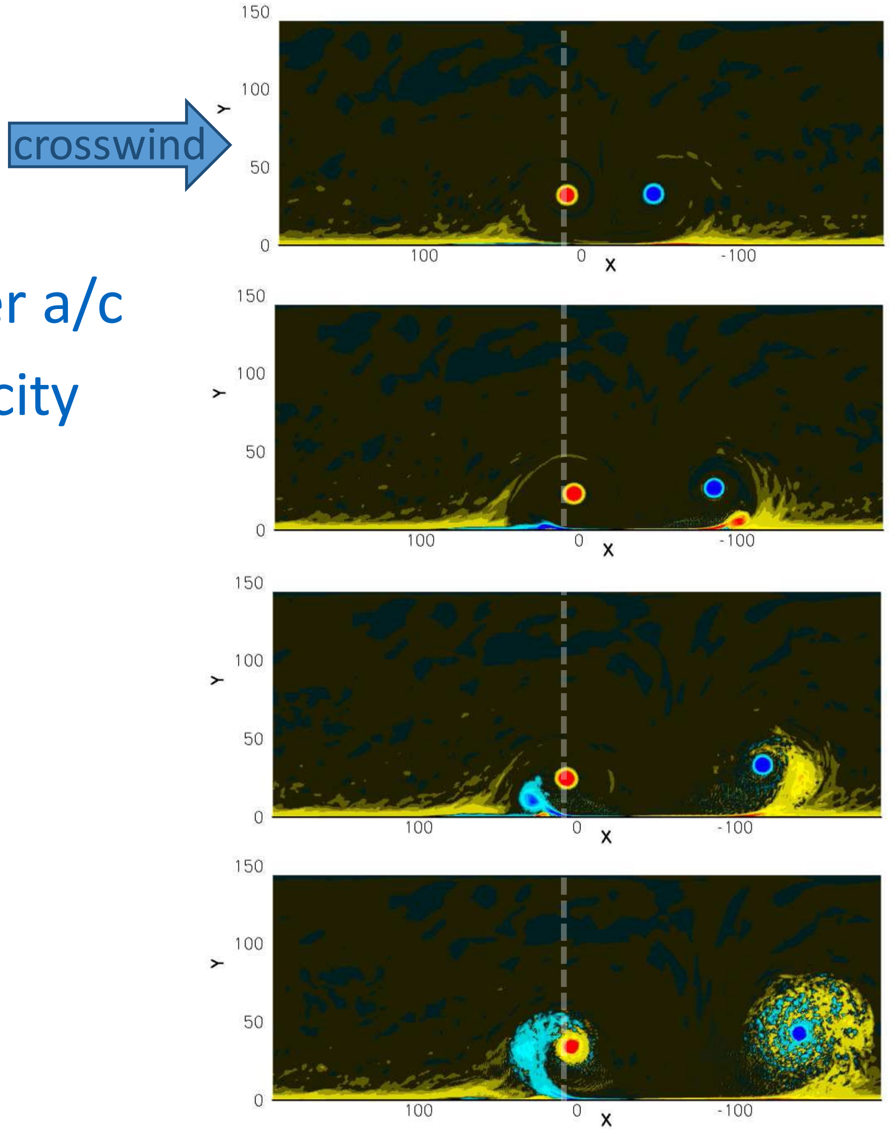
Why Plate Lines?

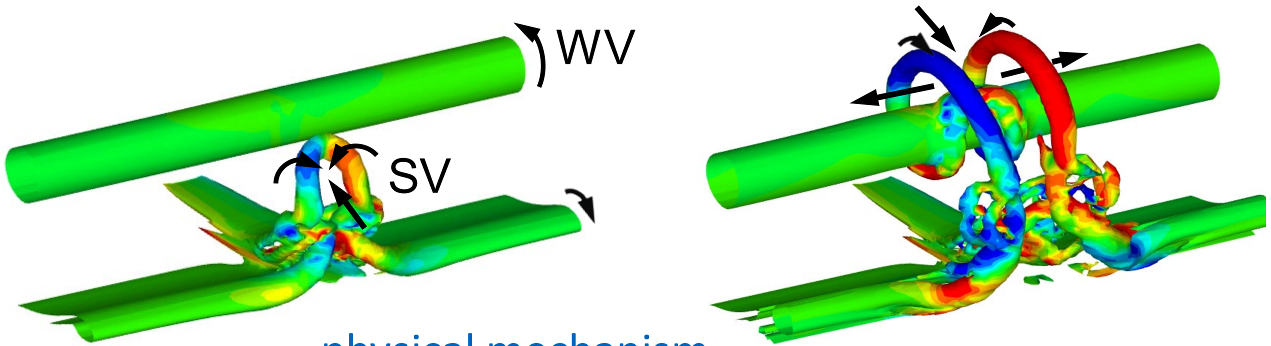
- Wake Vortices (WV) pose potential risk to follower a/c

