

Time Based Separation

NATS

Experience with World first
implementation at London Heathrow



TBS Info Day
October 2017

Heathrow
Making every journey better

Heathrow Background

Airport Statistics

180

Destinations

35% of flights are
long haul

34% of pax transfer

Daily average of
1,350
movements

95
Airlines

474,000
Annual movements

4
Terminals

90
Countries

Monthly movement
record of
42,030

Daily record of
1,391
movements

2
Runways

Hourly record of
100
movements



Arriving aircraft (Pre TBS)

- Segregated mode (dedicated arrival/departure runway) between 0700-2300 due Government policy for Runway Alternation
- Night curfew
- Arriving medium sized aircraft are spaced 3 miles apart (minimum 2.5nm)
- Arriving heavy aircraft are spaced to the time equivalent of 4 miles apart
- This gives a declared landing rate of approximately 40 landings per hour (36-44 declared based on scheduled wake vortex mix)



Arrival Management

Aim to reduce orbital holding and sequence aircraft over wider distance – Heathrow 350nm

Speed reduction in en-route & descent when holding predicted to be greater than 7 minutes

Speed reduction in en-route/descent saves 1.5 minutes orbital holding

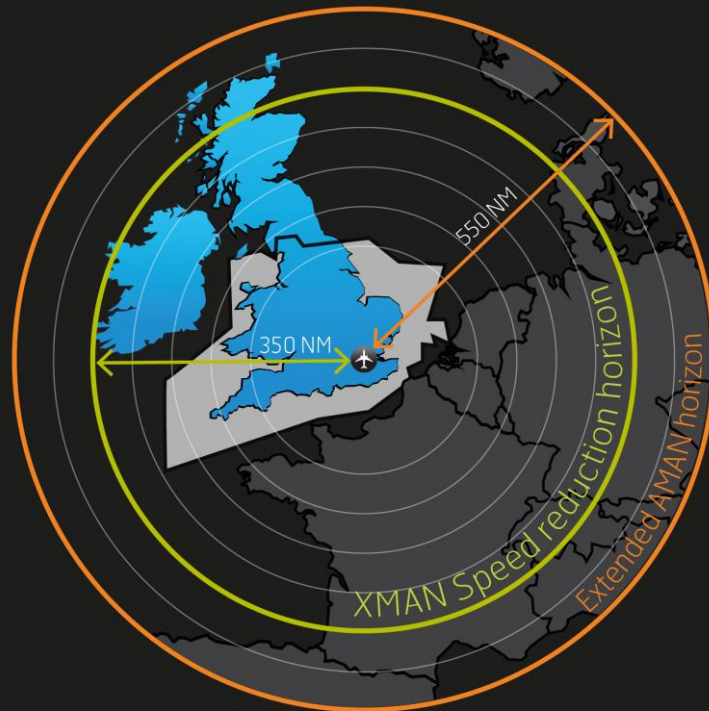
Aircraft burn c.90% less fuel than in orbital holds = over \$10m* savings per annum

Supported by DSNA, IAA, MUAC & PC

In 2018 Heathrow horizon will be extended to 500nm & Gatwick to 350nm through SESAR VLD which will also test Target Time of Arrival

*based on \$500/metric Tonne

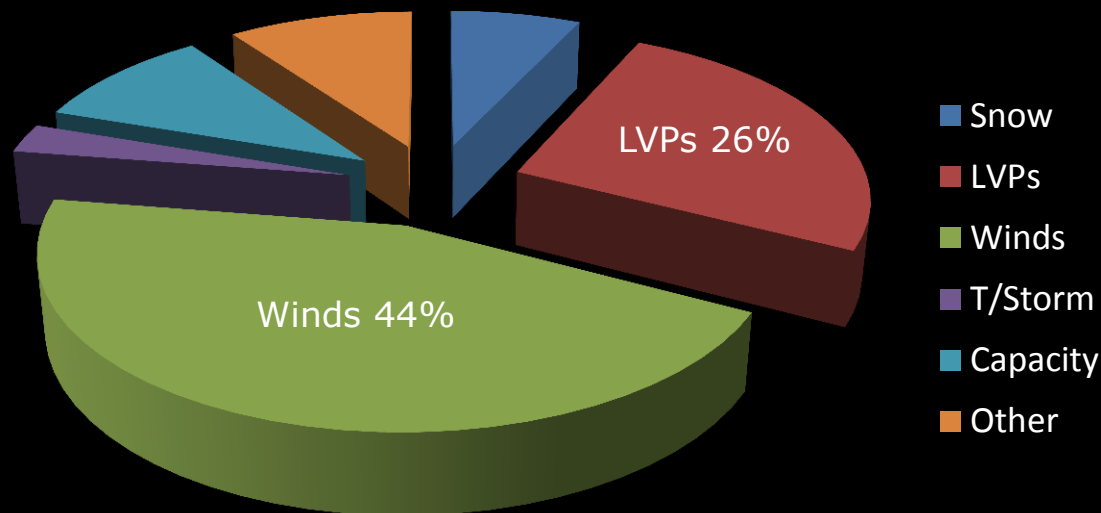
Heathrow Cross Border Arrival Management



The case for TBS at Heathrow

Heathrow Arrival Delay (ATFM)

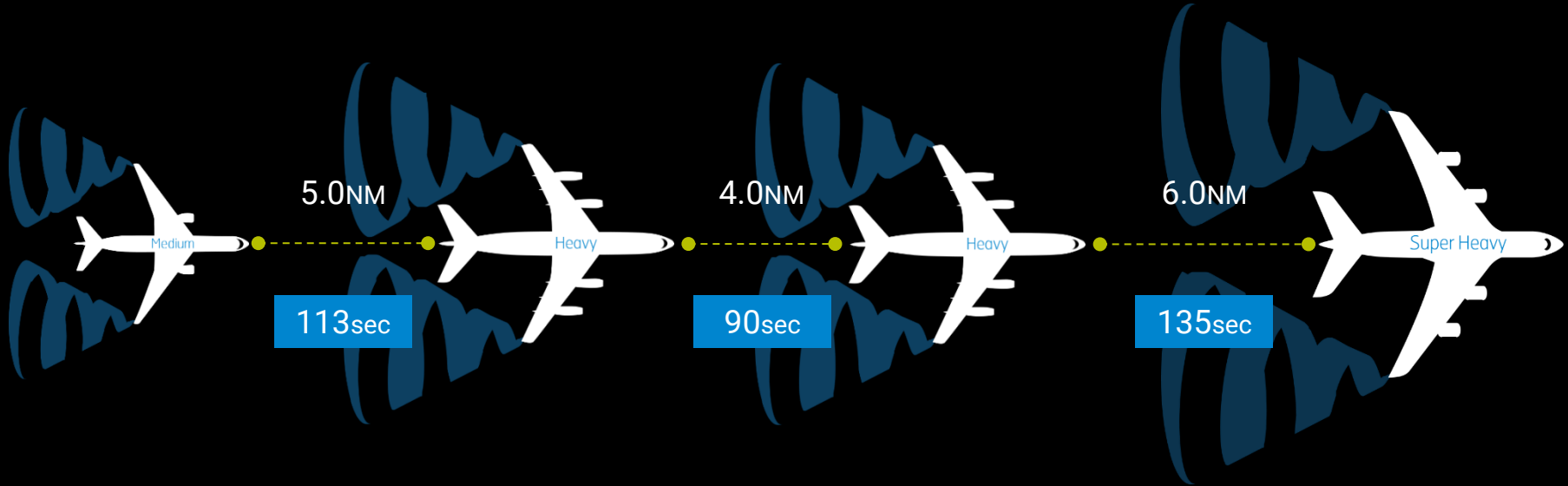
- Strong headwinds on final approach up to 3000ft were the biggest single cause of delay at Heathrow
- Wind related ATFM delay of 160,000 – 180,000 minutes per annum
- Wind causes significant delays on 55-65 days per annum (2015 had 95 days with headwinds >20knots)
- This was the original business case driver for TBS at Heathrow – since then the benefits case is more broadly linked to overall runway capacity/resilience



