



2019
World ATM Congress

SESAR walking tours



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Stand 849

GBAS

An enabler of diverse SESAR solutions

- Both the ground system and the airborne system have been included in industry research projects and demonstrations.
- GBAS allows for most of the advanced procedures that are being designed, developed, simulated and demonstrated within SESAR projects/solutions.
- Different GBAS-based approach procedures have been widely simulated to assess KPIs improvements.



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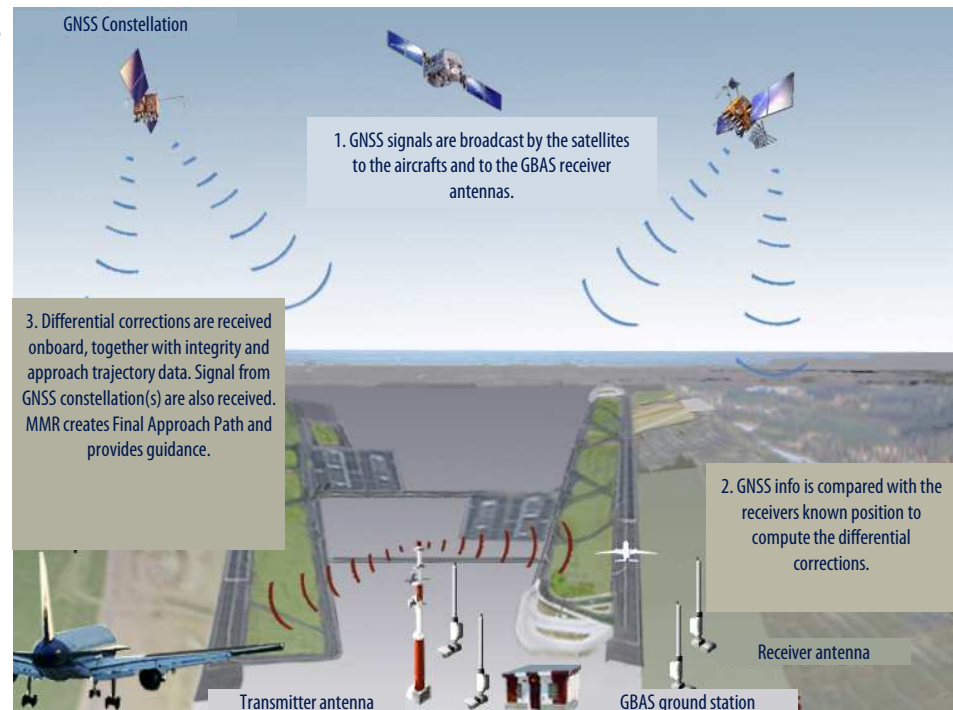


What is GBAS?

- GBAS is a system that improves GPS performances (accuracy, integrity).
- Local area, local augmentation (23NM).
- GBAS might be used in approach, taxiing, SIDs and STARs.

Three segments drive the GBAS operations:

-  **Space Segment.** The GNSS constellation(s).
-  **Ground Segment.** GNSS receivers antennas, VHF transmitter antenna, processing unit, database.
-  **Onboard Segment.** GNSS receiver antenna, VHF receiver antenna, Multi-mode receiver (MMR), FMS and cockpit displays.



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GBAS operating principle



A perspective of GBAS Benefits

Airports

All weather operations (CAT I, II and III)
Elimination of ILS critical area
Greater accuracy and availability over ILS
Optimizes arrivals and departures
Supports noise reduction goals



Airlines

Low aircrew training
Schedule resiliency
More efficient routes → financial impact

ANSPs

Facilitates ILS rationalization
Reduces maintenance costs (one system serves multiple runways)
Reduces flight inspection frequency

Operational (airspace)

GBAS is an enabler of advanced approach procedures:

- RNP to GLS operations → More flexible trajectories
- Allows stabilized short final approach segments of 4NM
- Programmable touchdown points. Variable trajectories to the same runway
- Variable glide path angle. Noise reduction, wake turbulence management

More closely spaced parallel operations.



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SESAR GBAS Projects participated by ENAIRE

SESAR 1

- PJ06.08.05
- PJ15.03.06
- PJ15.03.07

SESAR 2020

- PJ02 – Solutions 02 and 11
- PJ14.03.01 – Tasks 3 and 4



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GBAS facilities in Spain

- Malaga Airport – GBAS CAT I
- Tenerife Norte Airport – GBAS GAST D ‘Datalogger’
- Barcelona Airport – GBAS GAST F
- ENAIRE Headquarters – Portable GNSS Monitoring System (GPS/SBAS/GAST C/GAST D)



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Deployment of Enhanced TBS at London Heathrow

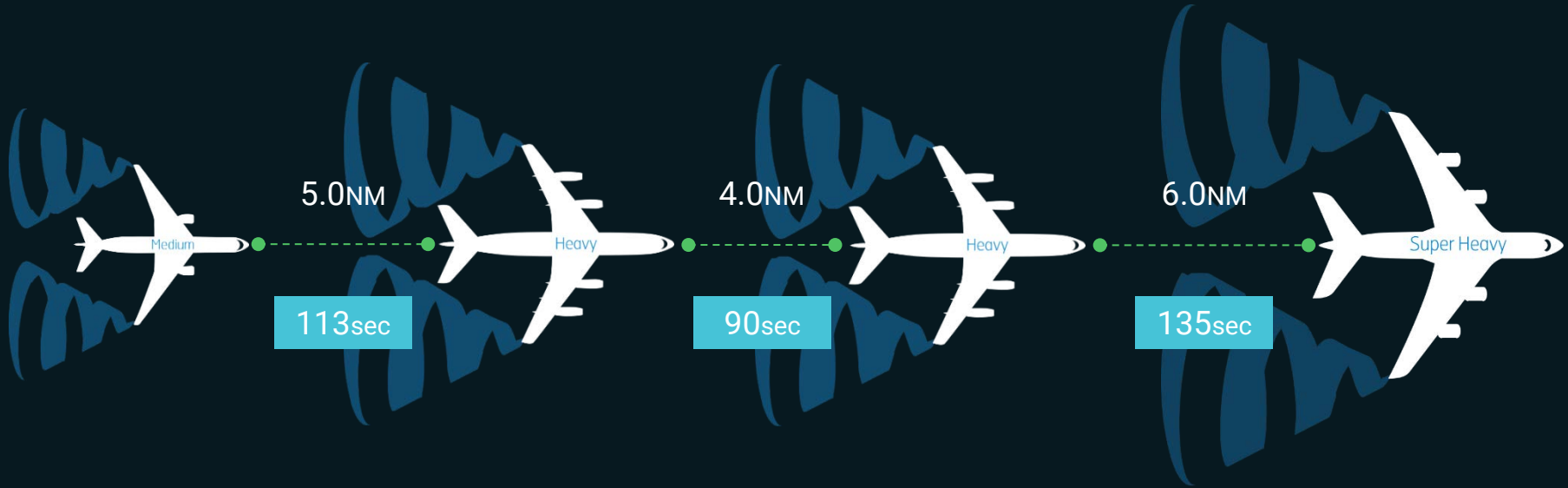


TBS Concept

NATS

Headwind

5 knots



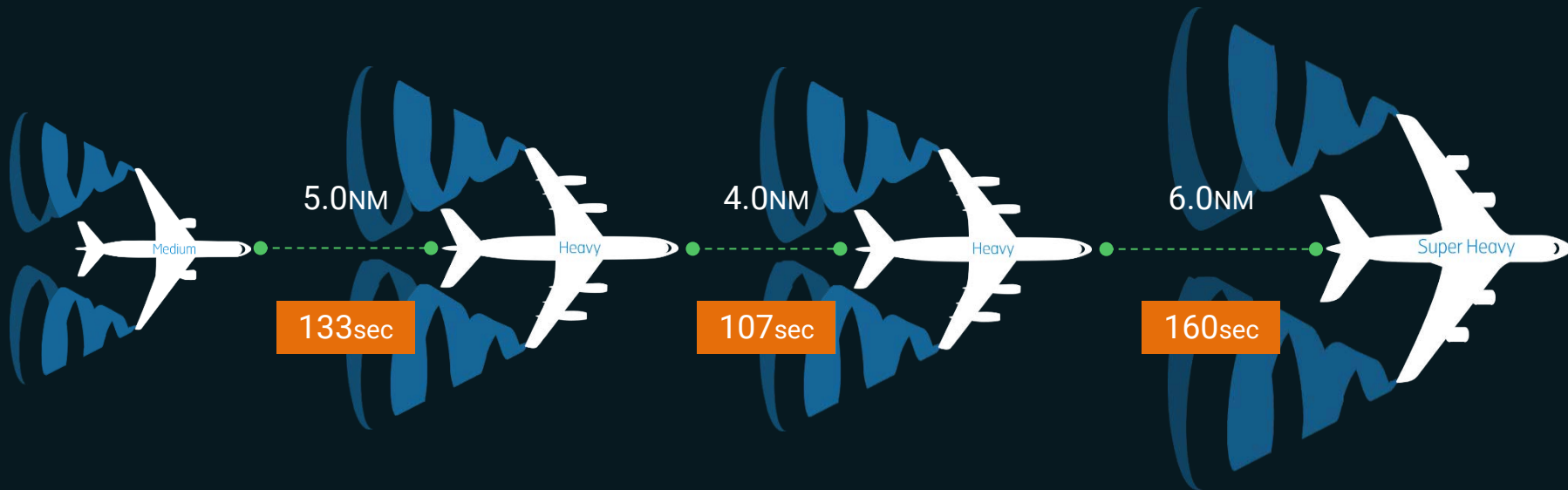
With standard **distance based separation**
aircraft are separated by **fixed** distance on final approach based
on their wake vortex category