⇒ minimum separation distances limit airport capacity

- highest risk to encounter WV in ground proximity







physical mechanism

Concept

- plate line consists of several upright plates installed underneath glide path
- passive, economic, robust and safe method to accelerate WV decay

Benefits

- less go-arounds, increased safety
- compensation of increased encounter risks (RWY capacity enhancing methods, RECAT-EU-PWS, …)
- potential capacity gains by optimized (dynamic pairwise) separation distances

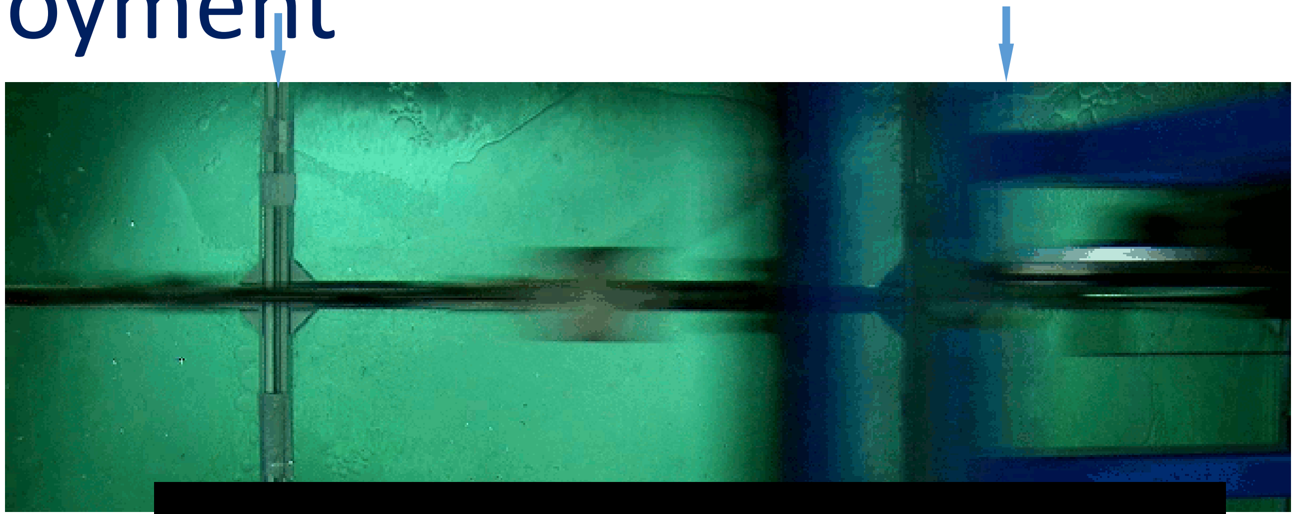
F. Holzäpfel, L. Strauss, C. Schwarz, Assessment of Dynamic Pairwise Wake Vortex Separations for Approach and Landing at Vienna Airport, Aerospace Science and Technology, Vol. 112, May 2021, Article 106618, https://doi.org/10.1016/j.ast.2021.106618.