Causes of arrival delay at Heathrow pre-TBS

Headwind

5 knots

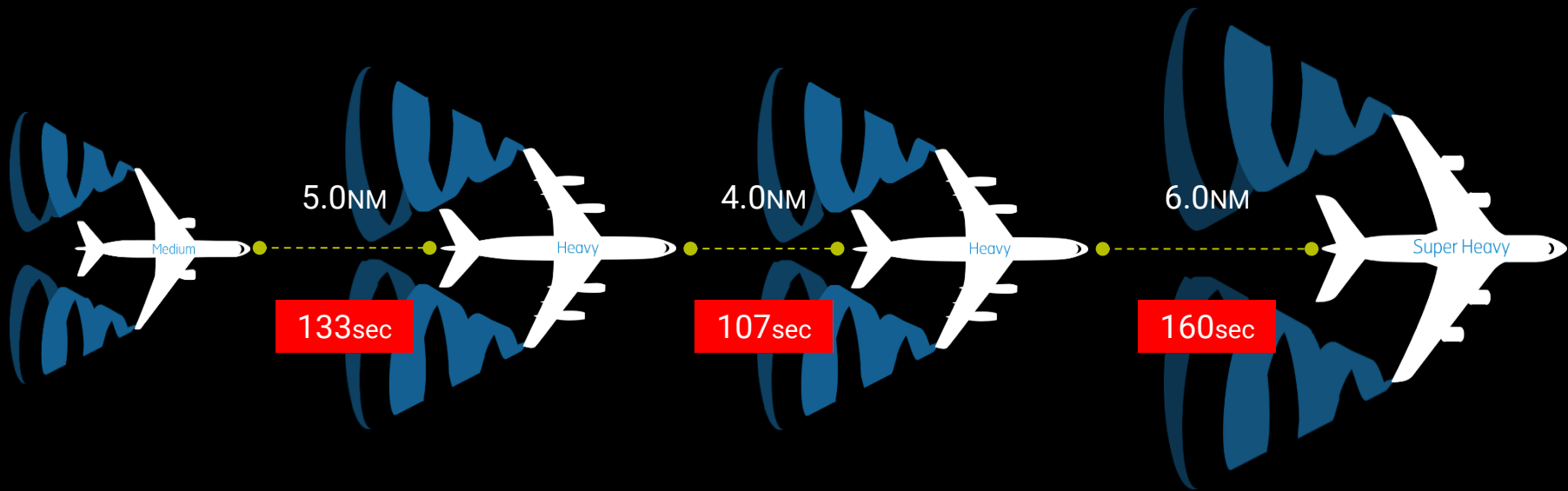


With standard **distance based separation**

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

Landing rate **40-45**

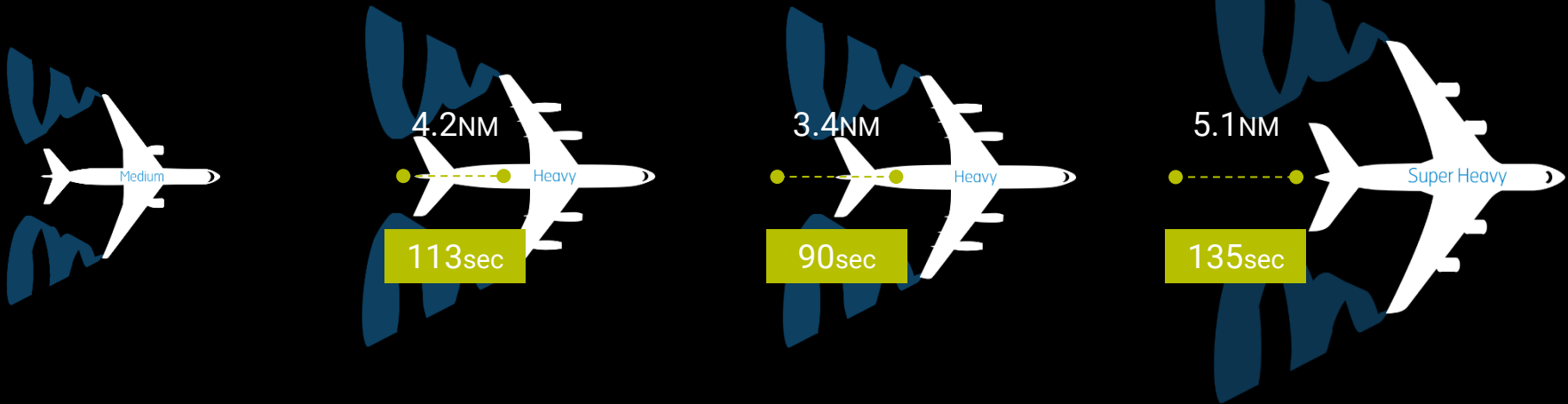
Headwind 35 knots



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

Landing rate **30-35**

Headwind **35 knots**



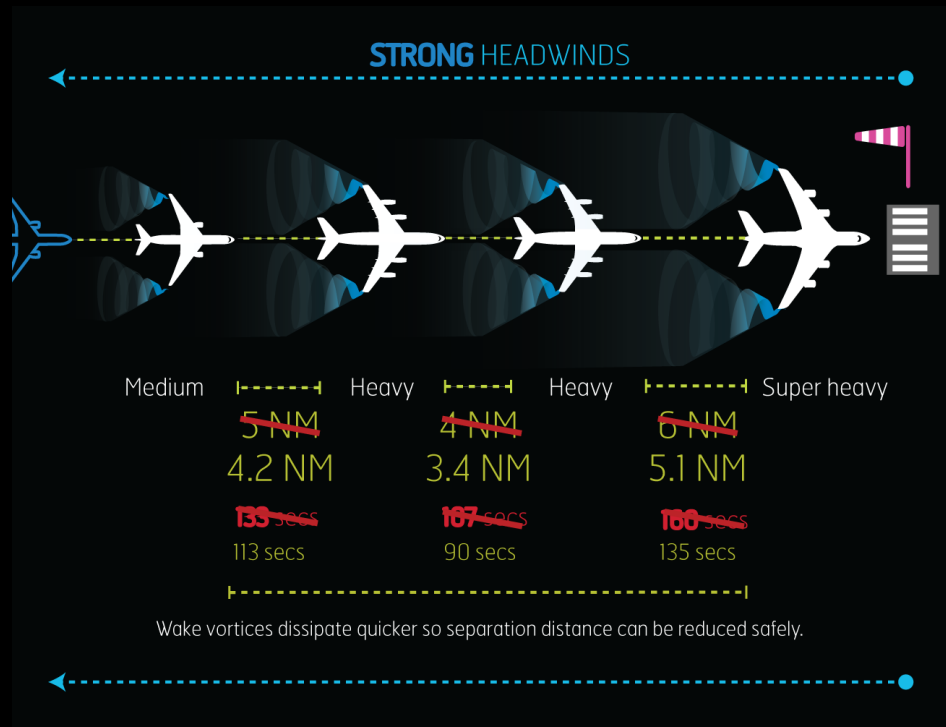
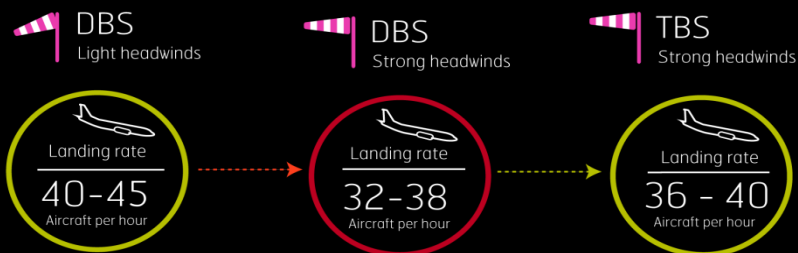
This increases resilience, reducing delay and cancellations

Landing rate **30-40**

Intelligent Approach

"Optimised and Resilient Landing Rates"

- Assured Operations – improved resilience and safety
- High Performance ATC – consistent delivery of approach spacing
- Maximising runway throughput

