Operational Service and Environment Definition (OSED) for Time Based Separation for Arrivals (TBS)

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Abstract

This document is the OSED related to the application of Time Based Separation for Arrivals (TBS) to provide for improved achieved arrival capacity resilience to headwind conditions on final approach. This is Phase 1 of Project 06.08.01. This update contains the relevant feedback and recommendations from the TBS VALR for the VP-303 Approach Simulation and the VP-302 Tower Simulation and from the TBS Safety Assessment and the TBS Human Performance Assessment.

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Executive Summary

This Operational Service and Environment Definition (OSED) falls under the Operational Focus Area (OFA) **01.03.01 Time Based Separation**. This OSED details the operational concept for [AO-0303]: Time Based Separation for Final Approach – Full Concept (TBS). The TBS concept relates to the approach phase of the WP05.02 TMA Detailed Operational Description (DOD) [72] and the surface-in runway phase of the WP06.02 Airport DOD [73]. This OSED is a top down refinement of the following Time Based Separation description in the WP06.02 Airport DOD [73]:

OFA 01.03.01 – Time Based Separation

> The application of time based wake turbulence radar separation rules on final approach (TBS), so as to aid towards stabilising the overall time spacing between arrival aircraft. The final approach controller and the Tower runway controller are to be provided with the necessary TBS tool support to enable consistent and accurate delivery to the TBS rules on final approach. The minimum radar separation and runway related spacing constraints will be required to be respected when applying the TBS rules. **[AO-0303]**

TBS Concept Description

The objective of applying time based separation on final approach is to improve the landing rate resilience to headwind conditions on final approach through recovering the lost landing rate currently experienced when applying distance based separations (DBS). This is to be achieved by stabilising the delivered time spacings between aircraft on final approach across headwind conditions.

The time spacing impact of headwind conditions when applying distance based separations is significant. A 15kts mean headwind on the glideslope has a 6.7% time spacing impact over the distance based separations, a 25kts headwind a 14.3% impact. The increase in time spacing as a result of a 20kts mean headwind on the glideslope over the distance based separations reduces the landing rate by up to 4 aircraft an hour.

The TBS Concept involves changing the separation rules on final approach from distance based separations to time based separations. There is a need to facilitate the delivery to time based separation constraints by the final approach controller and the tower runway controller. This is achieved through the provision of separation indicators displayed on the extended runway centre-line of the final approach controller radar display and the tower runway controller air traffic monitor display, and changing the controller separation / spacing procedures to take into account the use of the separation indicators in supporting the arrival delivery on final approach.

The wake turbulence time based separations have been derived from the distance based separations taking into account the ground speed profile of aircraft on the final approach glideslope in low headwind conditions. A complication is the diversity of airspeed profiles flown on final approach, both the procedural airspeeds prior to landing speed stabilisation, and the airspeed profiles employed during landing speed stabilisation in relation to the aircraft type, landing weight and other factors. These result in a multiplicity of time spacings associated with each distance based separation in the low headwind conditions.

To manage this complication a reference airspeed profile is used to establish the reference time based separations in low headwind conditions. This reference airspeed profile is applied to the prevailing glideslope wind conditions to calculate the TBS distance to be displayed by the separation indicator. The actual airspeed profile of the follower aircraft under TBS will still vary, but only in the same way that it varies under DBS today. Therefore, the variation in time spacing under TBS will be no different to that under DBS in low wind conditions, and for TBS this time spacing for a particular airspeed profile is stabilised across headwind conditions. In this way the diversity of airspeed profiles employed on final approach is accommodated without the need to explicitly take into account the airspeed profile intent of the aircraft.

A glideslope wind conditions service is required to provide the glideslope wind profile to the TBS tool.

The low headwind conditions proposed is a minimum of 5kts in order to provide additional spacing in the low, still and tail wind conditions in which pilot reported wake turbulence encounters are most prevalent for distance based separations.

The TBS distance is to be applied from the follower aircraft merging on to final approach until the lead aircraft crosses the landing runway threshold in the same way as for distance based separation.

The separation indicator represents the time based separation on the controller radar display. The final approach controller is responsible for efficiently delivering to the radar separation using the separation indicator as the reference for the separation to be applied from the follower aircraft merging on to final approach until the lead aircraft crosses the runway landing threshold. The follower aircraft is to be turned on in the zone behind the separation indicator with sufficient additional spacing for the distance spacing compression expected to be experienced in the prevailing glideslope wind conditions for the anticipated airspeed profiles of both the lead aircraft and the follower aircraft.

Ideally, sufficient spacing is set up by the final approach controller such that there is no need for further intervention action. In the event of unanticipated compression the final approach controller and the tower runway controller are required to take active steps to preserve the separation and to recover separation when infringed. System support can be provided for monitoring and alerting for aircraft employing abnormal airspeed profiles on final approach, and for monitoring and alerting for infringement scenarios from the distance spacing compression caused by lead aircraft with a slower than anticipated airspeed profile, or from follower aircraft with a faster than anticipated airspeed profile.

On first call to Approach ATC, the pilot is required to confirm the aircraft type of the aircraft and to provide notification of approach speed non-conformances against the procedural airspeed profile published in the AIP. Pilots should also provide notification of the intent to employ an abnormally slow or an abnormally fast landing stabilization speed profile for the aircraft type (e.g. from landing light or landing heavy).

TBS awareness briefings are to be provided to airline operators and pilots. Pilots are to be informed that TBS procedures apply at a destination airport at the pre-departure briefing and when entering the destination airport airspace through the airport air traffic information service. TBS procedures are to be incorporated into the top of descent briefing.

The wake turbulence time based separations are to be applied in the context of all the other separation and spacing constraints on final approach. These include the minimum radar separation constraints, the runway spacing constraints appropriate for the runway visual conditions, the runway surface braking conditions and exit taxiway serviceability, the scenario specific spacing requirements such as for a runway inspection or for accommodating conflicting or crossing traffic, and the interlaced departure gap spacing for interlaced mode operations. The separation indicator is required to clearly represent the maximum separation or spacing constraint to be applied between the arrival pair.

The tower supervisor in coordination with the approach supervisor, or the tower runway controller in coordination with the final approach controller, are responsible for changes to the runways-in-use, changes to the runway modes, and changes to the separation and spacing constraints that are required to be applied on each runway-in-use. Scenario specific spacing may be initiated through tower procedures or approach procedures depending on the specific scenario and coordinated across tower and approach operations. This information is required to be provided to the TBS tool.

The arrival sequence order and the aircraft landing runway intent indicating which aircraft are to land on the departure runway for parallel dependent runway operations, is coordinated by the approach supervisor and the intermediate approach controllers, and reflected in the approach arrivals sequence. This information together with the incorporation of late changes to the arrival sequence order or the aircraft landing runway intent is required to be provided to the TBS tool.

It is imperative that the sequence and separation / spacing information provided to the TBS tool is dependable because of safety implications. Approach controllers are required to be provided with the means to check and amend the sequence and separation / spacing information and to check the calculated separation indicator distance before each separation indicator is displayed.

Safety requirements have been identified for system checking of the sequence order on intermediate approach and for checking that the correct aircraft is turning on to each separation indicator.

Safety requirements have been identified for system monitoring and alerting for TBS system failure, glideslope wind conditions service failure and approach arrival sequence service failure so as to facilitate the required timely transition to degraded mode operations.

1 Introduction

1.1 Purpose of the document

The Operational Service and Environment Definition (OSED) describes the operational concept defined in the Detailed Operational Description (DOD) in the scope of its Operational Focus Area (OFA). It defines the operational services, their environment, use cases and requirements.

The OSED is used as the basis for assessing and establishing operational, safety, performance and interoperability requirements for the related systems further detailed in the Safety and Performance Requirements (SPR) document. The OSED identifies the operational services supported by several entities within the ATM community and includes the operational expectations of the related systems.

This OSED is a top-down refinement of the WP06.02 SESAR Airport DOD [73] produced by the federating OPS 06.02 project and of the WP05.02 SESAR TMA DOD [72] produced by the federating OPS 05.02 project. It also contains additional information which should be consolidated back into the higher level SESAR concepts using a “bottom up” approach.

The figure below presents the location of the OSED within the hierarchy of SESAR concept documents, together with the SESAR Work Package or Project responsible for their maintenance.

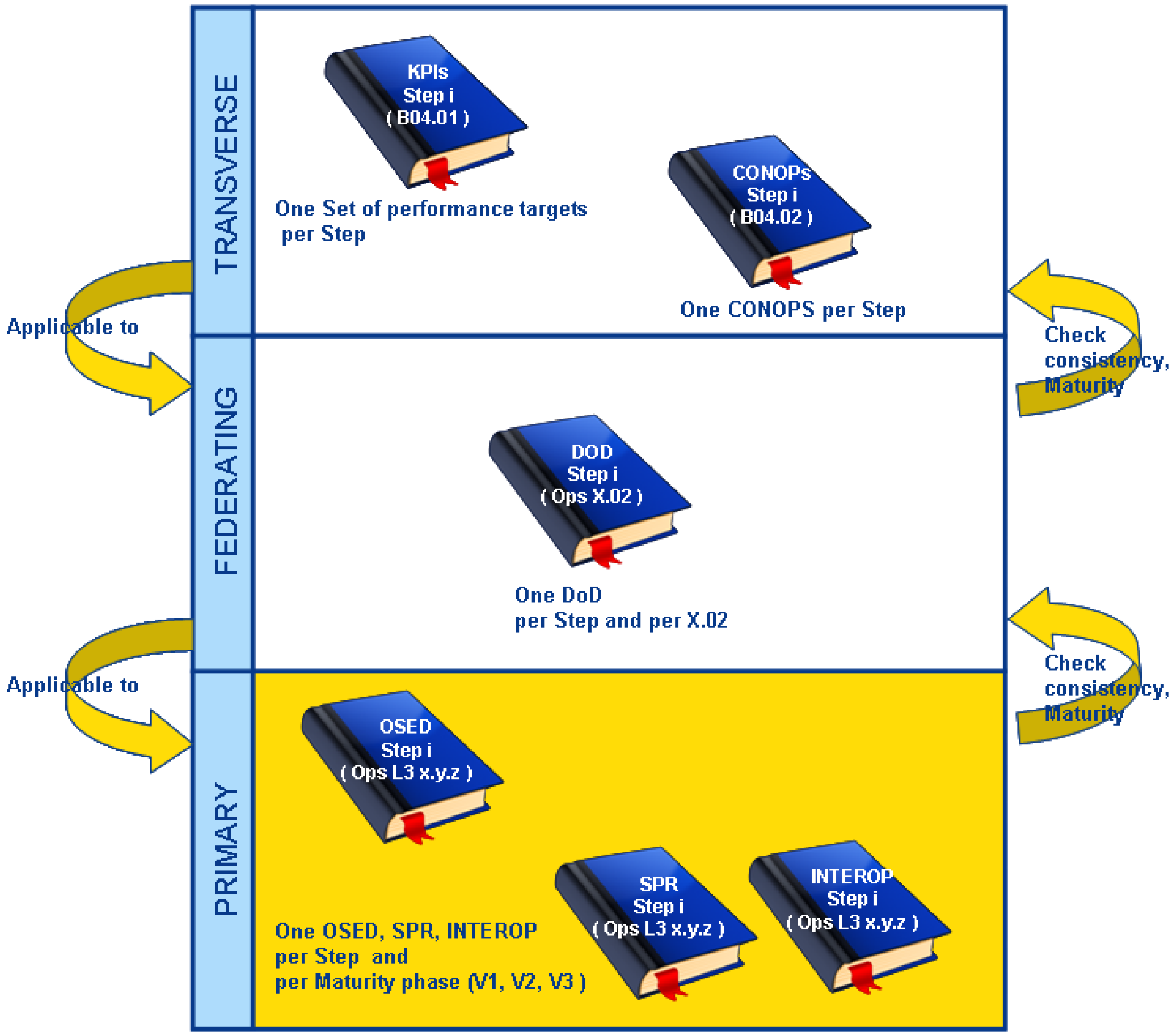


Figure 1: OSED document with regards to other SESAR deliverables

In Figure 1, the Steps are driven by the OI Steps addressed by the project in the Integrated Roadmap document.

It is expected that many updates to this OSED will be produced during the lifecycle of the P06.08.01 project execution phase.

1.2 Scope

This OSED details the operational concept for the Operational Focus Area (OFA) 01.03.01 Time Based Separation.

This OSED details the operational concept for [AO-0303]: Time Based Separation for Final Approach – Full Concept (TBS).

This is within the context of the SESAR Concept Storyboard Step 1 for Time Based Operations.

The TBS concept relates to the approach phase of the WP05.02 TMA DOD [68] and the surface-in runway phase of the WP06.02 Airport DOD [69].

This OSED is a top down refinement of the **OFA 01.03.01 – Time Based Separation** description in the WP06.02 Airport DOD [73].

1.3 Intended readership

This document is to support the TBS operational concept review activities with the operational stakeholder representatives from Approach ATC, Tower ATC, Airspace Users, ANSPs, Airport Operations and Safety Regulators.

The document is to support the system project operational concept and operational services environment review activities with the corresponding system projects P10.04.04 and P12.02.02.

This document is to support the consolidation activities within sWP06.08 and in particular with the P06.08.03 concepts reducing the separation and spacing constraints impacting final approach operations.

At a higher project level OPS 06.02 and WPB are expected to use this document as an input into the consolidation activities and the architecture and performance modelling activities respectively.

1.4 Structure of the document

The structure of the document is as follows:

- §1: (this section) introduces the document.
- §2: This section addresses what is to be developed and provides traceability to the WP05.02 TMA DOD [68] and the WP06.02 Airport DOD [69]. It details in simple terms and plain language the operational concept in the scope of the addressed OFA 01.03.01 Time Based Separation.
- §3: This section develops further the concept defined in the WP06.02 Airport DOD [69] and further summarised in section 2 of this document.
- §4: This section characterises the operational environment into which the initial TBS concept implementation is foreseen.
- §5: This section contains the relevant TMA Operational Scenarios from the WP05.02 Validation Strategy for Time Based Operations [70], the relevant Airport Operational Scenarios from the WP06.02 DOD [69] and details the TBS Operational Scenario.
- §6: This section defines the requirements.
- §7: This section lists the reference documents used in producing this document.
- Appendix A: This appendix is a placeholder for the justification of the requirements allocation.

- Appendix B: This appendix describes the TBS concept for the specimen Heathrow parallel dependent approach environment employing UK distance based separation and the associated Heathrow procedures and practices on final approach.
- Appendix C: This appendix is a placeholder for the detailed descriptions of the new information elements.

1.5 Background

The **Time Based Separation for Arrivals (TBS) concept** has been extensively evaluated refined and partially validated by EUROCONTROL and NATS since 2001 [references [16] to [66]]:

- Model based assessments have been conducted in order to quantify the risk of a wake vortex encounter associated with the use of time based separations [28].
- Model based assessments have been conducted in order to quantify the costs and benefits and the return on investment of the time based separation concept [36].
- NATS has developed, evaluated and carried out initial validation of the ATC tools that can provide for spatial visualisation of the time based separation rules to the final approach controller and Tower runway controllers [26].
- Real time simulations were conducted in order to assess the usability of time based separations by the final approach controller. These including real time simulation executed both by EUROCONTROL for the TBS project [39] [46], and by the Swedish ANSP, LFV for EC 6th FP RESET project [51].
- A detailed TBS concept of operation has been produced in cooperation with NATS [45] [49].
- An IP1 implementation project has been conducted in cooperation with NATS to assess the feasibility and options for implementing a procedural reduction of the final approach wake turbulence separations in strong head wind conditions.
- A dedicated wake turbulence and wind LIDAR measurement campaign was conducted at London Heathrow from October 2008 to December 2010 at IGE/NGE (in-ground effect / near ground effect) glideslope elevations.
- TBS user group workshops were held in NATS throughout 2010 and 2011 with Heathrow approach controllers and Tower runway controllers [50] [55] [57] [60] [64] [66] [68] [69] [70] [71].
- A human-in-the-loop real time simulation validation with Heathrow approach controllers was conducted by NATS in October 2010 [65].

The positive outcome of all of these activities has demonstrated the benefits and the operational feasibility of the concept (V2). So the first phase of the P06.08.01 started at maturity level V2 with the validation activities of P06.08.01 working towards maturity level V3.

Below is the list of validation exercises that have been performed through the V1, V2 and V3 maturity steps, including the details of the dependencies between the different validation exercises. The exercises in bold are the exercise performed by P06.08.01 [76].

Exercise ID	Title	Year	Dependent Projects
	NATS Planned Spacing Tool Project validation simulations	2004 & 2005	NATS Planned Spacing Tool Project user requirements and concept of operations developed in 2003/2004
	NATS Heathrow Landing Rate Resilience Project workshops and simulation	2004 - 2005	NATS Planned Spacing Tool concept of operations and validations simulations in 2004 & 2005

Exercise ID	Title	Year	Dependent Projects
	NATS Advanced Separation Criteria Project approach speeds behaviour analysis and modelling	2004 - 2006	
	NATS Advanced Separation Criteria Project Wake Turbulence Encounter Safety Analysis and TBS Rules and TBS Tool support proposal for Heathrow	2004 - 2005	NATS Planned Spacing Tool concept of operations and validation simulations in 2004 & 2005.
	EUROCONTROL TBS Preliminary Safety and Benefits Studies	2004 - 2005	EUROCONTROL TBS Project concept specifications developed in 2003 - 2004. NATS Advanced Separation Criteria Project TBS Rules Proposal for Heathrow in 2004 - 2005.
	EUROCONTROL EuroBen CBA Study	2005 - 2006	EUROCONTROL TBS Project Concept of Operations. NATS Advanced Separation Criteria Project TBS Rules proposal for Heathrow further developed in 2005 - 2006.
	EUROCONTROL TBS Validation Simulation	2005	EUROCONTROL TBS Project Concept of Operations and TBS Tool Specifications developed in 2004 -2005
	EUROCONTROL OPS HAZID Workshop at Heathrow	2006	EUROCONTROL TBS Project Concept of Operations and TBS Tool Specifications developed in 2005-2006. NATS Advanced Separation Criteria Project TBS Rules and TBS Tool Support proposal for Heathrow further developed in 2005 - 2006
	EUROCONTROL TBS Validation Simulation	2007	EUROCONTROL TBS Validation Simulation in 2006. EUROCONTROL TBS Concept of Operations and TBS Tool Specifications refined from the results of the EUROCONTROL TBS Validation Simulation in 2006.
	EC 6FP RESET Project TBS Validation Simulation at LFV	2008	RESET Project TBS Concept of Operations for 2020 and TBS Tool support developed with EUROCONTROL and NATS contributions.
	EC 6FP RESET Project TBS Safety and Human Factors Assessment	2008 - 2009	RESET Project TBS Concept of Operations for 2020 and the conclusions and recommendations of the RESET Project TBS Validation Simulation at LFV.

Exercise ID	Title	Year	Dependent Projects
	EUROCONTROL project Aircraft Wake Vortex Modelling in Support of the Time-Based Separation project	2007 - 2009	EUROCONTROL TBS Concept of Operations refined from the results of the EUROCONTROL TBS Validation Simulation in 2007.
	NATS/EUROCONTROL NGE/IGE LIDAR Wake Vortex Behaviour Data Collection Campaign at Heathrow	2008 - 2011	To provide NGE/IGE WV track data for the WV safety assessment.
	NATS TBS Approach Simulation	2010	NATS TBS Concept of Operations and TBS tool support based on the NATS Planned Spacing Tool fixed distance Indicator option, and the EC 6FP RESET Project TBS Tool track history option, and incorporating decisions from the NATS TBS User Group workshops in 2009 - 2010.
P06.08.01 VP-134	**OGE LIDAR Wake Vortex Behaviour Data Collection at Heathrow**	**2011 - 2013**	**To provide OGE WV track data for the WV safety assessment.**
P06.08.01 VP-303	**Heathrow TBS Approach Simulation**	**2012**	**NATS TBS Approach Simulation in 2010 incorporating the decisions from the TBS User Group Workshops in 2011.**
P06.08.01 VP-302	**Heathrow TBS Tower Simulation**	**2012**	**VP303 Heathrow TBS Approach Simulation**
P06.08.01	**WV Safety Assessment utilising the NGE/IGE and the OGE WV track data**	**2012**	**NATS/EUROCONTROL NGE/IGE LIDAR Wake Vortex Behaviour Data Collection Campaign at Heathrow. VP-134 OGE LIDAR Wake Vortex Behaviour Data Collection at Heathrow**
P06.08.01 VP-136	System Emulator Test using P10.4.4 and P12.2.2 System Prototype	TBD 2013/2014	P6.8.1 OCD & OSED for TBS P6.8.1 SPR for TBS Conclusions and Recommendations from the VP303 & VP302 Simulations

Table 1: Validation Exercise List and Dependencies

1.6 Glossary of terms

Term	Definition
Additional Spacing	The extra spacing above the required separation or spacing required to accommodate the distance spacing changes and the time spacing changes that will occur between both lead and follower aircraft establishing on the final approach localiser, until the lead aircraft crosses the runway landing threshold to touchdown.

Term	Definition
Duty Runway-In-Use	The identifier of the runway designated for in-use.
Glideslope Wind Conditions	The wind conditions profile on the final approach glideslope.
Ground Speed Profile	The evolution of the ground speed values over a defined path segment. In the context of TBS over a defined path segment on the final approach glideslope.
Final Approach	The approach path commencing at the interception of the localiser and glideslope path and ending at the runway landing threshold or a missed approach.
Final Approach Arrivals Sequence	The order intent of arrival aircraft on final approach.
Final Approach Threshold	The location on final approach to which separations for arrival aircraft are applied, e.g. the landing runway threshold for ICAO separation rules or start of landing speed stabilisation (4DME for London Heathrow).
Forecast Wind Conditions Aloft Profile	The wind conditions forecast at a specified time in the future in the form of an evolution of the wind speed and the wind direction over a defined path segment aloft. In the context of TBS over a defined path segment on final approach.
Intermediate Approach	The downwind, base and intercept approach path segments for positioning and turning on to merge on to final approach ending at the interception of the final approach localiser and glideslope.
Landing Stabilisation Speed Profile	The evolution of the indicated airspeed on final approach path from the reference position from the landing runway threshold for commencing landing speed stabilisation and ending at the runway landing threshold.
Reference Airspeed Profile	A specified evolution of the indicated airspeed over a defined path segment used as a reference speed behaviour profile. In the context of TBS the reference evolution of the IAS over a defined path segment on the final approach glideslope.
Runway Contaminants	Substances on the runway surface that impact the operational performance of aircraft on the runway.
Final approach threshold	The start of the touchdown zone on the runway.
Separation Constraint	The separation to keep aircraft operating safely on final approach. Examples are minimum radar separation to keep risk of collision to an acceptable safe level and wake turbulence radar separation to keep the risk of an adverse wake turbulence encounter to an acceptable safe level.
Spacing Constraints	The spacing required to be set on final approach for runway operations in the prevailing meteorological conditions. Examples are VIS2 spacing, LVP spacing, runway surface inspection spacing and non-nominal runway occupancy spacing.

Term	Definition
Spacing Minimum Pairs	Arrival pairs with no wake turbulence separation constraint which can be separated by the minimum separation or spacing constraint on final approach.
Spacing Practice	The practice of the final approach controller for managing the uncertainties in the changing distance spacing and time spacing between each arrival pair on the final approach glideslope such that the required Separation Constraints and Spacing Constraints are observed.
Standard Procedural Air Speed Profile	The reference airspeed profile resulting from standard practice application of the controller speed control instructions. In the context of TBS the standard practice application of the controller speed control instruction on intermediate approach and final approach up to the start of landing speed stabilisation.
TBS Distance	The TBS distance is the distance separation equivalent of the TBS rules in the prevailing wind conditions on final approach for displaying to the final approach controller and the tower runway controller. The TBS rules are converted to the TBS distance by applying the reference airspeed profile to the final approach threshold that was used to derive the TBS rules. The reference airspeed profile is to be applied in the context of the final approach wind conditions on the glideslope that the lead aircraft is forecast to experience over the distance separation to the final approach threshold.
TBS Rules	The time based wake turbulence radar separation rules on final approach derived from the distance based wake turbulence separation rules. The TBS rules are based on a ground speed profile conversion from applying the DBS rules in low headwind conditions. The ground speed profile conversion is based on a reference airspeed profile over the distance based separation to the final approach threshold. The TBS rules are the reference time separations that apply for the reference airspeed profile For example for the ICAO DBS rules where the final approach threshold is the runway landing threshold; the reference airspeed profile is aligned to a 150kt IAS standard reference landing stabilisation speed profile to the runway landing threshold and is aligned to a 170kt IAS standard procedural airspeed profile to 6Nm from the runway landing threshold prior to landing speed stabilisation.
Wind Conditions Profile	The evolution of the wind speed and wind direction over a defined path segment. In the context of TBS over defined path segments of the final approach glideslope.