From the lab towards deployment

Scientific background

development & validation activities since 2008:

- towing tank experiments
- high-end computational fluid dynamics
- flight experiments with DLR research aircraft HALO (Gulfstream G550)



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PJ02 EARTH

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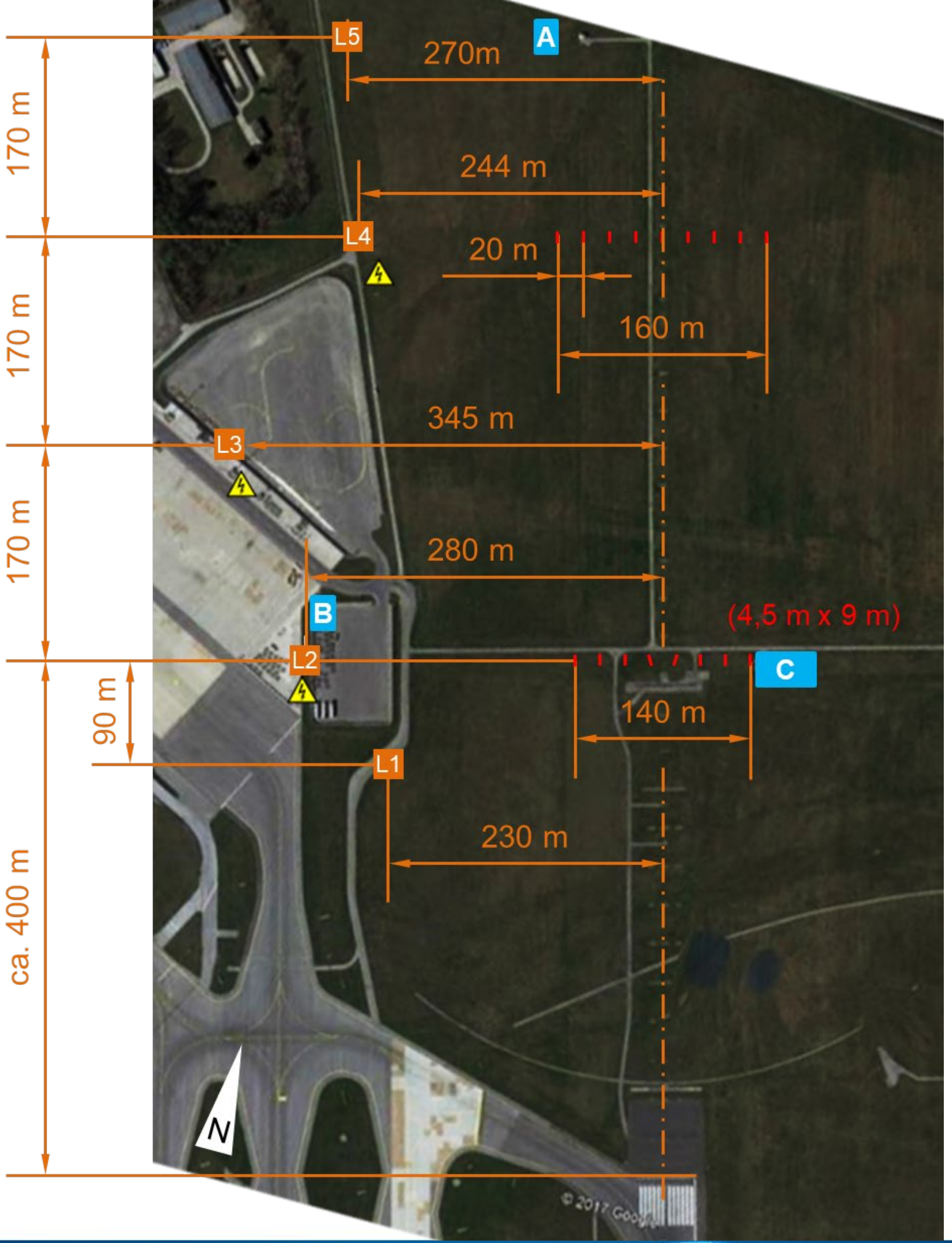
S RT
Safely Optimised Runway Throughput

Vienna measurement campaign

6 May - 28 November 2019

- two experimental plate line prototypes temporarily installed at Vienna Airport
- 9473 landings measured with three lidars
- 589 vortex pair evolutions with and 637 vortex pair evolutions without plates used for analysis