Landing rate **40-45**

TBS Concept

NATS

Headwind 35 knots



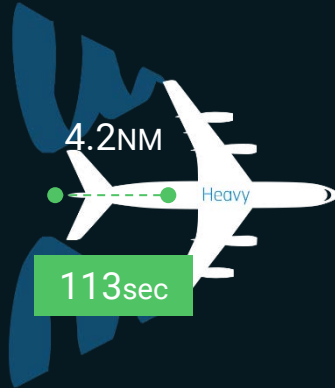
In stronger headwinds it takes **longer** to cover the distance resulting in a **reduced landing rate**

Landing rate **32-38**

TBS Concept

NATS

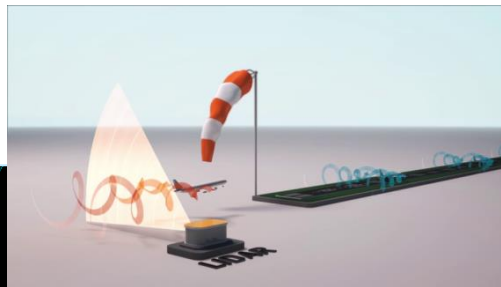
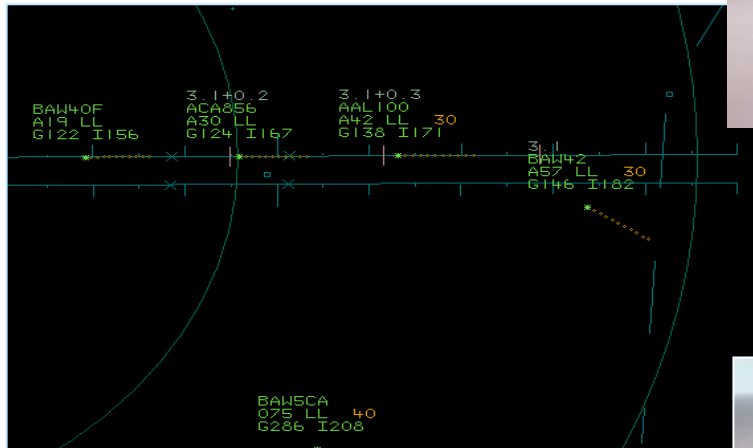
Headwind **35 knots**



This increases resilience, reducing delay and cancellations

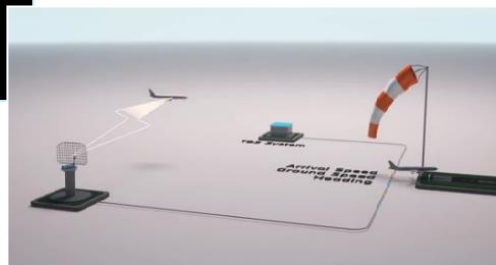
Landing rate **36-40**

Time Based Separation



Time based wake rules.
Safety case based on LIDAR
wake vortex measurements
from 150,000 movements
supported by SESAR/Eurocontrol

Controller HMI with Dynamic separation
Indicators based on TBS rules and Actual
winds – designed by controllers for controllers



Real time wind data
derived from Mode S
downlinked aircraft
parameters

Enhanced Time Based Separation

Time Based Separation entered operational service at Heathrow 24 March 2015 and has been in continuous operations since then

On 16 March 2018 “enhanced” Time Based Separation (eTBS) entered operational service

The system is consistently delivering significantly higher benefits than original business case

NATS



Co-financed by the European Union
Connecting Europe Facility



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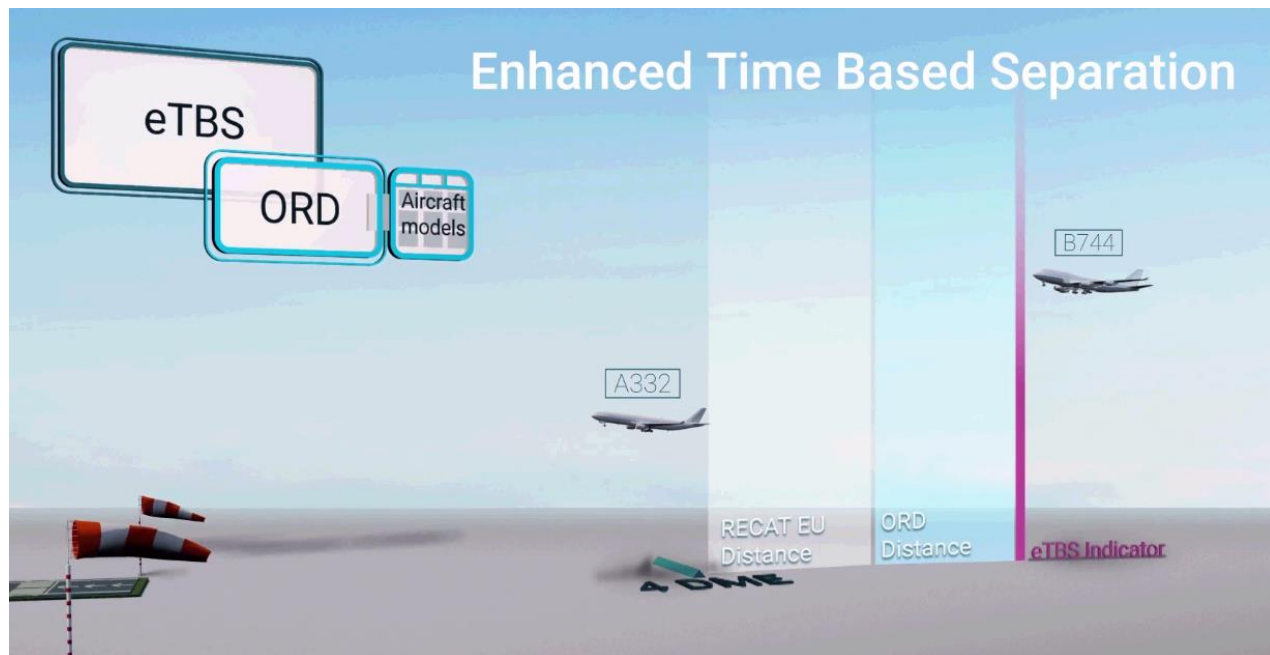


Enhanced Time Based Separation

Optimised Runway Delivery (ORD) provides separation indicators to threshold taking into account spacing compression inside 4 miles from threshold

System uses RECAT EU wake vortex categories

Provides runway occupancy indicators to controller where that is more limiting



Enhanced Time Based Separation Benefits

Benefits measured from 4 months of live operation

- **Capacity** - average daily saving in arrival spacing 1,794 seconds
Equivalent to **30 minutes more arrivals per day**
- **Resilience** >60% reduction in delays due to headwinds
- **Environment** >230,000 minutes reduction in airborne holding
equivalent to >15,000 Tonnes of fuel (>47,000 Tonnes of CO₂)
saved each year
- **Safety** – no increase in wake encounter reports or go-arounds
- **Punctuality** – airport punctuality improved by c.2.5%
- **Savings** – Combined savings >€30m Euro per annum



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Enhanced Time Based Separation **Result**

**Happy Airlines
Happy Airport
Happy Passengers
Happy ATC**

And the developments continue....