1.7 Acronyms and Terminology

Term	Definition
4DME	4Nm from the runway landing threshold (The DME zero datum for final approach)

Term	Definition
A/G	Air/Ground
A-CDM	Airport Collaborative Decision Making
A-RNP	Advanced Required Navigational Performance
A-SMGCS	Advanced Surface Movement Guidance and Control System
aal	above aerodrome level
Ac	Aircraft
ACC	Area Control Centre
ACK	Acknowledgement
ADS-B	Automatic Dependent Surveillance - Broadcast
AFTN	Aeronautical Fixed Telecommunications Network
AIBT	Actual In Block Time
AIP	Aeronautical Information Publication
ALDT	Actual Landing Time
AMAN	Arrival Manager (System)
ANSP	Air Navigation Service Provider
AOC	Airline Operations Centre
AOP	Airport Operations
APP	Approach
APV	Approach Procedures with Vertical Guidance
ASAS	Airborne Separation Assistance Systems
ATC	Air Traffic Control
ATFCM	Air Traffic Flow and Capacity Management
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Services
BT	Business Trajectory
BTV	Brake to Vacate

Term	Definition
CAT A	Medical flights that are in conflict with the final approach glideslope at Heathrow
CAT B	Police flights that are in conflict with the final approach glideslope at Heathrow
CAVOK	Ceiling and Visibility OK
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CFFT	Controlled Flight Towards Terrain
CSPR	Closely Spaced Parallel Runways
CTA	Controlled Time of Arrival
CWP	Controller Working Position
D-ATIS	Digital service ATIS
DBS	Distance Based Separation
DCT	Direct Routing
DMAN	Departure Manager (System)
DME	Distance Measurement Equipment
DOD	Detailed Operational Description
E-AMAN	Extended AMAN
EC 6th FP	European Commission 6th Framework Project
ECAC	European Civil Aviation Conference
ENR	Enroute
ETA	Estimated Time of Arrival
FAF	Final Approach Fix
FAP	Final Approach Point
FIN	Final Approach Controller
FL	Flight Level
FMS	Flight Management System
G/G	Ground/Ground

Term	Definition
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GS	Ground Speed
H/H	High Density/High Complexity
HAZID	Hazard Identification
HF	Human Factors
HIL	Human-in-the-loop
HMI	Human Machine Interface
HWS	Headwind component Speed
i4D	Initial 4-Dimensional Trajectory
IAF	Initial Approach Fix
IAS	Indicated Air Speed
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
IMC	Instrument Mode Conditions
INTEROP	Interoperability
IP1	Implementation Period 1
KPA	Key Performance Area
KPI	Key Performance Indicator
kt or kts	Knots (Nautical Miles per Hour)
LIDAR	Light Detecting and Ranging (system)
LFV	Swedish ANSP
LVC	Low Visibility Conditions
LVP	Low Visibility Procedures
M/M	Medium Density/Medium Complexity

Term	Definition
MATS	Manual of Air Traffic Services
MAYDAY	International distress signal in R/T voice procedure used to signal a life-threatening emergency and requesting immediate assistance; derived from the French *venez **m'aider***, which means "come help me"
METAR	Meteorological Aerodrome Report
MLS	Microwave Landing System
MTOW	Maximum Take-Off Weight
NATS	UK ANSP
NDB	Non Directional Radio Beacon
Nm	Nautical Mile
NOP	Network Operations Plan
NOTAM	Notice to Airmen
OCD	Operational Concept Description
OFA	Operational Focus Area
OI	Operational Improvement
OM	Outer Marker
OS	Operational Scenario
OSED	Operational Service and Environment Definition
P&S	Processes & Services
PAN PAN	International distress signal in R/T voice procedures used to signal urgency on board but no immediate danger to life or to the vessel; derived from the French word ***panne,*** nominally referring to a mechanical failure or breakdown.
PANS	Procedures for Air Navigation Services
PBN	Performance Based Navigation
PI	Performance Indicator
PSR	Primary Surveillance Radar
PWS	Pair Wise Separation
R/T/RT	Radio Telephony/Radio Telephone
RECAT2	Re-categorisation Phase 2

Term	Definition
RECAT Europe	Re-categorisation Phase 1 for Europe
RESET	EC 6th FP Reduced Separation Minimum project
REQ	Requirement
RNAV	Area Navigation
RNP	Required Navigational Performance
ROT	Runway Occupancy Time
RTS	Real-Time Simulation
RVR	Runway Visual Range
SARPS	Standards and Recommended Practices
SBT	Shared Business Trajectory
SEMP	System Engineering Management Plan
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
SL2	Service Level 2
SJU	SESAR Joint Undertaking
SM	Spacing Minimum
SNOWTAM	Special series NOTAM notifying the presence or removal of hazardous conditions
SPR	Safety and Performance Requirements
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
SUP	Supervisor
T	Tonnes (1,000kg)
TAS	True Air Speed
TBS	Time Based Separation (for Arrivals)
TLDT	Target Landing Time
TMA	Terminal Manoeuvring Area/Terminal Movement Area

Term	Definition
TP	Trajectory Predictor
TTA	Target Time of Arrival
TTG	Time to Gain
TTL	Time to Lose
TTOT	Target Take-Off Time
TWR	Tower
UC	Use Case
UK	United Kingdom
VIS2	Visibility Conditions 2 Procedures
VMC	Visual Mode Conditions
VNAV	Vertical Navigation
VOR	Very High Frequency Omni-Directional Radio Range
WDS	Weather Dependent Separation
WT	Wake Turbulence
WTE/WVE	Wake Turbulence Encounter/Wake Vortex Encounter

2 Summary of Operational Concept from DOD

2.1 Mapping tables

This section contains the link with the relevant DOD, scenarios and use cases, environment, processes and services relevant for this particular OSED.

The following tables shall be coherent with the related WP06.02 Airport DOD Step 1 [73] and the WP05.02 TMA Step 1 DOD [72].

Table 2 lists the Operational Improvement steps (OIs from the definition phase or new OIs) within the associated Operational Focus Area addressed by the OSED.

Relevant OI Steps ref. (coming from the Integrated Roadmap)	Operational Focus Area name / identifier	Story Board Step	Master or Contributing (M or C)	Contribution to the OIs short description
OFA 01.03.01: AO 0303: Time Based Separation for Final Approach - Full Concept	Time Based Separation	1	M	OSED preparation in co-operation with other primary projects and OI validation

Table 2: List of relevant OIs within the OFA

Table 3 identifies the link with the applicable scenarios and use cases of the DOD.

Scenario identification	Use Case Identification	Reference to DOD section where it is described
Implement TMA/APP in H/H environment, ground solution	TMA Sub scenario 1	TMA Step 1 DOD Section 4.4 [72]
Implement TMA/APP in H/H environment, air solution	TMA Sub scenario 2	TMA Step 1 DOD Section 4.5 [72]
Implement TMA/APP in M/M environment, ground solution	TMA Sub scenario 3	TMA Step 1 DOD Section 4.6 [72]
Implement TMA/APP in M/M environment, air solution	TMA Sub scenario 4	TMA Step 1 DOD Section 4.7 [72]
Surface In	Landing General (UC 6 15)	Airport DOD Step 1 Section 4.6.2.2 [73]

Table 3: List of relevant DOD Scenarios and Use Cases

Table 4 identifies the link with the applicable environments of the DOD.

Operational Environment	Class of environment	Reference to DOD section where it is described
TMA Characterisation	1: Environmentally Constrained TMA 2: Airspace Constrained TMA 3: Traffic Volume and Variation Constrained TMA 4: Airfield Interaction Constrained TMA 5: ATC Staff or Equipment Constrained TMA	TMA Step 1 DOD Section 3.1 [72]

Operational Environment	Class of environment	Reference to DOD section where it is described
Network Function	1: Intercontinental Hub 2: European Hub 3: Primary Node 4: Secondary Node	Airport DOD Step 1 Section 3.1.1.1 [73]
Layout & Basic Operational Criteria	1: Multiple Independent Runways, complex surface layout 2: Multiple Dependent Runways, complex surface layout 3: Single Runway, complex surface layout 4: Multiple Independent Runways, non-complex surface layout 5: Multiple Dependent Runways, non-complex surface layout 6: Single Runway, non-complex surface layout	Airport DOD Step 1 Section 3.1.1.2 [73]
Capacity Utilisation	1: Highly utilised airports/runways, traffic mix of heavy, medium and light aircraft. More than 90% load during 3 or more peak periods a day. 2: Highly utilised airports/runways, homogeneous traffic (dominant heavy or medium or light). More than 90% load during 3 or more peak periods a day 3: Normally utilised airports/runways. 70 – 90% load during 1 or 2 peak periods a day	Airport DOD Step 1 Section 3.1.1.3 [73]
External Influencing Factors	1: Highly Constrained (Geographical / Weather issues) 2: Highly Constrained (Political / Community issues) 3: Moderately Constrained (both Geographical / Weather and Political / Community)	Airport DOD Step 1 Section 3.1.1.4 [73]

Table 4: List of relevant DOD Environments

Table 5 identifies the link with the applicable Operational Processes and Services defined in the DOD.

DOD Process / Service Title	Process/ Service identification	Process/ Service short description	Reference to DOD section where it is described
Balance Demand and Capacity	5.2.2.1 Balance Demand and Capacity	Measures (from long term to short term) allowing ATS to manage a complex and dense TMA environment	TMA Step 1 DOD Section 5.2.2.1 [72]

DOD Process / Service Title	Process/ Service identification	Process/ Service short description	Reference to DOD section where it is described
Plan Arrival Sequence	5.2.2.3.1 Plan Arrival Sequence	Arrival sequences planning and synchronisation activities starting during the En-Route phase and strongly linked to airport operations through AMAN/DMAN coordination	TMA Step 1 DOD Section 5.2.2.3.1 [72]
Execute Descent	5.2.2.2.1 Execute Descent	During the descent, several possibilities are offered to the controller to separate the aircraft and optimize the traffic flow.	TMA Step 1 DOD Section 5.2.2.2.1 [72]
Monitor Traffic	5.2.2.2.3 Monitor Traffic	The "Monitor traffic" sub-process is part of the "Execute Trajectory" process as a routine activity of the controller. It corresponds to the trajectory conformance monitoring and to the conflict detection activities of the ATS.	TMA Step 1 DOD Section 5.2.2.2.3 [72]
Airport Long Term Planning	5.2.1 Airport Long Term planning process	The processes occurring at the airport level during the long-term planning phase and the relevant interactions among airport actors.	Airport DOD Step 1 Section 5.2.1 [73]
Airport Medium / Short Term Planning	5.2.2 Airport Medium / Short Term planning process	Overview of all the planning activities required for the continuous refinement of the AOP during the Medium/Short Term Planning Phase	Airport DOD Step 1 Section 5.2.2 [73]

DOD Process / Service Title	Process/ Service identification	Process/ Service short description	Reference to DOD section where it is described
Surface-in	5.2.5 Surface-in process	The processes and interactions that an aircraft encounters from the time when the Flight Crew lands the aircraft (wheels on ground; CDM milestone: ALDT) until the aircraft arrives in-block at the parking stand	Airport DOD Step 1 Section 5.2.5 [73]
Post-Operations Analysis	5.2.6 Post-Operations Analysis process	Means to capture performance based information to examine if agreed local performance targets have been achieved and to provide feed-back to the planning (both mid and short term) as well to the actual operations, enabling a learning cycle	Airport DOD Step 1 Section 5.2.6 [73]

Table 5: List of relevant DOD Processes and Services

Table 6 summarizes the Requirements including Performance (KPA related) requirements relevant of the OSED. This table supports defining the performance objectives in the scope of the addressed OFA. The DOD performance requirements are structured to respond to Key Performance Indicators (PI) targets / decomposed PIs, so this table will support traceability to the performance framework.

DOD Requirement Identification	DOD requirement title	Reference to DOD section where it is described
REQ-05.02-DOD-ENV1.0001	OFA “Time Based Separation” shall deliver a 5% reduction in fuel burn per flight in the TMA arrival phase of flight	TMA Step 1 DOD Section 6.3.2 [72]
REQ-05.02-DOD-CAP1.0002	OFA “Time Based Separation” shall deliver a 2.5% increase in capacity in respect to Improved Separation Management TMA.	TMA Step 1 DOD Section 6.3.3 [72]
REQ-05.02-DOD-CEF1.0002	OFA “Time Based Separation” shall deliver a 2.5% improvement in predictability in respect to TWR APP Controller Productivity.	TMA Step 1 DOD Section 6.3.4 [72]
REQ-05.02-DOD-PRE1.0004	OFA “Time Based Separation” shall deliver a 5.0% improvement in predictability in the TMA Arrival phase.	TMA Step 1 DOD Section 6.3.5 [72]

DOD Requirement Identification	DOD requirement title	Reference to DOD section where it is described
REQ-06.02-DOD-6200.0015	The final approach controller and the Tower runway controller shall be able to use reduced aircraft separations using consistent and accurate TBS (time based wake turbulence radar separation) rules on final approach.	Airport DOD Step 1 Section 6.1 [73]
REQ-06.02-DOD-6200.0055	The pilot shall be provided with easy access to the widest possible range of meteorological and operational information derived from ATIS, METAR and NOTAMs/SNOWTAMs, specifically relevant to the departure, approach and landing flight phases to support the decision making process .	Airport DOD Step 1 Section 6.1 [73]

Table 6: List of the relevant DOD Requirements

2.2 Operational Concept Description

2.2.1 Summary of TBS Concept

The WP06.02 Airport DOD Step 1 [73] has the following summary information on the TBS concept:

OFA 01.03.01 – Time Based Separation

> The application of time based wake turbulence radar separation rules on final approach (TBS), so as to aid towards stabilising the overall time spacing between arrival aircraft. The final approach controller and the Tower runway controller are to be provided with the necessary TBS tool support to enable consistent and accurate delivery to the TBS rules on final approach. The minimum radar separation and runway related spacing constraints will be required to be respected when applying the TBS rules. **[AO-0303]**

The summary of the operational concept in this section reflects the TBS concept development and validation activities conducted by NATS and EUROCONTROL and updated as a result of the validation and transversal assessment activities conducted in phase 1 of P06.08.01 from May 2010 to March 2013 [75] [77] [78] [79] [80].

This section provides a brief description of the TBS concept including how the TBS operational concept is proposed to be integrated with all of the other separation and spacing constraints of final approach operations.

Section 3.2 describes in detail the concept and the associated system support requirements in the context of European Generic Approach Environments employing standard ICAO distance based separation and associated procedures and practices on final approach.

2.2.1.1 Time Based Separation Concept Proposal

The TBS Concept involves changing the separation rules on final approach from distance based separations to time based separations. There is a need to facilitate delivery to time based separation constraints by the final approach and tower controllers. This is achieved through the provision of separation indicators displayed on the extended runway centre-line of the final approach controller radar display and the tower runway controller air traffic monitor display, and changing the controller separation/spacing procedures to take into account the use of the separation indicators in supporting the arrival delivery on final approach.

The TBS operational concept applies on final approach, from when both the lead and follower aircraft establish on the final approach localiser, until the lead aircraft crosses the runway landing threshold to touchdown.

The time based separation concept proposal is to apply time based wake turbulence radar separation rules on final approach, so as to aid towards stabilising the overall time spacing between arrival aircraft across the headwind conditions experienced on final approach. This will partially recover the reduction in achieved arrival capacity currently experienced when applying distance based wake turbulence radar separation rules in the headwind conditions experienced on final approach. The amount of recovery is dependent on the other surveillance and runway operations separation and spacing constraints.

The final approach controller and the tower runway controller are to be provided with the necessary TBS tool support to enable consistent and accurate delivery and monitoring to time based wake turbulence radar separation rules on final approach. A separation indicator is to be displayed on the extended runway centre-line of final approach of the separation or spacing required behind the lead aircraft of each arrival pair as a separation or spacing reference for the follower aircraft.

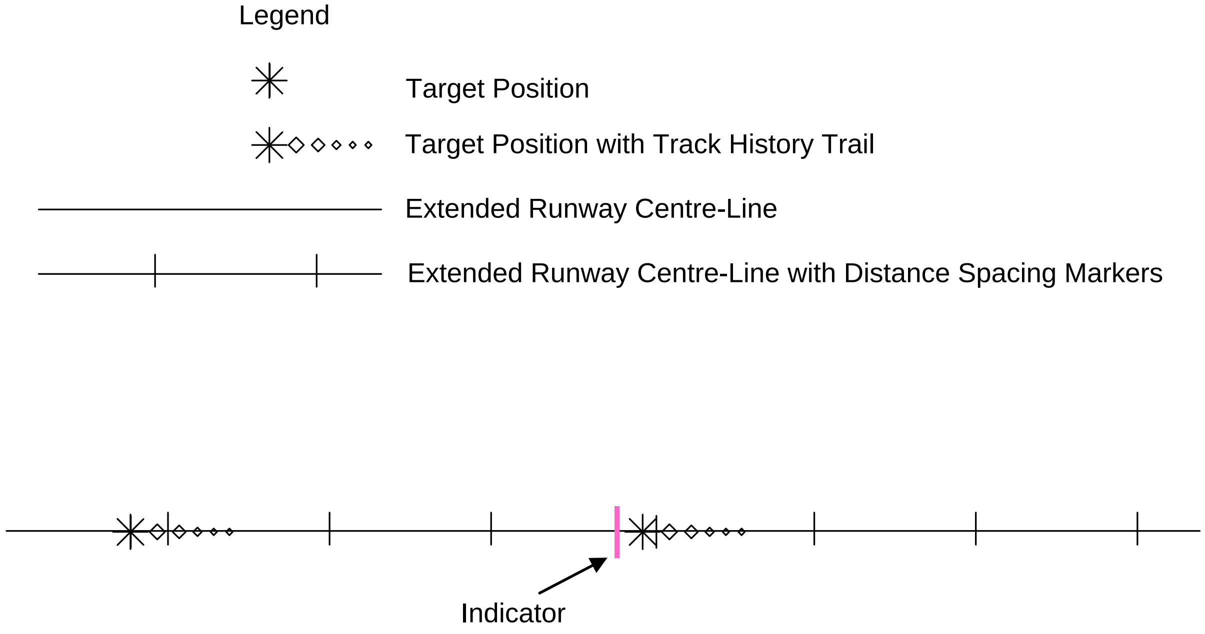


Figure 2: Separation Indicator of the Separation or Spacing required behind the Lead Aircraft

The final approach controller and the tower runway controller remain responsible for monitoring for separation infringement and for timely intervention action. There is a significant potential for separation infringement scenarios on final approach because of the diversity of approach speed profiles being employed and the resulting uncertainties about the amount of distance spacing change and time spacing change that will be experienced between each arrival pair on final approach.

The final approach controller and the flight deck will be required to adopt procedures and practices to ensure that the variations in the distance spacing changes and time spacing changes on final approach are consistently managed.

2.2.1.2 Time Based Wake Turbulence Radar Separation Rules

The time based wake turbulence radar separation rules (TBS rules) are derived from the distance based wake turbulence radar separation rules (DBS rules) in wind conditions when the achieved arrival capacity with the DBS rules are currently acceptable to busy capacity constrained aerodrome operations. From operational experience this is in low headwind conditions.

A complication is the diversity of airspeed profiles flown on final approach, both the procedural airspeed profiles prior to landing speed stabilisation, and the airspeed profiles employed during landing speed stabilisation in relation to the aircraft type, landing weight and other factors.

To manage this complication a reference airspeed profile is used to establish reference time based separations in the reference low headwind conditions. The TBS rules are to be based on a ground speed profile conversion from applying the DBS rules in the reference low headwind conditions. The ground speed profile conversion will be based on a reference airspeed profile over the distance based separation to the final approach threshold that the local DBS rules are applied. The TBS rules are the reference time separations that apply for the chosen reference airspeed profile.

A variety of local procedural airspeed profiles are employed on final approach as illustrated for the specimen final approach segment in figure 30 in §4.1.1.4. These are typically between 220kts and 160kts on joining the final approach localiser, reducing to between 180kts and 160kts to the start of landing speed stabilisation, with landing speed stabilisation starting from between 6Nm and 4Nm from the runway landing threshold.

The landing stabilisation speed profiles, starting from around 6Nm to 4Nm from the runway landing threshold until touchdown, vary considerably depending on aircraft type, landing weight, stabilisation altitude, stabilisation mode, and the associated airline operator cockpit procedures. The range of stabilisation airspeeds varies from under 100kts for some Light wake category aircraft types to over 160kts for some Heavy wake category aircraft types.

In the reference low headwind conditions the time to fly the distance based separation of the DBS rules is dependent on which portion of final approach the DBS rules are being applied, on what procedural airspeed profile is being employed, and on what landing stabilisation speed profile is being employed. It is also dependent on the impact of runway elevation above sea level, and the glideslope angle, on the relationship between the IAS and TAS profiles on the final approach glideslope.

The low headwind conditions proposed is a minimum of 5kts in order to provide additional spacing in the low, still and tail wind conditions in which pilot reported wake turbulence encounters are most prevalent for distance based separations. This is a minimum of a 5kts average headwind on the glideslope over the DBS to the final approach threshold that the local DBS rules are applied.

The reference airspeed profile is to be representative of the local airspeed procedures of the aerodrome. For the generic concept a reference landing stabilisation airspeed of 150kts IAS is proposed. The impact of the runway elevation and glideslope angle on the true airspeed profile and resulting ground speed profile is to be taken into account when establishing the reference time based separations.

The ground speed profile conversion will be based on the local reference airspeed profile over the distance based separation to the final approach threshold that the DBS rules are applied.

2.2.1.3 Calculating the TBS Distance

The TBS distance is the distance separation equivalent of the TBS rules in the prevailing wind conditions on final approach for displaying to the final approach controller and the tower runway controller. The TBS distance is to be applied in same way as the DBS is applied on final approach as a stable distance separation equivalent of the TBS rules independent of the actual airspeed and ground speed profiles of the lead aircraft or follower aircraft on final approach.

The TBS rules are converted to the TBS distance by applying the chosen reference airspeed profile to the final approach threshold that was used to derive the reference time separations of the TBS rules. The reference airspeed profile is to be applied in the context of the final approach wind conditions on the glideslope that the follower aircraft is forecast to experience over the distance separation to the final approach threshold that the local TBS rules are to be applied.

The reference airspeed profile is applied to the prevailing glideslope wind conditions to calculate the TBS distance to be displayed by the separation indicator. The actual airspeed profile of the follower aircraft under TBS will still vary, but only in the same way that it varies under DBS today. Therefore, the variation in time spacing under TBS will be no different to that under DBS in the reference low wind conditions, and for TBS this time spacing for a particular airspeed profile is stabilised across headwind conditions. In this way the diversity of airspeed profiles employed on final approach is accommodated without the need to explicitly take into account the airspeed profile intent of the aircraft.

This will result in the TBS distance changing as the final approach wind conditions on the glideslope change over the distance separation to the final approach threshold that the local TBS rules are to be applied. The TBS distance in comparison to the DBS reduces as headwind conditions increase above the reference low headwind conditions for deriving the TBS rules, is the same as the DBS in the reference low headwind conditions, and increases in still and tailwind conditions over the TBS to the final approach threshold that the local TBS rules are to be applied; as illustrated in figure 3.

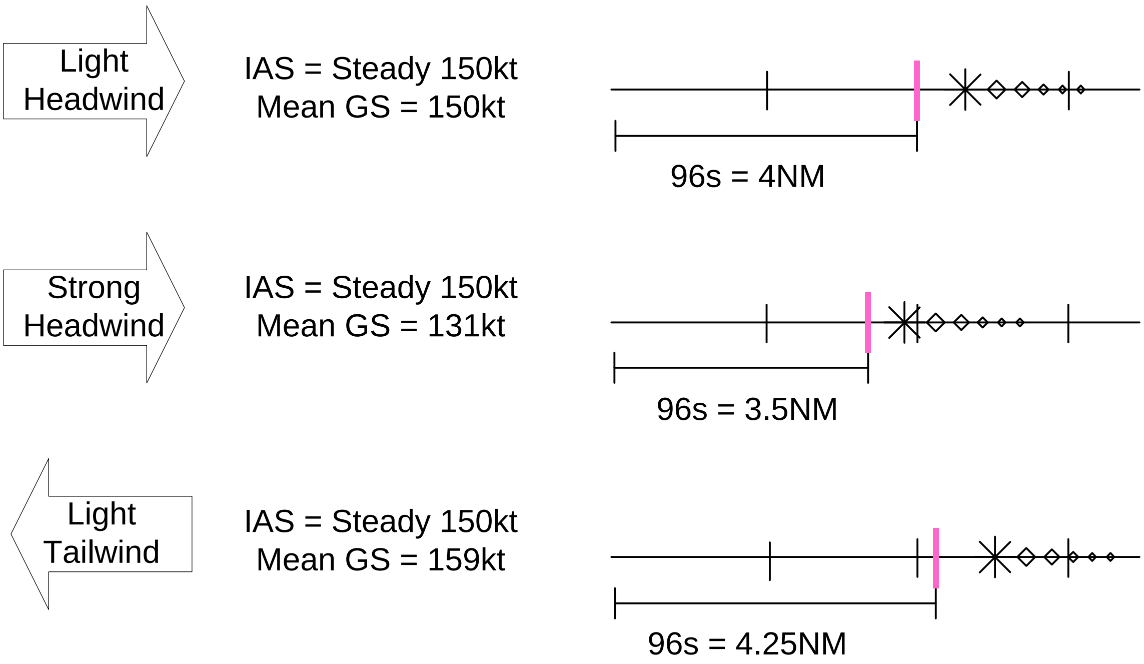


Figure 3: Variation of the Distance Separation of the TBS with Headwind Conditions

The TBS distance is to be applied from the follower aircraft merging on to final approach until the lead aircraft crosses the final approach threshold in the same way as for distance based separation.

The separation indicator is required to be first displayed to the final approach controller while the follower aircraft is on intermediate approach, before the turn on decisions that sets up the initial distance spacing on merging on to final approach. This may be over 20Nm to 25Nm flying distance to the runway landing threshold or up to over 7 to 10 minutes flying time to the runway landing threshold.

The final approach glideslope wind conditions that the follower aircraft is forecast to experience is the wind conditions at the time the follower aircraft is predicted to fly the separation to the final approach threshold that the local TBS rules are to be applied.

The latest measured wind conditions on the glideslope over the distance separation to the final approach threshold, from a wind profiler, or from the last aircraft to fly final approach to the final approach threshold in pressured traffic, may sufficiently represent the wind conditions in stable wind conditions.

In changing wind conditions, either some contingency provision for the changing wind conditions, or forecast wind conditions, may be required, dependent on the potential impact on the wake turbulence encounter risk. The results from the LIDAR data analysis [75] indicate that the probability of vortex persistence under TBS rules decreases as wind strength increases which may be sufficient contingency provision subject to safety analysis.

2.2.1.4 Harmonisation with Other Separation and Spacing Constraints on Final Approach

The time based wake turbulence separation rules (TBS rules) and the TBS distances are required to be applied in the context of all of the other separation and spacing constraints on final approach. These include (but are not limited to):

- The minimum radar separation constraints.
- The runway spacing constraints appropriate for the runway visual conditions.
- The runway spacing constraints appropriate for the runway surface braking conditions and exit taxiway serviceability.
- The scenario specific spacing requirements such as for a runway inspection or for accommodating conflicting or crossing traffic.
- The interlaced departure gap spacing for interlaced mode operations.

These other surveillance separation and runway operations spacing constraints need to be taken into account alongside the dynamically calculated TBS distance.

The other surveillance separation and runway operations spacing constraints that are to be applied at any time are normally determined by the Tower Supervisor in coordination with the Approach Supervisor. This information is required to be provided electronically to the TBS tool. In some situations the surveillance separation and runway operations spacing may need to be tactically changed through coordination between the Tower Runway Controller and the Final Approach Controller.