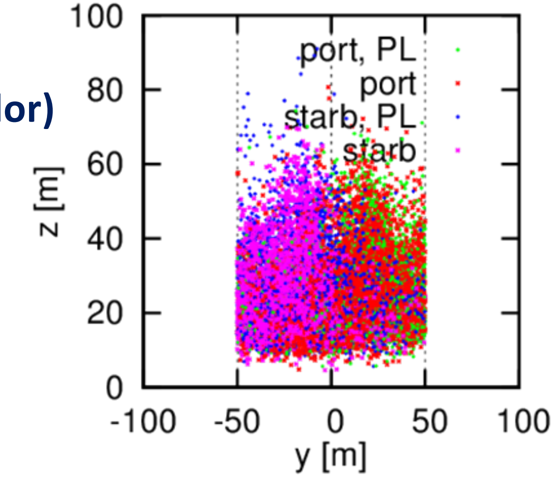


DLR · austro CONTROL · AT-One · LEONARDO · Radiometer Physics GmbH

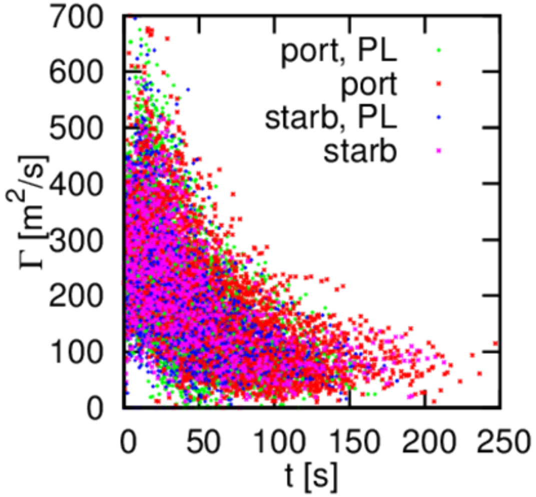
Vienna measurement campaign

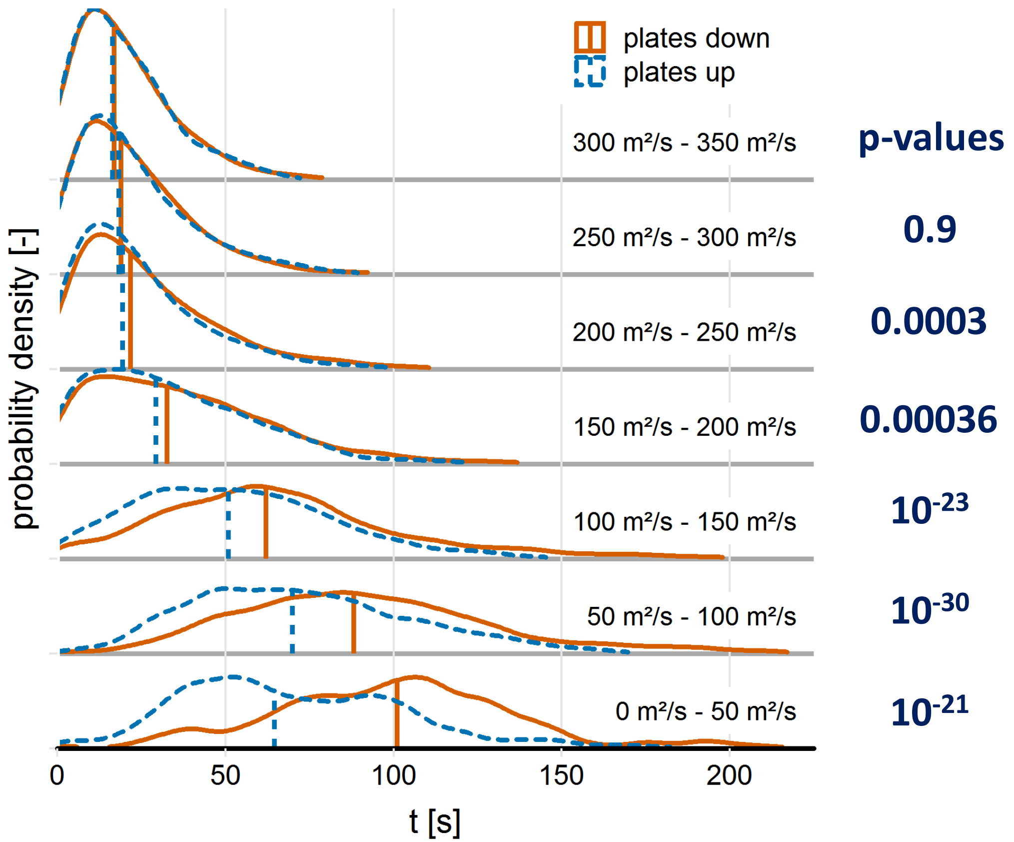
exemplary results

vortex transport
(±50 m safety corridor)



vortex decay
(Γ = circulation)