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28-11-2018
06:53 - 07:13

RWY SP
3.0

AFR74VF
243 BB 220

BAW81V
A09 LL

4+0+0+3
ENG6VP
A22 LL

BAW176A
A35 LL

3.5
BAW142
A47 LL 40

BEL11Y
290 EB 290

3.5
VIR118
A53 LL 50

	TBS Distances					
DBS	3	4	5	6	7	8
TBS	3+1	4+1	4+8	5+7	6+6	7+4



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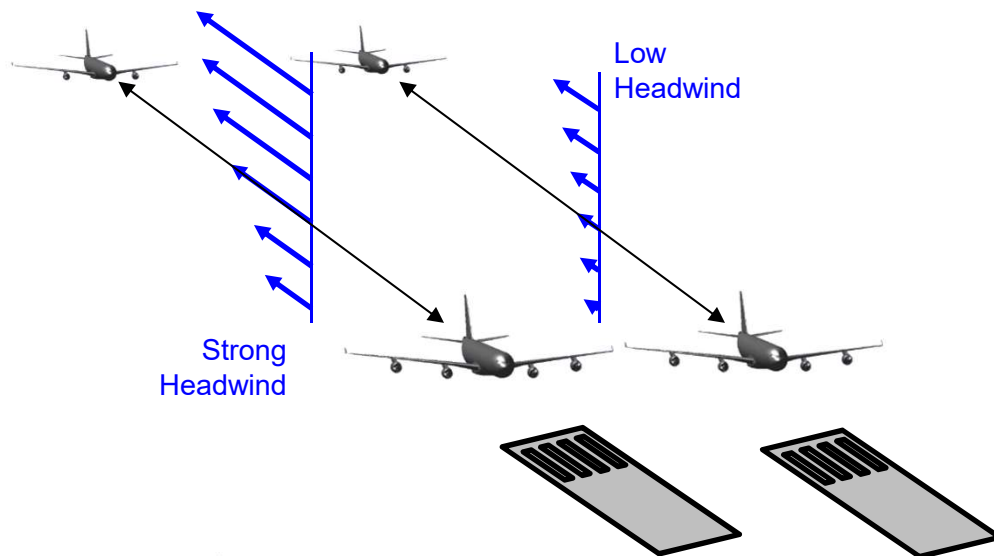


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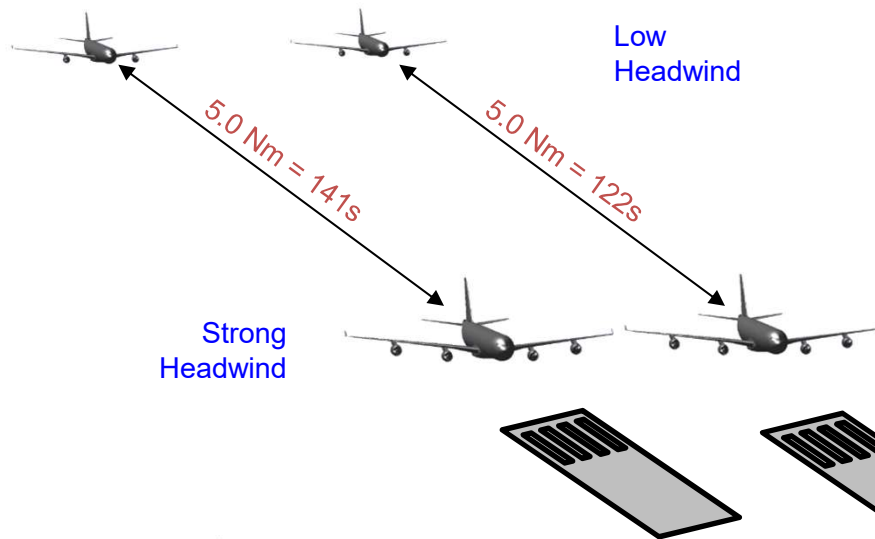
Time Based Separation

Time Based Separation (TBS) permits the adaptation of separations to maintain runway throughput in strong headwind conditions



Time Based Separation

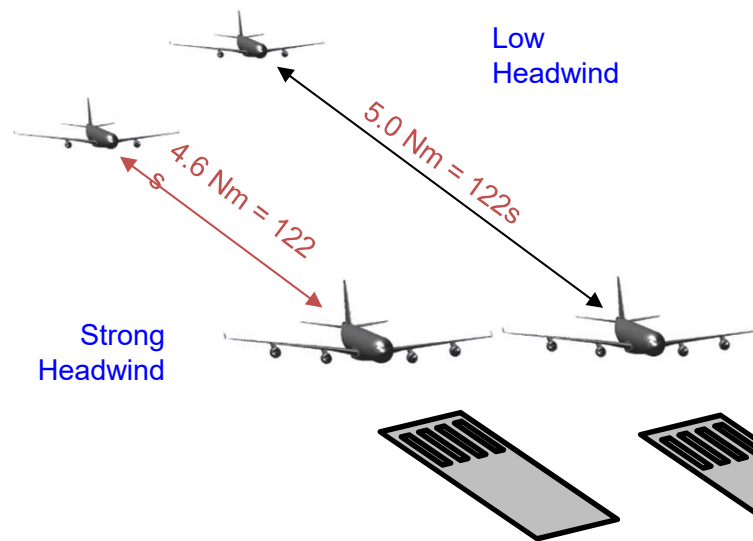
Time Based Separation (TBS) permits the adaptation of separations to maintain runway throughput in strong headwind conditions



- Strong headwind increases time separation for constant distance applied

Time Based Separation

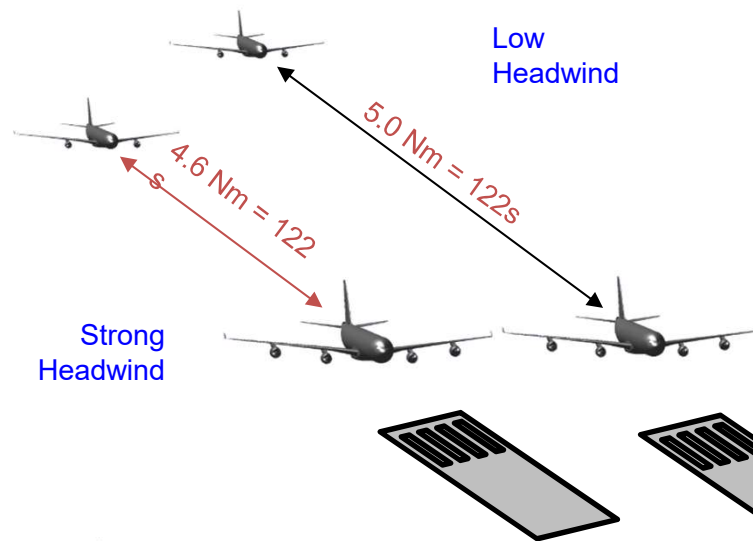
Time Based Separation (TBS) permits the adaptation of separations to maintain runway throughput in strong headwind conditions



- Strong headwind increases time separation for constant distance applied
- Reduced separations support constant time between 2 landings in strong headwind conditions
- This was allowed following years of wake vortex data collection in Paris, Frankfurt and London

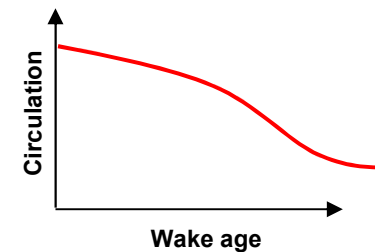
Time Based Separation

Time Based Separation (TBS) permits the adaptation of separations to maintain runway throughput in strong headwind conditions

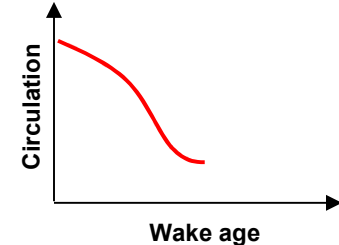


WT risk to remain acceptable compared to DBS

HW < 5kt



HW > 10 kt

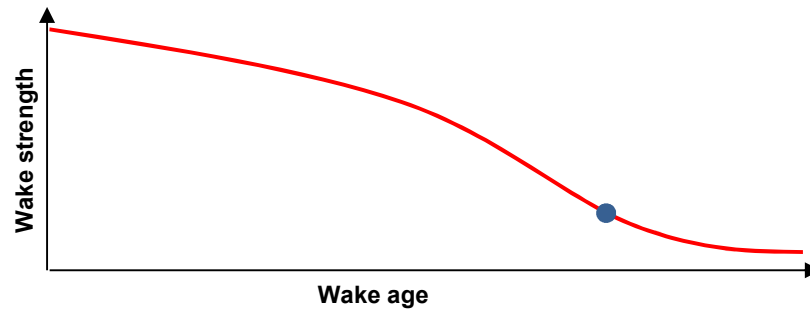
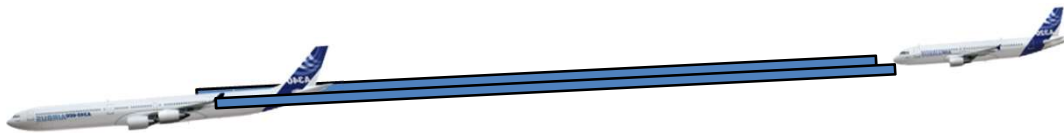


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Time Based Separation

TBS WT risk to remain acceptable compared to DBS



Even if time between touchdowns remains constant...