The minimum separation or spacing to be set up on final approach is required to be at least that of the maximum separation or spacing constraint that is required to be applied.

The separation indicator position is required to clearly reflect the maximum separation or spacing constraint to be applied between the arrival pair.

2.2.1.5 Management of the Other Separation and Spacing Constraints on Final Approach

In order to be able to calculate the minimum separation or spacing that needs to be set up between each arrival aircraft on final approach there is a need for the other surveillance separation and runway operations spacing constraints to be specified and maintained through, for example, a separation / spacing mode tool.

The Tower Supervisor in coordination with the Approach Supervisor is normally required to specify and maintain the other separation and spacing constraints. In some situations the surveillance separation and runway operations spacing constraints may need to be tactically changed through coordination between the Tower Runway Controller and the Final Approach Controller.

2.2.1.6 Establishing the Required Separation or Spacing between each Arrival Pair

All of the final approach separation and spacing constraints need to be taken into account when establishing the minimum required separation or spacing between each arrival pair. The other surveillance separation and runway operations spacing constraints need to be taken into account alongside the dynamically calculated TBS distance.

There is a need for the provision of a reliable final approach arrival sequence order. Additionally for the multiple runway operational layouts of closely spaced and dependent parallel runway operations there is a need for the provision of reliable landing runway intent for each arrival aircraft. This is so as to be able to establish the minimum required separation for both in-trail arrival pairs established on the same final approach localiser and not-in-trail arrival pairs established on separate parallel localisers. This could be the AMAN sequence order with landing runway intent with the incorporation of late sequence order and landing runway intent changes.

For interlaced mode operations, there is the additional need for the provision of reliable information on the departure gaps required to be interlaced into the approach arrival sequence order. The departure demand could be provided from the DMAN sequence, with the departure demand being integrated into the Approach Arrivals Sequence through the automatic population of the departure gap demand.

2.2.1.7 TBS Tools Support for Visualisation of the Required Separation or Spacing

To provide for the consistent and accurate delivery and monitoring to time based wake turbulence separation rules the final approach controller and tower runway controller require visualisation of the TBS distance separation of the TBS rules. This is to at least a distance separation step resolution of 0.1Nm.

Current workstation facilities support consistent and accurate spacing delivery to the DBS rules which are defined to a step resolution of 1.0Nm for wake turbulence radar separation and 0.5Nm for the minimum radar separation. Extended runway centre-line distance markings are provided on the surveillance display of the approach controllers and the air traffic monitor display of the tower runway controller of the distance to touchdown in 2Nm and sometimes 1Nm steps as illustrated in figure 4.

Figure 4: Illustration of Displayed Extended Runway Centre-Line Distance Markings

To facilitate the visualisation of the TBS distance, to the required resolution of the converted TBS rules, a separation indicator is to be displayed on the final approach centre-line, behind the lead aircraft target position on the radar display as a visual separation reference to the follower aircraft. This is illustrated for in-trail follower aircraft in figure 5.

Figure 5: Illustration of Separation Indicator Visualisation of the TBS Distance behind each Lead Aircraft

For not-in-trail follower aircraft establishing on a different runway localiser the separation indicator is to be displayed on the extended runway centre-line of the landing runway of the follower aircraft. This is illustrated for parallel runway operations in the figure 6.

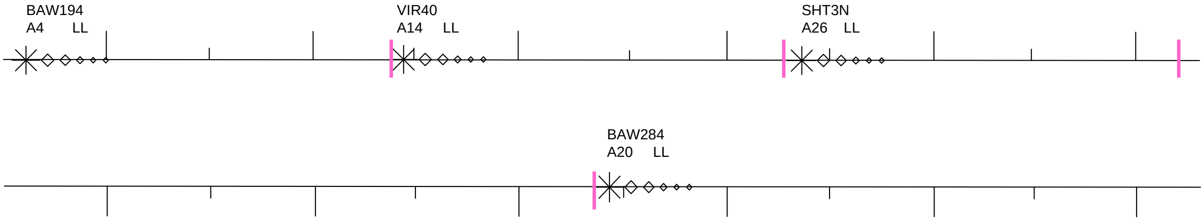


Figure 6: Separation Indicator Visualisation for Not-In-Trail Aircraft in Parallel Runway Operations

The separation indicator position is required to clearly reflect the maximum separation or spacing constraint that is required to be applied between the arrival pair.

The separation indicator position is to be updated in synchronisation with the track position updates of the lead and follower aircraft in order to provide for a stable visual reference of the applicable separation or spacing constraint.

The final approach controller requires a visual reference of the required separation or spacing constraint when setting up and refining the spacing when turning aircraft on from intermediate approach and establishing on the final approach localiser.

The final approach controller and the tower runway controller require a visual reference of the required separation or spacing constraint when monitoring for separation infringement as the arrivals descend on the final approach glideslope to the runway landing threshold.

The separation indicator is usually to be removed when the lead aircraft crosses the runway landing threshold to touchdown or the lead aircraft target position is removed from the radar display.

The tower runway controller may require selective removal of the separation indicators between spacing minimum pairs as the lead aircraft crosses 4DME with just the separation indicators for wake pairs requiring to be displayed until the lead aircraft crosses the runway landing threshold. This is subject to local preferences.

For large spacing gaps (e.g. runway inspection gaps of 12Nm to 15Nm) there may be a requirement to support the displaying of the separation indicator after the lead aircraft has crossed the runway landing threshold and been removed from the radar display. This is in order to provide separation indicator support until the follower aircraft has established on final approach.

The separation indicators associated with a missed approach aircraft are to be removed when the aircraft is automatically tracked on to the missed approach.

2.2.1.8 Final Approach Spacing Practice

The final approach controller is required to set up and refine the distance spacing on establishing on the final approach localiser such that the required separation or spacing constraints are observed on final approach to the runway landing threshold.

The separation indicator is required to display a stable distance separation of the separation or spacing constraint that is required to be observed by the follower aircraft. The final approach controller is required to set up distance spacing with the additional spacing required to accommodate the anticipated distance spacing changes that will occur between the follower aircraft establishing on the final approach localiser, until the lead aircraft crosses the runway landing threshold to touchdown.

The follower aircraft is to be turned on in the zone behind the separation indicator with sufficient additional spacing for the distance spacing compression expected to be experienced in the prevailing glideslope wind conditions for the anticipated airspeed profiles of both the lead aircraft and the follower aircraft. Ideally, sufficient spacing is set up by the final approach controller such that there is no need for further intervention action. In the event of unanticipated distance compression the final approach controller and the tower runway controller are required to take active steps to preserve the separation and to recover separation when infringed.

There is a need to ensure the efficiency of the final approach spacing practice with respect to the additional spacing applied with the separation indicator. This efficiency is impacted by the amount of uncertainty about the intended landing stabilisation speed profiles of the respective lead and follower aircraft.

It has been proposed that the flight deck inform Approach ATC of their intended landing stabilisation speed on first call to Approach ATC so as to enable the application of more consistent and efficient final approach spacing practice by the final approach controller. The R/T and workload consequences are such that in the short term the current procedure with DBS is proposed to be taken forward for the initial deployment. The current DBS procedures consist of applying the approach controller on on-the-job training and experience, supplemented with the ad-hoc flight crew reporting when there is the intention to employ an exceptional landing stabilisation speed.

In phase 2 of P06.08.01 the requirements for Optimised Runway Delivery are being investigated with the objective of extending the scope of the TBS tool support to include advice on the additional spacing required between each arrival pair taking into account their respective landing stabilisation speed profile intentions or characteristics.

The final approach controller and the tower runway controller remain responsible for monitoring for separation infringement and for timely intervention action.

There is a significant potential for separation infringement scenarios on final approach because of the diversity of approach speed profiles being employed and the resulting uncertainties about the amount of distance spacing change and time spacing change that will be experienced between each arrival pair on final approach.

2.2.1.9 Airspace User Considerations

An important objective of the development of the TBS Concept is to have a minimum impact on airspace users and airframe equipage so as to facilitate early deployment.

Easy to assimilate multi-media awareness briefing material is required to enable flight crews to be aware of the principles of TBS and what to expect in terms of the separation on final approach. This would be used in the pre-departure briefing and the top of descent briefing.

Notification is required that TBS is being employed on final approach through the terminal information service (D-ATIS) which may need to include the related prevailing wind conditions on final approach.

It has been proposed that the flight deck inform Approach ATC of their intended landing stabilisation speed on first call to Approach ATC so as to enable the application of more consistent and efficient final approach spacing practice by the final approach controller. The R/T and workload consequences are such that in the short term the current procedure with DBS is proposed to be taken forward for the initial deployment. The current DBS procedures consist of applying the approach controller on on-the-job training and experience, supplemented with the ad-hoc flight crew reporting when there is the intention to employ an exceptional landing stabilisation speed for the aircraft type.

The flight deck may need to be able to monitor that the spacing being set up on final approach is appropriate for the reported prevailing wind conditions. A simple procedure may be required for establishing the distance spacing for the TBS rules.

The cautionary wake vortex advisory phraseology may require to be modified so as to be able to be employed with the TBS Concept.

2.2.1.10 Safety Mitigation Elements for the TBS Concept

The SESAR P06.08.01 Safety Assessment [78] and Human Performance Assessment [79] have identified a number of safety mitigation elements associated with the causal factors and outcomes of the identified Hazards resulting from the provision and use of separation indicators.

Note that the mitigations identified are proposals for ways in which associated risk could be managed, without risk classification or analysis to determine which ones are absolutely necessary. Further assessment is needed during V4 and V5 maturity validation activities to determine which subset of proposed mitigations will be required.

It is imperative that the sequence and separation / spacing information provided to the TBS tool is dependable because of the safety implications associated with inducing a severe wake turbulence encounter risk if not. Approach controllers are required to be provided with the means to check and amend the sequence and separation / spacing information and to check the calculated separation indicator distance before each separation indicator is displayed. The following system support mitigation has been identified:

- **Approach Arrival Sequence Display** to facilitate the identification of aircraft not in the arrival sequence, the checking of the arrival sequence order, the identification of aircraft without a separation indicator, the coordination and checking of the aircraft landing runway intent, the checking and coordination of the final approach separation and runway spacing constraints, the checking of each aircraft wake vortex category and aircraft type, the coordination and checking of scenario specific spacing requests including departure gap spacing constraints, and the checking of the separation indicator distance prior to being displayed
- **Glideslope Wind Conditions and TBS Distance Display** to facilitate checking that each TBS distance matches the glideslope wind conditions, checking of the separation indicator distance displayed in the **Approach Arrival Sequence Display** prior to the separation indicator being displayed, and checking of the separation indicator distance when the separation indicator is displayed and prior to the follower aircraft being turned on.

Approach controller procedures for checking and updating the arrival sequence order may not be 100% effective. In addition the final approach controller may inadvertently turn the wrong aircraft to merge behind a separation indicator or a pilot may inadvertently act on a turn instruction for another aircraft. The following system support mitigation has been identified:

- **Arrival Sequence Order Monitor** to facilitate checking and alerting when the arrival sequence order delivered on intermediate approach mismatches the arrival sequence order in the **Arrival Sequence Display** used to calculate the separation indicator distances.
- **Visual Indication of the Separation Indicator / Aircraft Pairing** to facilitate controller association to the correct follower aircraft to each separation indicator.
- **Wrong Aircraft Turned on to Separation Indicator Monitor** to facilitate checking and alerting for when the wrong aircraft is turned on to a separation indicator.
- **Aircraft Turned on to Wrong Localiser Monitor** to facilitate checking and alerting for when an aircraft is merged on to the wrong final approach localiser.

It is imperative in the event of a system failure that there is timely transition to degraded mode operations. The following system support mitigation has been identified:

- **TBS System Monitor** to facilitate monitoring and alerting of a TBS System failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.
- **Arrival Sequence Service Monitor** to facilitate monitoring and alerting of an Arrival Sequence Service failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.
- **Glideslope Wind Conditions Service Monitor** to facilitate monitoring and alerting of a Glideslope Wind Conditions Service failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.

The final approach controller and the tower runway controller require the means to distinguish between the different types of separation / spacing. The following system support has been identified:

- **Separation Indicator Type Support** to facilitate providing the controllers the means to visually distinguish between the different types of in-trail separation / spacing and the different types of not-in-trail separation / spacing.

In the event of unanticipated aircraft behaviour the following system support has been identified to facilitate timely controller intervention action:

- **Abnormal Indicated Airspeed Monitor** to facilitate monitoring and alerting for abnormal final approach airspeed behaviour that significantly increases the risk of separation infringement.
- **Distance Spacing Compression Monitor** to facilitate monitoring and alerting for distance spacing compression that is causing an imminent separation infringement or has caused a separation infringement.

To aid the consistency of the application of additional spacing to compensate for the distance spacing compression experienced during the lead aircraft landing stabilisation phase of final approach, the following system support has been identified:

- **Optimised Runway Delivery Support** to provide an indication of the additional spacing that needs to be set up behind the lead aircraft prior to commencing landing speed stabilisation in order to compensate for the distance spacing compression that is anticipated during landing speed stabilisation to the lead aircraft crossing the runway landing threshold to land.

2.2.1.11 Transition into Service Elements of the TBS Concept

The SESAR P06.08.01 Human Performance Assessment [79] has identified the potential requirement to support a stepped introduction of TBS from current DBS operations:

- First step of DBS operations with separation indicator tool support.
- Next step introduce TBS gradually, slowly increasing the amount of allowable reduction in the TBS distance compared to DBS.

2.2.1.12 Reduction to the 2.5Nm Minimum Radar Separation on Final Approach

It is proposed that the current 3Nm and 2.5Nm minimum radar separation on final approach be applied on the initial deployment of the TBS.

However, the 2.5Nm minimum radar separation on final approach constrains the efficiency with which the spacing minimum pairs can be delivered to the TBS on final approach.

For the future it is proposed that a 2Nm minimum radar separation is applied during the landing stabilisation speed phase of final approach to the runway threshold.

For the future, it is also proposed that a reduced minimum radar separation below the 2.5Nm minimum radar separation is applied during the procedural airspeed phase of final approach when both the lead and follower aircraft are established on the final approach glideslope.

P06.08.03 is addressing reducing the minimum radar separation on final approach.

2.2.1.13 Operational Roles and Responsibilities

The TBS concept operationally impacts Tower ATC, Approach ATC, Flight Deck and Aircraft Operators.

2.2.1.14 Failure Scenarios and Degraded Mode Operations

On a glideslope wind conditions service failure, reversion to separation indicators for DBS is proposed.

On an arrival sequence order service failure or the arrival sequence order integrity not being maintained there will be a need to switch off the separation indicators and revert to using DBS without separation indicators.

On a TBS tool failure and a sudden loss of separation indicators, there will be a need to revert to using DBS without separation indicators. For aircraft already set up on final approach it is proposed to continue with the separation/spacing set up provided the final approach controller and tower runway controller consider it is safe to continue.

2.2.1.15 Other Related Issues

The benefits from the TBS concept will be impacted by the consistency of the arrival flow demand into the initial approach fixes, and the flow of arrivals on to intermediate approach. The benefits will also be impacted by the consistency of the expedited runway vacation behaviour of the lead aircraft of spacing minimum pairs.

The intermediate approach controllers require the display of the separation indicators on their radar displays so as to provide visual feedback on the appropriateness and consistency of the presentation of aircraft on intermediate approach.

There are expected to be requirements to collect sensor data, radar data, weather data, and wake related reports from flight crew and controllers, in order to ensure the continued safe operation of TBS. This may include the requirement for more systematic and system supported monitoring of wake turbulence encounter risks.

2.2.2 Objectives and Expected Benefits

2.2.2.1 Objectives

The objective of the TBS for arrivals concept is to develop a solution to permanently provide arrival capacity resilience to headwind conditions on final approach. With today's DBS operations the achieved arrival capacity is impacted as increasing headwind conditions on final approach increases the time to fly the distance based separations.

A reduction of the aircraft ground speed is observed when the headwind speed increases (despite the landing stabilisation speed adjustments). This results in increased time separation for each aircraft pair, a reduction of the landing rate and a lack of stability of the runway throughput during arrival operations. This impacts not only the achieved capacity, but also the predictability of operations, time and fuel efficiency, and the environment (emissions).

The impact on predictability for core hubs is particularly important at the network level. The service disruption caused by the reduction in achieved runway throughput compared to declared capacity in medium and strong headwinds has a significant impact on the overall network performance and is particularly exacerbated if this occurs on the first rotation of the day because of the impact on all the other rotations throughout the day.

The Time Based Separation (TBS) concept is addressing this problem by defining procedures and specifying user and high level system requirements to allow stable arrival runway throughput in all headwind conditions on final approach.

The objective of time based separation is to improve the landing rate resilience to headwind conditions on final approach through recovering the lost landing rate currently experienced when applying distance based separations. This is to be achieved by stabilising the delivered time spacings between aircraft on final approach across headwind conditions.

The time spacing impact of headwind conditions when applying distance based separations is significant. The table below shows the increase in the time spacings for the distance based separations when compared to the reference landing rate for a 160kts ground speed in low headwind conditions.

Mean Headwind	Time Spacing Impact
15kts	6.7 %
25kts	14.3 %
35kts	23.1 %

Table 7: Time Spacing Impact of Headwind Conditions

A procedural airspeed of steady 160kts indicated airspeed (IAS) is applied to 4DME (4Nm from the runway landing threshold) on final approach at Heathrow. For the 3 degree glideslope and the runway surface elevation of 80ft at Heathrow, this is at glideslope altitudes of 1400ft at 4DME to 3,300ft at 10DME, where headwind conditions of 15kts to 25kts occur frequently. In low headwind condition where the typical landing rate for the Heathrow traffic mix is around 40 aircraft an hour, the increase in time spacing in a 20kts headwind reduces the landing rate by up to 4 aircraft an hour.

2.2.2.2 Validation Targets Allocated to TBS OFA

The B4.1 Step 1 validation targets cascaded down to the OFA level are presented in the table below from the P06.08.01 TBS VALP [76].

Primary KPAs	Step 1 Validation target allocated to Time-based separation OFA[1]	Applicability to TBS OFA	KPI	Relevant influence factors from B4.1 influence diagrams
Capacity	Airport capacity: 0,67% runway throughput improvement Airspace capacity (TMA capacity): 0,16% TMA throughput improvement	Yes	Runway throughput per hour	Arrival separation minima; Arrival spacing buffer
			IFR movements per airspace volume per unit time	Improved separation management (TMA)
			Unaccommodated traffic	N/A
Efficiency (+Environment)	0,03 % fuel reduction per flight (through TMA arrival fuel efficiency)	Yes	Average fuel burn per flight	TMA arrival
			Average delay length per delayed flight	
Predictability	0,38% reduction of block-to-block variability (through TMA arrival variability improvement)	Yes	Block to block variability	TMA arrival
			Flight cancellations due to bad weather	
Safety	No increase in frequency of severe WVE in TBS operations compared to DBS operations	Yes	Severe WVE rate	Traffic separation minima on final approach;

[1] Ref. B4.1 Proposed Step 1 Validation targets, May 2011

Primary KPAs	Step 1 Validation target allocated to Time-based separation OFA[1]	Applicability to TBS OFA	KPI	Relevant influence factors from B4.1 influence diagrams
	No more than 5% increase in frequency of WVE in TBS operations compared to DBS operations		WVE rate	
	No increase in frequency of tactical separation conflicts in TBS operations compared to DBS operations		Separation minima infringement rate	
	No increase in frequency of runway incursions in TBS operations compared to DBS operations		Runway incursion rate	
	No increase in frequency of CFTT in TBS operations compared to DBS operations		Controlled Flight Toward Terrain (CFTT) rate	
Cost-effectiveness	-0,02% reduction of ATM cost per flight (through TWR approach controller productivity increase)	Yes	TWR APP controller productivity	TWR APP controller productivity

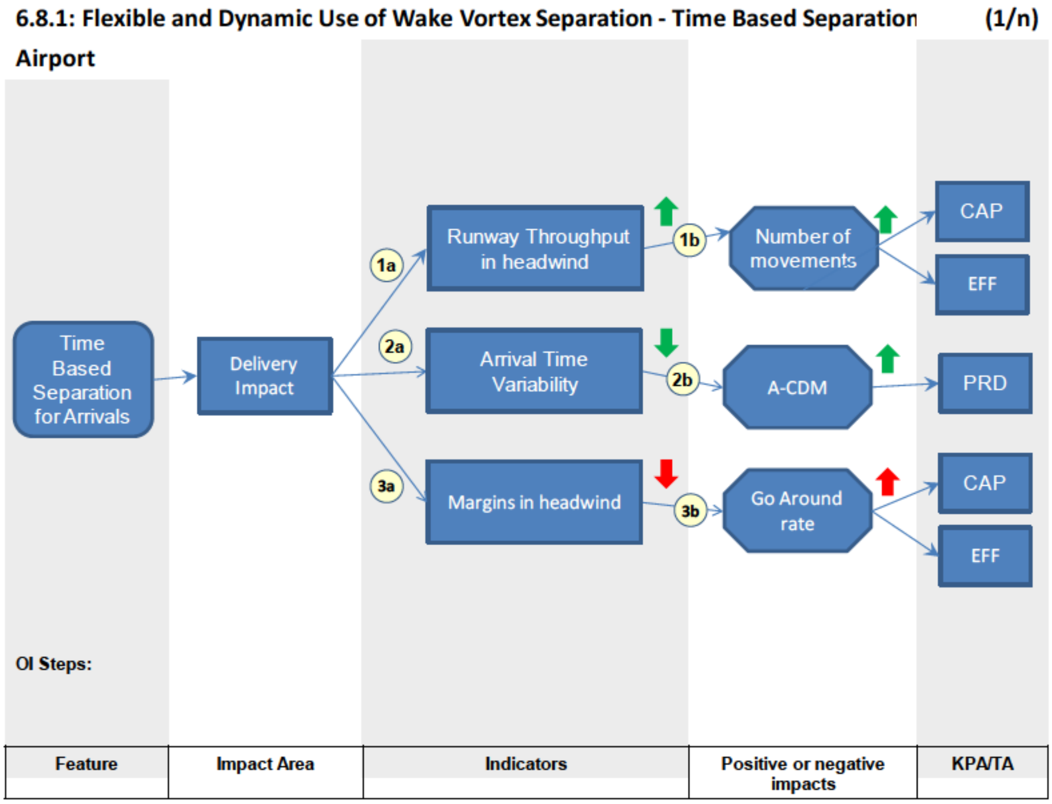
Table 8: B4.1 Step 1 Validation Targets Cascaded Down to the OFA level

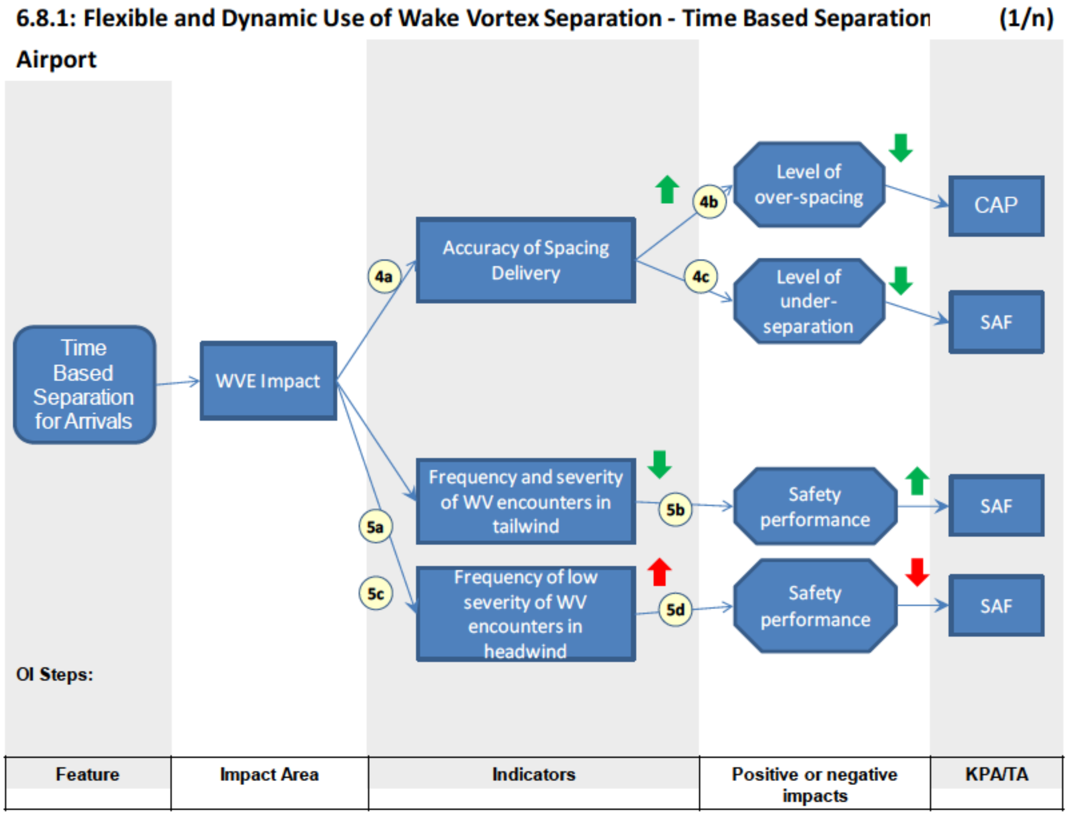
2.2.2.3 Benefits Mechanisms

Benefit mechanisms have been developed from Airport, TMA ANSP and Airspace User points of view. These were developed for the P06.08.01 TBS VALP [76] and updated in the P06.08.01 Benefits Assessment [80].

2.2.2.3.1 Benefit Mechanisms - Airport

Airport





From the **Airport** point of view:

(1a) With headwind conditions the runway throughput will be maintained in comparison to non-headwind conditions and increased compared to using distance based separation when there is a headwind.

(1b) For airports where there are significant headwind conditions this will results in an increased number of movements which links to Capacity and Time Efficiency, i.e. more TMA charges.

(2a) TBS will reduce the arrival time variability because of more consistent spacing delivery in all wind conditions.

(2b) This reduced variability will provide more stable data in the airport systems which will help increase the effectiveness of Airport Collaborative Decision Making (A-CDM), this links to Predictability.