Vienna measurement campaign

key results



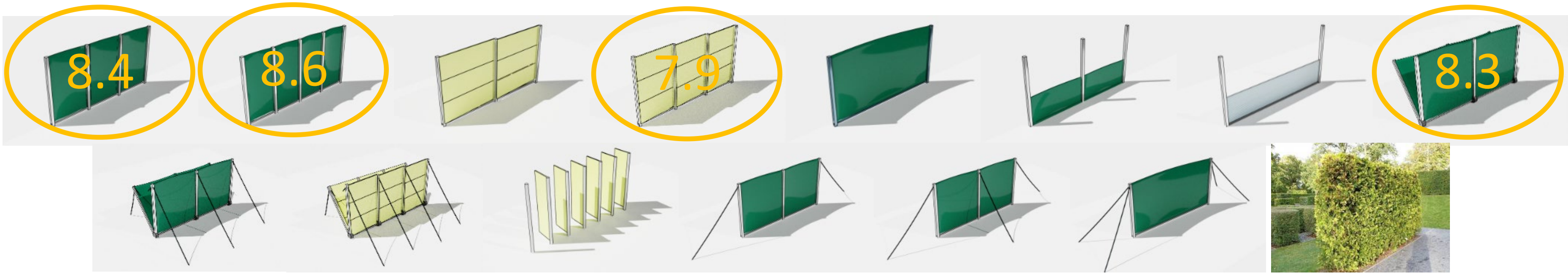
- lifetime reduction potential achieved by plate lines and high turbulence regime similar
- single plate line almost as effective as two lines
- lifetime reductions increase with aircraft size from 22% (A320) to 37% (B777)
- 50% circulation reduction for HVY assuming 120 s separation to following MED

F. Holzäpfel, A. Stephan, G. Rotshteyn, S. Körner, N. Wildmann, L. Oswald, T. Gerz, G. Borek, A. Floh, C. Kern, M. Kerschbaum, R. Nossal, J. Schwarzenbacher, M. Strobel, L. Strauss, C. Weiß, S. Kauczok, C. Schiefer, H. Czekala, G. Maschwitz, I. Smalikho: Mitigating Wake Turbulence Risk During Final Approach via Plate Lines, AIAA Journal, publ. online 10 August 2021, https://doi.org/10.2514/1.J060025.