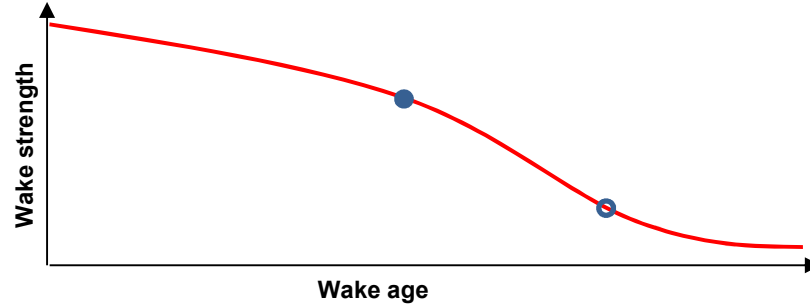
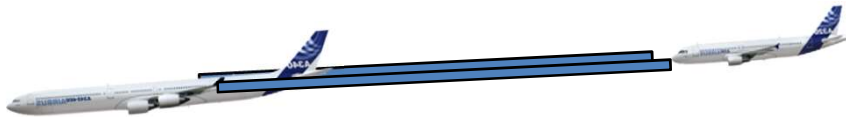


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Time Based Separation

TBS WT risk to remain acceptable compared to DBS



... reduction of separation will reduce the “age” of the wake encountered BUT ...

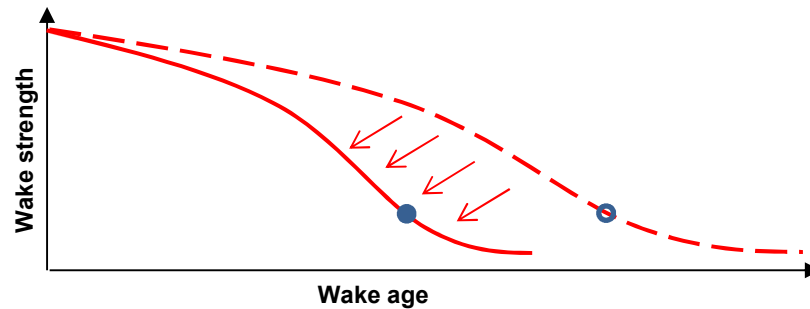
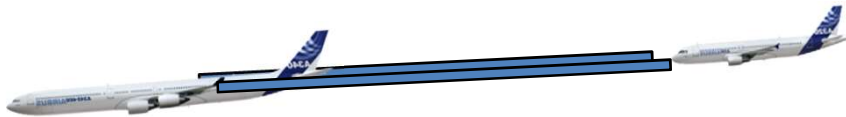


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Time Based Separation

TBS WT risk to remain acceptable compared to DBS



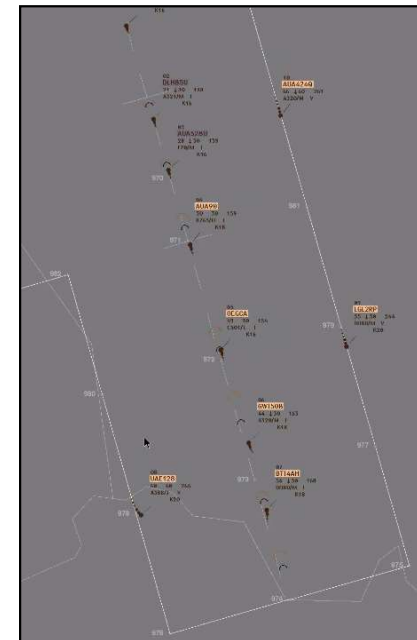
... wind effect on wake decay
always mitigates that
reduction.



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Time Based Separation



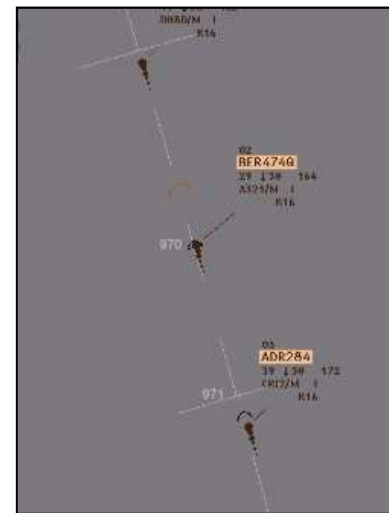
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Time Based Separation



Catch-up alert



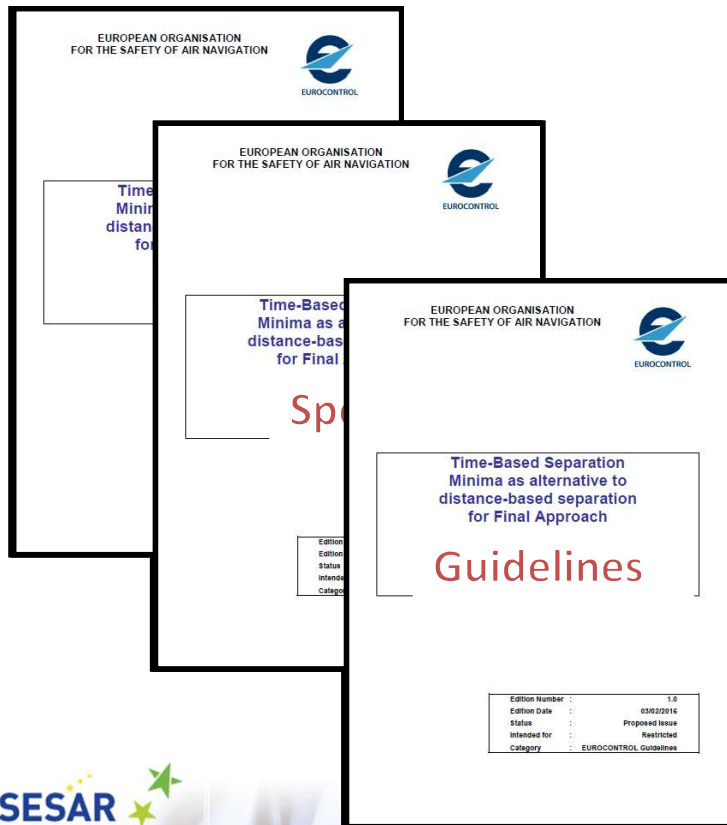
ITD Infringement alert



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Time Based Separation



- Safety case for moving from DBS to TBS
- Specifications reviewed by Stakeholders in ENPRM (EUROCONTROL Notice of the Proposed Rule Making)
- Guidelines are supporting the local implementations (currently under development)

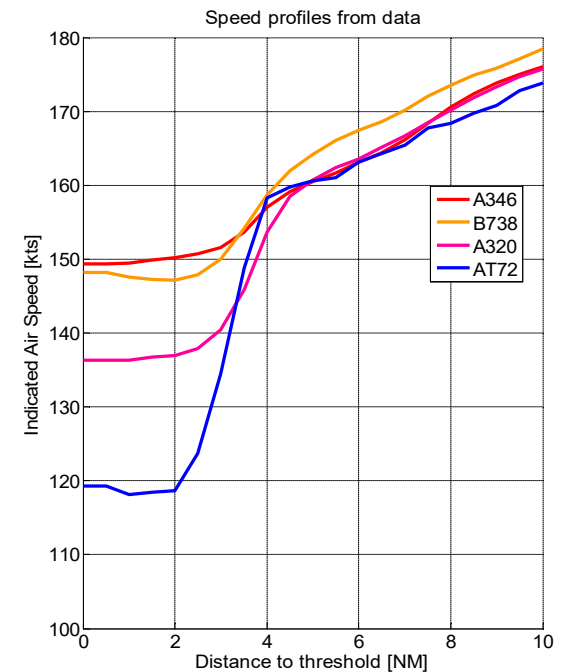
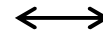
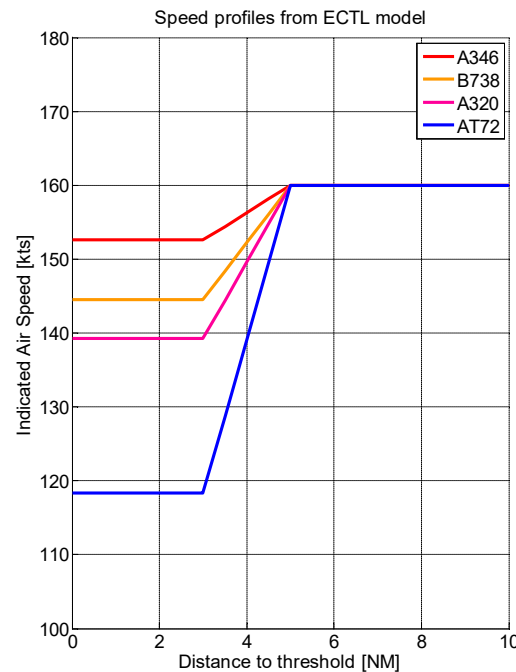