(3a) TBS will reduce the margins delivered today in headwind conditions.

(3b) This may increase the go-around rate, if the margins delivered today are, in part, required for clearance to land in headwind conditions. This will affect Capacity and Time Efficiency.

(4a) Using Separation Indicators will allow controllers to deliver aircraft with greater accuracy than today.

(4b) Improving spacing accuracy will enable more aircraft to be sequenced with reduced spacing which links to Capacity.

(4c) Improving spacing accuracy will reduce the number of aircraft that are under-separated and severely under-separated (>0.5nm under-separation) which links to Safety

(5a) Using TBS will allow a reduction in frequency and severity of potential Wake Vortex Encounters WVEs) in tailwind conditions (increased separation compared to current DBS rules leading to extra protection in worst case wind conditions).

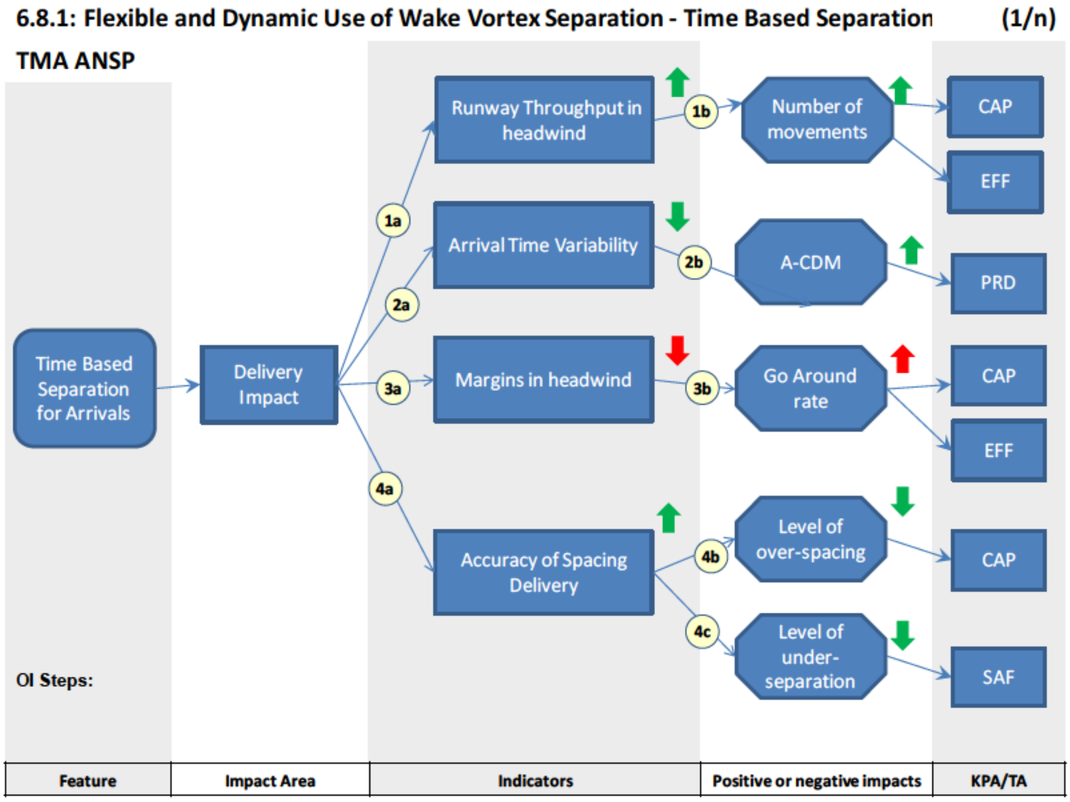
(5b) Reduction of potential WVEs in tailwind conditions will have a positive impact on consistency of safety performance – links to Safety.

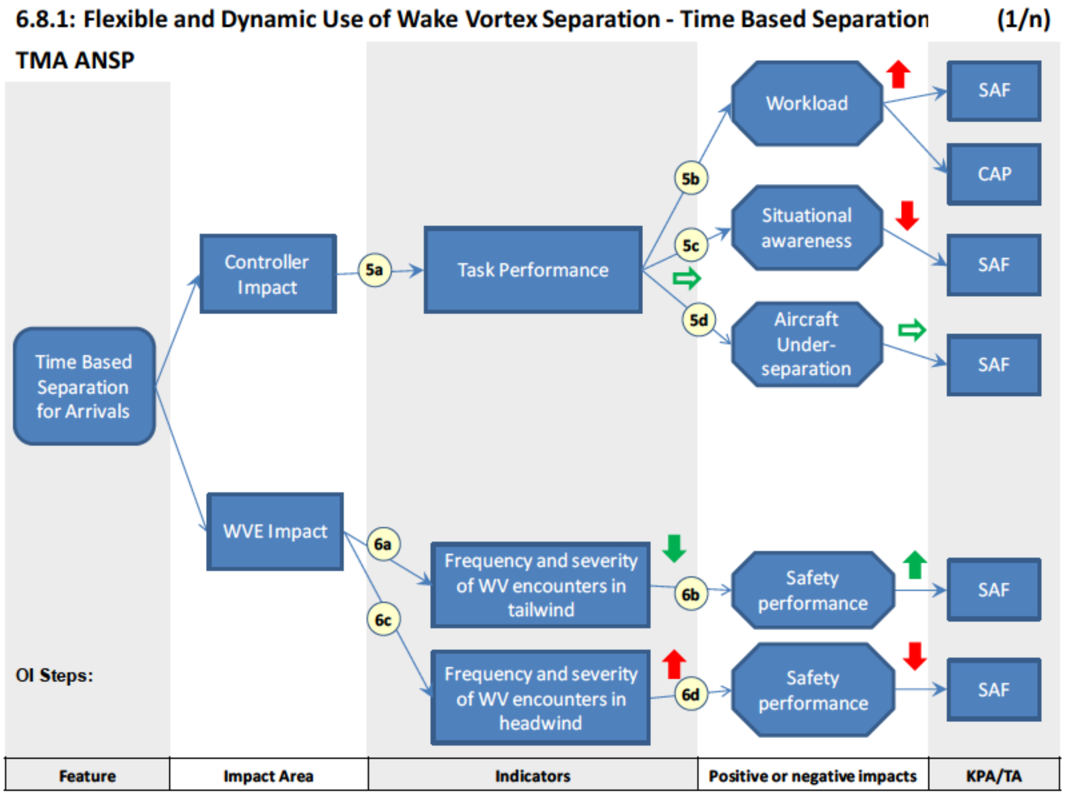
(5c) Using TBS may increase the frequency of low severity potential WV encounters in headwind conditions (decreased separation compared to current DBS rules leading to decreased time to encounter in headwind conditions).

(5d) Increase in potential WVEs in headwind conditions will have a negative impact on consistency of safety performance – links to Safety. The increase in WVEs in headwind conditions is expected to be of an order of magnitude lower than the decrease in tailwind conditions.

2.2.2.3.2 Benefit Mechanisms – TMA ANSP

TMA ANSP





From the **TMA ANSP** point of view:

(1a) With headwind conditions the runway throughput will be maintained in comparison to non-headwind conditions and increased compared to using distance based separation when there is a headwind.

(1b) For airports where there are significant headwind conditions this will result in an increased number of movements which links to Capacity and Time Efficiency, i.e. more TMA charges.

(2a) The arrival time variability will be reduced because of more consistent spacing delivery in all wind conditions.

(2b) This will result in improved arrival sequence stability which links to Predictability.

(3a) TBS will reduce the margins delivered today in headwind conditions.

(3b) This may increase the go-around rate, if the margins delivered today are, in part, required for clearance to land in headwind conditions. This will affect Capacity and Time Efficiency.

(4a) Using Separation Indicators will allow controllers to deliver aircraft with greater accuracy than today.

(4b) Improving spacing accuracy will enable more aircraft to be sequenced with reduced spacing which links to Capacity.

(4c) Improving spacing accuracy will reduce the number of aircraft that are under-separated and severely under-separated (>0.5nm under-separation) which links to Safety

(5a) Controller reliance on Separation Indicators may impact Task Performance (nb: Workload, Situational Awareness, User Acceptance).

(5b) Increased workload may reduce Capacity and reduce Safety

(5c) Reduced Situational Awareness, if below acceptable levels, could result in a decreased Safety performance

(5d) Reduced awareness of the leader-follower pair could lead to the wrong aircraft delivered to reduced vortex separation resulting in decreased Safety performance.

(6a) Using TBS will allow a reduction in frequency and severity of potential Wake Vortex Encounters WVEs) in tailwind conditions (increased separation compared to current DBS rules leading to extra protection in worst case wind conditions).

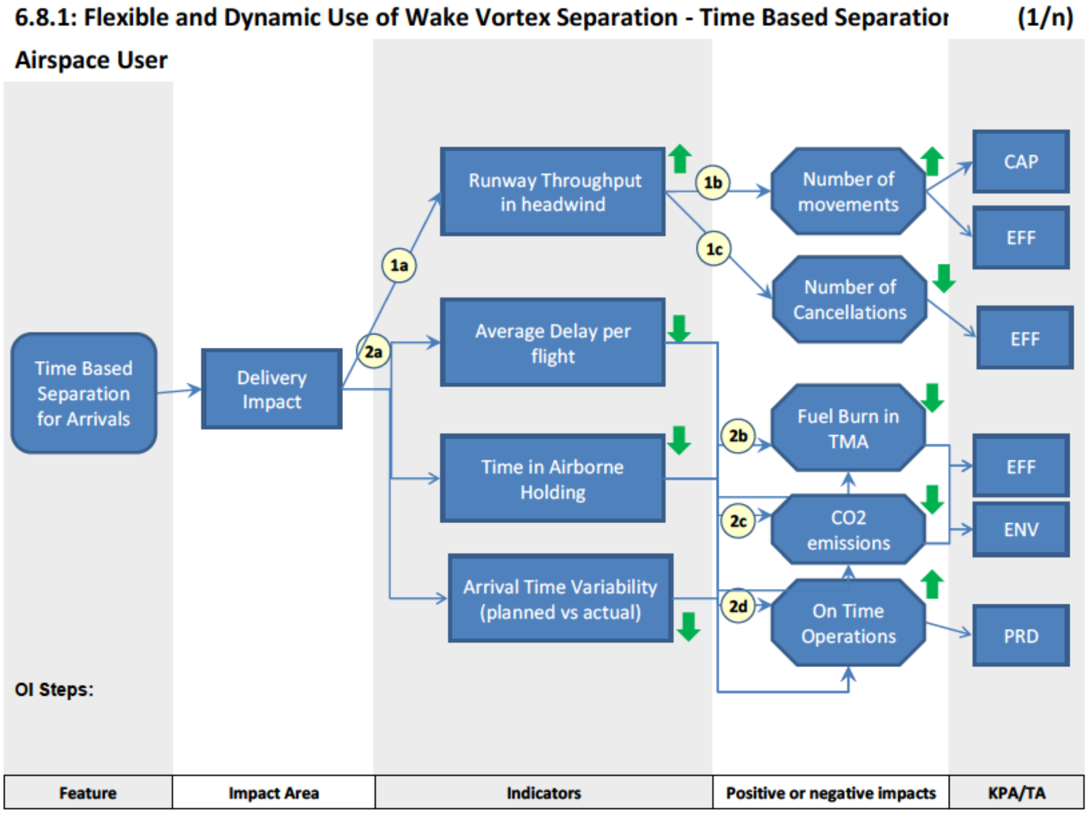
(6b) Reduction of potential WVEs in tailwind conditions will have a positive impact on consistency of safety performance – links to Safety.

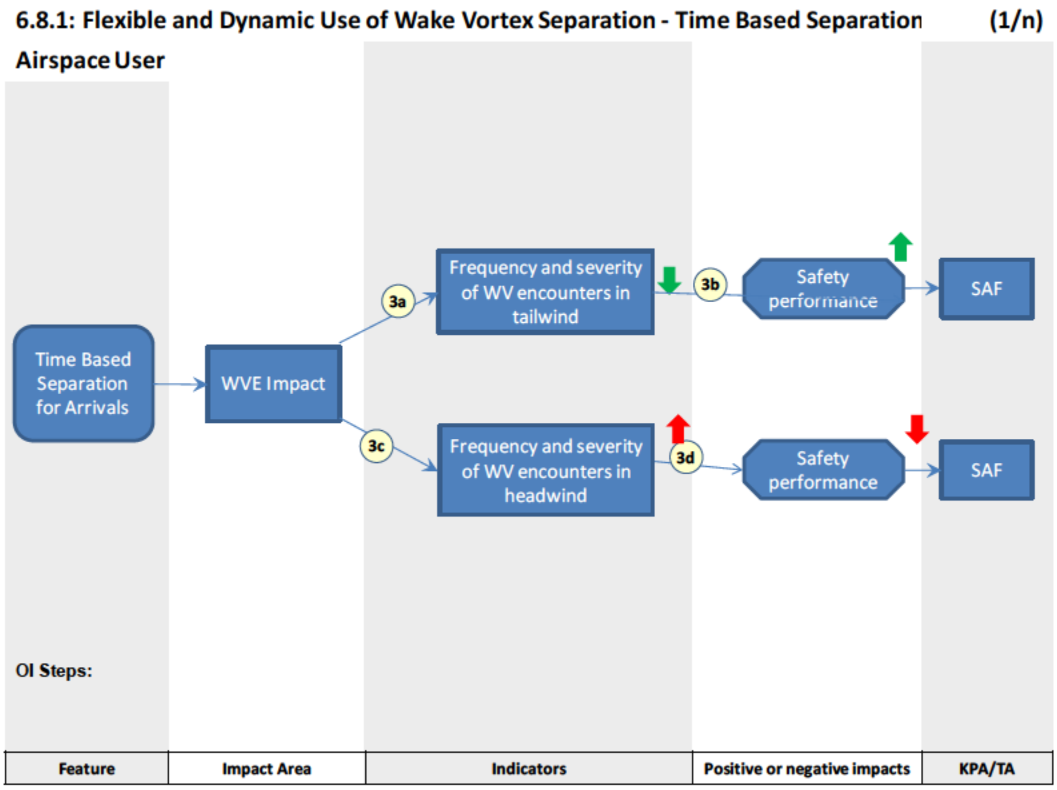
(6c) Using TBS may increase the frequency and severity of potential WV encounters in headwind conditions (decreased separation compared to current DBS rules leading to decreased time to encounter in headwind conditions).

(6d) Increase of potential WVEs in headwind conditions will have a negative impact on consistency of safety performance – links to Safety. The increase in WVEs in headwind conditions is expected to be of an order of magnitude lower than the decrease in tailwind conditions.

2.2.2.3.3 Benefit Mechanisms – Airspace User

Airspace User





From the **Airspace User** point of view:

(1a) With headwind conditions the runway throughput will be maintained in comparison to non-headwind conditions and increased compared to using distance based separation when there is a headwind.

(1b) This will increase the number of movements because in headwind situations the separations are reduced and this has an impact on Capacity and Time Efficiency, i.e. if headwinds prevail for a significant percentage of time, then using TBS could allow the airport to schedule more slots therefore enabling AU to schedule more flights.

(1c) This will decrease the number of cancellations in headwind conditions, saving airline costs for schedule disruption and passenger compensation

(2a) TBS can allow the actual flight duration to be closer to the planned duration thereby reducing the average delay experienced by flights, including that due to airborne holding, which will reduce the variability of the arrival time.

(2b) As airborne delay uses more fuel, a reduction in this delay will result in reduced fuel burn in the TMA, this links to Environment and Time Efficiency.

(2c) The reduced fuel burn has a direct link to C02 emissions which link to Environment and Time Efficiency.

(2d) Reduced delays per flight will enable airspace users to perform more ‘on-time operations’. A longer term consequence of this will be that AU can reduce the buffers within their schedules. This links to Predictability.

(3a) Using TBS will allow to reduce frequency and severity of potential WV encounters in tailwind conditions (increased separation compared to current DBS rules leading to extra protection in worst case wind conditions).

(3b) Reduction of potential WVEs in tailwind conditions will have a positive impact on consistency of safety performance – links to Safety.

(3c) Using TBS may increase the frequency and severity of potential WV encounters in headwind conditions (decreased separation compared to current DBS rules leading to decreased time to encounter in headwind conditions).

(3d) Increase of potential WVEs in headwind conditions will have a negative impact on consistency of safety performance – links to Safety. The increase in WVEs in headwind conditions is expected to be of an order of magnitude lower than the decrease in tailwind conditions.

2.3 Processes and Services (P&S)

2.3.1 Balance Demand and Capacity Process

This is a high level process in the WP05.02 TMA Step 1 DoD [72]. These are the measures (from long term to short term) allowing ATS to manage a complex and dense TMA environment.

There is a requirement to balance the demand of traffic into the TMA with the anticipated fluctuating arrivals capacity. For airports employing time-based separation on final approach, this is the anticipated fluctuating arrival capacity taking into account the traffic wake category mix, the forecast final approach wind conditions, the forecast visual conditions, the anticipated final approach separation and runway spacing constraints, and the anticipated additional spacing delivery performance.

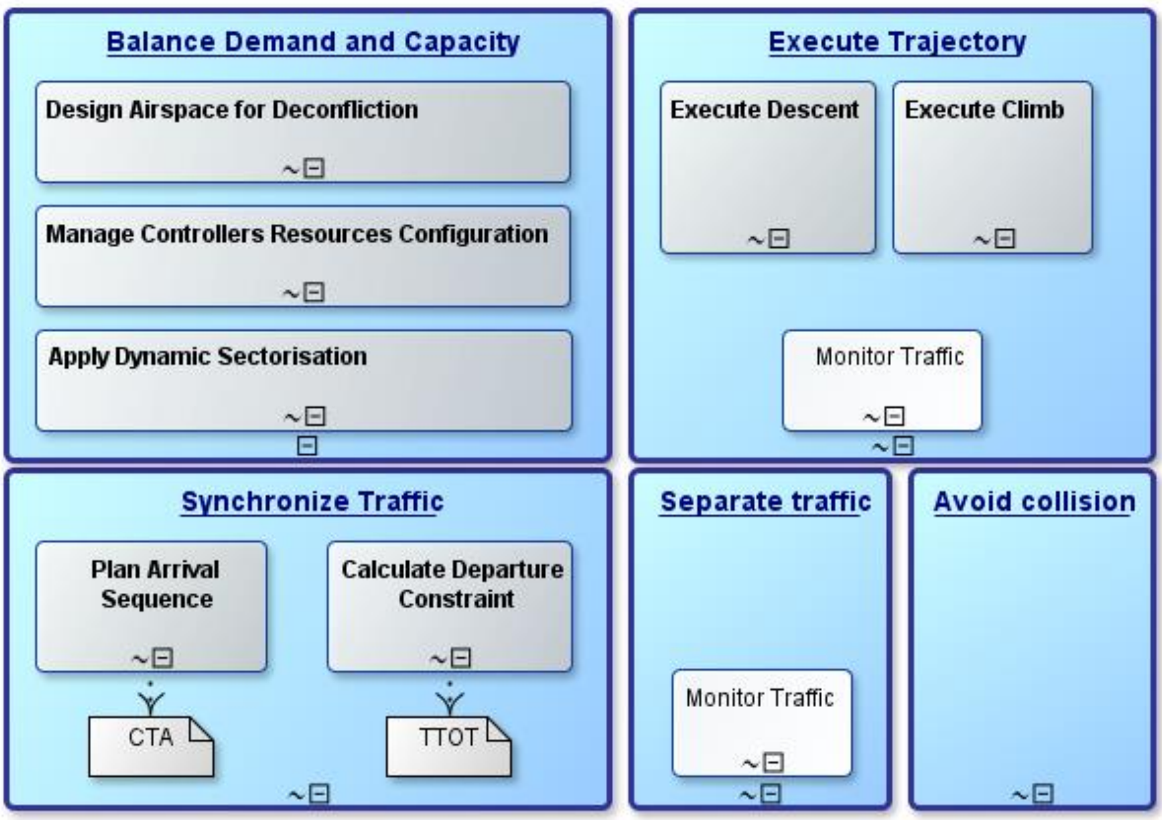


Figure 7: TMA High Level Process Diagram

2.3.2 Plan Arrival Sequence Process

This is a process in the WP05.02 TMA Step 1 DoD [72]. These are the arrival sequences planning and synchronisation activities starting during the En-Route phase and strongly linked to airport operations through AMAN/DMAN coordination.

There is a requirement for the arrival sequence planning to take into account the anticipated fluctuating arrival capacity. For airports employing time-based separation on final approach, this is the anticipated fluctuating arrival capacity taking into account the traffic wake category mix, the forecast final approach wind conditions, the forecast visual conditions, the anticipated final approach separation and runway spacing constraints, and the anticipated additional spacing delivery performance.

The following diagrams show the planning of the arrival sequence by the AMAN. Even though a time constraint applies in both cases, i4D equipped and non-equipped aircraft have to be considered as two different options. In the first case, a CTA is directly negotiated with flight crew, whereas in the second, speed and route advisories allow the aircraft to respect the time constraint over the metering point (TTL / TTG = Time To Lose / Time To Gain).

The process starts at T4, when the aircraft is within the E-AMAN operational horizon. It can be en-route or still on ground. Applying a time constraint is necessary mainly in capacity restricted environment.

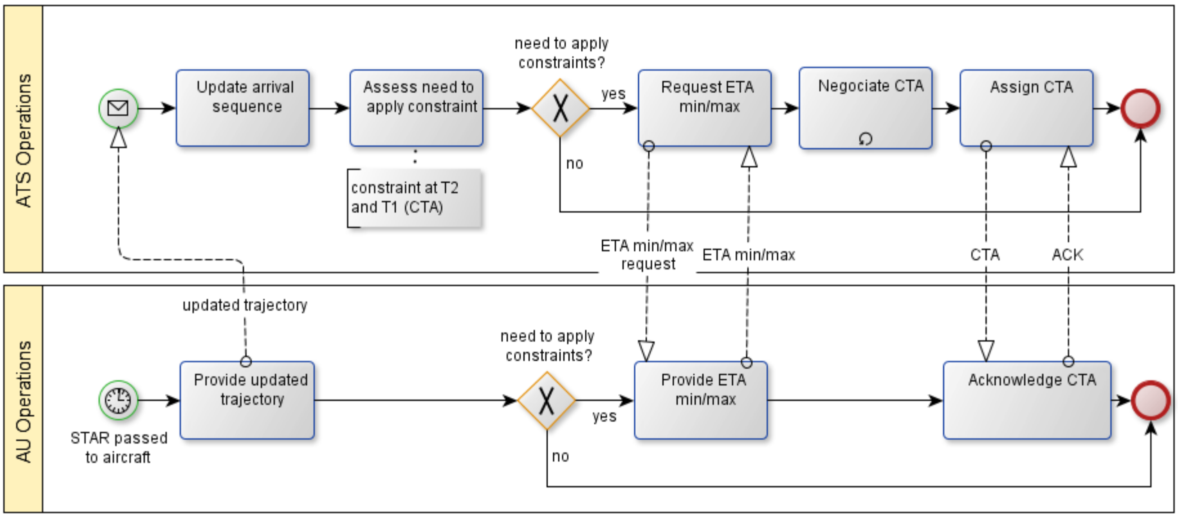


Figure 8: Plan arrival sequence [i4D equipped aircraft] process diagram

Regarding the "Negotiate CTA" activity, one should note that setting the CTA within the ETA min/max provided by the flight crew might not be possible if the sequence is already full. In that case, an update of the arrival sequence involving other aircraft is necessary.

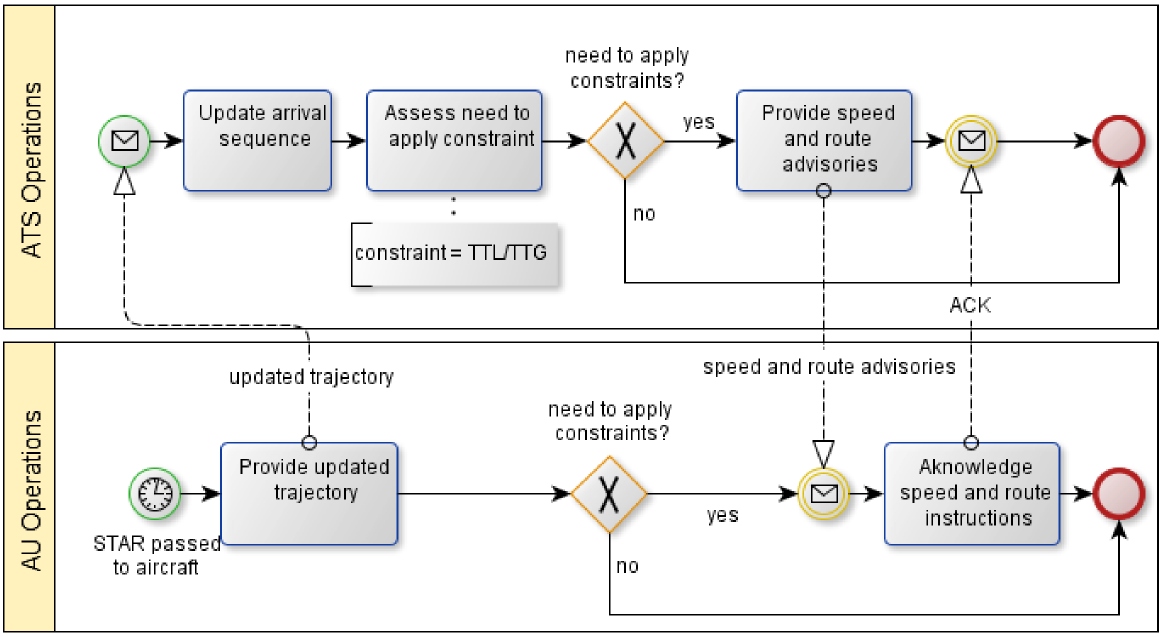


Figure 9: Plan arrival sequence [non i4D equipped aircraft] process diagram

2.3.3 Execute Descent Process

This is a process in the WP05.02 TMA Step 1 DoD [72]. During the descent, several possibilities are offered to the controller to separate the aircraft and optimize the traffic flow. They are depicted in the following diagram.