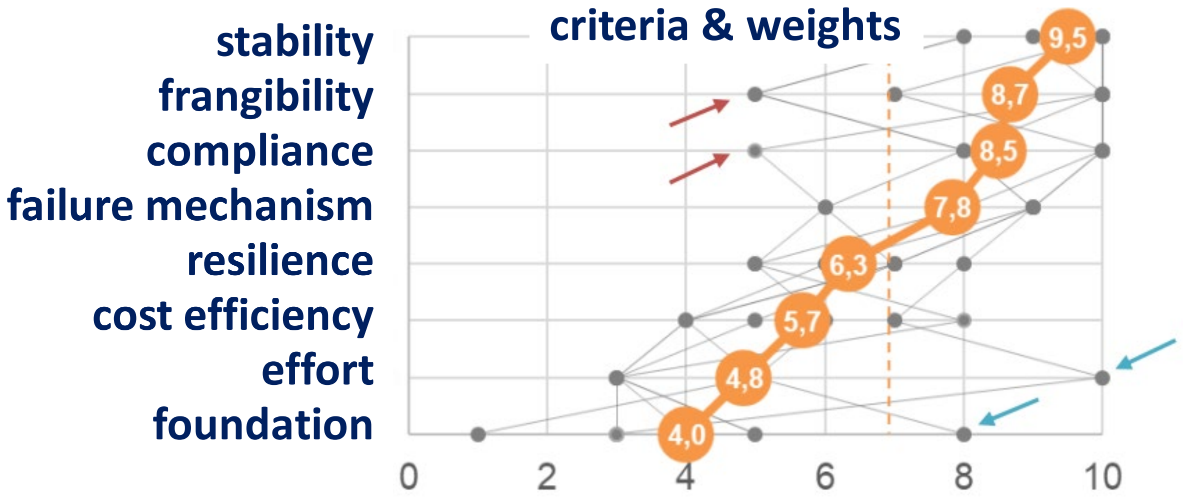
VLD3-W2-SORT

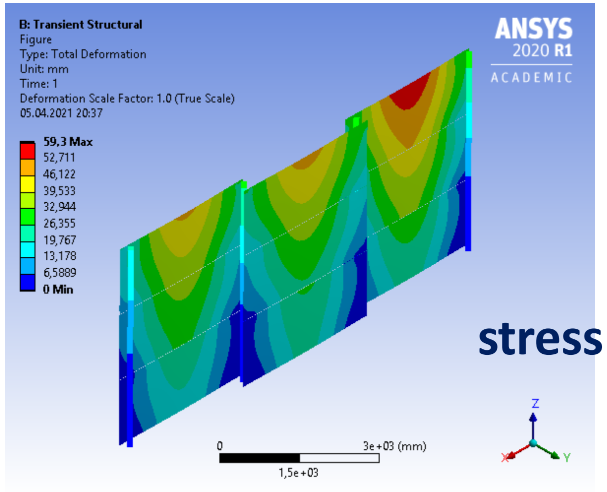
SORT
Safely Optimised Runway Throughput

technical plate design for permanent deployment at an airport



15 plate designs ranked by experts





stress analyses

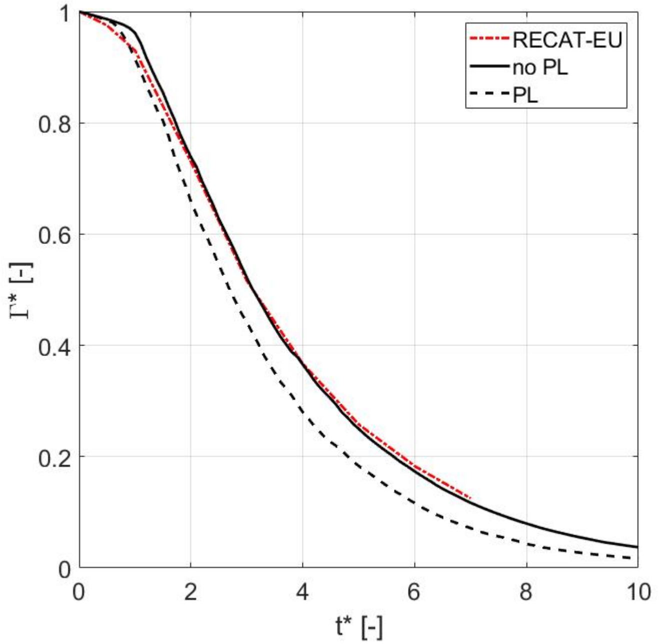
technical plate design for permanent deployment at an airport

selected design:
four frangible aluminum masts covered by nine honeycomb composite panels
(dimensions: 4.5 m x 9 m)

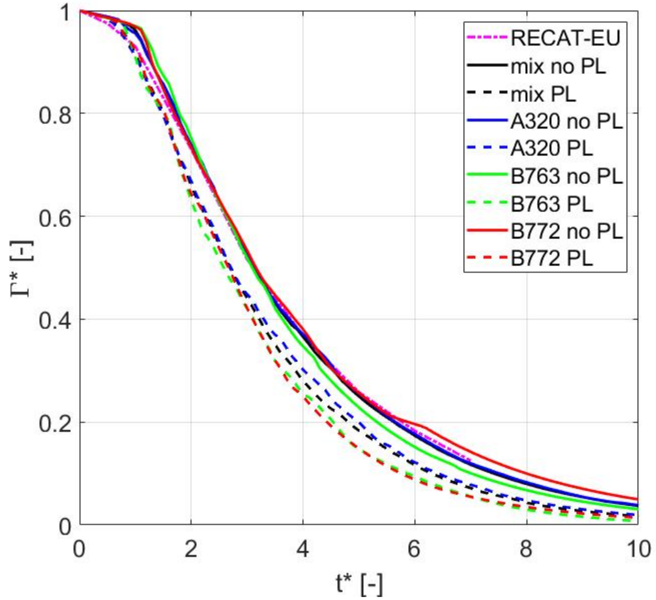
next step:
approval from authorities (BMK) for installation of plate line at Vienna airport

separation reduction potential for RECAT-EU-(PWS)

