



Use of automation in Time Based Separation for approach operations

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Content

- The TBS/Tools concept
- Benefits
- Elements of the tool
- Use of ML/automation to tune the tools
- Safety case and certification
- Future roadmap



Experience with Approach Spacing Tools at Heathrow Airport

24 March 2015 Heathrow became the first airport to in the World to use Time Based Separation (TBS) on final approach.

Tools developed jointly by NATS/Leidos based on SESAR R&D

Implementation was done jointly with Heathrow Airport and in close collaboration with the Airlines

TBS has been in continuous operation in all wind conditions since then

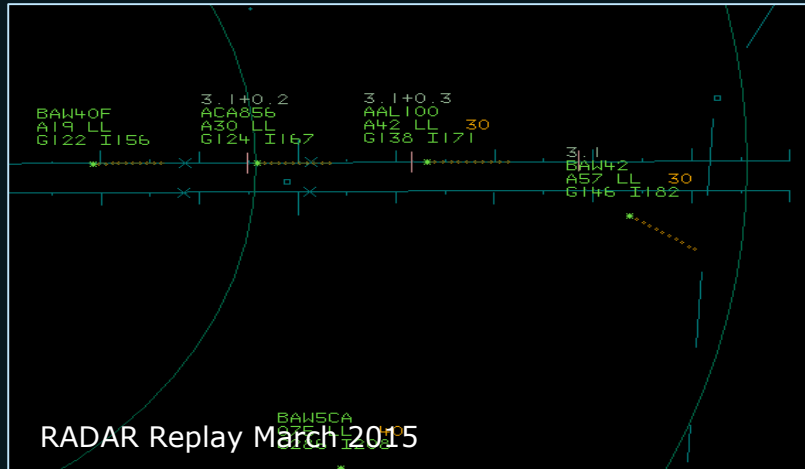
In March 2018 TBS was upgraded to “enhanced” TBS:

- Using RECAT EU wake vortex categories
- Providing separation indicators to runway threshold for both wake & runway occupancy

Benefits have surpassed our expectations



Summary experience at Heathrow

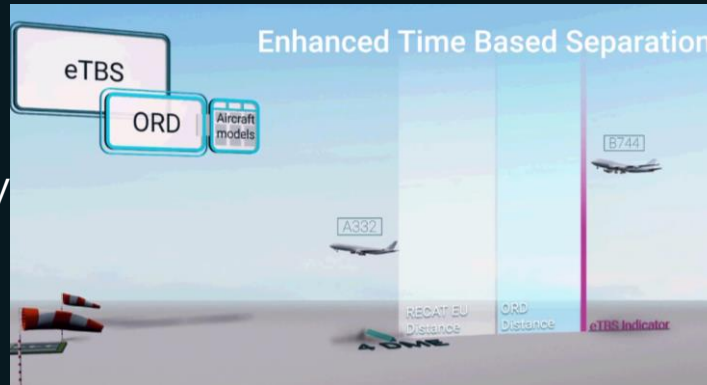


- >62% reduction in Arrival (ATFM) delays due headwinds & more stability in landing & flow rates
- Over 230,000 minutes p.a. reduction in average airborne holding saving 47kT CO₂ p.a.
- No increase in Wake Turbulence Encounter reports & Go Around rate related to TBS
- Average landing rate increased by +2 - 4.2 landings/hour & improved consistency of ATC spacing
- Arrival spacing savings equivalent to over 30 minutes extra landings per day (TBS +eTBS)
- No Tactical flight cancellations due headwinds
- **Overall savings inc. holding & delay > €30m p.a.***
- **Happy ATC, happy airport & happy airlines.....**

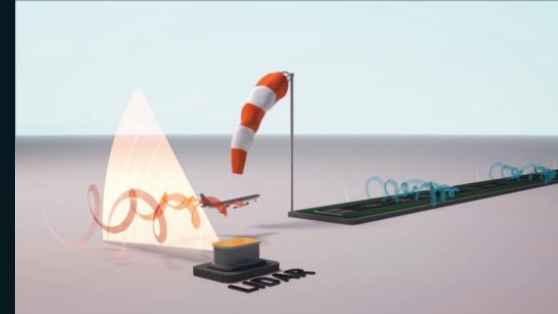
*based on fuel price of €469/mT & €81/min delay cost including primary arrival delay & estimate of rotational delay