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Time Based Separation

- ❑ Performance database based on years of **Radar** and **Wind** data
- ❑ It provides **local** parametrisation
- ❑ **Buffers** are added to account for speed profile and wind measurements uncertainties



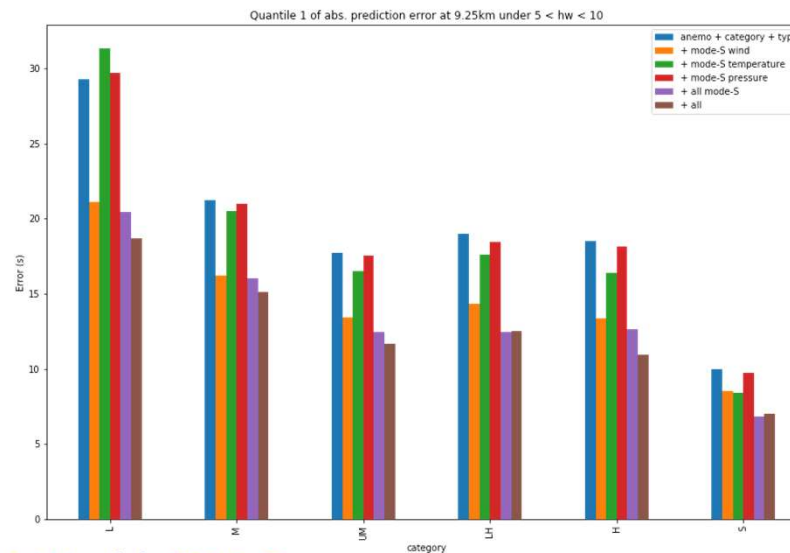
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Time Based Separation

EUROCONTROL Support - TBS Factory and Machine Learning

- ❑ Allowing reduction of the time-to-fly prediction model uncertainties
- ❑ Allowing further capacity increase thanks to reduction of required buffer in separation indicators



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Time Based Separation

EUROCONTROL Support - TBS Factory and Machine Learning

- ❑ Allowing reduction of the time-to-fly prediction model uncertainties
- ❑ Allowing further capacity increase thanks to reduction of required buffer in separation indicators

Pair type	Ground HW range [kts]	DBS	TBS with FTD Analytical	TBS with FTD M/L
UM-UM	0-5	-	0.3%	0.5%
UM-UM	5-10	-3.1%	-2.2%	2.5%
UM-UM	10-30	-7.2%	3.0%	5.6%
UM-M	0-5	-	0.0%	0.3%
UM-M	5-10	-3.9%	-1.7%	0.8%
UM-M	10-30	-8.7%	1.4%	3.1%



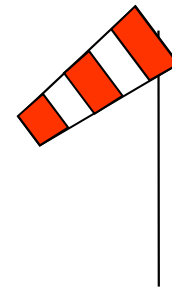
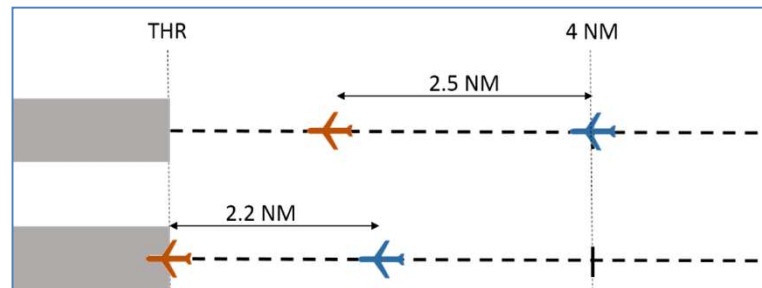
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Up to + 13 %

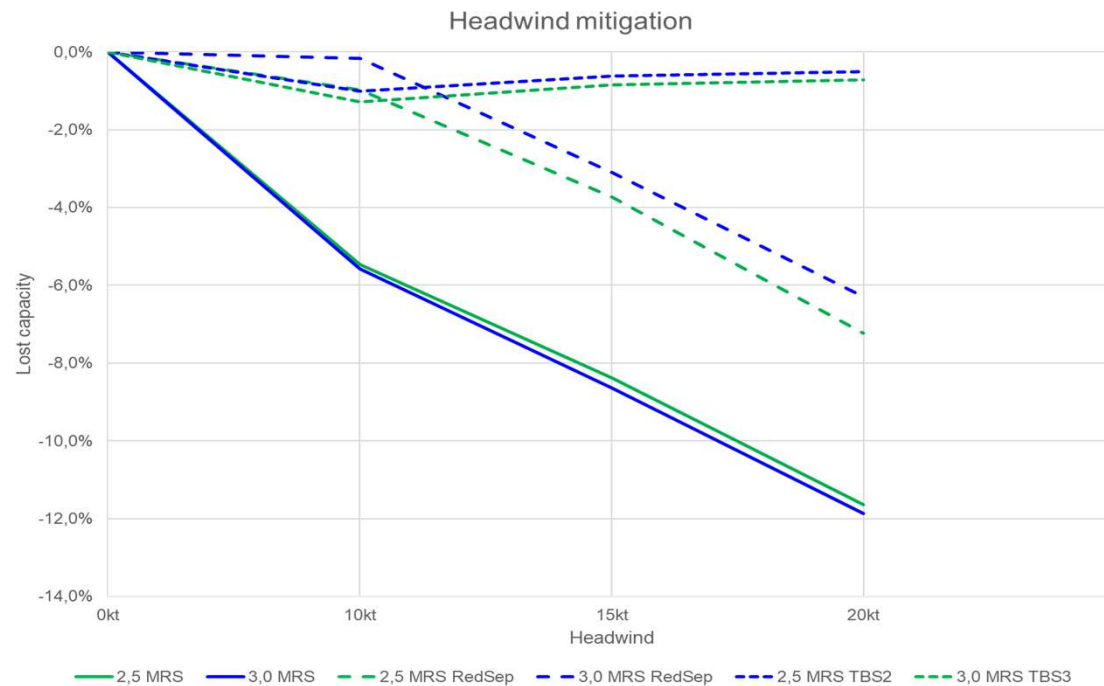


Time Based Separation

Procedural TBS: Move separation delivery point above a certain headwind threshold



Time Based Separation



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Questions?



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 699238



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Arrival wake turbulence separation optimization

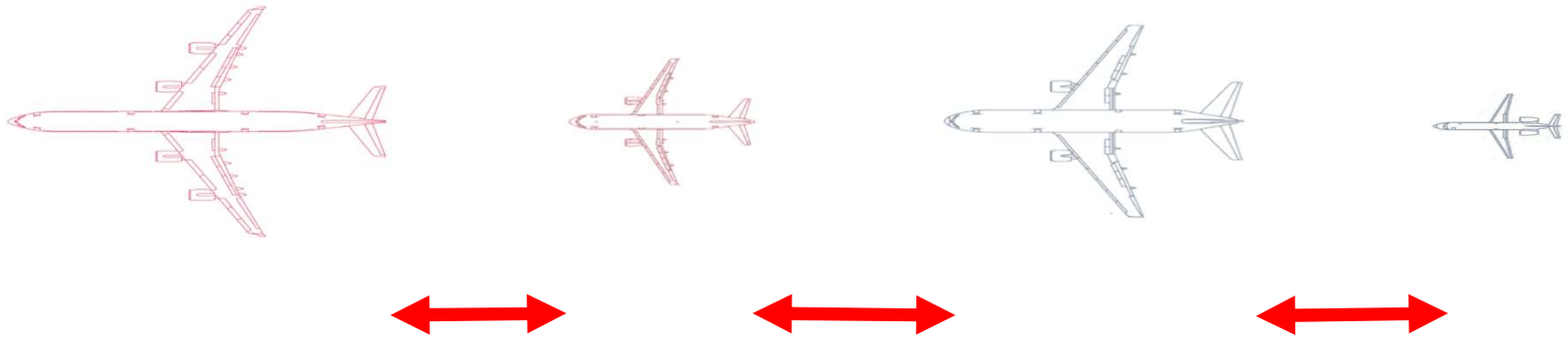
How separation reductions lead to increased runway through put?