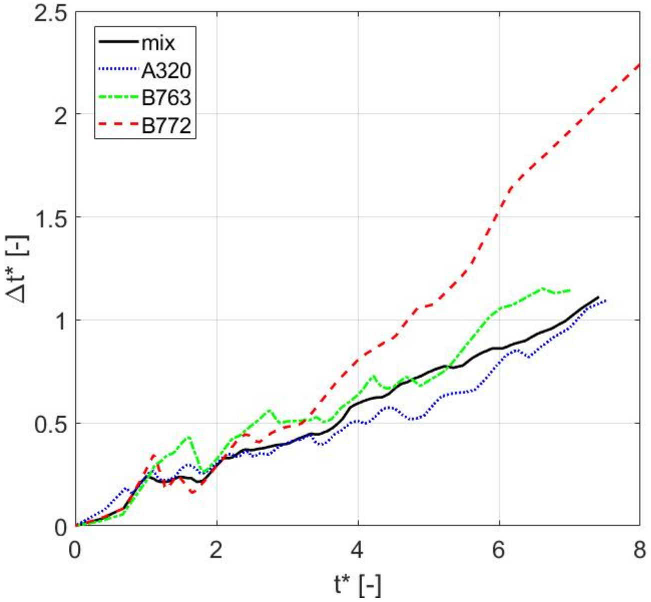
reasonable worst case decay curves



different aircraft types / categories



potential reduced aircraft separations



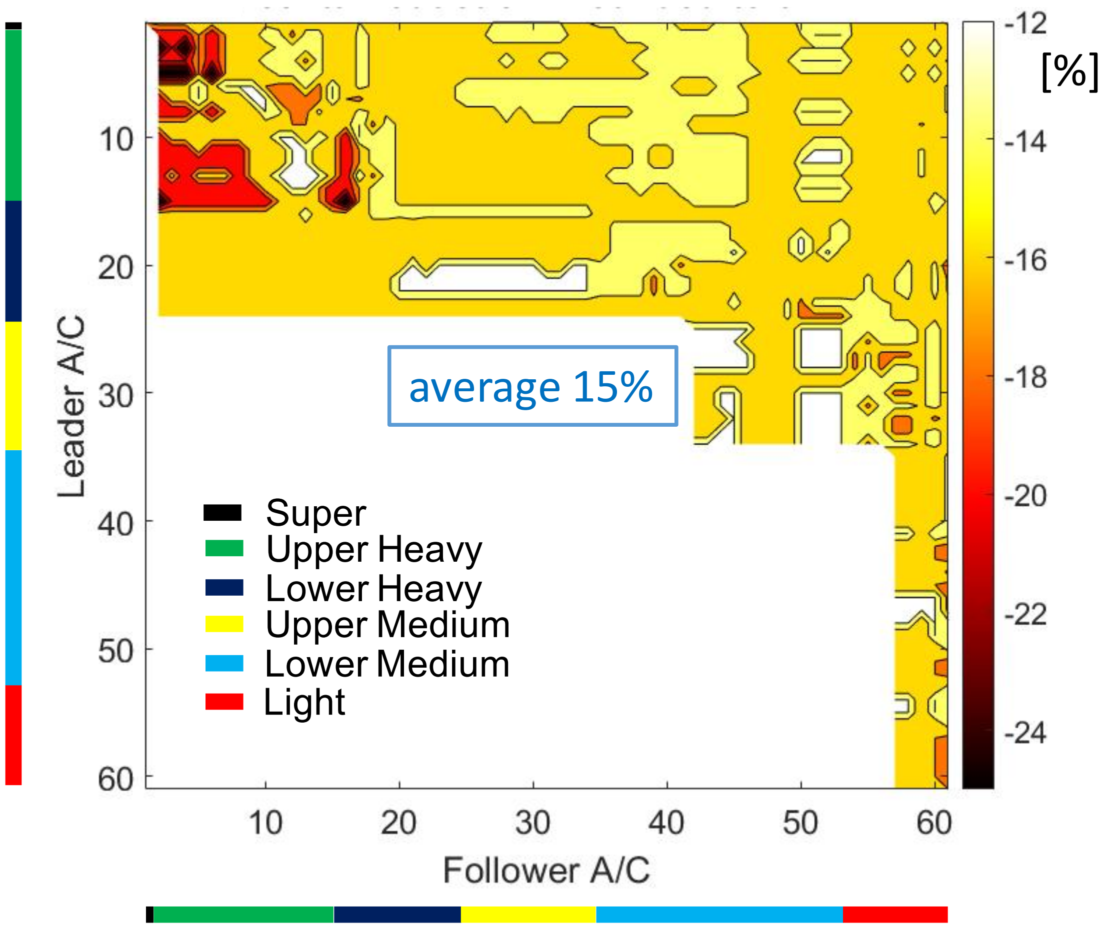
RECAT-EU data processing: z_0 = B, normalized curves, fit to 2-phase decay model, t^* > 3.5, …