Spacing Tool Features

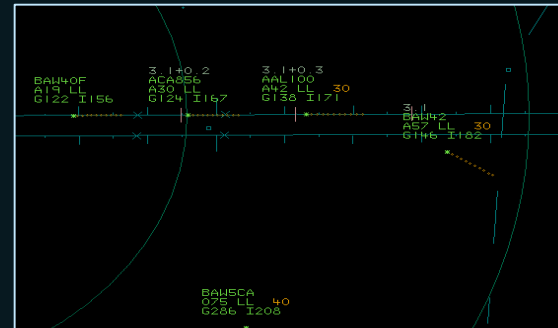
RECAT EU Wake Rules +
Optimised Runway Delivery
+ Runway Occupancy
indicators



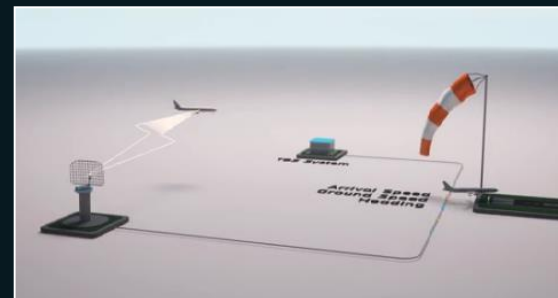
Enhanced TBS
Introduced March 2018



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



HMI designed by controllers
for controllers
Dynamic separation
Indicators



Real time wind data
derived from Mode S
downlinked aircraft
parameters

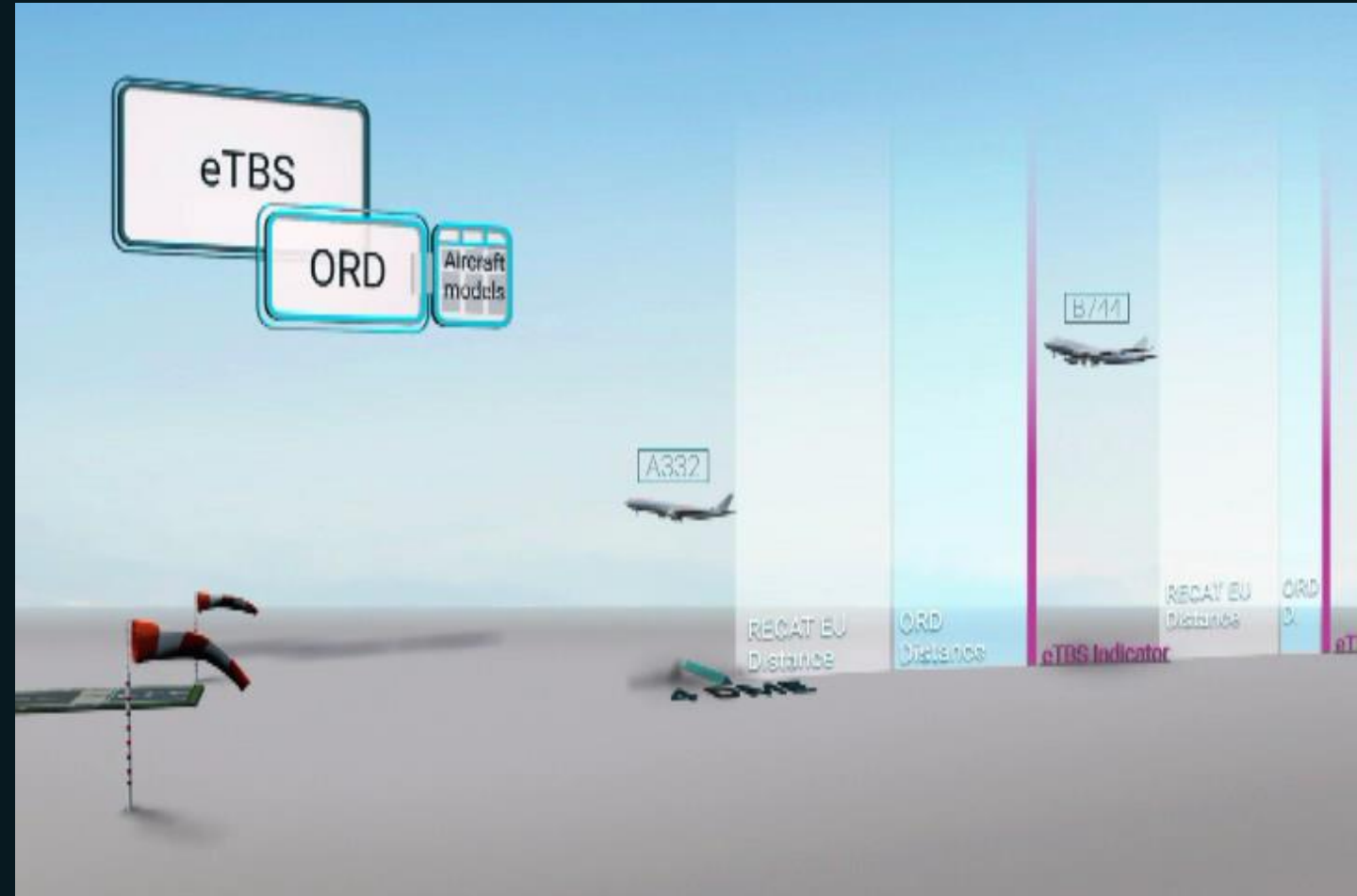
Tuning the tools