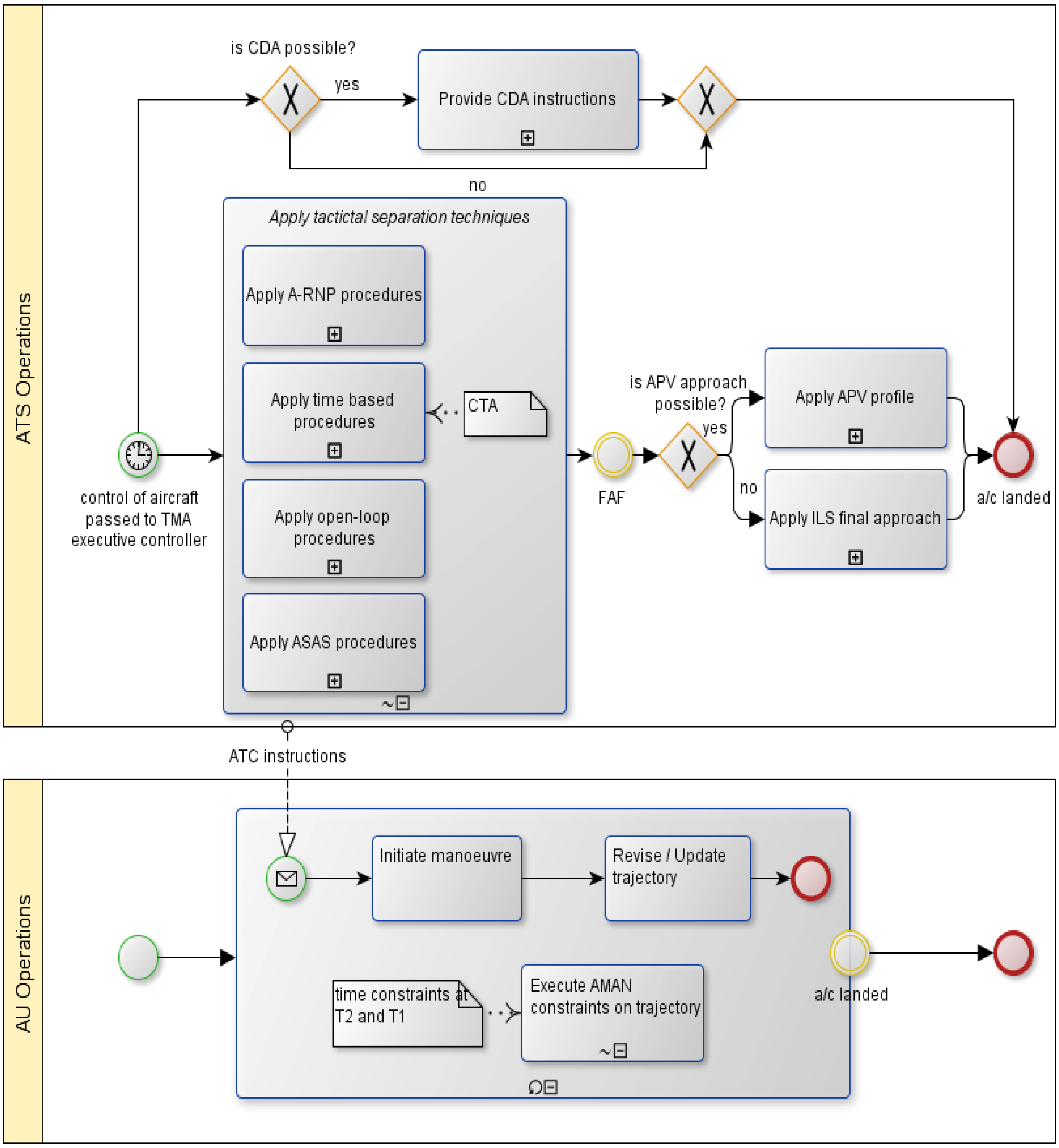


Figure 10: Execute Descent detailed process diagram

The box "Apply tactical separation techniques" contains 4 options for different separation techniques. The choice of technique can be determined by the following decision tree.

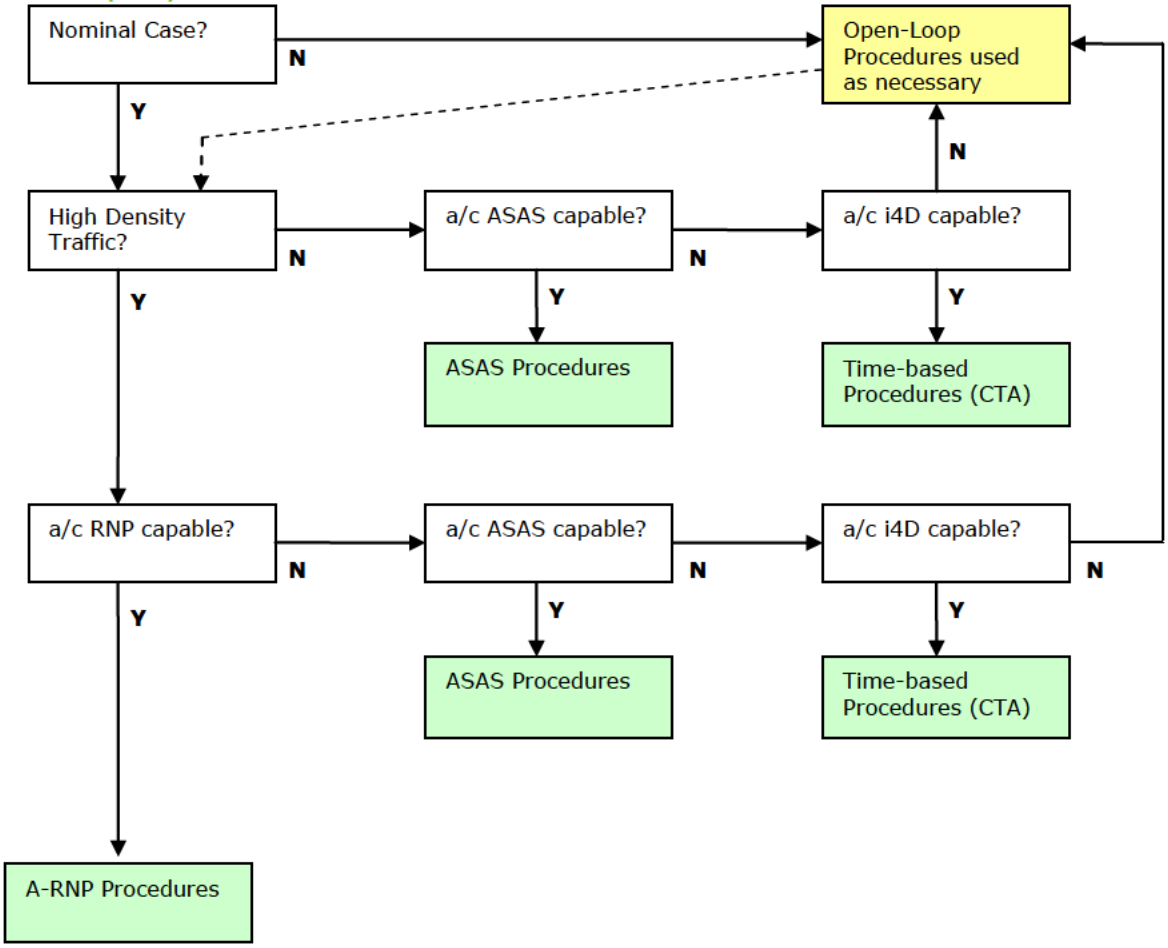


Figure 11: Apply separation technique decision tree

2.3.4 Monitor Traffic Process

This is a process in the WP05.02 TMA Step 1 DoD [72]. The "Monitor Traffic" sub-process is part of the "Execute Trajectory" process as a routine activity of the controller. It corresponds to the trajectory conformance monitoring and to the conflict detection activities of the ATS.

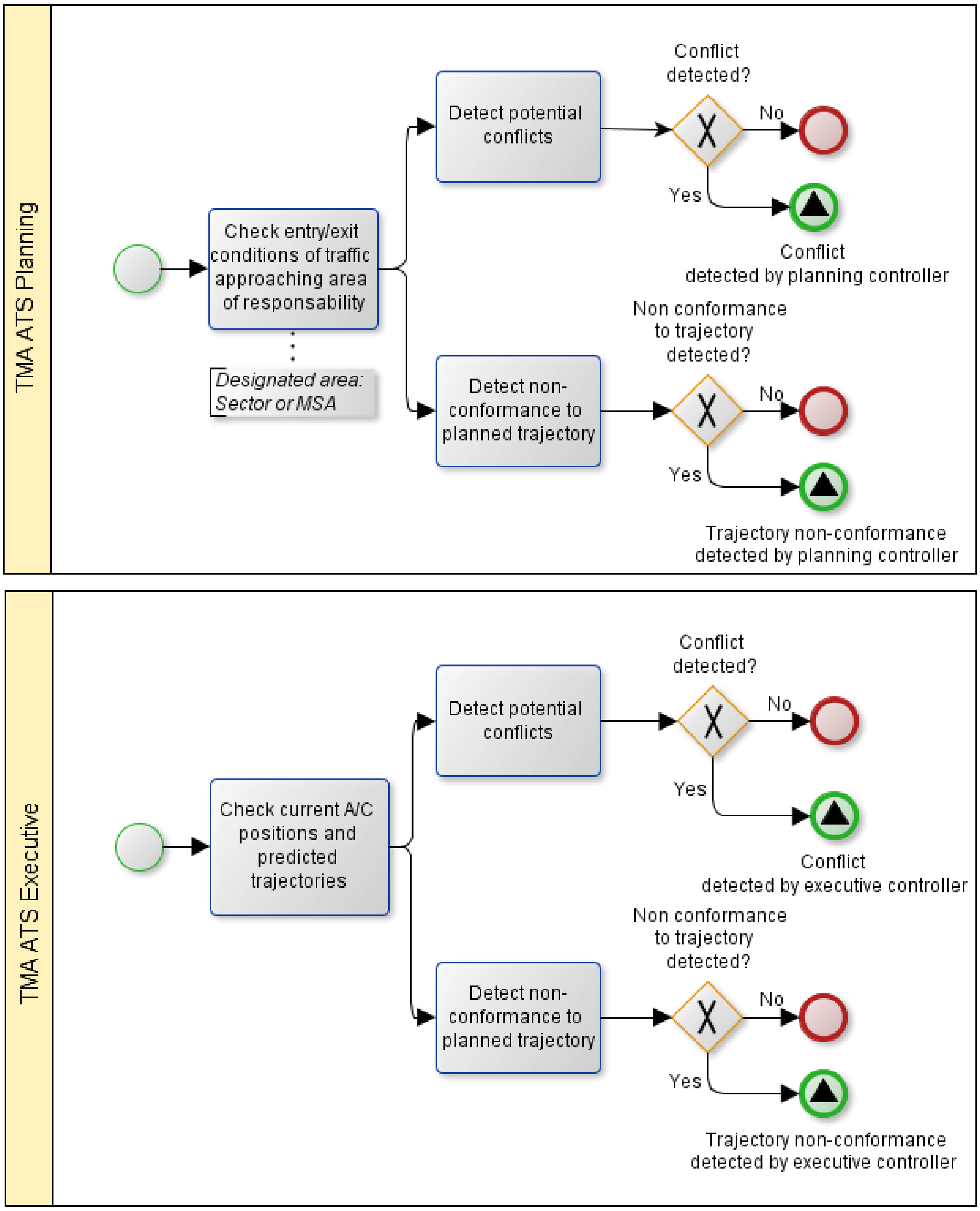


Figure 12: "Monitor Traffic" process

2.3.5 Airport Long Term Planning Process

This is a process in the WP06.02 Airport DOD Step 1 [73]. These are the processes occurring at the airport level during the long-term planning phase and the relevant interactions among airport actors.

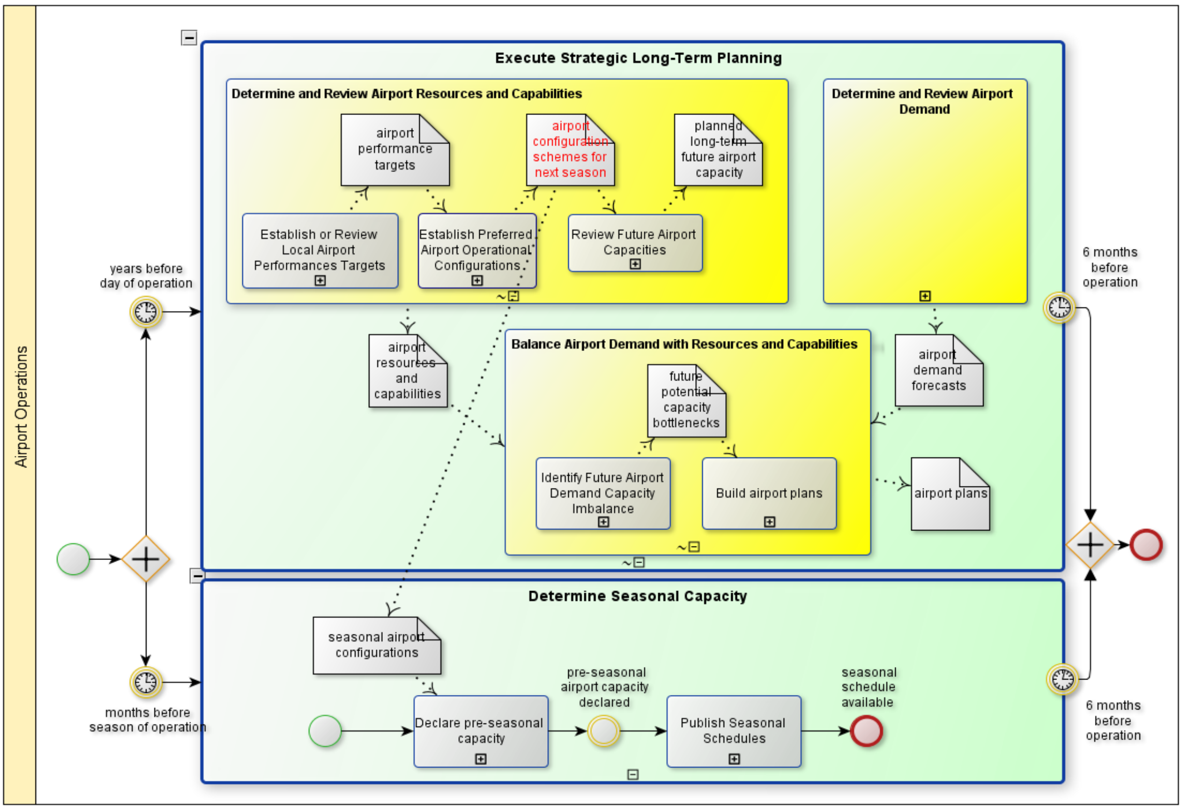


Figure 13: Airport Long Term Planning Process

Underpinning the long term planning processes are a number of identified use cases for long term planning.

Use Case ID	Use Case Title
UC 6 01	Establish / Review Local Airport Performance targets
UC 6 02	Determine and Review Airport Demand
UC 6 03	Establish Preferred Airport Operational Configurations
UC 6 04	Review Future Airport Capacities
UC 6 05	Identify the Future Airport demand Capacity Imbalance
UC 6 06	Propose Airport Infrastructure Enhancement Plans
UC 6 07	Initiate Introduction of new ATM Systems
UC 6 08	Planning for External Issues
UC 6 09	Review of and Preparation for the Response to Extraordinary and Emergency Situations
UC 6 10	Pre-Seasonal Capacity Declaration
UC 6 11	Publish Seasonal Schedules

Table 9: Identified Use Cases for Long Term Planning

The business case for TBS is established through the following use cases in the context of providing landing rate resilience to headwind conditions on final approach:

- UC 6 01: Establish / Review Local Airport Performance Targets
  - Establish Capacity, Efficiency (+ Environment), Predictability, Safety, and Cost Effectiveness performance targets in the context of the operational impact of headwind conditions on final approach.
- UC 6 02: Determine and Review Airport Demand
  - Determine the extent of the periods of arrival demand where the achieved arrival capacity is detrimentally impacted by headwind conditions on final approach.
- UC 6 03: Establish Preferred Airport Operational Configurations
  - Establish the runway configurations and modes.

- UC 6 04: Review Future Airport Capacities
  - Review the future traffic growth and the impact on the extent of the periods of arrival demand where the achieved arrival capacity is detrimentally impacted by headwind conditions on final approach.
- UC 6 07: Initiate Introduction of New ATM Systems
  - Glideslope Wind Conditions Service
    - Taking into account future related requirements of Weather Dependent Separation (WDS) for arrivals and WDS for departures
  - Approach Arrival Sequence Order Service
    - Incorporating runways-in-use and planned changes
    - Incorporating runway mode and final approach separation and runway spacing and planned changes for each runway-in-use
    - Incorporating aircraft landing runway intent
    - Incorporating scenario specific spacing requirements including departure gap requirements for interlaced mode operations.
  - Arrival Separation Tool Support (TBS Tool Support)
    - Taking into account future related requirements for supporting Pair Wise Separation (PWS) for arrivals and WDS for arrivals.
  - Safety Mitigation Support
- UC 6 08: Planning for the Management of External Issues
  - Flight Crew related issues
- UC 6 10: Pre-Seasonal Capacity Declaration
  - Review potential impact of TBS on the need to provide fire-breaks in the schedule.

2.3.6 Airport Medium / Short Term Planning Process

This is a process in the WP06.02 Airport DOD Step 1 [73]. These are the overview of all the planning activities required for the continuous refinement of the AOP during the Medium/Short Term Planning Phase.

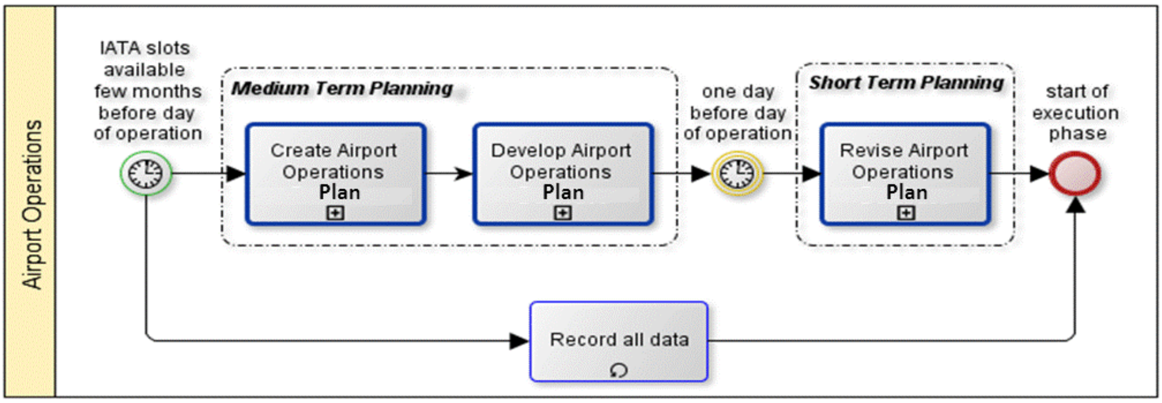


Figure 14: Airport Medium / Short Term Planning Process

There is a requirement for the airports medium / short term planning to take into account the anticipated fluctuating arrival capacity. For airports employing time-based separation on final approach, this is the anticipated fluctuating arrival capacity taking into account the traffic wake category mix, the forecast final approach wind conditions, the forecast visual conditions, the anticipated final approach separation and runway spacing constraints, and the anticipated additional spacing delivery performance.

2.3.7 Surface-In Process

This is a process in the WP06.02 Airport DOD Step 1 [73]. These are the processes and interactions that an aircraft encounters from the time when the Flight Crew lands the aircraft (wheels on ground; CDM milestone: ALDT) until the aircraft arrives in-block at the parking stand.

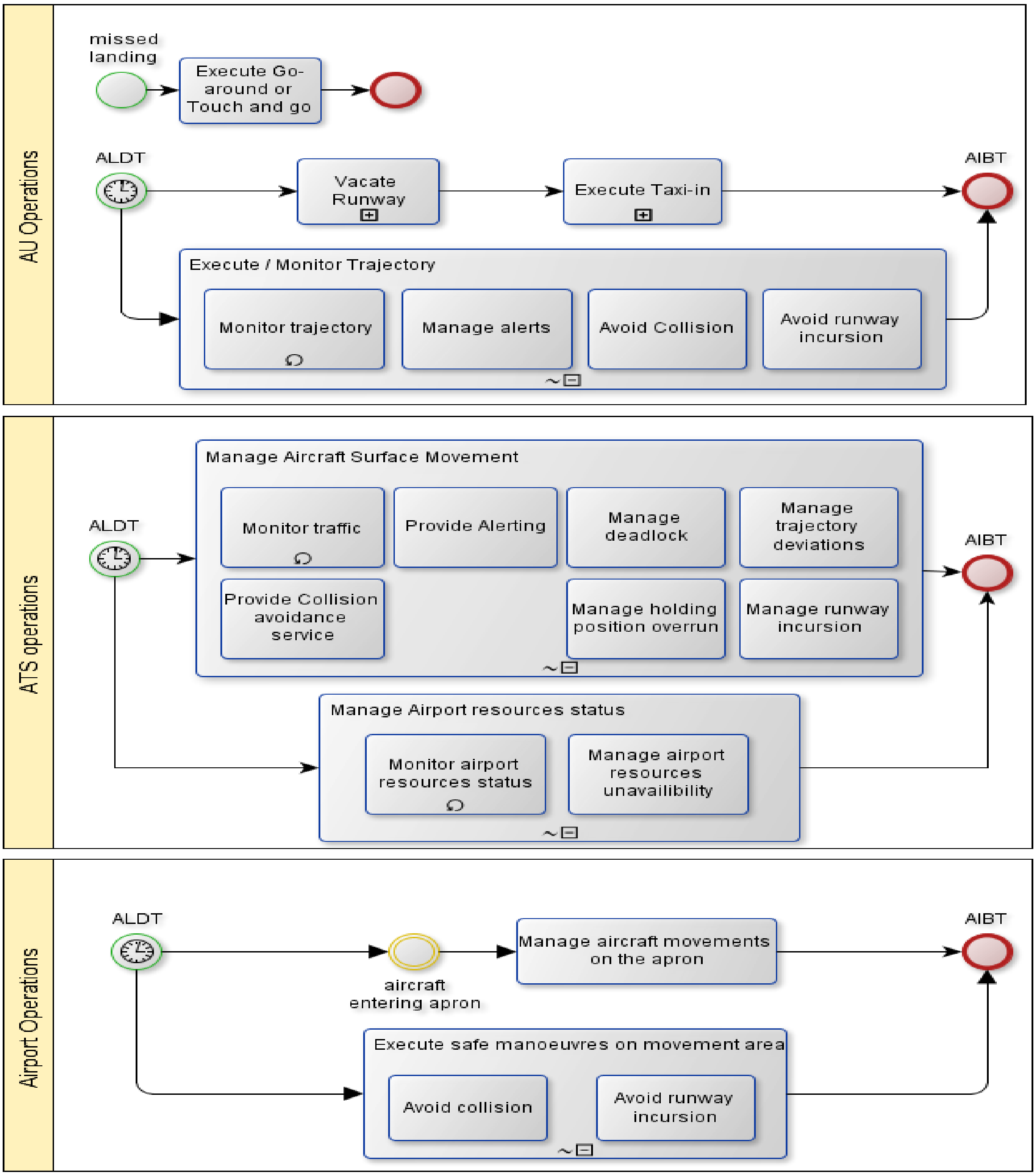


Figure 15: Surface-In High Level Process

The relevant use cases for time-based separation on final approach are those impacting the landing and runway vacation phases of the Surface-In process.

Use Case ID	Use Case title
UC 6 15	Landing
UC 6 16	Touch and go
UC 6 17	Go around
UC 6 18	Aircraft not leaving the runway as expected
UC 6 19	Exit not available
UC 6 20	Unplanned blockage of assigned exit
UC 6 27	Low visibility procedures
UC 6 38	Runway change
UC 6 39	Runway Inspection
UC 6 40	Bird Control on active runway
UC 6 42	Aircraft blocking the active runway due to technical reasons
UC 6 43	Aircraft blocking the active runway with an emergency
UC 6 44	Major accident on active runway
UC 6 50	Winter conditions with on- going winter operations (snow/ice removal)

Table 10: Surface-In Uses Cases Relevant to TBS

2.3.8 Post Operations Analysis Process

This is a process in the WP06.02 Airport DOD Step 1 [73]. These are the means to capture performance based information to examine if agreed local performance targets have been achieved and to provide feed-back to the planning (both mid and short term) as well to the actual operations, enabling a learning cycle.

Relevant to time-based separation for arrivals is the monitoring of the operational performance of the following:

- Monitoring of separation / spacing delivery performance on final approach
- Monitoring of pilot reported wake vortex encounter rates on final approach
- Monitoring of aircraft airspeed behaviour conformance on final approach

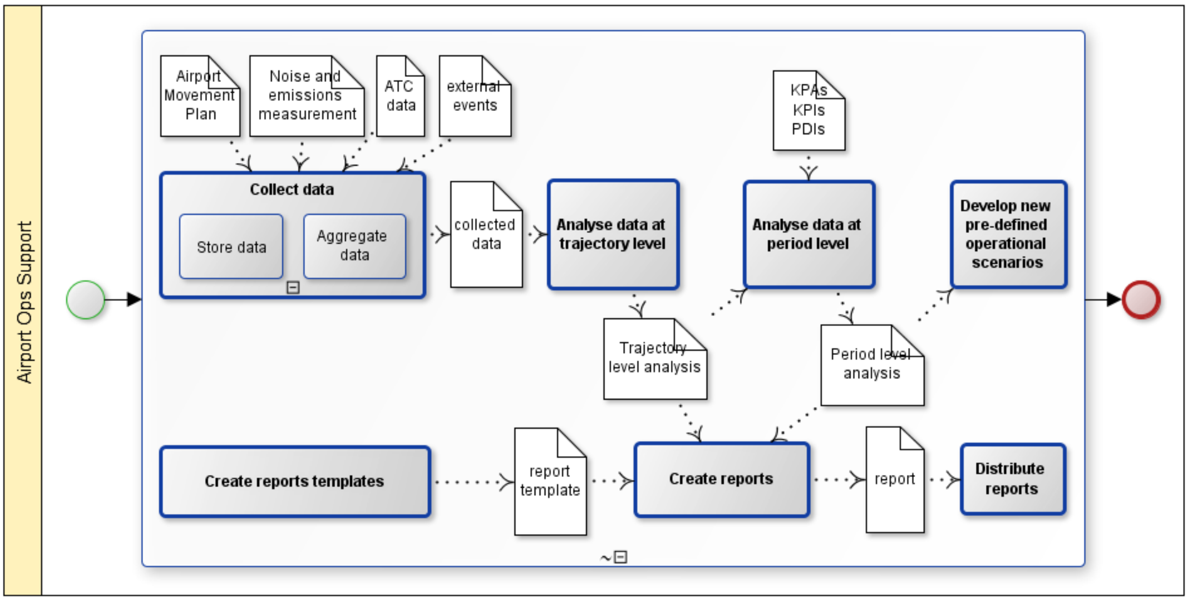


Figure 16: Post Operations Service

2.3.9 Services

There are currently no services listed in the WP06.02 Airport DOD Step 1 [73].