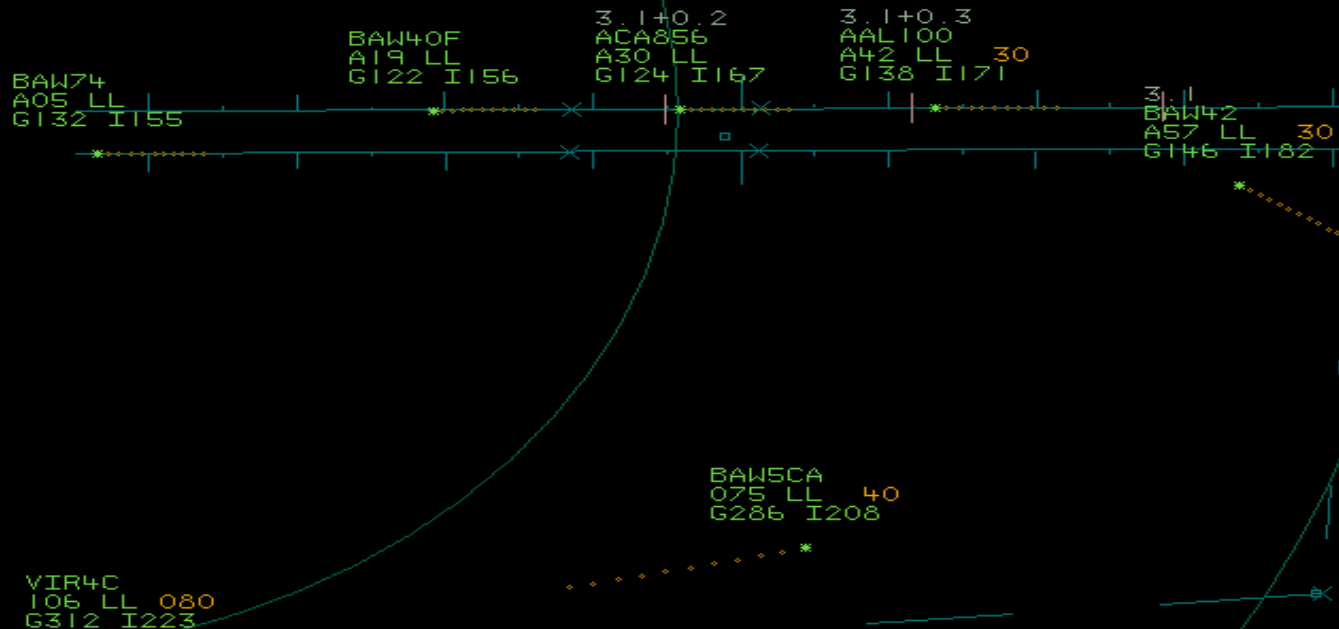


TBS Flight Crew Video

www.NATS.Aero/TBS

DBS	3	4	5	6	7	8
TBS	3.0	3.1	3.8	4.5	5.3	6.0

29 March 2015 RADAR Replay



NATS Private

Live operation replay 29th March 2015, headwind at
3000ft 55kts.

Time Based Separation

Benefits



Time Based Separation (TBS)

Originally planned for 2018

TBS Entered Operational Service on 24 March 2015 (LOS)

Project completed 1 May 2015

Heathrow TBS has been in operation constantly since March 2015 in all wind conditions

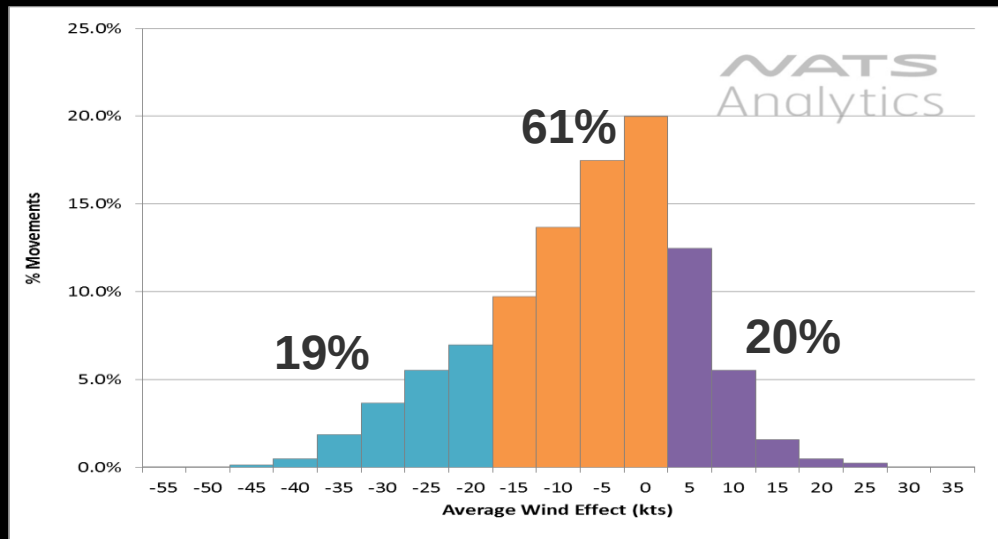


Average Wind Effect (May 2015 – April 2016)

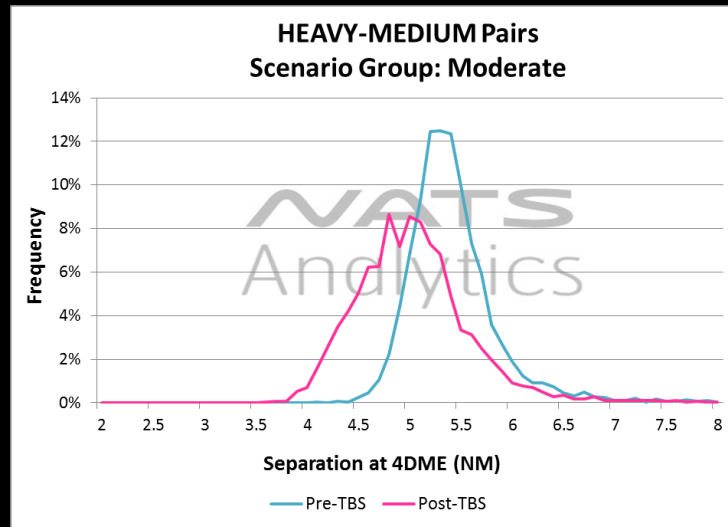
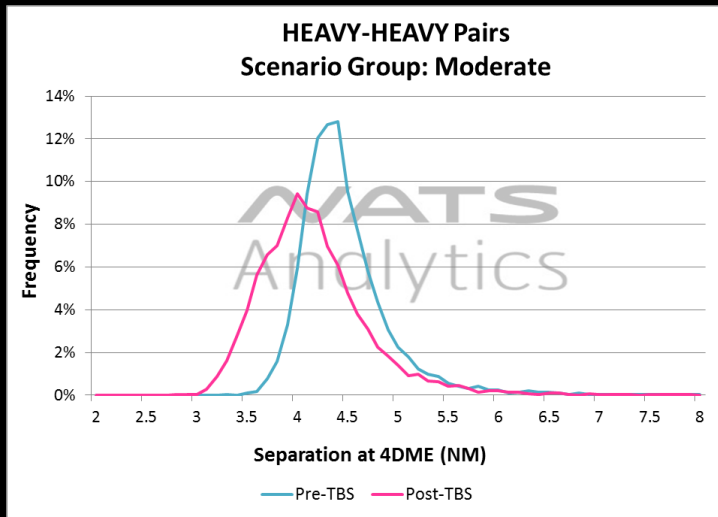
80% of aircraft experienced smaller Arrival-Arrival separations than Distance Based Separation

Based on data from 199,611 pairs
(representing 87% of arrivals)

Average Wind Effect (AWE)	Definition	Percentage of Sample
Strong	$\leq -20\text{kts AWE}$	19%
Low - Moderate	$-20\text{kts} > \text{AWE} \leq 0\text{kts}$	61%
Tailwind	$0\text{kts} > \text{AWE}$	20%