Optimised Runway Delivery (ORD) is tuned for Runway, Aircraft Types & Speed Profiles

Runway Occupancy Time is tuned for runway and will be adjustable for conditions as we introduce Pairwise

Capture and Sequence Logic is set for airspace and procedures allowing the tools to “follow the controllers actions”

These parameters are all monitored & maintained



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

RWY SP

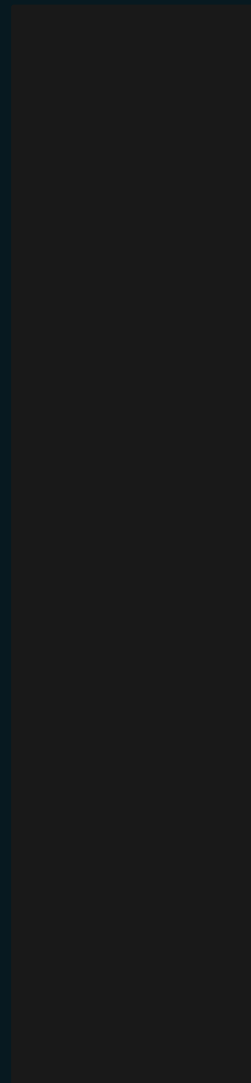
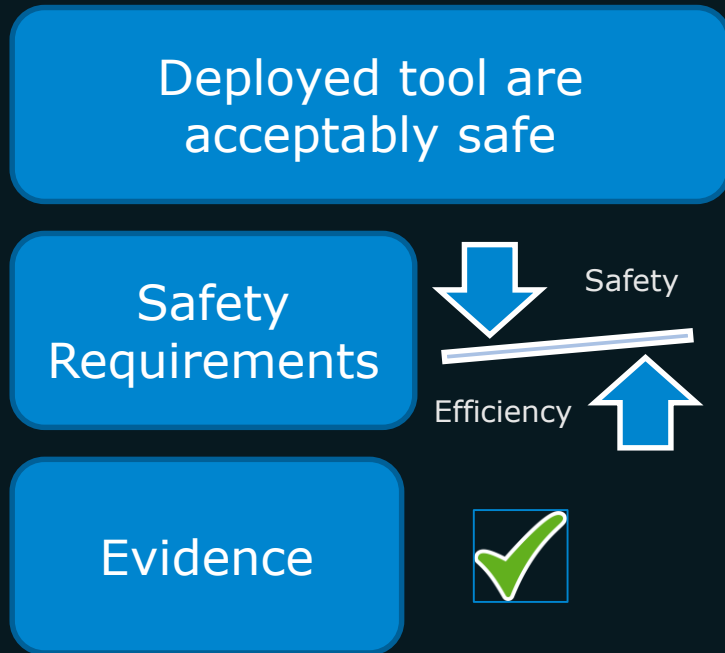
3.0