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Arrival wake turbulence separation optimization



90s average separation means 40 landings per hour

86s average separation means 42 landings per hour



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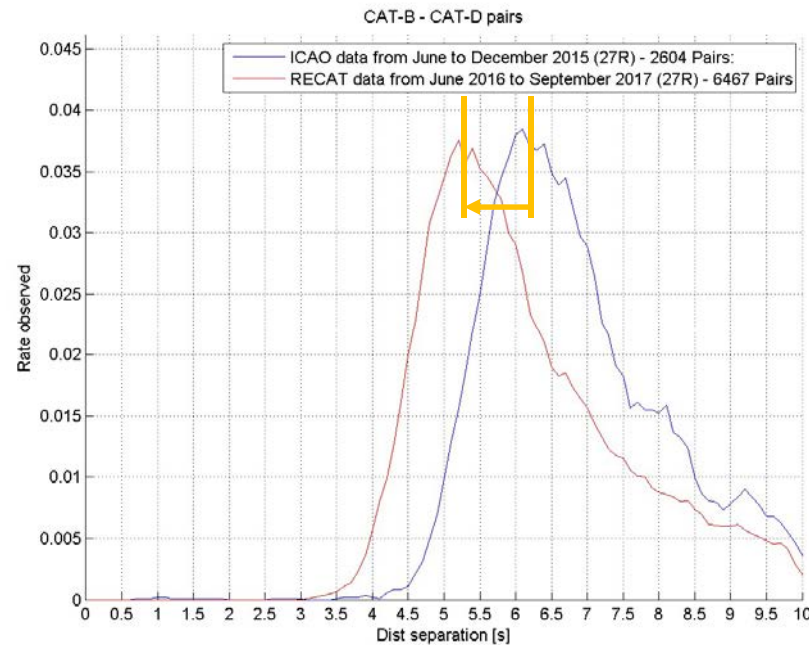


Arrival wake turbulence separation optimization

A332



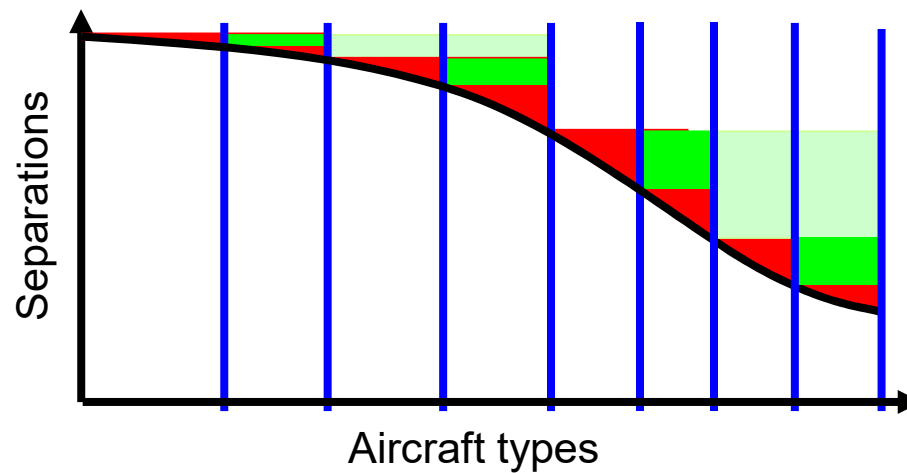
A320



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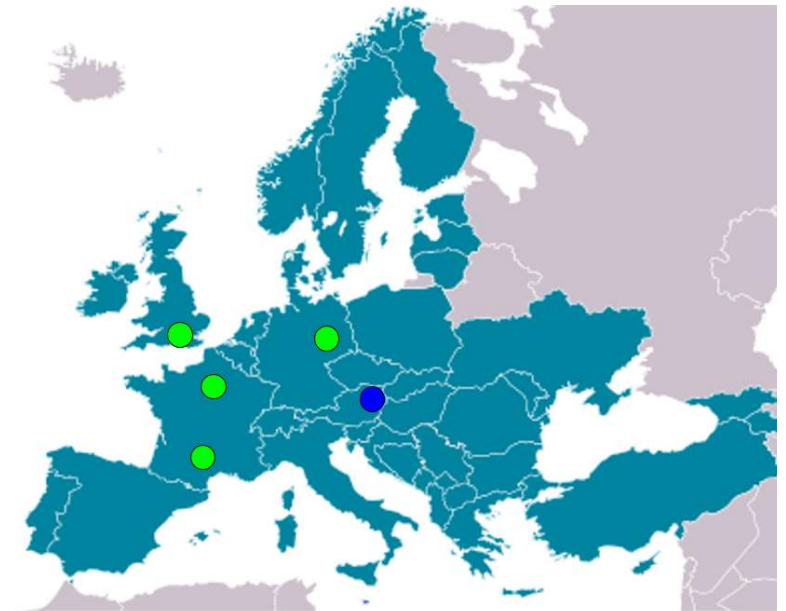
Arrival wake turbulence separation optimization



Arrival wake turbulence separation optimization

Procedural – Level 1

RECAT-EU categories		SUPER HEAVY	UPPER HEAVY	LOWER HEAVY	UPPER MEDIUM	LOWER MEDIUM	LIGHT
SUPER HEAVY	AN-124 A380	3.0	4.0	5.0	5.0	6.0	8.0
UPPER HEAVY	A332 B744		3.0	4.0	4.0	5.0	7.0
LOWER HEAVY	MD11 B763		MRS*	3.0	3.0	4.0	6.0
UPPER MEDIUM	B738 A320						5.0
LOWER MEDIUM	E190 AT45						4.0
LIGHT	SF34 LJ35						3.0



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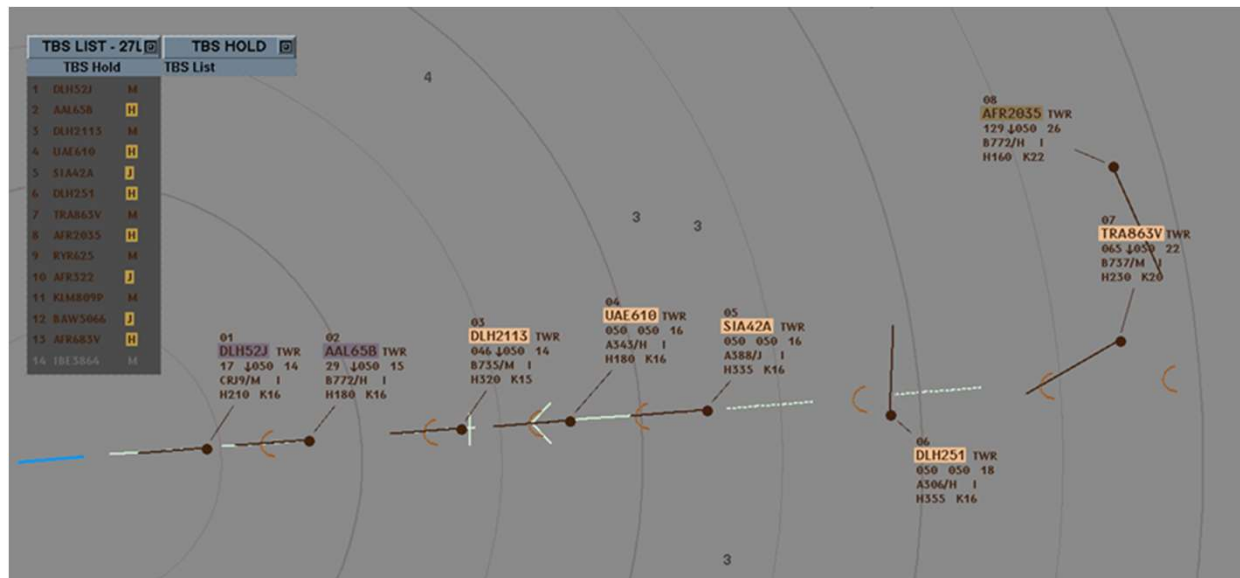
Arrival wake turbulence separation optimization

- 96x96 pair-wise separation matrix

- 96x96 pair-wise separation matrix
- Covering most frequent aircraft types:
 - 97.1 % of top 25 ECAC traffic
 - 4.6% of the 9000+ ICAO aircraft list

Arrival wake turbulence separation optimization

“Simple” system – Level 2

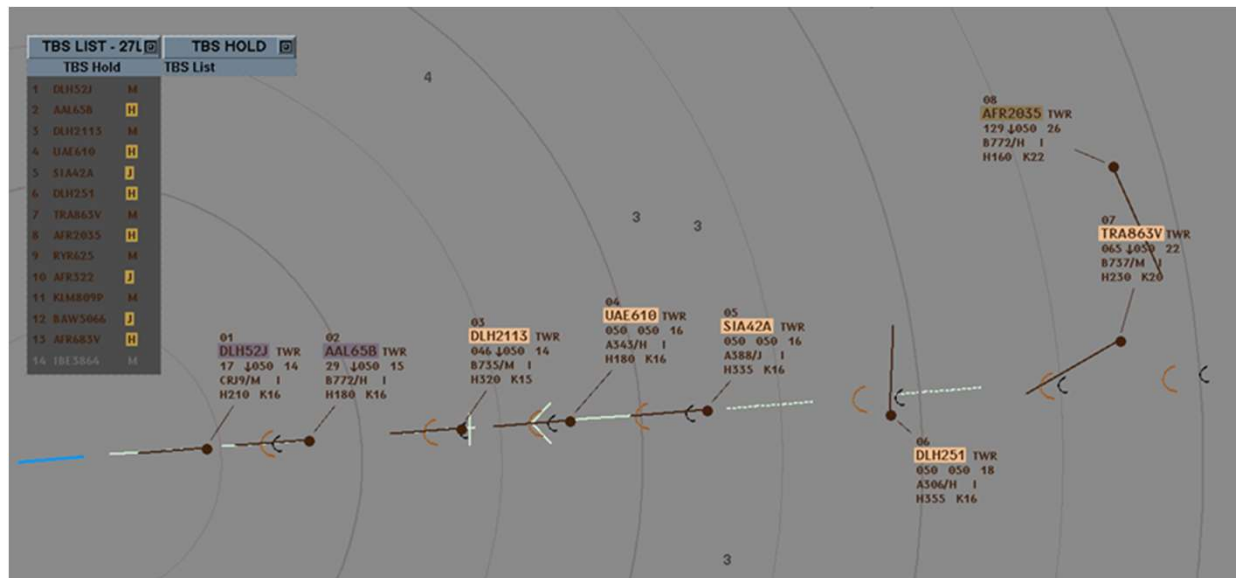


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Arrival wake turbulence separation optimization