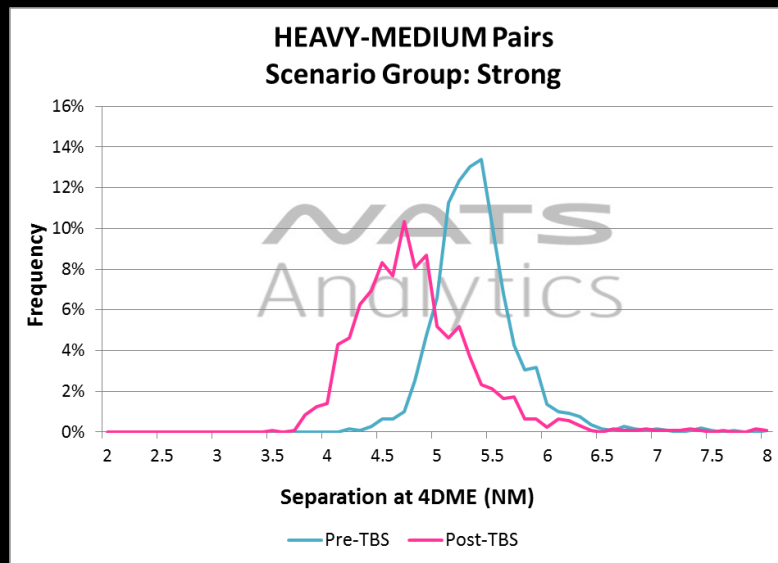
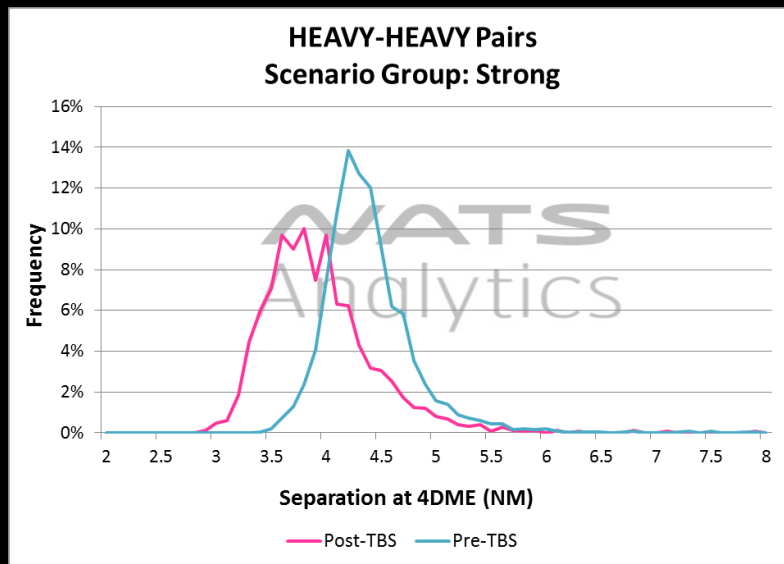


Pre and Post TBS (0-20kts Wind)



Heavy-Heavy arrival pairs have on average reduced from 4.48 to 4.18 (-0.30NM).
Heavy-Medium arrival pairs have on average reduced from 5.46 to 5.07 (-0.39NM).

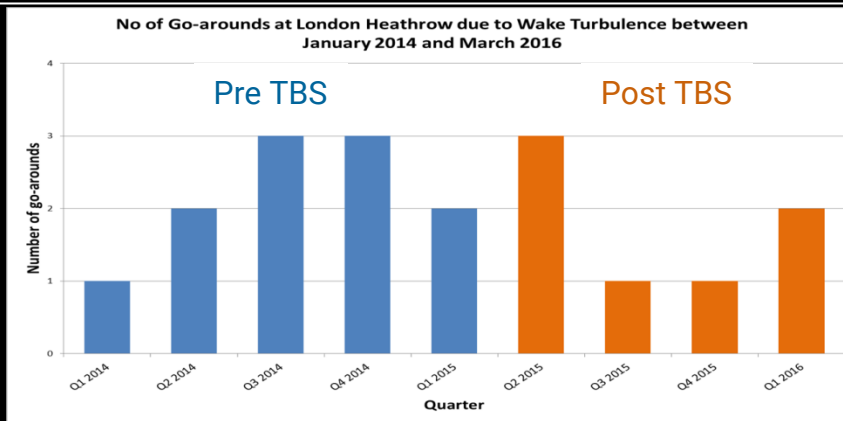
Pre and Post TBS (>20kts headwind)



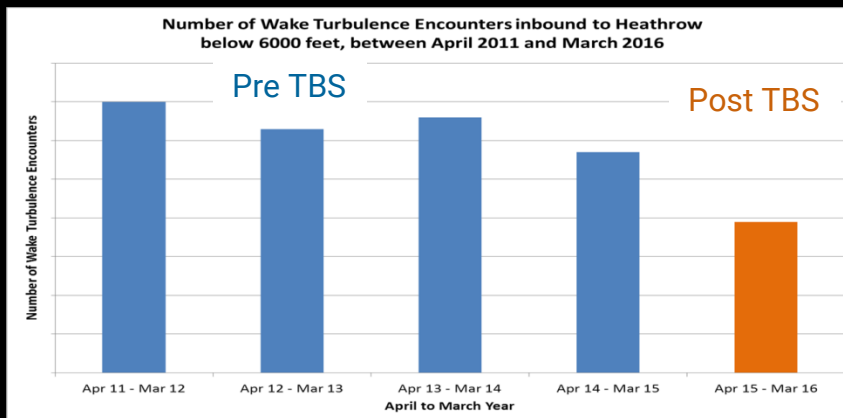
Heavy-Heavy arrival pairs have on average reduced from 4.40 to 3.96 (**-0.44NM**).
Heavy-Medium arrival pairs have on average reduced from 5.41 to 4.84 (**-0.57NM**).

Go arounds & Wake Turbulence Encounters at Heathrow

Go Arounds



Wake Encounter Inbound to EGLL <6000ft



Runway Throughput Benefits (May 15 – April 16)

Across all wind conditions

- Savings is 52NM per day
- **Increase of 13 movements/day**

In strong wind conditions

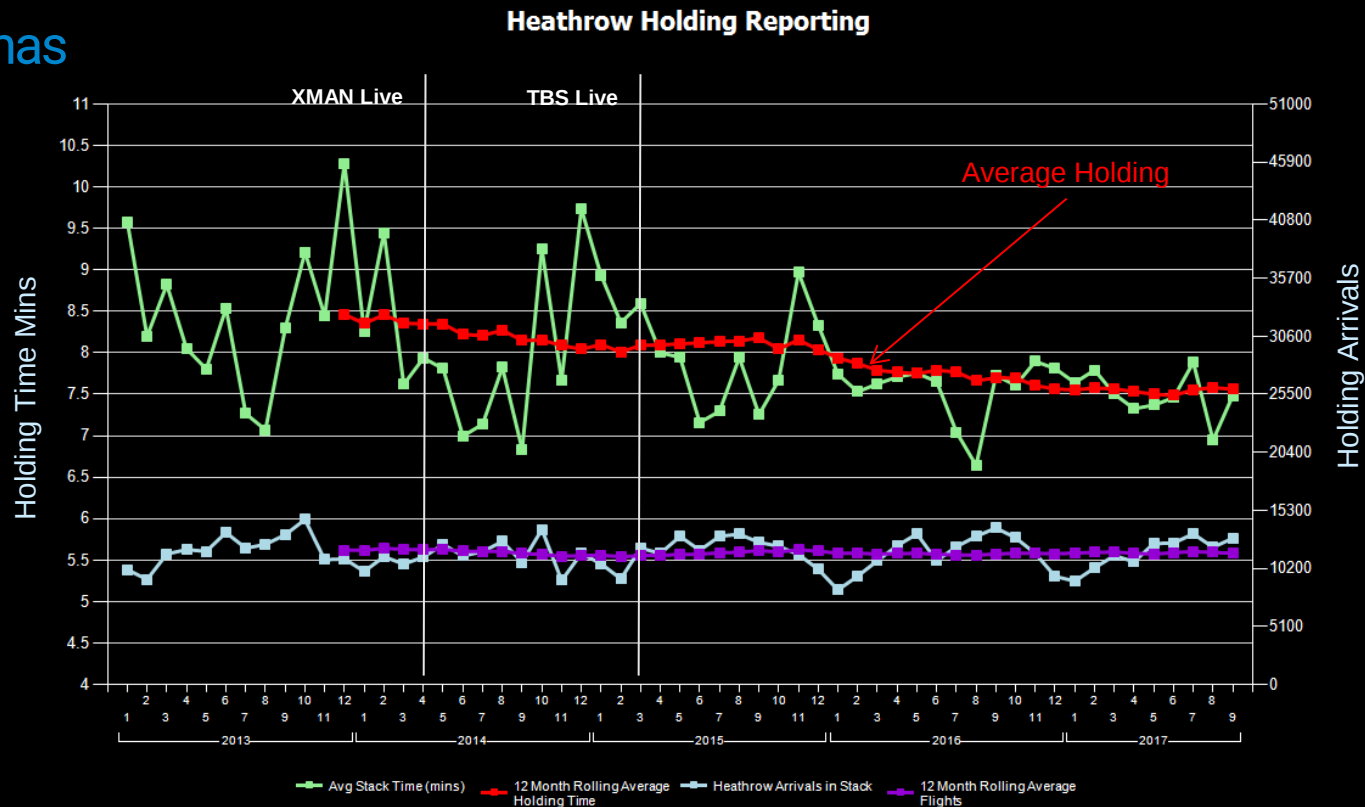
- Saving is 162NM per day
- **Increase of 44 movements/day**