The following services have been identified as being required for the local deployment of the time-based separation for arrivals concept:

- Final Approach Glideslope Wind Conditions Service
- Approach Arrivals Sequence Service
- Arrival Separation Indicator Service
- Safety Mitigation Related Services:
  - Approach Arrival Sequence Display Service
  - Glideslope Wind Conditions and TBS Distance Display Service
  - Arrival Sequence Order Monitor Service
  - Wrong Aircraft Turned on to Separation Indicator Monitor Service
  - Aircraft Turned on to Wrong Localiser Monitor Service
  - TBS System Monitor Service
  - Arrival Sequence Service Monitor Service
  - Glideslope Wind Conditions Service Monitor Service
  - Abnormal Indicated Airspeed Monitor Service
  - Distance Spacing Compression Monitor Service
  - Optimised Runway Delivery Support Service

2.3.10 Mapping to Service Portfolio and Systems

There are currently no services listed in the WP06.02 Airport DOD Step 1 [73].

3 Detailed Operating Method

3.1 Previous Operating Method

3.1.1 TMA Operating Method

The WP05.02 TMA Step 1 DoD [72] details the following TMA operating method.

Aircraft approaching one or more aerodrome(s) from surrounding sectors typically follows a number of Standard Arrival Routes (STARs) – each aircraft follows one STAR - providing the transition from the En-route structure, and are progressively merged into a single flow for each active landing runway.

Conversely, aircraft departing from one or more aerodrome(s) are allocated through Standard Instrument Departures (SIDs) so as to join the en route network according to their planned destination; at this stage, departing aircraft are also subject to a number of tactical open loop instructions[2] (e.g. level offs) to manage conflicts with other interacting flows in the Terminal Area.

The separation of arrivals and departures is facilitated by strategic segregation of flows through airspace structures. The separation of arrivals from other arrivals is often closely related to the building and maintenance of the sequence. These tasks are performed through the use of open loop vectoring, issuing a large number of headings, speeds and level instructions.

Holding patterns may be used for arrivals, subject to local practices, either when the TMA capacity is exceeded at peak times, or more systematically to maintain the pressure at the runway.

RNAV Procedures have been defined to replace open-loop vectors. In such procedures ideally the principle is to keep aircrafts on their routes; the procedures are designed so that the trajectory can be stretched or shortened through pre-defined/fixed route modifications if this is needed for the merging of arrival flows; these procedures are generally fully applied only under low to medium traffic loads.

An “efficient landing sequence” refers both to an optimised sequence order (e.g. according to wake turbulence constraints), and to the achievement of appropriate spacing between flights, both aspects contributing to maintain the throughput as close as possible to the available runway capacity. This involves:

- Planning the sequence (i.e. allocate landing runway if needed, and define sequence order);
- Building the sequence (including order and appropriate spacing);
- Maintaining the sequence (including optimisation of inter-aircraft spacing).

The controller is the authority for assuring safe operations in TMA and issues information and instructions to aircraft under control in order to assist pilots to navigate safely and timely in the TMA.

Voice communication is the primary A/G communication in TMA.

The G/G connection is ensured through an overall network approach using common protocols such as AFTN (Aeronautical Fixed Telecommunication Network). It covers exchanges of surveillance, trajectory data and other flight planning information.

Navigation services using conventional terrestrial navigation aids (such as VOR/DME/NDB and ILS for the final approach phase) are the primary form of ground based navigation aid, however there is an increased usage of developing technologies such as GPS and GNSS. A large range of airborne navigation capability exists, usually based on multi-sensor navigation systems.

Surveillance Coverage is provided by the use of SSR (Secondary Surveillance Radar) in combination with PSR (Primary Surveillance Radar).

[2] Open-loop means there are potentially no bounds on the instructions that could be issued (the aircraft could be instructed to fly anywhere within the airspace at the controllers discretion). Conversely, Closed-loop instructions are finitely bounded.

3.1.2 Airport Operating Method

The WP06.02 Airport DOD Step 1 [73] details the following Airport operating method.

The notion of a runway as a protected surface for aircraft to land and take-off safely will remain unchanged.

The Tower Runway Controller will remain the authority for assuring safe operations on the runway.

The main aspect of current surface movement operations that will remain is the reliance on ‘see and avoid’ principle as the primary mean to ensure the safety of surface movements.

Controllers will remain responsible for issuing information and instructions to aircraft under control in order to assist pilots to navigate safely and timely on the airport surface.

Voice communication for time critical and tactical clearances will also remain.

A range of technical and procedural solutions, both ground and airborne, will have been introduced or more widely implemented. The following is applicable to the TBS Concept:

OFA 01.03.01 – Time Based Separation

- A reduction from the final approach distance-based wake turbulence radar separation through the adoption of time base-separation. This will require specified minimum headwind conditions that are sufficiently stable over a given time-frame. The proposal will effectively enable a 0.5Nm reduction for standard arrival distance-based wake turbulence separations of 4Nm and greater **[AO-0302]**.

This procedure has not to date been introduced into operations.

3.1.3 Separation Standards on Final Approach

Separation standards on final approach are of particular relevance to the TBS Concept. See figure 28 in Section 4.1.1.1 for the ICAO separation table for DBS.

In current operations for arrivals, the separation on final approach is attained by the final approach controller by applying radar separation. Radar separation has so far been determined as a distance separation, expressed in the metric Nautical Miles, and applied with a granularity of no less than 0.5Nm. For aircraft that are subject to wake turbulence radar separation, a larger separation than the mandated minimum radar separation has to be applied by the final approach controller.

If the flight crew request a visual approach, the separation mode changes, and the responsibility lies with the flight crew to determine the spacing. ICAO Doc 4444 [10] has no rules specific to wake turbulence in this case. Visual approach could therefore result in either smaller distances between aircraft or, in some cases larger compared to wake turbulence radar separation, depending on the flight crew decision concerning the wake hazard.

In dense traffic situations and due to the relatively rare visual conditions, visual approaches are becoming less and less used in Europe, at least on larger airports. This is mainly because it introduces uncertainties about what each aircraft will do. Thus, there is no other more efficient alternative to separate aircraft on final approach, than to apply radar separation.

Radar distance separation is expressed as a distance in all weather conditions. So the same distance being flown in calm winds, as in headwinds, will take longer time to fly in the headwind conditions. This results in a loss of runway throughput when in peak traffic and headwind conditions.

Radar separation is applied by observing the headings, distances, and speeds, between consecutive aircraft. The final approach controller knows the ICAO wake turbulence radar separation table. From the respective aircraft wake turbulence categories from the flight strips, or from the target labels, the controller establishes the wake turbulence radar separation required between the respective aircraft.

The separation distance limits are determined by the controller by the use of scales on the radar map and through the observation of catch-up from the separation distance progression observed between the follower aircraft and the lead aircraft. In case of possible infringement, the controller will first use speed instructions, and then use vectoring, or order a go-around. Inside of 4Nm from the runway threshold no speed instructions are advised.

3.1.4 Runway Layout Configuration

Runway direction is chosen, based on many criteria, but the main one is the wind direction. Headwind conditions at the runway surface are the preferred wind for arrivals and departures, compared to crosswind conditions or tailwind conditions.

In a large airport, you can distinguish between two main runway operations. One is the segregated mode, where one duty runway-in-use is used for arrivals, and another duty runway-in-use is used for the departures. The other configuration is mixed mode, where the arrival and departure streams are interlaced on to a duty runway-in-use.

If operating in mixed mode, the penalty of having to apply distance based separation is less, since controllers are typically able to reduce the 'Gap' size required to depart one aircraft between two arrivals, as the headwind increases, without becoming constrained by the wake turbulence separation minimum.

The two modes can also be combined, so that a few arrivals will land on the departure runway, or vice versa.

Segregated runway configuration is still the most common, and therefore the penalty effect of operating during headwinds remains a large obstacle on many major airports.

3.1.5 Arrival Management

In current operations, an AMAN (automatic arrival manager) is often used for the TMA approach sector. The AMAN organises the arriving traffic, so that it can be merged and sequenced to one or more runways, as efficiently as possible. The AMAN can integrate wake turbulence categories (and distance needed) for each aircraft pair, and allocate them accordingly into the sequence. Aircraft speeds are taken into account, as well as wind speeds.

The arrival controllers will, as far as is feasible, accommodate the AMAN proposed sequence order. Normally, the sequence order in AMAN is not updated after aircraft have passed the initial approach fix. This means that the sequence order intent can be changed by the approach controllers without any update input into the associated system support. Through procedural coordination the approach controllers know the changed sequence order, which can also be deduced by looking at the relative display positions of the aircraft lined up on intermediate and final approach. As a consequence there is currently no need for the approach controllers to update the associated system support.

For the runway controller, the same logic applies, since there will in most cases be a slave radar display in the tower. For other actors, it is not as clear what the real sequence actually is, or will be.

Different airports have developed different solutions, in order to provide the airport with correct landing estimates, and the correct landing runway for each aircraft.

When aircraft approach final approach, the final approach controller will separate, sequence and merge all arrivals to a specific runway. This task is very precise, and requires skills in determining the correct headings and speeds to be applied, in order to be both efficient and remain safely separated.

3.1.6 Planning

In current operations at an airport, one important aspect of the short term planning, and reiterative planning done during the execution phase, is to select the most appropriate runway combination and configuration. This takes into account many criteria, such as weather forecast, infrastructure status, traffic demand, and traffic mix.

For arrivals, the planning horizon is at least 20-30 minutes, in order to smoothly change the runway for landing, when in high traffic demand. Even so, a runway change will often lead to disruptions and delays.

3.1.7 Runway Control of Arrivals

In current operations, the runway controller is responsible for providing landing clearance to arriving aircraft. In order to do this, the arrival traffic is transferred to the runway controller a few nautical miles from the threshold, and the runway controller monitors that the runway occupancy of preceding aircraft is progressing as expected. The runway controller monitors the speed and position of the next approaching arrival, in order to determine when to give a landing clearance, or to order a go-around, if the previous aircraft runway occupancy exceeds the applied separation. Both visual out of the window, and surveillance equipment, is used.

If in mixed mode, the runway controller also has to deliver line-up and take-off clearances to departing aircraft, and time this so that the gap between the two associated arrivals can be used.

3.2 New SESAR Operating Method

3.2.1 Detailed Description of the TBS Concept

This detail description of the operational concept in this section reflects the TBS concept development and validation activities conducted by NATS and EUROCONTROL and updated as a result of the validation and transversal assessment activities conducted in phase 1 of P06.08.01 from May 2010 to March 2013 [75] [77] [78] [79] [80].

This section describes the TBS operational concept elements in the context of European Generic Approach Environments employing standard ICAO distance based separation and associated procedures and practices on final approach. The European Generic Approach Environments initially considered are:

- Independent single runway segregated or mixed mode operations
- Dependent parallel runway segregated mode operations with enhanced arrival management supporting arrival aircraft landing on the departure runway
- Closely spaced parallel runway segregated mode operations

3.2.1.1 Time Based Wake Turbulence Radar Separation Rules

The time based wake turbulence radar separation rules (TBS rules) are derived from the distance based wake turbulence radar separation rules (DBS rules) in wind conditions when the achieved capacity with the DBS rules are acceptable to busy capacity constrained arrival runway operations. From operational experience this is in low headwind conditions.

A complication is the diversity of airspeed profiles flown on final approach, both the procedural airspeed profiles prior to landing speed stabilisation, and the airspeed profiles employed during landing speed stabilisation in relation to the aircraft type, landing weight and other factors.

To manage this complication a reference airspeed profile is used to establish reference time based separations in the reference low headwind conditions. The TBS rules are to be based on a ground speed profile conversion from applying the DBS rules in the reference low headwind conditions. The ground speed profile conversion will be based on a reference airspeed profile over the distance based separation to the final approach threshold that the local DBS rules are applied. The TBS rules are the reference time separations that apply for the chosen reference airspeed profile.

The ICAO DBS rules applied on final approach to the runway landing threshold are presented in Table 11 below.

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="4">Follower</th></tr>
<tr><th>Super Heavy</th><th>Heavy</th><th>Medium</th><th>Light</th></tr>
<tr><td rowspan="4">Leader</td><td>Super Heavy
A380 (560T)</td><td>SM</td><td>6Nm</td><td>7Nm</td><td>8Nm</td></tr>
<tr><td>Heavy
136T or more</td><td>SM</td><td>4Nm</td><td>5Nm</td><td>6Nm</td></tr>
<tr><td>Medium
136T – 7T</td><td>SM</td><td>SM</td><td>SM</td><td>5Nm</td></tr>
<tr><td>Light
7T or less</td><td>SM</td><td>SM</td><td>SM</td><td>SM</td></tr>
</table>

Table 11: ICAO DBS rules on final approach

SM equates to the spacing minimum of the minimum radar separation on final approach. The minimum radar separation on final approach may be 3Nm when local radar capabilities permit, and may be reduced to 2.5Nm between succeeding aircraft which are established on the same final approach track within 10Nm of the runway threshold provided [ICAO Doc 4444 [10]]:

- The average runway occupancy time of landing aircraft is proven not to exceed 50 seconds.
- Braking action is reported as good and runway occupancy times are not adversely affected by runway contaminants.
- The local radar system has appropriate azimuth and range resolution and an update rate of 5s or less and is used in combination with suitable radar displays.
- The aerodrome runway controller is able to observe the runway-in-use and associated exit and entry taxiways.
- The wake turbulence radar separation minima do not apply.
- Aircraft approach speeds are closely monitored by the controller and when necessary adjusted so as to ensure the separation is not reduced below the minimum.
- Aircraft operators and pilots have been made fully aware of the need to exit the runway in an expeditious manner.
- Procedures concerning the application of the reduced minimum are published in AIPs.

A variety of local procedural airspeed profiles are employed with the ICAO DBS rules on final approach as illustrated for the specimen final approach segment in figure 30 in §4.1.1.4. These are typically between 220kts and 160kts on joining the final approach localiser, reducing to between 180kts and 160kts to the start of landing speed stabilisation, with landing speed stabilisation starting from between 6Nm and 4Nm from the runway landing threshold.

The landing stabilisation airspeed profiles, starting from around 6Nm to 4Nm from the runway landing threshold until touchdown, vary considerably depending on aircraft type, landing weight, stabilisation altitude, stabilisation mode, and the associated airline operator cockpit procedures. The range of stabilisation airspeeds varies from under 100kts for some Light wake category aircraft types to over 160kts for some Heavy wake category aircraft types.

In the reference low headwind conditions the time to fly the distance based separation of the DBS rules is dependent on which portion of final approach the DBS rules are being applied, on what procedural airspeed profile is being employed, and on what landing stabilisation speed profile is being employed. It is also dependent on the impact of runway elevation above sea level, and the glideslope angle, on the relationship between the IAS and TAS profiles on the final approach glideslope.

The low headwind conditions proposed is a minimum of 5kts in order to provide additional spacing in the low, still and tail wind conditions in which pilot reported wake turbulence encounters are most prevalent for distance based separations. This is a minimum of a 5kts average headwind on the glideslope over the DBS to the final approach threshold that the local DBS rules are applied.

In order to ensure suitable separation to the final approach threshold the ground speed profile conversion will be based on a reference airspeed profile over the distance based separation to the final approach threshold that the local DBS rules are applied.

The reference airspeed profile is to be aligned to a standard reference landing stabilisation speed profile to the final approach threshold. The reference landing stabilisation speed profile must ensure sufficient distance separation for follower aircraft with landing stabilisation airspeeds above 150kts such that sufficient time separation results between the lead aircraft crossing the runway landing threshold and the follower aircraft crossing the runway landing threshold.

The reference airspeed profile is to be aligned to a standard procedural airspeed profile prior to landing speed stabilisation. It is proposed to employ the standard procedural airspeed profile defined by the RECAT project [67] of a steady 170kts to 6Nm from the runway landing threshold.

Thus the chosen standard procedural airspeed profile for the conversion of the ICAO DBS rules to the TBS rules to the runway landing threshold is a standard procedural airspeed of a steady 170kts to 6Nm from the runway landing threshold (6DME), with an airspeed reduction of 20kts per Nm to a steady landing stabilisation speed of 150kts IAS to the runway landing threshold.

This is to be applied in a minimum of 5kts average low headwind on the glideslope over the DBS to the runway landing threshold. For the 3 degree glideslope at an airport with a runway elevation of 80ft above mean sea level this will result in the TBS rules on final approach in Table 12[3]. For spacing minimum pairs, 60s is proposed to provide sufficient time for the runway occupancy time of the lead aircraft for clearance to land.

		Follower			
		Super Heavy	**Heavy**	**Medium**	**Light**
Leader	**Super Heavy** A380 (560T)	60s	145s	167s	189s
	Heavy 136T or more	60s	98s	122s	145s
	Medium 136T – 7T	60s	60s	60s	122s
	Light 7T or less	60s	60s	60s	60s

Table 12: TBS rules on final approach for 3 degree glideslope and runway elevation of 80ft

The reference airspeed profile represents a single profile applicable to all aircraft. An alternative may be to consider individual reference air speed profiles defined for groups of aircraft, e.g. for each aircraft type. These individual reference air speeds could be defined based on historic data and potentially enhanced by taking into account the current conditions. Potential sources for defining individual reference air speed profiles include historic Mode S data, historic radar data, and direct airborne transmissions of aircraft intent. Both the advantages and disadvantages of moving from a single reference air speed profile to multiple air speed profiles should be considered in the V4 and V5 maturity steps of the TBS concept.

[3] Note that the times in Table 12 reflect a 5kts headwind which means that the resulting ground speed will be less than the reference IAS profile described.

3.2.1.2 Calculating the TBS Distance

The TBS distance is the distance separation equivalent of the TBS rules in the prevailing wind conditions on final approach for displaying to the final approach controller and the tower runway controller. The TBS distance is to be applied in same way as the DBS are applied on final approach as a stable distance separation equivalent of the TBS rules independent of the actual airspeed and ground speed profiles of the lead aircraft or follower aircraft on final approach.

The TBS rules are converted to the TBS distance by applying the chosen reference airspeed profile to the final approach threshold that was used to derive the reference time separations of the TBS rules. The reference airspeed profile is to be applied in the context of the final approach wind conditions on the glideslope that the follower aircraft is forecast to experience over the distance separation to the final approach threshold that the local TBS rules are to be applied.

The reference airspeed profile is applied to the prevailing glideslope wind conditions to calculate the TBS distance to be displayed by the separation indicator. The actual airspeed profile of the follower aircraft under TBS will still vary, but only in the same way that it varies under DBS today. Therefore, the variation in time spacing under TBS will be no different to that under DBS in the reference low wind conditions, and for TBS this time spacing for a particular airspeed profile is stabilised across headwind conditions. In this way the diversity of airspeed profiles employed on final approach is accommodated without the need to explicitly take into account the airspeed profile intent of the aircraft.

This will result in the TBS distance changing as the final approach wind conditions on the glideslope change over the distance separation to the final approach threshold that the local TBS rules are to be applied. The TBS distance in comparison to the DBS reduces as headwind conditions increase above the reference low headwind conditions for deriving the TBS rules, is the same as the DBS in the reference low headwind conditions, and increases in still and tailwind conditions over the TBS to the final approach threshold that the local TBS rules are to be applied; as illustrated in figure 17.

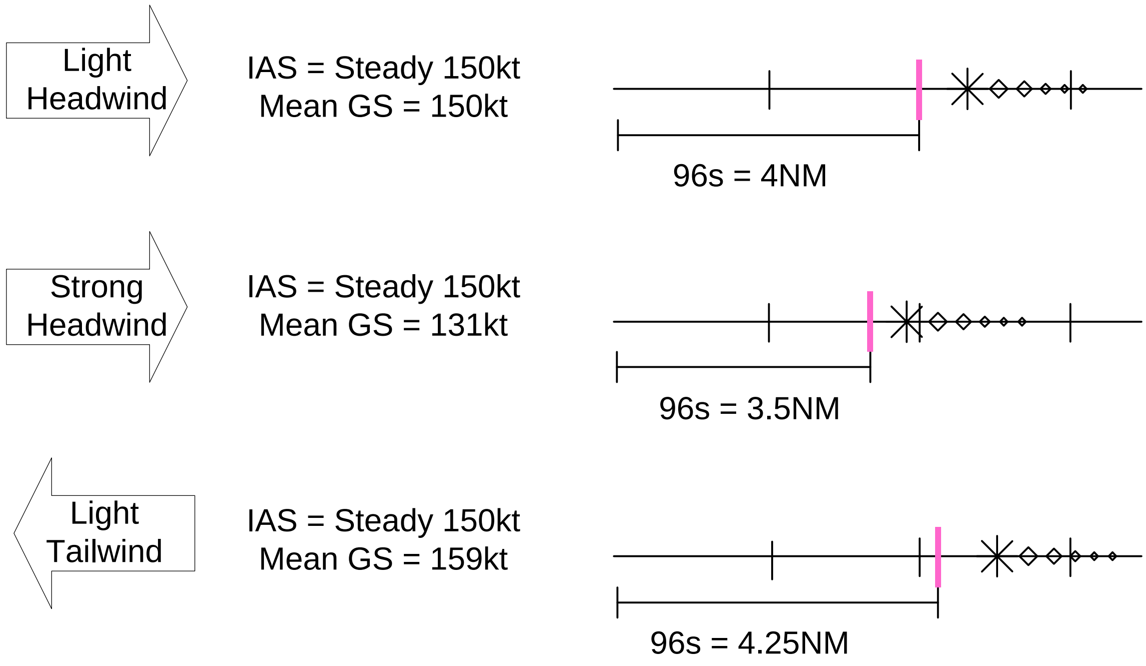


Figure 17: Variation of the Distance Separation of the TBS with Headwind Conditions

The TBS distance is to be applied from the follower aircraft merging on to final approach until the lead aircraft crosses the runway landing threshold in the same way as for distance based separation.

The separation indicator is required to be displayed to the final approach controller while the follower aircraft is on intermediate approach, before the turn on decisions that sets up the initial distance spacing on merging on to final approach. This may be with over 20Nm to 25Nm flying distance to the runway landing threshold or up to over 7 to 10 minutes flying time to the runway landing threshold.

The final approach glideslope wind conditions that the follower aircraft is forecast to experience is the wind conditions at the time the follower aircraft flies the separation to the final approach threshold that the local TBS rules are to be applied.

The latest measured wind conditions on the glideslope over the distance separation to the final approach threshold, from a wind profiler, or from the last aircraft to fly final approach to the final approach threshold in pressured traffic, may sufficiently represent the wind conditions in stable wind conditions.

In changing wind conditions, either some contingency provision for the changing wind conditions, or forecast wind conditions, may be required, dependent on the potential impact on the wake turbulence encounter risk. The results from the LIDAR data analysis [75] indicate that the probability of vortex persistence under TBS rules decreases as wind strength increases which may in itself be sufficient contingency provision subject to safety analysis.

TBS distance separations of over 8Nm are required to be supported (A380 – Light in tailwind conditions) and so a glideslope wind conditions profile is required from the final approach threshold out to 9Nm or 10Nm from the final approach threshold on the glideslope for the wake turbulence separations.

There is also a need to consider departure gap spacing and scenario specific spacing being defined as time based spacings, for example runway inspection gap spacing of 12Nm to 15Nm.

3.2.1.2.1 Overall Process for Calculating the TBS Distance

The TBS distance for an arrival pair is established by:

- Looking up the required time based wake turbulence radar separation for the arrival pair using the table of TBS rules, taking into account the respective wake turbulence categories of the lead and follower aircraft.

○		**Follower**			
		Super Heavy	**Heavy**	**Medium**	**Light**
Leader	**Super Heavy**	60s	145s	167s	189s
	Heavy	60s	98s	122s	145s
	Medium	60s	60s	60s	122s
	Light	60s	60s	60s	60s

Figure 18: Looking up the Time Based Wake Turbulence Separation for a Heavy - Medium Pair

- Establishing the ground speed profile resulting from applying the reference airspeed profile over the separation to the final approach threshold in the wind conditions on the glideslope at the time the follower aircraft is forecast to fly the separation to the final approach threshold.
- Calculating the TBS distance by applying the ground speed profile over the required time based wake turbulence radar separation.

The TBS distance is first calculated when the follower aircraft is on intermediate approach. This is in order to support the final approach controller decisions for turning and merging the follower aircraft on to final approach.

The TBS distance for an arrival pair shall be re-calculated whenever the ground speed profile changes up until the lead aircraft turns on to intercept the localiser. After the lead aircraft has turned on to intercept the localiser the final approach controller and the tower runway controller require a stable separation indicator distance separation to support the refinement of the distance spacing that is set up on merging on to final approach and for the monitoring for separation infringement until the lead aircraft crosses the runway landing threshold.

Note that the proposal to stabilise the TBS distance after the lead aircraft has turned on to intercept the localiser is subject to analysis of the consequences on the management of the wake turbulence encounter risk in changeable wind conditions.