More complex system – Level 3



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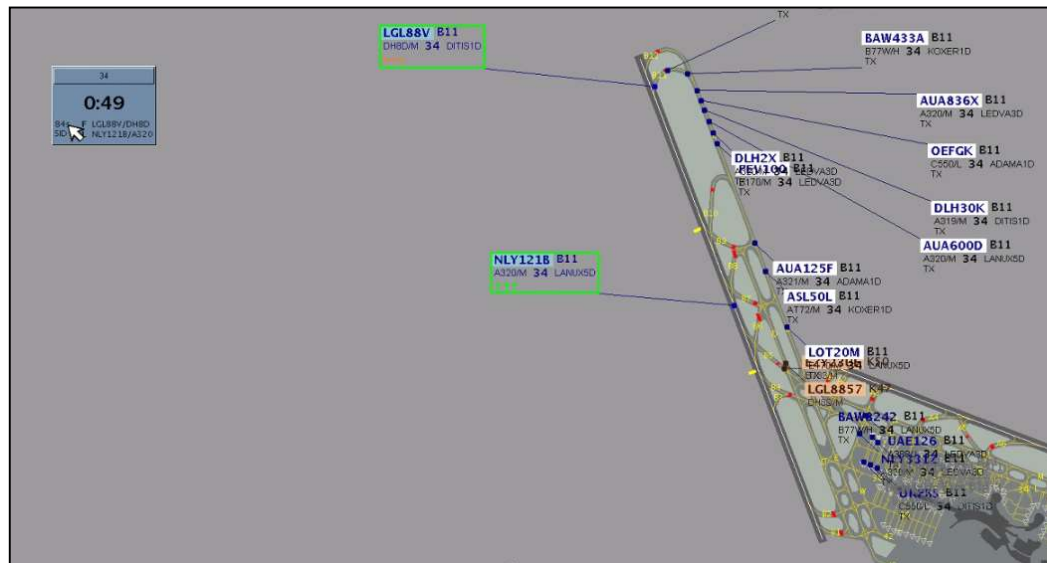
Arrival wake turbulence separation optimization



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Departure wake turbulence separation optimization



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Wake turbulence separation optimization



RTS 1 (Paris CDG)	EUROCONTROL	WDS-A & ORD
RTS 2 (Vienna)	THALES	PWS-A & ORD
RTS 3a (Vienna)	EUROCONTROL	PWS-A/D and ORD/OSD
RTS 3b (Copenhagen)	EUROCONTROL	ORD
RTS 4a (Vienna)	EUROCONTROL	PWS-A/D and ORD/OSD
RTS 4b (Paris CDG)	EUROCONTROL	PWS-A/D, WDS-A/D and ORD/OSD
RTS 5 (London Heathrow)	NATS	PWS-D, WDS-D & OSD
RTS 6 (Barcelona El Prat)	ENAIRE in Madrid	WDS-A and ORD, PWS-D and OSD
FTS 9 (Paris CDG & Vienna)	EUROCONTROL	PWS-A/D, WDS-A/D & ORD/OSD
LT 10 (Vienna)	DLR (AT-ONE)	Wake Decay Enhancing Devices

Intended Benefits:

Increase arrival and departure runway capacity, efficiency, predictability and resilience while maintaining or increasing safety.
Mitigate the impact on ATCO workload and Human Performance and deliver cost efficiency targets, thanks to ATC support tools.

Capacity, Efficiency, Predictability, Resilience, Safety, Human performance, Cost effectiveness

01-12-2016

• Project start

03-03-2020

• V3 Maturity Gate

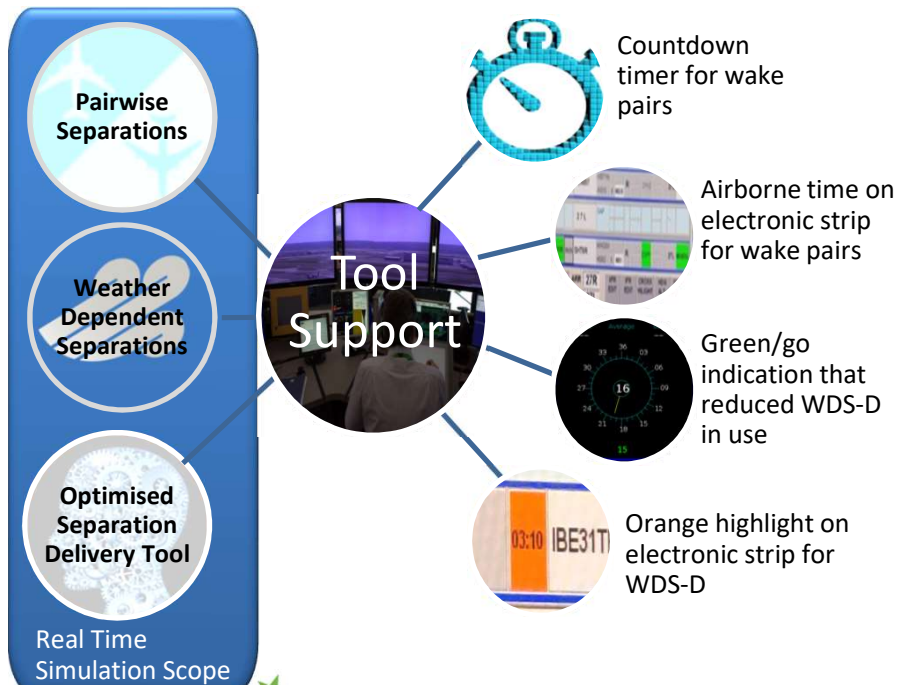
31-03-2020

• Project ends

NATS

Leading the Solution and the Departure Concepts

Departure wake turbulence separation optimization Heathrow



5 Heathrow Controllers involved

- 1 Ground Movement Controller Position
- 1 Runway Controller Position

12 Validation Days

- 48 runs
- 4 Organization (Reference + 3 Solution Scenarios)
- 2 RWY directions (09R and 27R)
- 4 Traffic Samples and 3 Callsign Variants
- 10 Wind Samples



Results under assessment

- Very promising feedback from ATCOs
- 😊 Reduced ATCOs workload
- ✈️ Envisaged benefit in using with current operations
- 📈 Potential Margin of Increasing Departure Rate (+1 DEP per hour)

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CDG 2020

DEPLOYING HIGH-PERFORMING
AIRPORT OPERATIONS
For Safety, Environment and Capacity

BAYLE Jérémie
DE RANCOURT Loïc



**World ATM
Congress 2019**
A CANSO partnership with ATCA



Co-financed by the Connecting Europe
Facility of the European Union

PARIS-CDG ENVIRONMENT

- ◉ 500,000 movements per year
- ◉ Peak traffic: up to 78 incoming flights per hour
- ◉ Opened 24/7
- ◉ 200 airlines
- ◉ Main hubs for Air France and FEDEX
- ◉ 4 parallel runways
- ◉ 130 km of taxiways
- ◉ 3 Control Towers
 - + 1 Apron Management Tower



PARIS-CDG ENVIRONMENT

Paris-CDG and Paris-Le Bourget,
a robust ATC coordination
between the two air navigation
service units





3 INNOVATIVE CONCEPTS IN OPERATIONS TO SAFELY INCREASE CAPACITY



RWSL
RECAT-EU
PBN triple



Safety



Environment



Capacity



Cost-efficiency

..... Thanks to our partners !