Wind Conditions	Extra Movements	
	17-hour scheduled period	Per Hour
All AWE	13	0.8
Strong AWE	44	2.6

AWE = Average Wind Effect

Wind related ATFM delay reduced by >62%

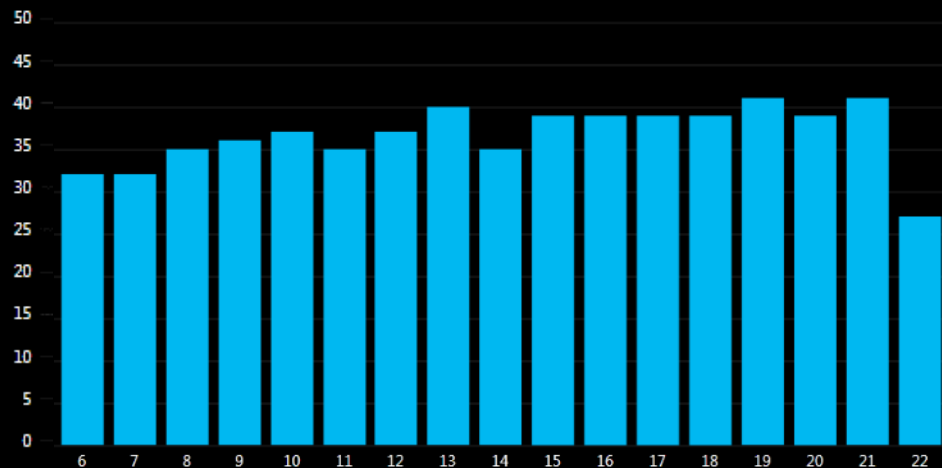
Average air holding has
reduced by
c.115,000 minutes
p.a.
since TBS live



Data updated 11 Oct 17

November 15th was Windy (Storm Barney)

- EUROCONTROL: Strong winds generated 65% of the total European daily ATFM delay
- LHR at the runway 21kts, gusting to 32kts, 80kts at 4000ft and 60kts straight down the runway at 3000ft
Still delivering 35-40 landings per hour
- CDG: at the runway 13kts, gusting to 24kts
- FRA: at the runway 19kts, gusting to 29kts,
- AMS: at the runway 26kts, gusting to 36kts,



Actual LHR Arrival Rate, 15 NOV



Time Based Separation has been in operation at Heathrow Since March 2015

"Time Based Separation addresses the biggest single cause of arrival delay at the airport. Heathrow has been operating at 98% capacity for over a decade so technology like this is essential, providing the best service possible to our passengers."

Derek Provan, Heathrow Director of Airside Operations

Heathrow estimate that Intelligent Approach (TBS) has already improved overall airport on time performance (arrivals and departures) by more than 1.5% and tactical cancellations due to strong headwinds have been almost eradicated.

These benefits will increase when enhanced TBS goes live in 2018

Summary experience at Heathrow

*TBS went live 24 March 2015
and has been in operation at all
times in all wind conditions
since then*

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

- 80% of aircraft receive smaller arrival separations that pre-TBS in all wind conditions
- >62% reduction in Arrival (ATFM) delays due headwinds & more stability in landing & flow rates
- 2016 - 37 days with strong headwinds & no ATFM delay
- No Tactical flight cancellations due headwinds
- Circa 115,000 minutes per annum reduction in Heathrow average airborne holding since TBS went live
- No Increase in Wake Turbulence Encounter Reports & none associated with TBS separations
- No increase in go around rate
- No increase in R/T
- **Overall savings inc. holding & delay > c.€23m p.a.***
- **Happy ATC, happy airport & happy airlines.....**

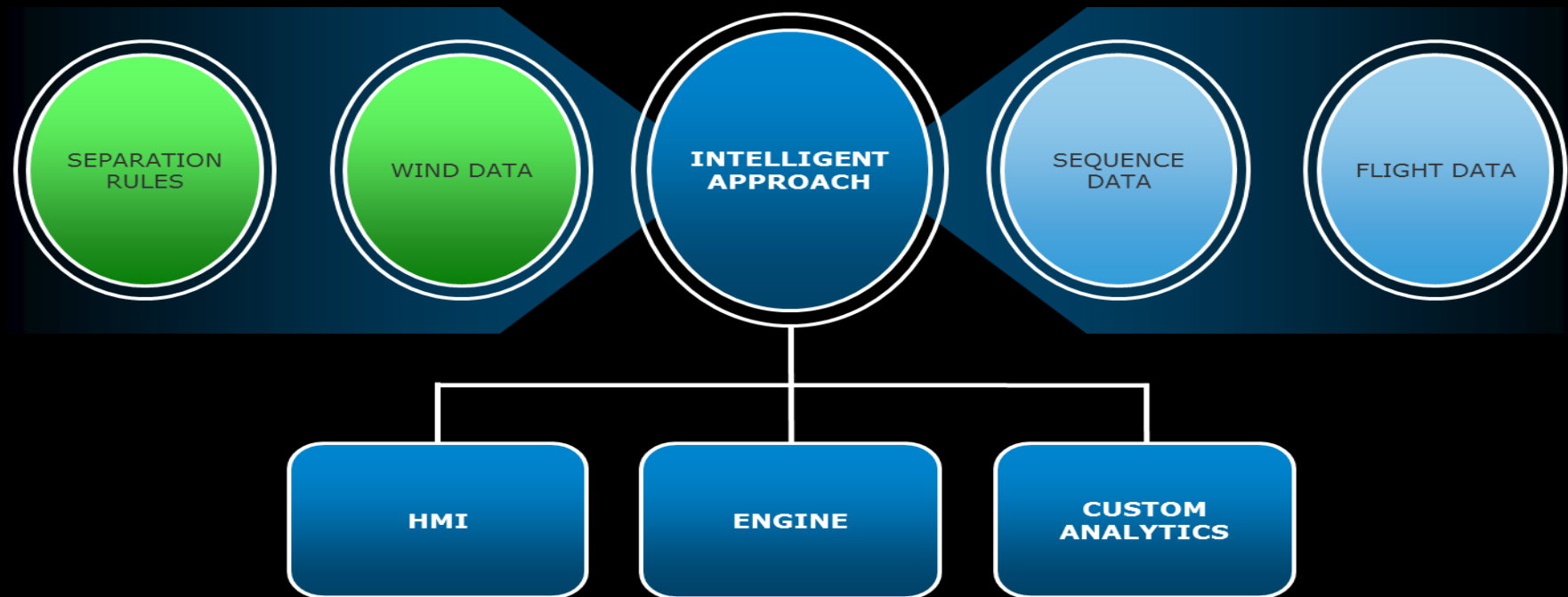
Intelligent Approach

TBS Introduction at Heathrow



Intelligent Approach

“Modular Design”



Implementation Approach taken for Heathrow

- Jan 15 – TBS Shadow Mode operation allowed controllers to see the tool in the ops room
- Feb 15 – Live Tools based DBS allowed controllers to get used to the HMI but still using standard distance based separation
- Mar 15 – Live TBS in Limited Operational Service – tool was in live operation at all times but subject to adaptation of elements including capture logic
- Operational Conversion Training 2-3 days
- May 15 – TBS fully signed off by NATS/CAA