separation reduction potential for RECAT-EU schemes

RECAT-EU

Leader / Follower		Super Heavy	Upper Heavy	Lower Heavy	Upper Medium	Lower Medium	Light
		A	B	C	D	E	F
Super Heavy	A	2.6 NM -0.4 NM -13.3 %	3.4 NM -0.6 NM -15.0 %	4.4 NM -0.6 NM -12.0 %	4.4 NM -0.6 NM -12.0 %	5.2 NM -0.8 NM -13.3 %	6.9 NM -1.1 NM -13.8 %
Upper Heavy	B		2.6 NM -0.4 NM -13.3 %	3.5 NM -0.5 NM -12.5 %	3.5 NM -0.5 NM -12.5 %	4.4 NM -0.6 NM -12.0 %	6.0 NM -1.0 NM -14.3 %
Lower Heavy	C			2.6 NM -0.4 NM -13.3 %	2.6 NM -0.4 NM -13.3 %	3.5 NM -0.5 NM -12.5 %	5.2 NM -0.8 NM -13.3 %
Upper Medium	D						4.3 NM -0.7 NM -14.0 %
Lower Medium	E						3.4 NM -0.6 NM -15.0 %
Light	F						2.6 NM -0.4 NM -13.3 %

RECAT-EU-PWS



Conclusions & Outlook

- smart exploitation of vortex dynamics enables passive, cost-effective, robust, and safe plate line methodology
- installation of plate lines reduces wake vortex lifetimes by 22% to 37%
- improved safety levels, resilience and fuel efficiency by avoiding go-arounds
- separation reduction potential for RECAT-EU-(PWS) schemes from 12% up to 24%
- compensate for encounter risks brought along with solutions like RECAT-EU, RECAT-EU-PWS, AROT, reduced MRS, and TBS
- dedicated WV decay measurements enable exploiting reduced dynamic pairwise separations
- more efficient use of airport capacity contributes to climate and environment friendly aviation by avoiding delays and holding patterns and may postpone building new runways

references, links & awards

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- Increased Runway and Airport Throughput | PJ02 EARTH Project | H2020 | CORDIS | European Commission (europa.eu)
- SESAR Joint Undertaking | Wake decay enhancing devices (sesarju.eu)
- SESAR Joint Undertaking | Improving runway throughput in one airport - SORT (Wave 2) (sesarju.eu)
- SESAR2020 VLD3 Wave-2 SORT | LinkedIn

- ATM Awards 2019: 2nd Place, SESAR Joint Undertaking | SESAR innovation recognised in 2019 ATM Magazine Awards (sesarju.eu)
- Maverick Innovation Awards 2020: Finalist.

plate design – frangibility

hooks of panels can be pushed off their respective bolts in one direction, while movement in the other direction is inhibited

stops on opposite sides of the panels prevent any movement during normal operation

during a collision, the hooks are pushed off their bolts as one mast bends, ensuring frangibility