AIRBUS



easyJet



RUNWAY STATUS LIGHTS SYSTEM (RWSL) @CDG



24 OCT 2016
(09R/27L)

IMPLEMENTED

An efficient
safety net
against runway
incursions

23 MAY 2017
(08L/26R)



RUNWAY STATUS LIGHTS SYSTEM (RWSL) @CDG



IMPLEMENTED

An efficient
safety net
against runway
incursions

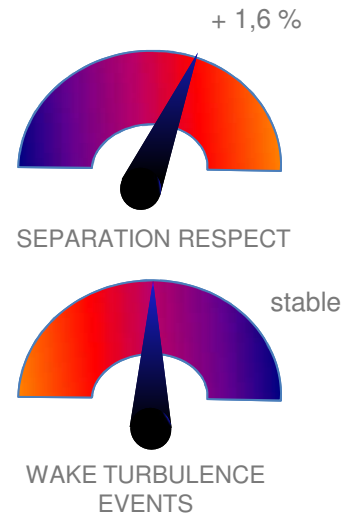


RECAT-EU @CDG & LE BOURGET

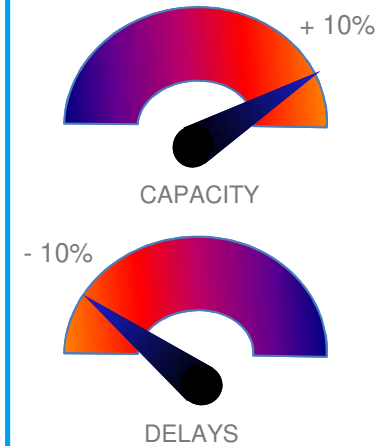
22 MARCH
2016



Safety monitoring



Runway throughput



RECAT-EU: WHAT'S NEXT ?

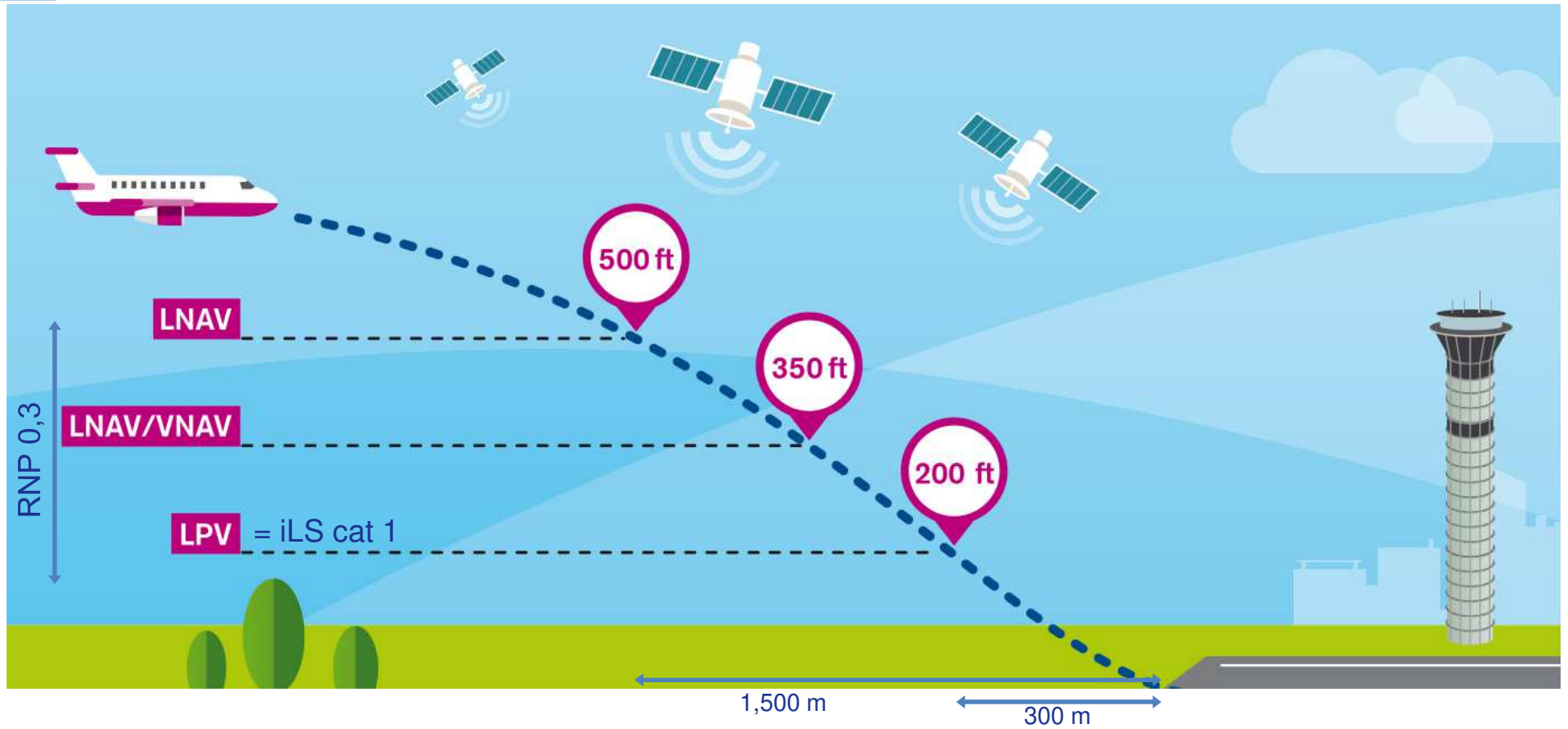
Separation target indicator
on radar display including:

- Time Based Separation (TBS)
- Runway Occupancy Time (ROT)
- Weather Dependent Separation (WDS)
- Pair Wise Separation (PWS)
- Closely Spaced Parallel Runway (CSPR)

RECAT-EU Scheme ^{SEP} Leader\Follo wer		Super ^{SEP} H eavy	Upper ^{SEP} H eavy	Lower ^{SEP} Heavy	Upper ^{SEP} Me dium	Lower ^{SEP} Me dium	Light
		S	G	H	K	M	L
Super ^{SEP} He avy	S		100s	120s	140s	160s	180s
Upper ^{SEP} He avy	G				100s	120s	140s
Lower ^{SEP} He avy	H				80s	100s	120s
Upper ^{SEP} M edium	K						120s
Lower ^{SEP} M edium	M						100s
Light	L						80s



PBN APPROACH PROCEDURES @CDG & LE BOURGET



IMPLEMENTED

TRIPLE (2 AT CDG + 1 AT LE BOURGET),
PARALLEL,
INDEPENDENT PBN / ILS
approach procedures



Operational Benefits:



Maintaining high level capacity
during ILS maintenance or unavailability

Aircraft equipment:

- ⦿ 95% at Paris-CDG
- ⦿ 60% at Paris-Le Bourget

From July 8th to October 30th 2019:

Replacement of ILS 27 at Le Bourget

**> In TMA Paris next summer:
Most capable, Best served !**

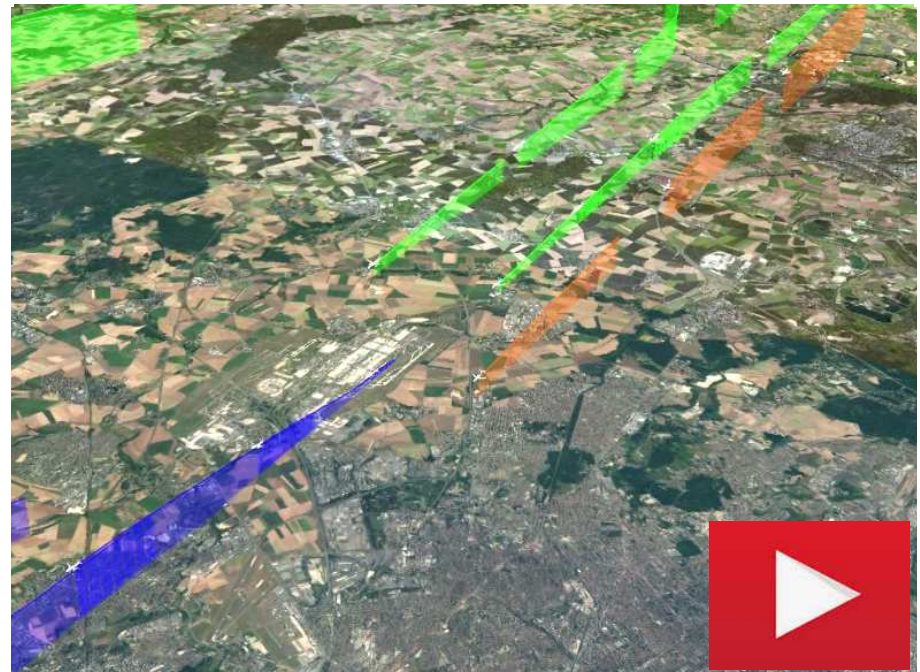


DEPLOYING HIGH-PERFORMING AIRPORT OPERATIONS



**& PARIS-CDG
LE BOURGET**

**Pioneers for innovative,
operational concept**





jeremie.bayle@aviation-civile.gouv.fr
loic.de-rancourt@aviation-civile.gouv.fr