Separation Rules

“As wind speed increases, wake decays more rapidly”

- Based on direct measurement of wake turbulence using LIDAR
- LIDAR data collected at Heathrow between 2008-2013 with support from Eurocontrol/SESAR
- Measured 150,000 Aircraft tracks at 2 glideslope locations
 - ~110,000 Aircraft tracks In-ground effect
 - ~40,000 Aircraft tracks Out-Of-Ground effect
- Data confirms - As wind speed ↑ wake turbulence encounter risk ↓
- New TBS Separation Rules Developed
- Assured by the regulator as safe for wake turbulence encounter risk
- TBS minima replace ICAO wake separation minima at Heathrow with full regulatory approval
- Analysis can be used for other airports
- eTBS builds on this safety case with RECAT separation rules

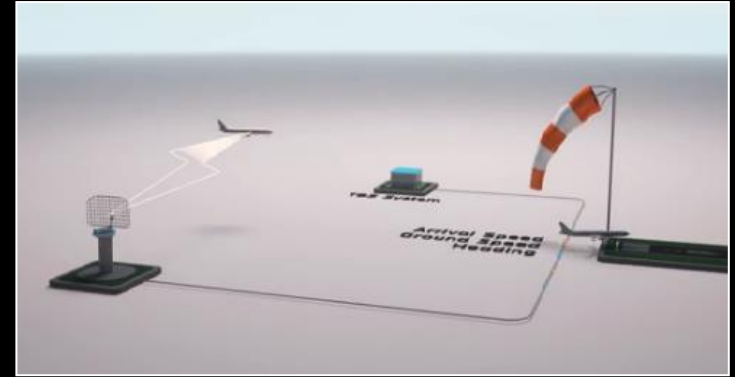


Windtracer LIDAR

Wind Data - Real Time Wind Information

"Glideslope Wind Conditions Service (GWCS)"

- Uses downlinked (Mode-S DAPS in London TMA i.e. it is Real Time Wind Data downlinked from each aircraft in the TMA)
- GWCS validated using 1 years data
- Characterised for all runways & separation minima
- Performance incorporated into safety requirements
Example performance 0.006% +/-10 knot error
- Safety analysis uses forecast performance variation
- Wind data could equally be provided by LIDAR if no Mode S available



TBS uses real time wind data derived from downlinked aircraft parameters

Successful Delivery

“A great example of the benefits of collaborative working”

- TBS concept originally developed through SESAR R&D
- TBS tool jointly developed for deployment by NATS and LM (Leidos)
- Adopted “AGILE” approach to project – very successful
- The project was accelerated by 2-3 years from an initial planned deployment date of Winter 2017/18
- Early and consistent engagement of regulator
- Core ATC team involved from outset
- Early and consistent stakeholder engagement – airport & airlines
- Use of video materials & crew briefings to engage with customers and airspace users proved very effective
- Strong support from Airline & Airport customers



Consistent Stakeholder Group

- Main Heathrow Airlines
- IATA
- Heathrow Airport
- NATS Programme
- ATC Core Team
- Analytics
- Regulator (UK CAA)

Plus Briefings to European Cockpit Association, CNS ATM JURG
IATA RCG etc....

Topics

- Objective of implementing TBS
- Cost/Benefits – via NATS SIP & airport stakeholder briefings
- Concept of Operations & safety case
- ATC procedures
- Implementation plan
- Crew Briefing & Crew Procedures
- Need for compliance with ATC Speeds
- Regulatory approval
- + Discussion between operators on best practice/SOPs

Work with stakeholders
on Speed Compliance

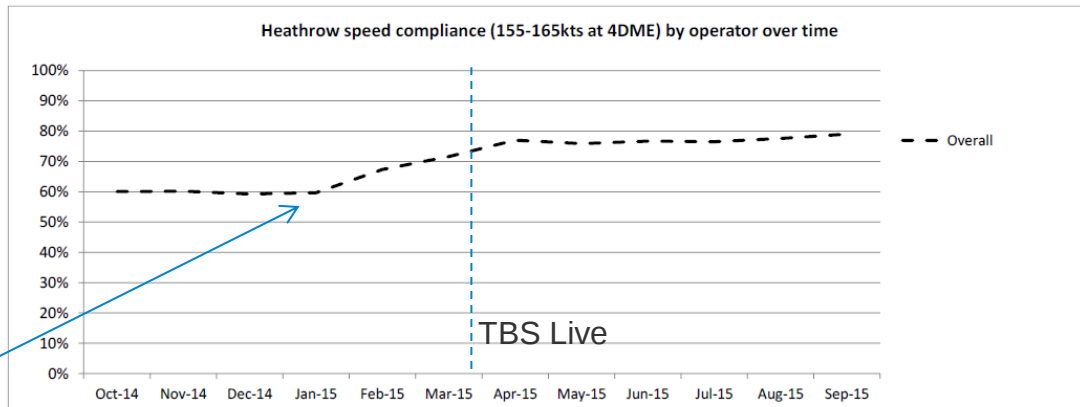
Pre TBS speed
compliance was 60%

Now average typically
between 79-82%

82% in Sept 17

Speed Campaign
Started

Heathrow Final Approach Speed Adherence Monthly Comparison



* Please note: A380 traffic has been excluded in this analysis.

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www.NATS.Aero/TBS

Web

FACT SHEET

Progress
being made

Time Based Separation (TBS) for Pilots flying into Heathrow

A NATS No. 1 above – December 2014

Time Based Separation will be in use at London Heathrow from March 2015.

ICAO recommended

The benefits to pilots will be less ATFM delay and lower fuel consumption. There will also be a reduction in the airborne holding on strong wind days. This is expected to save airlines £5 million to £2.5 million per annum.

TBS Separations are used in place of ICAO, achieving improved management of wake risk over and above ICAO.

By keeping the time constant, the actual distance between aircraft will often depend on the strength of the wind. In practice it may be that, in many instances, the distance will be reduced by more than a mile and the distance between wake pairs (e.g. heavy to medium) will remain reduced below 3mi.

Wake-tail downgraded aircraft on lower technology to be reduced

TBS has been assessed as safe for wake turbulence encounter risk. This and other research is ongoing. A detailed measurement of wake turbulence is being a USRB device was used at Heathrow between Oct 2013 and Dec 2012. 150,000 aircraft tracks were measured on two dimensions to

40-45 mins

20-30 mins

STC (Standard Traffic Control) 40-50 mins

Wake-tail downgraded aircraft on lower technology to be reduced

[illegible]

Crew briefing video for Time Based Separation at Heathrow



TBS

Is not the end of the Story

*We call the solutions
"Intelligent Approach™"*

What is Intelligent ApproachTM?

Building on the experience with TBS

Adaptive controller tools to safely optimise arrival spacing for all conditions, including:

- Optimised wake vortex spacing (RECAT, ORD & Pairwise)
= **additional runway capacity**
- Optimised spacing for mixed mode (arrival/departure)
runways = **additional runway capacity**
- Time Based Separation providing mitigation for lost capacity
due headwinds = **resilience**
- Improved consistency of operational service delivery
= **better overall on time performance**

Intelligent ApproachTM Roadmap & Capabilities

The Intelligent Approach suite of tools are designed to optimise arrival capacity, safety & resilience

The same toolset can be used for a number of applications.

Intelligent Approach allows ATC to safely optimise arrival spacing in all conditions and for all runway configurations.

It also comes with a set of analytics tools that can be used to help performance manage the operation.