RADAR Replay eTBS HMI

TBS Distances						
DBS	3	4	5	6	7	8
TBS	3.1	4.1	4.8	5.7	6.6	7.4

Safety Assurance



Wind Forecast



ORD



TBS



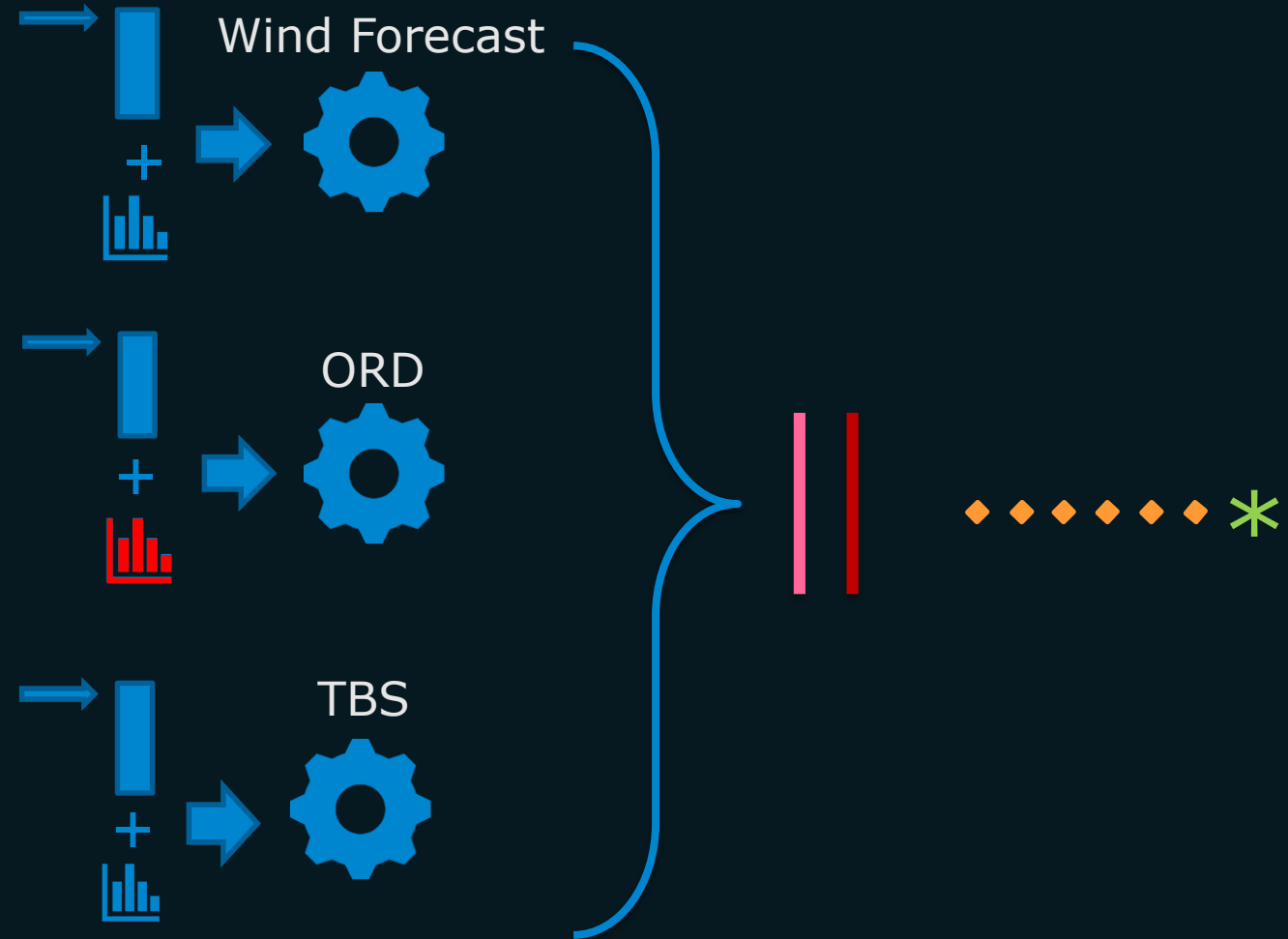
Complex Algorithms

- Wind forecast, ORD, TBS
- Parameters of tools are tuned/derived from data
- Large number of combinations