3.2.1.2.2 Process for Establishing the Ground Speed Profile

The process for establishing the ground speed profile resulting from applying the reference airspeed profile over the separation to the final approach threshold in the wind conditions on the glideslope at the time the follower aircraft is forecast to fly the separation to the final approach threshold involves the following:

- Establishing the reference IAS profile from the final approach threshold out to 9Nm or 10Nm from the final approach threshold on the glideslope.
- Establishing the TAS profile corresponding to the reference IAS profile, taking into account the runway elevation above mean sea level, the glideslope angle, and the glideslope elevation above the runway landing threshold.
- Establishing the mean TAS for each 0.5Nm or 1Nm segment of the final approach glideslope
- Establishing the mean headwind component of the wind conditions profile for each 0.5Nm or 1Nm segment of the final approach glideslope.
- Establishing the mean ground speed for each 0.5Nm or 1Nm segment of the final approach glideslope by subtracting the mean headwind component from the mean TAS for each 0.5Nm or 1Nm segment.
  - *Second order crosswind effects on the ground speed may need to be taken into account in which case the full aircraft vector will need to be applied.*

3.2.1.2.3 Process for Calculating the TBS Distance from the Ground Speed Profile

The process for calculating the TBS distance by applying the ground speed profile over the required time based wake turbulence radar separation involves the following:

- Converting the mean ground speed for each 0.5Nm or 1Nm segment of the final approach glideslope to a flying time for each 0.5Nm or 1Nm segment.
- From the final approach threshold applying the required time based separation over the flying time of each 0.5Nm or 1Nm segment to establish the distance to the final approach threshold that represents the required time based separation.

3.2.1.2.4 Process for Establishing the Mean Headwind Component of the Wind Conditions from Glideslope Wind Profiler Measurements

The process for establishing the mean headwind component of the wind conditions profile for each 0.5Nm or 1Nm segment of the final approach glideslope from glideslope wind profiler measurements involves the following:

- Mapping the glideslope wind profiler measurements to each 0.5Nm or 1Nm segment of final approach out to 9Nm or 10Nm from the final approach threshold on the glideslope.
- Calculating the mean wind speed and wind direction for each 0.5Nm or 1Nm segment of final approach, updated at least every minute.
- Calculating the mean headwind component on the final approach glideslope of the mean wind speed and wind direction for each 0.5Nm or 1Nm segment of final approach.
- *In changing wind conditions where the headwind is reducing, reducing the mean headwind component of the impacted 0.5Nm or 1Nm segments to reflect the change expected between lead aircraft turning on to intercept the localiser and the follower aircraft flying the distance separation to the final approach threshold. This will increase the TBS distance in these conditions thus providing additional distance separation contingency to accommodate the changing conditions.*

3.2.1.2.5 Options for Establishing the Mean Headwind Component of the Wind Conditions

There are a number of potential options for establishing the mean headwind component of the wind conditions for each 0.5Nm or 1Nm segment on final approach from the final approach threshold out to 9Nm or 10Nm from the final approach threshold on the glideslope:

- The down linked airborne parameters of the IAS and the Ground Speed of aircraft on the final approach glideslope, over the extent of the possible required separation to the final approach threshold, can be used to maintain a wind conditions effect profile over the extent of the possible required separation to the final approach threshold.
    - These are both mandated enhanced Mode S surveillance parameters in Europe.
    - There is an equipage profile of better than 95% and improving at most major European hubs.
    - There are some issues with the dependability of these airborne parameters that need to be managed to ensure the dependability of the wind conditions effects profile.
        - These airborne parameters are significantly impacted by airframe turn manoeuvres.
        - The dependability of these parameters across airframes is variable.
        - The surveillance coverage for the down link of these airborne parameters may not adequately extend to the lower altitudes of final approach.
    - This provides a wind effects profile at the time when the last aircraft to touchdown descended on the glideslope over the separation to the final approach threshold.
- A wind conditions aloft profile from real-time measurement of the wind conditions on the final approach glideslope can be used to determine the ground speed profile impact of the prevailing wind conditions.
    - There may be a need for a separate wind conditions aloft profiler for each final approach glideslope in order to be adequately responsive to changing wind conditions.
    - This provides a mean wind effects profile at the time, or just before, the profile is used to calculate the TBS.
- A forecast wind conditions aloft profile can be used to determine the ground speed profile impact of the wind conditions at the time the follower aircraft is predicted to fly over the required separation to the final approach threshold.
    - There will be a need to develop a forecast wind conditions aloft profile for the local aerodrome with suitable performance.
    - There will be a need for area resolution to distinguish between the wind conditions on each final approach glideslope in order to be adequately responsive to changing wind conditions.
    - There will be a need for vertical resolution so as to distinguish the wind conditions effects on the ground speed down to potentially each 0.5 Nm or 1Nm of distance spacing on the glideslope.
    - There will be a need for temporal resolution so as to distinguish between the timing of successive aircraft on the final approach glideslope with down to 60s time separation and where the flying time over each 0.5 Nm of distance spacing is around 10s to 15s.
    - The forecast is to be applied over a time horizon of up to 7 to 10 minutes in the future, the time it takes for lead aircraft being turned from intermediate approach to merge on to final approach, and for the follower aircraft to descend on the final approach glideslope to the final approach threshold.

3.2.1.3 Separation Constraints between Arrival Pairs on Final Approach

The time based wake turbulence radar separation rules (TBS rules) and the TBS distances are required to be applied in the context of all of the other separation and spacing constraints on final approach. These include (but are not limited to):

- The minimum radar separation constraints for managing the mid-air collision risks taking into account radar surveillance and radar display performance.
- The runway spacing constraints appropriate for the runway visual conditions taking into account the operation type, the weather conditions, localiser critical area safeguarding and landing clearance requirements. .
- The runway spacing constraints appropriate for the runway surface braking conditions and exit taxiway serviceability.
- The runway spacing constraints appropriate for the operational equipment serviceability, staffing levels, and other operational restrictions.
- The scenario specific spacing requirements such as for a runway inspection or for accommodating conflicting or crossing traffic.
- The interlaced departure gap spacing for interlaced mode operations.

The other surveillance and runway operations separation and spacing constraints need to be taken into account alongside the dynamically calculated TBS distance.

The other surveillance and runway operations constraints impacting final approach include:

- Wake turbulence separation constraints options
    - DBS
    - TBS
    - Re-categorisation for Europe (RECAT Europe)
    - Re-categorisation 2 / Pair Wise Separation (RECAT2 / PWS)
    - Weather Dependent Separation (WDS)
- Radar surveillance constraints
    - In-trail final approach radar separation minimum
- Runway operations constraints
    - VMC, IMC, VIS2 and LVP runway visual conditions constraints
        - Spacing minimum behind all pairs
        - Spacing minimum behind Heavy aircraft types
        - Spacing minimum behind Super Heavy aircraft types
    - Runway occupancy minimum spacing constraints impacted by runway surface braking conditions and exit taxiway serviceability
        - Spacing minimum behind all pairs
        - Spacing minimum behind Heavy aircraft types
        - Spacing minimum behind Super Heavy aircraft types
    - Overload, staffing and equipment serviceability minimum spacing constraints
    - Night time operations minimum spacing constraints
- Scenario specific spacing requirements between specific arrival pairs, for example, for
    - Runway inspection spacing
    - Runway crossing spacing

        - Emergency spacing
        - CAT A / CAT B flight spacing
    - Interlaced mode runway operations departure gap constraints
        - Standard departure gap size for a single departure aircraft
        - Standard departure gap size for two departure aircraft
        - Additional departure gap spacing behind Heavy and Super Heavy arrival aircraft types (to accommodate the longer arrival aircraft runway occupancy times)
    - Dependent parallel runway operations constraints
        - Not-in-trail final approach radar separation minimum for closely spacing and dependent parallel runway operations
        - Not-in-trail spacing minimum
        - RNAV approach procedures separation constraints for not-in-trail separation
    - Closely spaced parallel runway operations constraints
    - Converging and crossing runway constraints

The other surveillance and runway operations separation and spacing constraints that are to be applied at any time are usually determined by the Tower Supervisor in coordination with the Approach Supervisor. This information is required to be provided electronically to the TBS tool. In some situations the runway separation and spacing constraints may need to be tactically changed through coordination between the Tower Runway Controller and the Final Approach Controller.

It is proposed that the other separation or spacing constraints for example for the minimum radar separation, for managing runway operations and between dependent parallel runways, are retained as the current distance based separation or spacing constraints.

With the introduction of TBS and the separation indicator support, separation and spacing constraints that are naturally time based are expected to change from being specified as distance based to being specified as time based. This is so as to take advantage of the improved resolution and resilience of the TBS concept. This is expected to apply to departure gap spacing, to runway operations related spacing minimum, and to runway operations related scenario specific spacing.

The minimum separation or spacing to be set up on final approach is required to be at least that of the maximum separation or spacing constraint that is required to be applied.

The separation indicator position is required to clearly reflect the maximum separation or spacing constraint to be applied between the arrival pair.

3.2.1.4 Management of the Other Separation and Spacing Constraints

In order to be able to calculate the minimum separation or spacing that needs to be set up between each arrival aircraft on final approach there is a need for the other surveillance separation and runway operations spacing constraints to be specified and maintained through, for example, a separation / spacing mode tool.

The separation and spacing constraints need to be specified for each runway-in-use, and need to include both the current constraints and planned changes to the constraints. The planned changes to the constraints should be specified with reference to an identified lead arrival aircraft.

The following separation and spacing constraints have been identified as being required to be specified and maintained for in-trail pairs for each runway-in-use:

- **Wake turbulence separation minimum** – TBS or DBS (including RECAT Europe, RECAT2 / PWS and WDS in the future).
- **Minimum radar separation** – 2.5Nm or 3Nm final approach in-trail minimum radar separation. There may be a need to support the ICAO changing minimum radar separation

of 3Nm until the follower aircraft is within 10Nm of the runway landing threshold, when the minimum radar separation may be reduced to 2.5Nm,

- **Spacing minimum** – 2.5Nm, 3Nm, 3.5Nm, 4Nm, 5Nm, 6Nm or greater (up to 12Nm) final approach runway operations related spacing applied across all in-trail arrival pairs.
- **Specific Heavy spacing minimum** – 5Nm or 6Nm runway operations related spacing constraint behind Heavy aircraft.
- **Specific Super Heavy spacing minimum** – 4Nm, 5Nm, 6Nm, or greater (up to 20Nm) runway operations related spacing constraint behind Super Heavy aircraft.
- **Scenario specific spacing constraint behind identified lead aircraft** – For example runway inspection spacing, runway crossing spacing and additional spacing (e.g. 15Nm) behind an emergency aircraft
- **Interlaced mode spacing minimum** – Standard gap spacing for interleaving a single departure, and for interleaving two departures, between arrival pairs.
- **Interlaced mode specific Heavy additional spacing** - Additional departure gap spacing behind Heavy arrival aircraft types to accommodate the longer arrival aircraft runway occupancy times
- **Interlaced mode specific Super Heavy additional spacing** - Additional departure gap spacing behind Super Heavy arrival aircraft types to accommodate the longer arrival aircraft runway occupancy times

The following separation and spacing constraints have been identified as being required to be specified and maintained for not-in-trail pairs for dependent parallel runway operations for each runway-in-use:

- **Dependent or closely spaced parallel approach minimum radar separation** – 2Nm, 2.5Nm or 3Nm lateral not-in-trail minimum radar separation for arrival pairs established on separate extended runway centre-lines. There may be a need to support a changing lateral not-in-trail minimum radar separation of 2.5Nm until both the lead and follower aircraft are confirmed as established on their respective localisers, when the lateral not-in-trail minimum radar separation may be reduced to 2Nm.
- **Spacing minimum** – Specified independently of the minimum radar separation, for example a 2.5Nm spacing minimum when 2Nm is the minimum radar separation.
- **Specific airborne procedure spacing constraints for identified aircraft** – For example the 2.5Nm not-in-trail separation constraint ahead of and behind aircraft performing an RNAV intermediate approach on to final approach.

An immediate change in the separation or spacing constraints can be required in some circumstances. Immediate changes apply to all arrival pairs.

The Tower Supervisor in coordination with the Approach Supervisor is normally required to specify and maintain the separation and spacing constraints. In some situations the runway separation and spacing constraints may need to be tactically changed through coordination between the Tower Runway Controller and the Final Approach Controller.

3.2.1.5 Establishing the Required Separation or Spacing Between Each Arrival Pair

All of the final approach separation and spacing constraints need to be taken into account when establishing the minimum required separation or spacing between each arrival pair. The other surveillance separation and runway operations spacing constraints need to be taken into account alongside the dynamically calculated TBS distance.

There is a need for the provision of a reliable final approach arrival sequence order. Additionally for the multiple runway operational layouts of closely spaced and dependent parallel runway operations there is a need for the provision of reliable landing runway intent for each arrival aircraft. This is so as to be able to establish the minimum required separation for both in-trail arrival pairs established on the same final approach localiser and not-in-trail arrival pairs established on separate parallel localisers. This could be the AMAN sequence order with landing runway intent with the incorporation of late sequence order and landing runway intent changes.

For interlaced mode operations, there is the additional need for the provision of reliable information on the departure gaps required to be interlaced into the approach arrival sequence order. The departure demand could be provided from the DMAN sequence, with the departure demand being integrated into the Approach Arrivals Sequence through the automatic population of the departure gap demand.

For in-trail arrival pairs, there is a need to establish the in-trail required separation for the arrival pair taking into account the wake turbulence category of each aircraft, the applicable spacing policy that applies for the landing runway of the aircraft and, if required, any specific spacing requirements that have been specified to apply behind the lead aircraft:

- Wake turbulence separation minimum
- Minimum radar separation
- Spacing minimum
- Specific Heavy spacing minimum, if applicable
- Specific Super Heavy spacing minimum, if applicable
- Scenario specific spacing constraint behind the lead aircraft, if applicable
- Interlaced mode spacing minimum, if applicable
- Interlaced mode specific Heavy additional spacing, if applicable
- Interlaced mode specific Super Heavy additional spacing, if applicable

For not-in-trail arrival pairs on adjacent parallel final approaches, there is a need to establish the not-in-trail required separation:

- Dependent or closely spaced parallel approach minimum radar separation
- Spacing minimum
- Specific airborne procedure constraints for identified aircraft, if applicable

3.2.1.6 TBS Tool Support for the Visualisation of the Final Approach Separation or Spacing

3.2.1.6.1 In-Trail Runway Operations

To provide for the consistent and accurate delivery and monitoring to time based wake turbulence separation rules the final approach controller and tower runway controller require visualisation of the TBS distance separation of the TBS rules. This is to at least a distance separation step resolution of 0.1Nm.

Current workstation facilities support consistent and accurate spacing delivery to the ICAO DBS rules which are defined to a step resolution of 1.0Nm for wake turbulence radar separation and 0.5Nm for the minimum radar separation. Extended runway centre-line markings are provided on the surveillance display of the approach controllers, and the air traffic monitor display of the tower runway controller, of the distance to touchdown in 2Nm and sometimes 1Nm steps as illustrated in figure 19.

Figure 19: Illustration of Displayed Extended Runway Centre-Line Distance Markings

To facilitate the visualisation of the TBS distance, to the required resolution of the converted TBS rules, a separation indicator is to be displayed on the final approach centre-line, behind the lead aircraft target position on the radar display as a separation reference for the follower aircraft. This is illustrated for in-trail follower aircraft in figure 20.

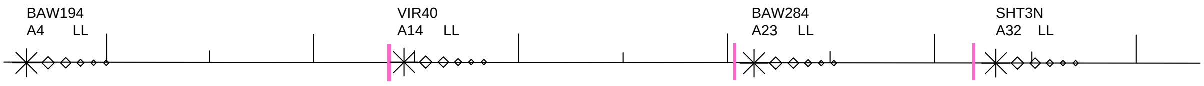


Figure 20: Illustration of Separation Indicator Visualisation of the TBS Distance behind each Lead Aircraft

The separation indicator position is required to clearly reflect the maximum separation or spacing constraint that is required to be applied between the arrival pair.

The separation indicator position is to be updated in synchronisation with the track position updates of the lead and follower aircraft in order to provide for a stable visual reference of the applicable separation or spacing constraint.

The final approach controller requires a visual reference of the required separation or spacing constraint when setting up and refining the spacing when turning aircraft on from intermediate approach and establishing on the final approach localiser.

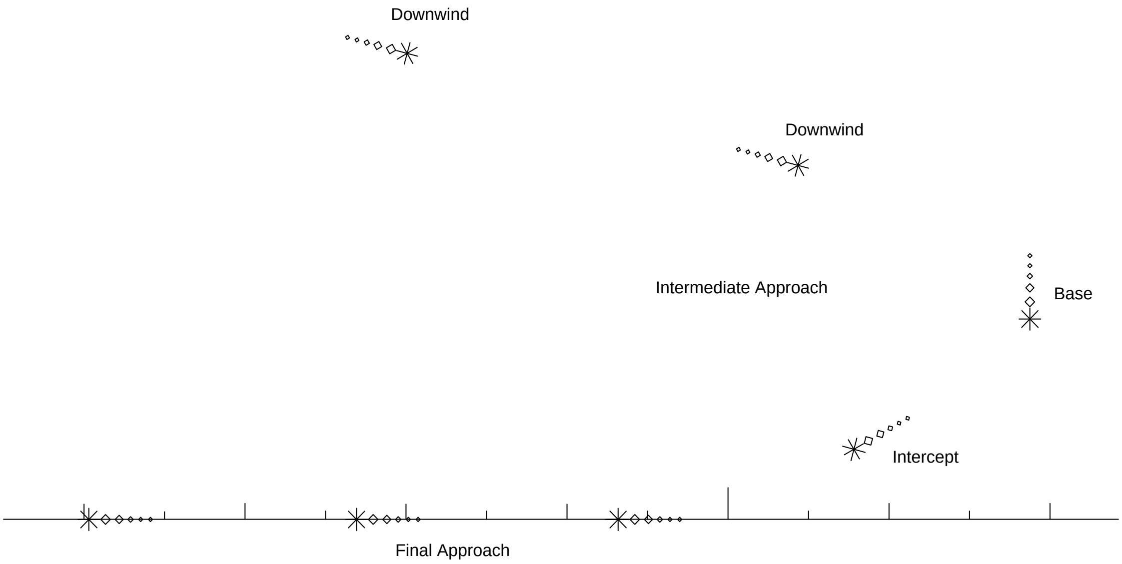


Figure 21: Intermediate and Final Approach

The separation indicator of the TBS distance is required to be first displayed to the final approach controller while the follower aircraft is on intermediate approach, before the turn on decisions that sets up the initial distance spacing on merging on to final approach. This may be with over 20Nm to 25Nm flying distance to the runway landing threshold or up to over 7 to 10 minutes flying time to the runway landing threshold.

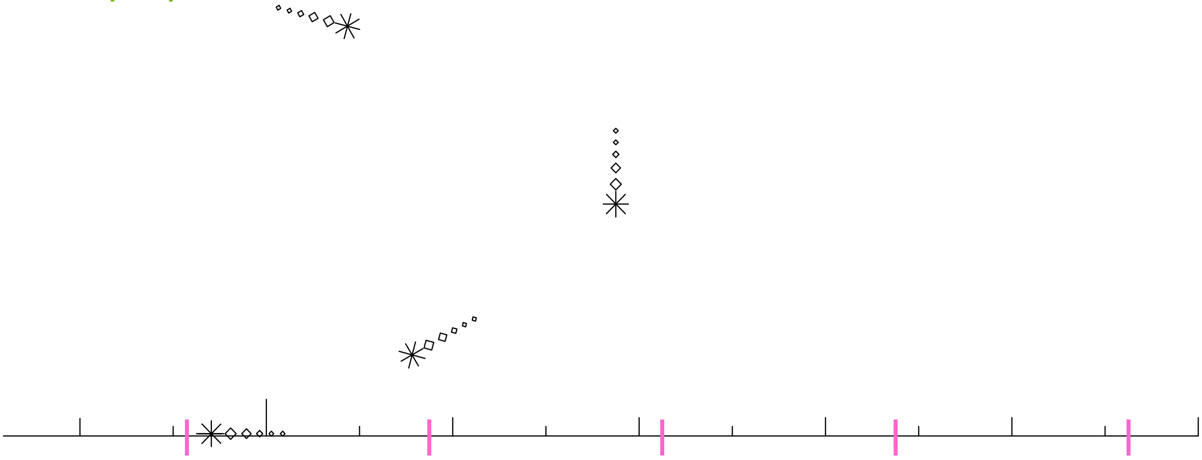


Figure 22: Displaying of Separation Indicators to Support Turn on Decisions on to Final Approach

The final approach controller and the tower runway controller require a visual reference of the required separation or spacing constraint when monitoring for separation infringement as the arrivals descend on the final approach glideslope to the runway landing threshold.

The separation indicator is required to be first displayed to the tower runway controller when both the lead and follower aircraft are established on their respective extended runway centre-lines to provide awareness of the separation and spacing constraint and to support monitoring for separation infringement.

The final approach controller and the tower runway controller require a stable separation indicator distance separation. The TBS distance for an arrival pair shall be re-calculated whenever the ground speed profile changes up until the lead aircraft turns on to intercept the localiser. After the lead aircraft has turned on to intercept the localiser the TBS distance is required to remain stable against subsequent ground speed profile changes.

Note that the proposal to stabilise the TBS distance after the lead aircraft has turned on to intercept the localiser is subject to analysis of the consequences on the management of the wake turbulence encounter risk in the changeable wind conditions.

A separation indicator is required to be displayed behind each lead aircraft established on final approach.

A separation indicator is required to be displayed for lead aircraft on intercept to final approach within a specified distance of the extended runway centre-line that they are merging on to. These include aircraft on intercept that have flown through the extended runway centre-line and are merging back from the other side of the centre-line. These separation indicators are to be positioned the required separation or spacing behind the separation indicator ahead when there is no gap between the separation indicator ahead and the aircraft on intercept to final approach.

A gap between a separation indicator and the aircraft being turned on occurs when the perpendicular projected position of the target position of the aircraft being turned on is behind the separation indicator further from the runway landing threshold.

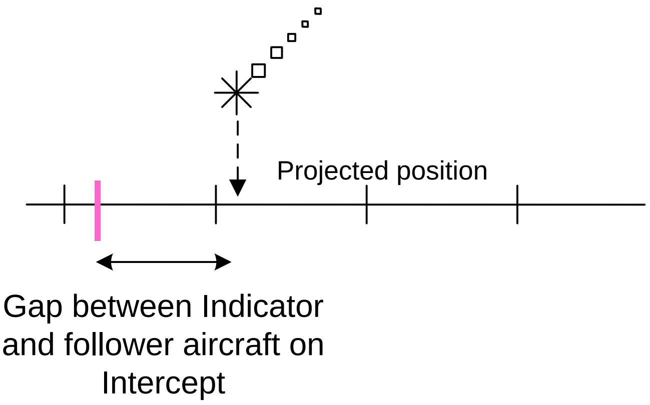


Figure 23: Gap between Separation Indicator and Follower Aircraft

A separation indicator is required to be displayed for a number of aircraft on intermediate approach that have yet to be turned on to intercept to merge on to final approach or which have been turned on to intercept and are more than the specified distance from the extended runway centre-line that they are merging on to. The number of separation indicators displayed should be just sufficient to support the turn on decisions of the final approach controller so as to avoid the confusion and screen clutter that will result from displaying too many separation indicators. There is a need to limit the number of separation indicators for aircraft on intermediate approach yet to turn on to intercept final approach, and the extent from the runway landing threshold that these separation indicators are displayed on final approach.

When a separation indicator is required to be displayed behind aircraft on intermediate approach that has yet to be turned on to intercept to merge on to final approach, the separation indicator is to be positioned the required separation or spacing behind the separation indicator ahead when there is no gap between the separation indicator ahead and the aircraft on intermediate approach.

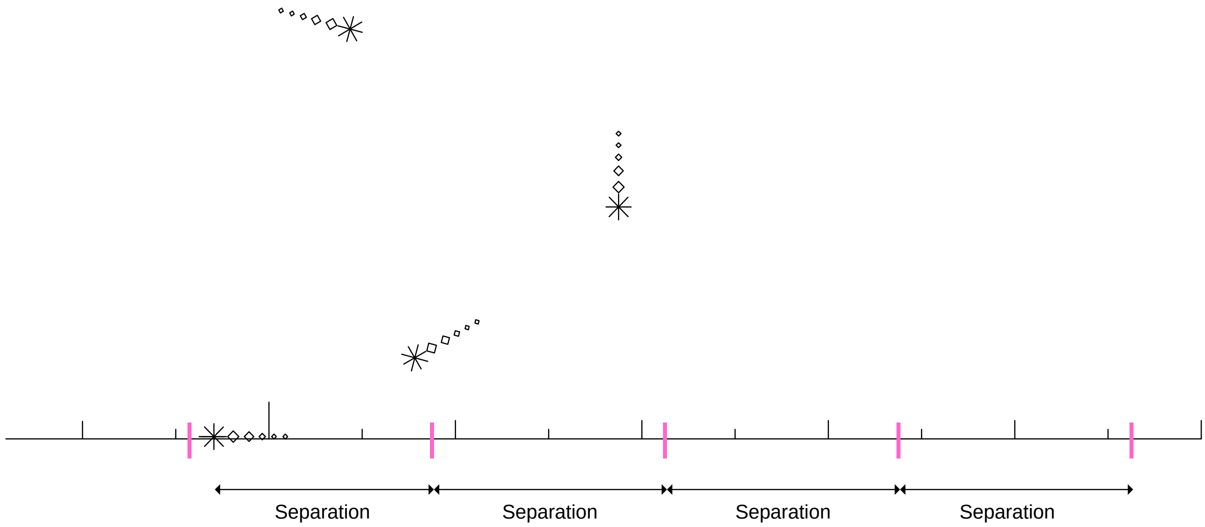


Figure 24: Separation Indicator Positioned the Required Separation behind the Separation Indicator ahead

When there is a gap between the separation indicator and follower aircraft being turned on when the follower aircraft is on base or intercept and within the specified distance of the extended runway centre-line, the separation indicator behind the follower aircraft is to be positioned the required separation or spacing behind the perpendicular projection of the target position of the follower aircraft being turned on.

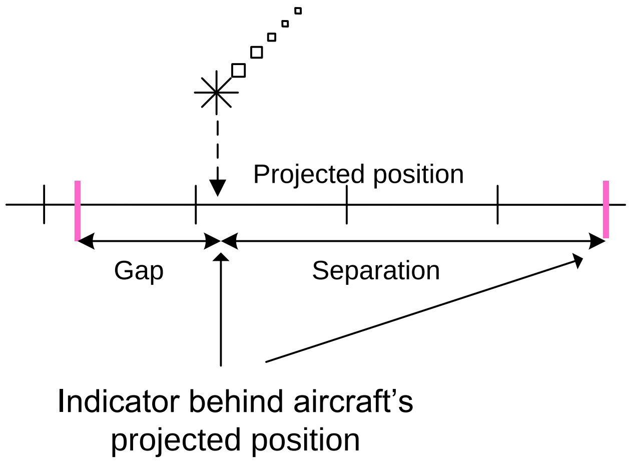


Figure 25: Separation Indicator behind Aircraft's Projected Position after a Gap

An aircraft is on base when the track is +/- 40 degrees to the perpendicular to the extended runway centre-line within the turn on region of final approach and at turn on altitudes for merging on to final approach.