Intelligent Approach tools are modular and designed to work with most ATC systems

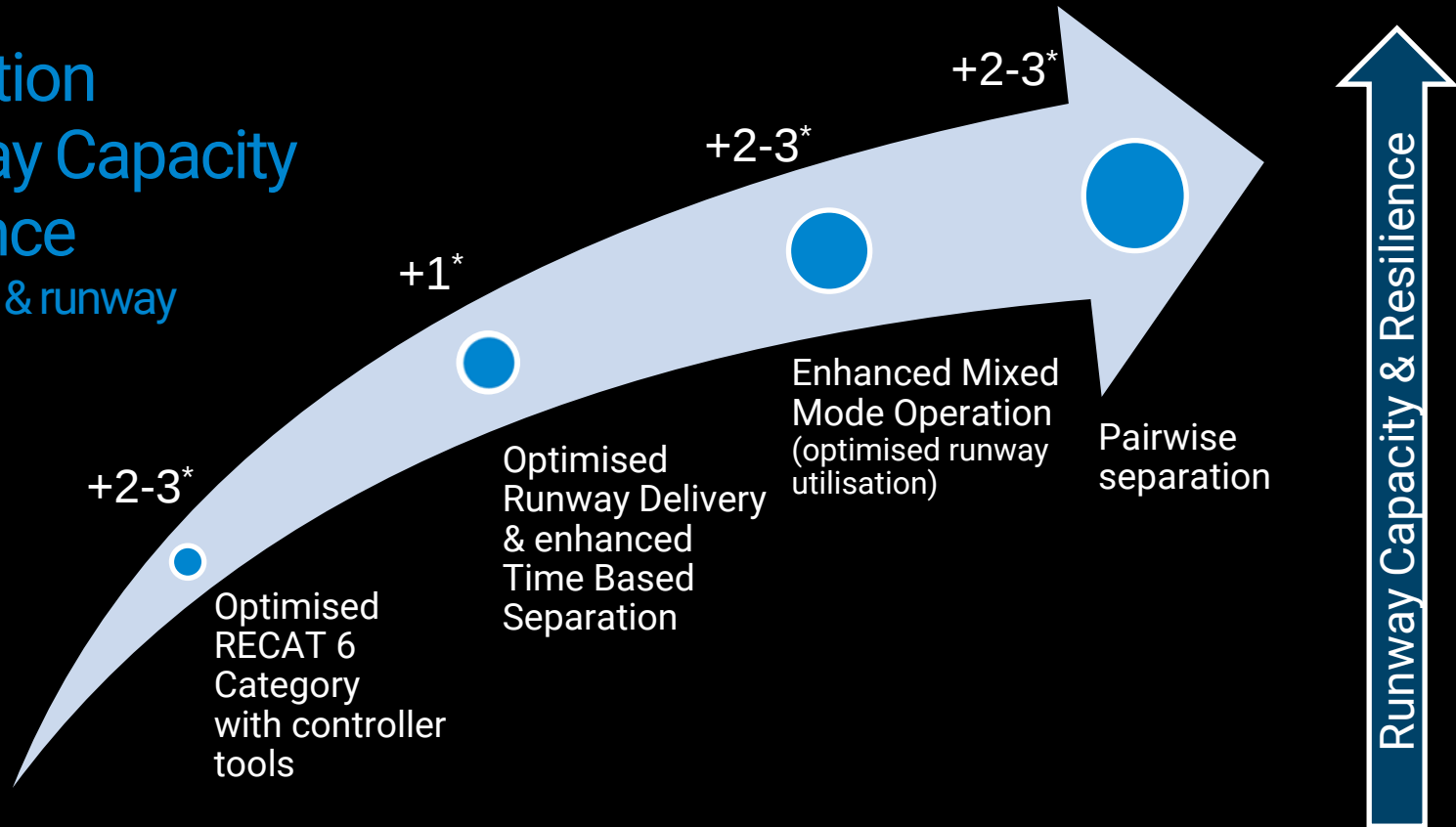
Benefits/Phasing

Capability	Benefit	Resilience	Capacity
Distance Based Separation with Tools & RECAT	Improved consistency of approach spacing + simplified RECAT		YES (going from current 4 ICAO WV Categories RECAT 6 category) = +2-3 landings/hour
Time Based Separation (With Optimised Runway Delivery)	Resilience to Headwinds & operational & safety improvements	YES Average recovery +3.6/hour in strong winds (max c.+6)	YES Heathrow is already 6 Cat but will see +1.8/hour average in all wind conditions (airports at ICAO 4 WV Cat may see + c.3-4/hour)
TBS Pairwise	Significant capacity gain in all wind conditions	YES	YES Heathrow would see extra +2-3 landings/hr
Optimised Runway Utilisation for Mixed Mode	Capacity & resilience gains for mixed mode runways	YES	YES +2-3 landings/hr based on SESAR simulation

Note: Benefits numbers quoted are based on Heathrow/Gatwick traffic mix so may vary by airport traffic presentation
Mixed Mode requires departure sequence data from DMAN or EFS

Optimisation Of Runway Capacity & Resilience

for any airport & runway
configuration



Heathrow Enhanced TBS
(+1 arrival per hour)*

Delivery Spring 2018

Also Implementing
RECAT Departures
(+1 departure/hour)*

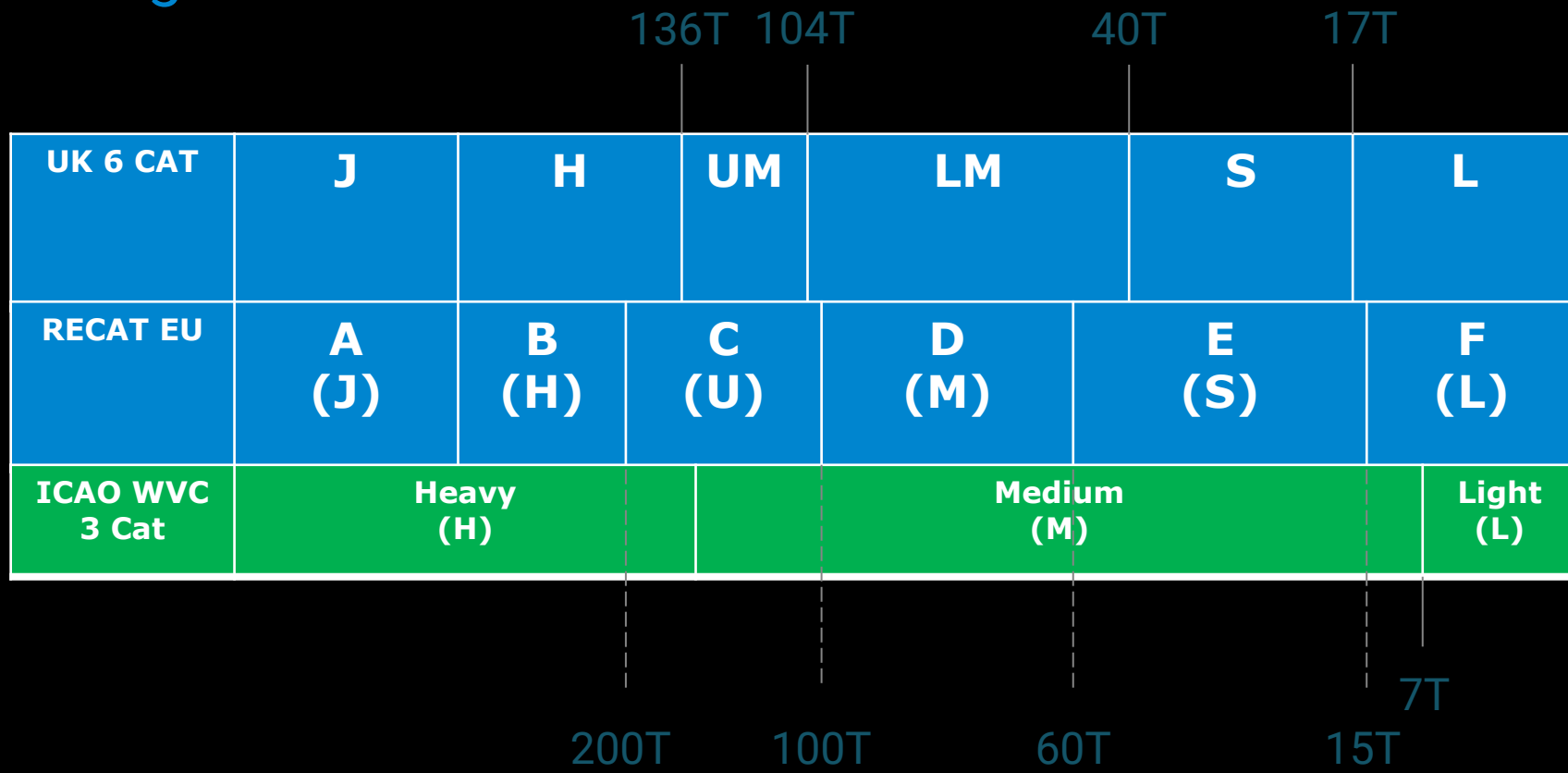
*Heathrow already uses 6 WV Categories
so benefits at other airfields may be higher

eTBS Scope

RECAT + ORD

- eTBS target delivery Spring 2018
- Enhance existing Heathrow TBS system
- Use more efficient wake separations based on RECAT-EU
- Separation to runway threshold supported by 'ORD' tool (Optimised Runway Delivery) so controllers are provided indication of Runway Occupancy & Wake separation (whichever is driving minimum spacing)
- Concept similar to current day TBS
- Minimal HMI changes
- Simple Training (classroom + OJT)
- Benefit is an additional +1 arrival per hour in all wind conditions (Heathrow already has 6 Cat) so at airfields still using ICAO 4 Cat will see higher benefits from RECAT + TBS/ORD
- TBS tool makes RECAT/ORD really simple