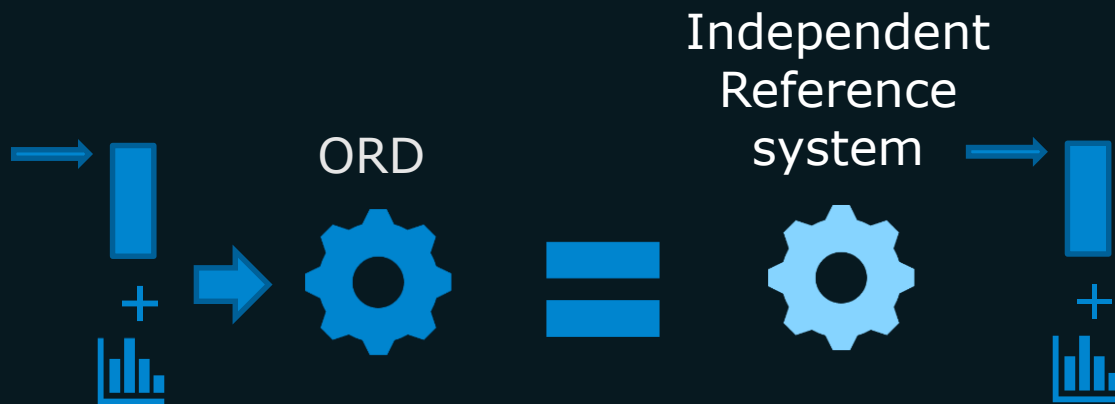
Safety Assurance

Dynamic separations

- Difficult for controllers to reliably detect errors
- Trust in the tools – software assurance