WV Categories



eTBS – Implementing RECAT EU+ORD

		Follower					
		A Super Heavy A380 (560T)	B Upper Heavy 200T or more	C Lower Heavy 100T – 200T	D Upper Medium 60T – 100T	E Lower Medium 15T – 60T	F Light 15T or less
Leader	A: Super Heavy A380 (560T)	3NM (+0.5NM)	4NM (-1.5NM)	5NM (-0.5NM) (-1.5NM)	5NM (-1.5NM)	6NM (-0.5NM) (-0.5NM) (-1.5NM)	8NM (+0.5NM)
	B: Upper Heavy 200T or more	SM	3NM (-0.5NM)	4NM (+0.5NM) (-0.5NM)	4NM (-0.5NM)	5NM (+0.5NM) (-0.5NM) (-1.5NM)	7NM (+0.5NM)
	C: Lower Heavy 100T – 200T	SM	SM (-1.5NM) (0.0NM)	3NM (-0.5NM) (-1.5NM) (+0.5NM) (+1.5NM)	3NM (-1.5NM) (-0.5NM)	4NM (-0.5NM) (-1.5NM) (-2.5NM) (+0.5NM) (+0.5NM) (-1.5NM)	6NM (-0.5NM) (+0.5NM)
	D: Upper Medium 60T – 100T	SM	SM	SM	SM	2.5NM* (+0.5NM) (0.0NM) (-2.0NM)	5NM (+0.5NM)
	E: Lower Medium 15T – 60T	SM	SM	SM	SM	SM (0.0NM) (-1.5NM) (-2.5NM) (0.0NM) (-0.5NM) (-1.5NM) (0.0NM) (0.0NM)	4NM (-0.5NM) (+0.5NM) (+1.5NM)
	F: Light 15T or less	SM	SM	SM	SM	SM	3NM (+0.5NM)

RECAT-EU 6-CAT to be applied to Threshold

- Building on deployed TBS and SESAR R&D we have been working to validate benefits for Heathrow by deploying RECAT EU separations to touchdown
- We have turned NATS R&D work into a change to TBS with proven benefits to deliver RECAT EU TBS separations to touchdown - some separations following A380s reduce
- The benefit is up to **+1 movement per hour in addition to RECAT Benefit**
- Is a joint project with Heathrow Airport Limited and our target is to deploy in Spring **2018**
 - Differences;
 - Separation to threshold
 - Tower has indications to threshold
 - Updated wake categories in FDP/AMAN
 - Update to TBS Winds to integrate winds to threshold
 - Safety case update & regulator approval in work
- Further development of TBS separations, e.g., static pairwise, will need changes in other systems such as AMAN and are under development and wider programming alignment so likely c.2020
- Pairwise benefits from simulator runs up to +5 movements/hour so expect further +2-3 in live operations.

Intelligent Approach™ Product Roadmap



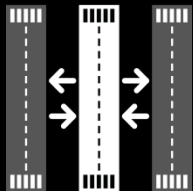
- **Mixed Mode Operations**

- Integration with departure manager systems



- **Pairwise Separation**

- RECAT
- Static pairwise separation
- Dynamic pairwise separation



- **Dependent Runway Operations**

- Converging runways / crossing runways - ensure de-confliction of go-arounds.



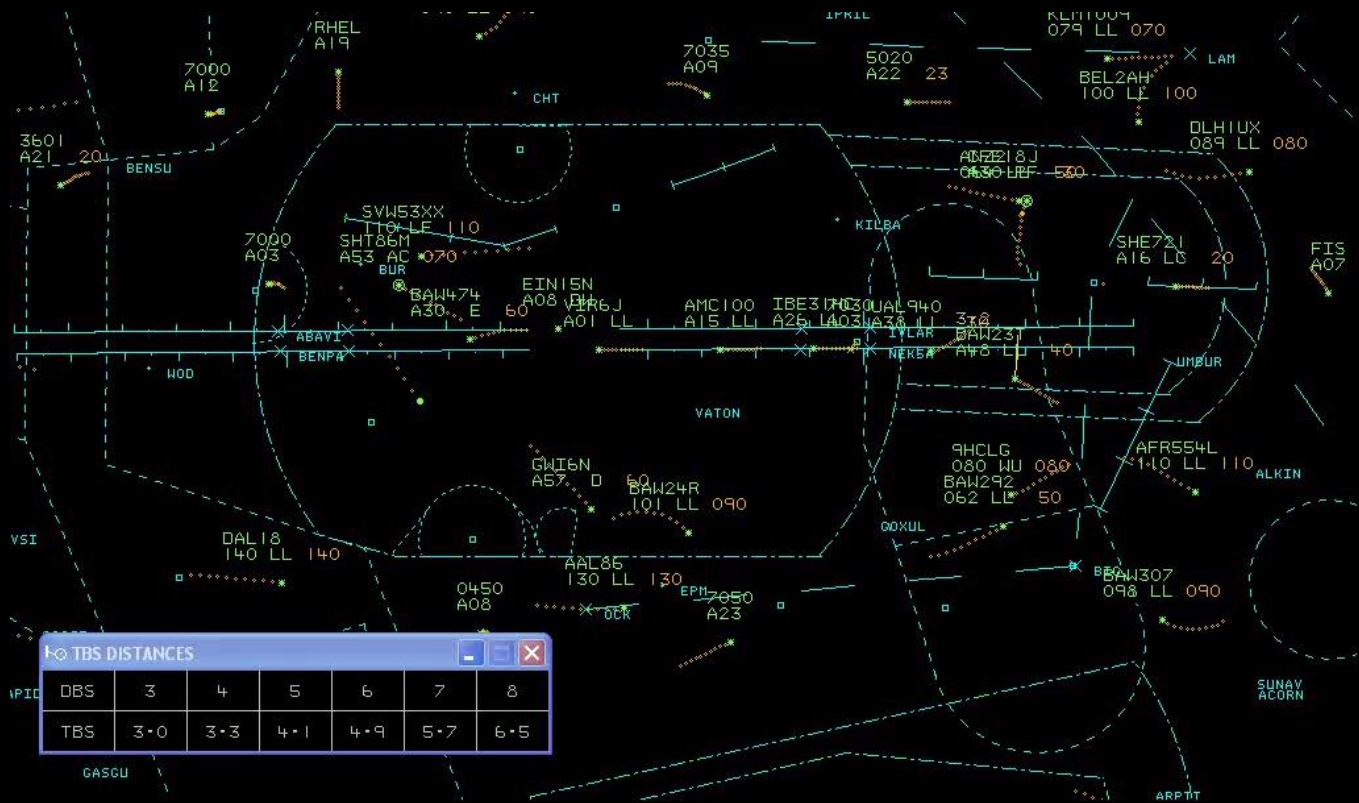
- **Low Visibility Procedures**

- Final approach spacing tailored to occupancy of the Localiser Sensitive Area.

Heathrow TBS was just the start...

Nov 10th Video Replay

Zero minutes
ATFM delay with
40 knot
Headwinds



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Information/articles include:

TBS Crew Briefing: www.NATS.Aero/TBS

WebEx livestream <https://vimeo.com/234993362>

Articles include:

<https://www.nats.aero/news/enhanced-time-based-separation-scheduled-arrival-early-2018/>

<https://www.internationalairportreview.com/article/23911/time-based-separation-single-european-sky/>