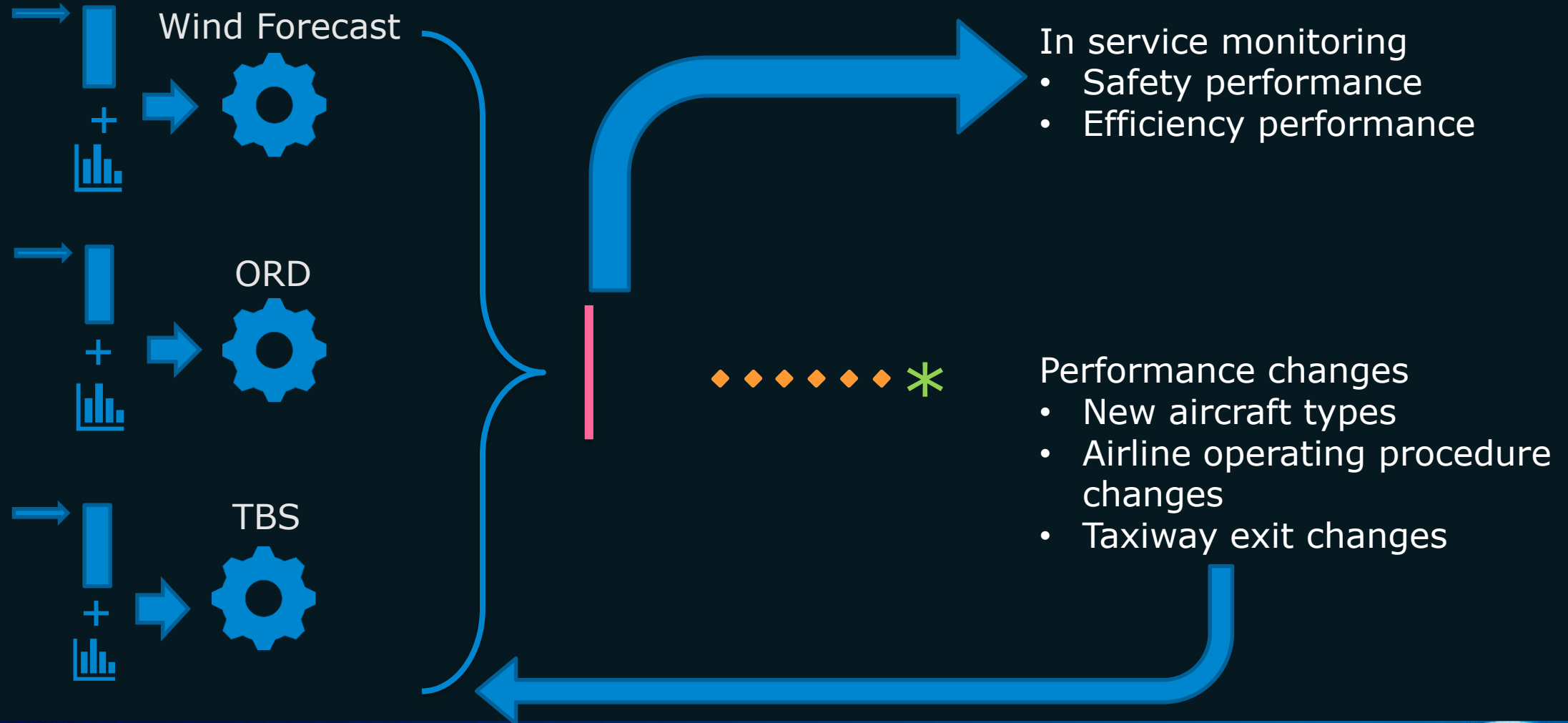
Safety Assurance



Assurance of total system through comparison to a reference model.

Outputs compared to be identical

Updates



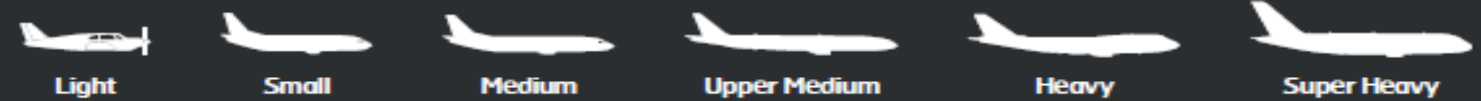
But that is not the end of the story.....

Pairwise Separation

+2 landings/hour vs. eTBS

Currently in development
supported by SESAR VLD3

Will include optimised
ROT



Pairwise Separation identifies safe separation distances between specific types of aircraft not just the wake vortex category

Safe separation based on 'worst-case scenario' from each class - e.g. heaviest lead aircraft and smallest following'

6 x 6

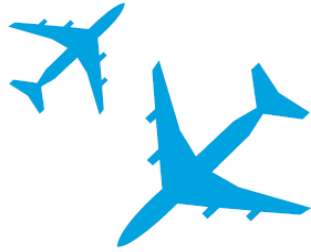
Now recognises

96
classes

of aircraft,
up from six classes

96 x 96

Roadmap



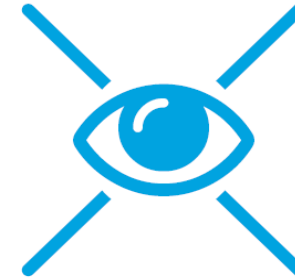
MIXED MODE OPERATIONS

Safely reduce the required inbound separation through integration with departure manager systems to take account of the aircraft runway occupancy on departure.



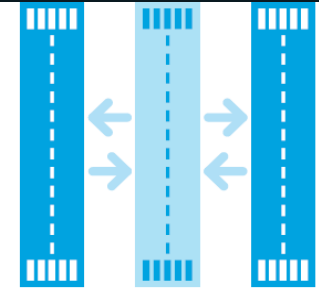
PAIRWISE SEPARATION

Further optimising time based separation to take account of the wake pairings of specific aircraft types. Moving from the current ICAO wake categories to RECAT 1 and then to RECAT 2 pairwise separation.



LOW VISIBILITY PROCEDURES

To tailor the final approach spacing to the preceding aircrafts occupancy of the localiser sensitive area. This allows for runway occupancy optimisation in LVP conditions.



DEPENDENT RUNWAY OPERATIONS

Converging runways – final approach spacing will take cognisance of departures to ensure de-confliction of go-arounds.

Thank You

For more information go to
www.NATS.Aero/IntelligentApproach
Or www.intelligentapproach.aero