An aircraft is on intercept when the track is +/- 20 degrees of a closing track of 30 degrees to the extended runway centre-line within the turn on region of final approach and at turn on altitudes for merging on to final approach.

An aircraft has captured final approach when the track is +/- 10 degrees of the extended runway centre-line, is stable with the aircraft not turning, and is within the localiser capture region of final approach and at localiser capture altitudes for final approach.

The final approach controller and the tower runway controller need to be able to clearly and consistently recognise at a glance the spatial relationship between each separation indicator displayed and the target position of the follower aircraft when both are in close proximity and overlapping.

The HMI design (i.e. shape, colour, size and display priority) of the separation indicator shall harmoniously integrate into the final approach controller radar display and the tower runway controller air traffic monitor display respectively.

The tower runway controller may need to easily distinguish between a separation indicator for wake separation and a separation indicator for minimum radar separation or spacing minimum. This is so as to easily distinguish wake separations which require cautionary wake advisories when the amount of distance spacing compression exceeds the acceptable levels of compression. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation types represented by the separation indicator.

The final approach controller may need to easily distinguish between a separation indicator for wake separation and a separation indicator for departure gap spacing. This is so as to easily distinguish between a wake separation which needs to be observed at all times and a spacing where there is some flexibility to reduce below the spacing provided the spacing is restored before handover to the tower runway controller. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation types represented by the separation indicator.

A separation indicator is to remain consistently displayed on the extended runway centre-line of the follower aircraft if the lead aircraft laterally drifts off the extended runway centre-line.

A separation indicator is to remain consistently displayed on the extended runway centre-line of the follower aircraft when controller vectoring intervention is used to increase the spacing between the lead aircraft and the aircraft in front by vectoring the lead aircraft away from the centre-line and then back on to the centre-line.

The separation indicator for an aircraft that lands is usually to be automatically removed when the lead aircraft crosses the runway landing threshold to touchdown. This may need to be when the lead target position is removed from the radar display when the aircraft descends below radar surveillance coverage before the runway landing threshold, or when entering an aerodrome blanking area suppressing surface movement targets from being displayed on the final approach controller display, which may extend beyond the runway landing threshold.

The tower runway controller may require selective removal of the separation indicators between spacing minimum pairs as the lead aircraft crosses 4DME with just the separation indicators for wake pairs requiring to be displayed until the lead aircraft crosses the runway landing threshold. This is subject to local preferences.

For large scenario specific spacing gaps (e.g. runway inspection gaps of 12Nm to 15Nm) and other separation indicator distances of 4Nm to 6Nm or more there may be a requirement to support the displaying of the separation indicator after the lead aircraft has crossed the runway landing threshold and been removed from the radar display. This is in order to provide separation indicator support until the follower aircraft has established on final approach, with the separation indicator position being updated and displayed until 6Nm or 4Nm from the runway landing threshold, based on a ground speed profile resulting from applying the reference airspeed profile in the prevailing wind conditions, before being removed. This is subject to local preferences.

For departure gap spacing, there is a requirement to support coasting of the separation indicator as the lead aircraft crosses 4DME and commences landing stabilisation procedures. This is in order to provide separation indicator support for follower aircraft establishing on final approach after the lead aircraft has crossed 4DME which is consistent with a Tower ATC requested gap spacing method which factors in the distance spacing compression that is occurring in the conditions as the lead aircraft progresses from 4DME to the runway landing threshold. The separation indicator position is to be updated and displayed until 6Nm or 4Nm from the runway landing threshold, based on the a ground speed profile resulting from applying the reference airspeed profile in the prevailing wind conditions, before being removed. Where this coasting results in distance spacing compression that reduces the spacing distance between the separation indicator and lead target position to the wake turbulence separation that is required between the lead and follower aircraft, the separation indicator is to be changed to a wake separation indicator type with the corresponding wake separation distance, and the coasting stopped. This is subject to local preferences. This is subject to validation confirmation in the P06.08.04 V3 maturity validation exercises.

The separation indicator for an aircraft that transitions from final approach on to a missed approach is to be automatically removed and the separation indicator distance re-calculated and the separation indicator position updated in front of the arrival aircraft following the missed approach aircraft. A missed approach may be characterised by an altitude divergence of 1000ft or greater above the glideslope or by a sustained climb of 20s or more, or may be characterised by aircraft diverging away from the final approach centre-line for 20s or more or by more than 1Nm.

When the separation or spacing constraints change behind a lead aircraft displaying a separation indicator, the separation indicator distance is to be re-calculated, and the separation indicator position updated.

When the follower aircraft changes behind a lead aircraft displaying a separation indicator, the separation indicator distance is to be re-calculated and the separation indicator position updated.

When an aircraft is removed from the arrival sequence, for example because of a late diversion to a different aerodrome, if a separation indicator is being displayed behind the aircraft, it is to be removed from the display.

When an aircraft is missing from the approach arrival sequence there may be a need to selectively suppress the displaying of the separation indicator between the arrival pair in the approach arrival sequence it is to be merged on between on final approach.

The intermediate approach controllers require the display of the separation indicators on their radar displays so as to provide visual feedback on the appropriateness and consistency of the presentation of aircraft on intermediate approach.

The display requirements established for the separation indicators during human-in-the-loop real-time validation exercises with operational approach controllers are specified in the following subsections:

2.2.6.3 General separation indicator display requirements

2.2.6.4 General separation indicator HMI design requirements

2.2.6.5 General separation indicator display positioning requirements

3.2.1.6.2 Not-In-Trail Dependent Parallel Runway Operations

The following need to be additionally supported for not-in-trail aircraft in dependent parallel runway operations.

For not-in-trail follower aircraft establishing on a different runway localiser the separation indicator is to be displayed on the extended runway centre-line of the landing runway of the follower aircraft.

In parallel runway operations and not-in-trail aircraft the perpendicular projection is on to the extended runway centre-line of landing runway intent of the follower aircraft.

For not-in-trail pairs for parallel runway operations there may also be an in-trail aircraft in front of the follower aircraft. The separation indicator displayed is to be for the maximum of the not-in-trail or in-trail separation or spacing constraints.

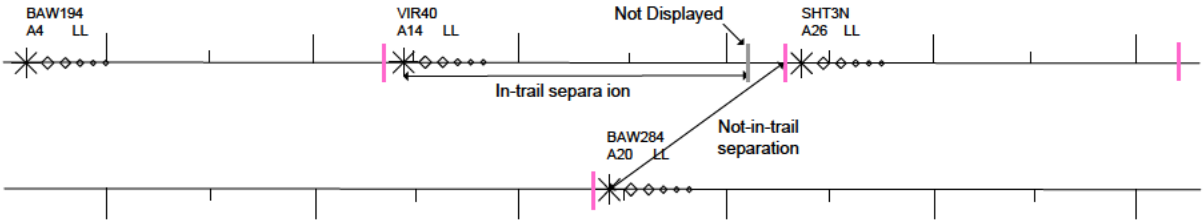


Figure 26: In-Trail Lead Aircraft in front of a Not-in-Trail Follower Aircraft

There is a need for a clear indication of whether the separation or spacing constraint for the displayed separation indicator is a not-in-trail constraint or an in-trail constraint because of the impact on the controller action when there is a risk of separation infringement. When the not-in-trail and in-trail constraints are close together there may be a requirement for both the not-in-trail separation indicator and the in-trail separation indicator to be displayed.

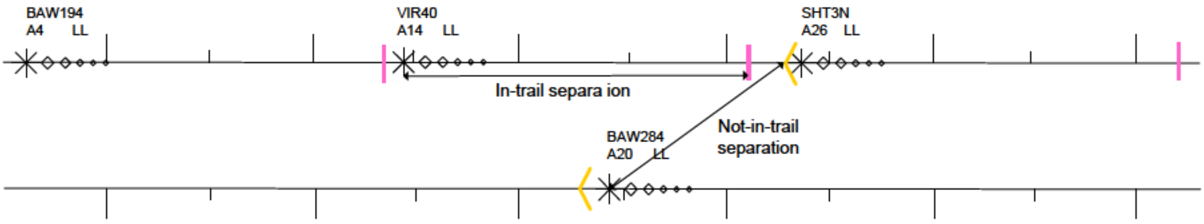


Figure 27: Illustration of Differentiation between In-Trail and Not-In-Trail Separation Indicators

A separation indicator is to remain consistently displayed when for parallel runway operations there is late switching of the landing runway of a single aircraft or multiple aircraft. During the transition between the extended runway centre-lines the impacted separation indicators are to continue to be updated on the extended runway centre-line on which they are being displayed until the aircraft switching landing runway establish on the extended runway centre-line of the switched runway.

When an aircraft undergoing a late runway switch establishes on the centre-line of the switched runway, the impacted separation and spacing constraints ahead and behind the switched aircraft are to be re-calculated because of the change of in-trail and not-in-trail separation and spacing constraints. The displayed position of the separation indicator ahead is to be switched to the extended runway centre-line of the switched runway.

3.2.1.6.3 General Separation Indicator Display Requirements

The following general separation indicator display requirements have been identified:

1. To provide for the consistent and accurate delivery and monitoring to time based wake turbulence separation rules the final approach controller and tower runway controller require

visualisation of the TBS distance separation of the TBS rules. This is to at least a distance separation step resolution of 0.1Nm

2. To facilitate the visualisation of the TBS distance, to the required resolution of the converted TBS rules, a separation indicator is to be displayed on the final approach centre-line, behind the lead aircraft target position on the radar display as a separation reference for the follower aircraft.
3. The separation indicator position is required to clearly reflect the maximum separation or spacing constraint that is required to be applied between the arrival pair.
4. The separation indicator position is to be updated in synchronisation with the track position updates of the lead and follower aircraft in order to provide for a stable visual reference of the applicable separation or spacing constraint.
5. The separation indicator is required to be first displayed to the final approach controller while the follower aircraft is on intermediate approach, before the turn on decisions that sets up the initial distance spacing on merging on to final approach.
6. The separation indicator is required to be first displayed to the tower runway controller when both the lead and follower aircraft are established on their respective extended runway centre-lines to provide awareness of the separation and spacing constraint and to support monitoring for separation infringement
7. A separation indicator required to be displayed behind each lead aircraft established on final approach.
8. A separation indicator is required to be displayed for lead aircraft on intercept to final approach within a specified distance of the extended runway centre-line that they are merging on to. These include aircraft on intercept that have flow through the extended runway centre-line and are merging back from the other side of the centre-line.
9. The specified distance from the extended runway centre line for lead aircraft on intercept shall be an adaptable parameter with a default value of 6Nm.
10. A separation indicator is required to be displayed for a number of aircraft on intermediate approach that have yet to be turned on to intercept to merge on to final approach or which have been turned on to intercept and are more than the specified distance from the extended runway centre-line that they are merging on to. The number of separation indicators displayed should be just sufficient to support the turn on decisions of the final approach controller so as to avoid the confusion and screen clutter that will result from displaying too many separation indicators. There is a need to limit the number of separation indicators for aircraft on intermediate approach yet to turn on to intercept final approach, and the extent from the runway landing threshold that these separation indicators are displayed on final approach.
11. The maximum displayable position of the separation indicator on the final approach centre-line from the runway threshold shall be an adaptable parameter with a default value of 25Nm.
12. The maximum number of additional aircraft behind the last aircraft on final approach or on intercept within the specified distance of the extended runway centre-line that they are merging on to shall be an adaptable parameter with a default value of 3.
13. A separation indicator shall consist of an indicator symbol placed at the required separation or spacing behind the lead aircraft target position.
14. A separation indicator shall always be displayed on the final approach centre-line of the designated landing runway of the follower aircraft for not-in-trail arrival pairs on parallel approaches.
15. A separation indicator is to remain consistently displayed on the extended runway centre-line of the follower aircraft if the lead aircraft laterally drifts off the extended runway centre-line.
16. A separation indicator is to remain consistently displayed on the extended runway centre-line of the follower aircraft when controller vectoring intervention is used to increase the spacing between the lead aircraft and the aircraft in front by vectoring the lead aircraft away from the centre-line and then back on to the centre-line.

17. A separation indicator position shall be updated at the same time as the lead and follower aircraft target positions. At the same time means no discernible delay as visually perceived by the final approach controller and tower runway controller.

18. The final approach controller and the tower runway controller need to be able to clearly and consistently recognise at a glance the spatial relationship between each separation indicator displayed and the target position of the follower aircraft when both are in close proximity and overlapping.

19. For in-trail separation indicators there may be a need to provide the controllers with the means to visually distinguish between the different types of in-trail separation / spacing including wake turbulence separation, minimum radar separation, minimum spacing for visual or runway conditions, and scenario specific spacing including departure gap spacing. This is subject to validation in the future maturity steps.

20. The tower runway controller may need to easily distinguish between a separation indicator for wake separation and a separation indicator for minimum radar separation or spacing minimum. This is so as to easily distinguish wake separations which require cautionary wake advisories when the amount of distance spacing compression exceeds the acceptable levels of compression. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation types represented by the separation indicator.

21. The final approach controller may need to easily distinguish between a separation indicator for wake separation and a separation indicator for departure gap spacing. This is so as to easily distinguish between a wake separation which needs to be observed at all times and a spacing where there is some flexibility to reduce below the spacing provided the spacing is restored before handover to the tower runway controller. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation types represented by the separation indicator.

22. There is a need for a clear indication of whether the separation or spacing constraint for the displayed separation indicator is a not-in-trail constraint or an in-trail constraint because of the impact on the controller action when there is a risk of separation infringement.

23. For not-in-trail pairs for parallel runway operations, there may also be an in-trail aircraft in front of the follower aircraft. The separation indicator displayed is to be for the maximum of the not-in-trail and in-trail separation or spacing requirements.

24. For not-in-trail pairs when the not-in-trail and in-trail constraint are close together there may be a requirement for both the not-in-trail separation indicator and the in-trail separation indicator to be displayed.

25. For not-in-trail separation indicators there may be a need to provide the controllers with the means to visually distinguish between the different types of not-in-trail separation / spacing including minimum radar separation, spacing minim um and RNAV procedures separation. This is subject to validation in the future maturity steps.

26. The separation indicator for an aircraft that lands is usually to be automatically removed when the lead aircraft crosses the runway landing threshold to touchdown. This may need to be when the lead target position is removed from the radar display when the aircraft descends below radar surveillance coverage before the runway landing threshold, or when entering an aerodrome blanking area suppressing surface movement targets from being displayed on the final approach controller display, which may extend beyond the runway landing threshold.

27. The tower runway controller may require selective removal of the separation indicators between spacing minimum pairs as the lead aircraft crosses 4DME with just the separation indicators for wake pairs requiring to be displayed until the lead aircraft crosses the runway landing threshold. This is subject to local preferences. This is subject to validation in the future maturity steps.

28. For large spacing gaps (e.g. runway inspection gaps of 12Nm to 15Nm) and other separation indicator distances of 6Nm or more there may be a requirement to support the displaying of the separation indicator after the lead aircraft has crossed the runway landing threshold and been removed from the radar display. This is in order to provide separation indicator support

until the follower aircraft has established on final approach with the separation indicator position being updated and displayed until 6Nm or 4Nm from the runway landing threshold, based on a ground speed profile resulting from applying the reference airspeed profile in the prevailing wind conditions, before being removed. This is subject to local preferences. This is subject to validation in the future maturity steps.

29. For departure gap spacing, there is a requirement to support coasting of the separation indicator as the lead aircraft crosses 4DME and commences landing stabilisation procedures. This is in order to provided separation indicator support for follower aircraft establishing on final approach after the lead aircraft has crossed 4DME which is consistent with a Tower ATC requested gap spacing method which factors in the distance spacing compression that is occurring in the conditions as the lead aircraft progresses from 4DME to the runway landing threshold. The separation indicator position is to be updated and displayed until 6Nm or 4Nm from the runway landing threshold, based on the a ground speed profile resulting from applying the reference airspeed profile in the prevailing wind conditions, before being removed. Where this coasting results in distance spacing compression that reduces the spacing distance between the separation indicator and lead target position to the wake turbulence separation that is required between the lead and follower aircraft, the separation indicator is to be changed to a wake separation indicator type with the corresponding wake separation distance, and the coasting stopped. This is subject to local preferences .This is subject to validation confirmation in the P06.08.04 V3 maturity validation exercises.

30. The separation indicator for an aircraft that transitions from final approach on to a missed approach is to be automatically removed.

31. When an aircraft undergoing a late runway switch establishes on the centre-line of the switched runway, the impacted separation and spacing constraints ahead and behind the switched aircraft are to be re-calculated because of the change of in-trail and not-in-trail separation and spacing constraints. The displayed position of the separation indicator ahead is to be switched to the extended runway centre-line of the switched runway.

32. When an aircraft is missing from the approach arrival sequence there may be a need to selectively suppress the displaying of the separation indicator between the arrival pair in the approach arrival sequence it is to be merged on between on final approach. This is subject to validation in the future maturity steps.

33. The intermediate approach controllers require the display of the separation indicators on their radar displays so as to provide visual feedback on the appropriateness and consistency of the presentation of aircraft on intermediate approach.

34. The display of separation indicators shall be selectable and de-selectable by the final approach controller, the intermediate approach controllers and the tower runway controller positions so as to be able to support reversion procedures to DBS without separation tool support.

3.2.1.6.4 General Separation Indicator HMI Design Requirements

The following general separation indicator HMI design requirements have been identified:

1. The HMI design (i.e. shape, colour, size and display priority) of the separation indicator shall harmoniously integrate into the final approach controller radar display and the tower runway controller air traffic monitor display respectively.

2. For not-in-trail pairs, there is a need for a clear indication of whether the separation or spacing constraint for the displayed separation indicator is a not-in-trail constraint or an in-trail constraint through employing different HMI designs for in-trail and not-in-trail separation indicators.

3. The default shape for the in-trail separation indicator shall be a marker line perpendicularly oriented to the extended runway centre-line.

4. The default shape and colour for the not-in-trail separation indicator may need to be easily distinguishable from the in-trail separation indicator.

5. An alternative shape for the separation indicators shall be a chevron of two lines at an angle of 140 degrees, with the separation indicator position defined as the point where the two chevron lines meet, and the orientation being in the direction aircraft move down the final approach centre-line of the landing runway (including curved approaches).
6. The separation indicator symbol shall be configurable for size and line width with default settings.
7. The separation indicator symbol shall be configurable for colour and intensity with default settings. The default settings are to be compatible with other local uses of colour coding and display intensity on the final approach controller display and the tower runway controller display.
8. There may be a need to provide the controllers with the means to visually distinguish between the different types of in-trail separation / spacing including wake turbulence separation, minimum radar separation, minimum spacing for visual or runway conditions, and scenario specific spacing including departure gap spacing. This is subject to validation in the future maturity steps.
9. The tower runway controller may need to easily distinguish between a separation indicator displaying a wake separation and a separation indicator displaying a minimum radar separation or spacing minimum. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation type represented by the separation indicator. This is subject to validation in the future maturity steps.
10. The final approach controller may need to easily distinguish between a separation indicator displaying a wake separation and a separation indicator displaying a departure gap spacing. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation type represented by the separation indicator. This is subject to validation in the future maturity steps.
11. There may be a need to provide the controllers with the means to visually distinguish between the different types of not-in-trail separation / spacing including minimum radar separation, spacing minimum and RNAV procedures separation. This is subject to validation in the future maturity steps.
12. When the separation indicator and target symbol overlap on the display, the target symbol shall be displayed over the separation indicator.
13. The separation indicator may require a separation indicator label with the callsign of the aircraft to be turned on to the separation indicator to support final approach controller checking that the correct aircraft is being turned on to the separation indicator.
14. The separation indicator label may be required to be selectable for display.

3.2.1.6.5 General Separation Indicator Display Positioning Requirements

The following general separation indicator display positioning requirements have been identified:

1. When the lead aircraft is on the final approach centre-line, the separation indicator shall be displayed the required separation or spacing behind the lead aircraft target position.
2. A gap between a separation indicator and the aircraft being turned on occurs when the perpendicular projected position of the target position of the aircraft being turned on is behind the separation indicator further from the runway landing threshold.
3. In parallel runway operations and not-in-trail aircraft the perpendicular projection is on to the extended runway centre-line of landing runway intent of the follower aircraft.
4. When the lead aircraft is on intercept to final approach and within a specified distance of the extended runway centre-line it is merging on to, the separation indicator shall be displayed behind the separation indicator ahead when there is no gap between the separation indicator ahead and the aircraft on intercept to final approach.
5. When a separation indicator is required to be displayed behind aircraft on intermediate approach that has yet to be turned on to intercept to merge on to final approach, the

separation indicator is to be positioned the required separation or spacing behind the separation indicator ahead when there is no gap between the separation indicator ahead and the aircraft on intermediate approach.

6. When there is a gap between the separation indicator and follower aircraft being turned on when the follower aircraft is on base or intercept and within the specified distance of the extended runway centre-line, the separation indicator behind the follower aircraft is to be positioned the required separation or spacing behind the perpendicular projection of the target position of the follower aircraft being turned on.
7. For not-in-trail follower aircraft establishing on a different runway localiser the separation indicator is to be displayed on the extended runway centre-line of the landing runway of the follower aircraft.

3.2.1.7 Final Approach Spacing Practice

The final approach controller is required to set up and refine the distance spacing on establishing on the final approach localiser such that the required separation or spacing constraints are observed on final approach to the runway landing threshold.

The separation indicator is required to display a stable distance separation of the separation or spacing constraint that is required to be observed by the follower aircraft. The final approach controller is required to set up distance spacing with the additional spacing required to accommodate the anticipated distance spacing changes that will occur between the follower aircraft establishing on the final approach localiser, until the lead aircraft crosses the runway landing threshold to touchdown.

Distance spacing changes are caused by the ground speed changes as aircraft reduce their airspeed on final approach, first during the procedural airspeed phase of final approach and then during the landing stabilisation speed phase of final approach. The slower the landing stabilisation speed and the sooner the aircraft stabilise on their landing stabilisation speed the more and the sooner the ground speed reduces and the more the distance spacing changes.

These distance spacing changes are impacted by the changing wind conditions experienced as aircraft descend on the glideslope. The wind speed usually drops off and the wind direction usually backs up as aircraft descend on the glideslope. In some wind conditions the headwind effect reduces as aircraft descend on the glideslope which can offset some of the ground speed changes caused by the reducing airspeed profile. In some wind conditions the headwind effect increases as aircraft descend on the glideslope which can add to the ground speed changes.

These distance spacing changes are impacted by changing time spacing between the lead and follower aircraft which are caused by the follower aircraft having a significantly faster or slower airspeed profile than the lead aircraft. This can significantly impact spacing minimum pairs because the follower aircraft will have commenced landing speed stabilisation before the lead aircraft crosses the runway landing threshold.

As an illustration of the distance spacing change effects observed, a 20kts reduction in ground speed during landing speed stabilisation can result in a 0.5Nm reduction in the distance spacing. Some aircraft types reduce their airspeed by more than 40kts during landing speed stabilisation causing the distance spacing to change by more than 1.0Nm. For spacing minimum pairs, a fast follower aircraft and a slow lead aircraft can result in around up to an additional 15s time spacing reduction between the lead aircraft starting landing speed stabilisation and the lead aircraft crossing the runway landing threshold. This can result in more than 1.5Nm distance spacing reduction between the lead aircraft commencing landing speed stabilisation and the lead aircraft crossing the runway landing threshold. To accommodate the 1.5Nm distance spacing reduction the final approach controller is required to apply 1.5Nm additional spacing at the start of landing speed stabilisation.

The follower aircraft is to be turned on in the zone behind the separation indicator with sufficient additional spacing for the distance spacing compression expected to be experienced in the prevailing glideslope wind conditions for the anticipated airspeed profiles of both the lead aircraft and the follower aircraft. Ideally, sufficient spacing is set up by the final approach controller such that there is no need for further intervention action. In the event of unanticipated compression the final approach controller and the tower runway controller are required to take active steps to preserve the separation and to recover separation when infringed.

In current operations the flight deck only informs Approach ATC of their intended approach speed profile if the selected landing stabilisation speed is exceptional (either slow or fast) or if the aircraft cannot conform to the procedural approach speed profile. In these situations the final approach controller is required to apply their on-the-job experience to judge the amount of distance spacing change to accommodate between each arrival pair for the intended approach speed profile.

There is a need to ensure the efficiency of the final approach spacing practice with respect to the additional spacing applied with the separation indicator. This efficiency is impacted by the amount of uncertainty about the intended landing stabilisation speed profiles of the respective lead and follower aircraft.

It has been proposed that the flight deck inform Approach ATC of their intended landing stabilisation speed on first call to Approach ATC so as to enable the application of more consistent and efficient final approach spacing practice by the final approach controller. The R/T and workload consequences are such that in the short term the current procedure with DBS is proposed to be taken forward for the initial deployment. The current DBS procedures consist of applying the approach controller on on-the-job training and experience, supplemented with the ad-hoc flight crew reporting when there is the intention to employ an exceptional landing stabilisation speed.

In phase 2 of P06.08.01 the requirements for Optimised Runway Delivery are being investigated with the objective of extending the scope of the TBS tool support to include advice on the additional spacing required between each arrival pair taking into account their respective landing stabilisation speed profile intentions or characteristics.

The final approach controller and the tower runway controller remain responsible for monitoring for separation infringement and for timely intervention action.

There is a significant potential for separation infringement scenarios on final approach because of the diversity of approach speed profiles being employed and the resulting uncertainties about the amount of distance spacing change and time spacing change that will be experienced between each arrival pair on final approach.

3.2.1.8 Airspace User Considerations

An important objective of the development of the TBS Concept is to have a minimum impact on airspace users and airframe equipage so as to facilitate early deployment.

Easy to assimilate multi-media awareness briefing material is required to enable flight crews to be aware of the principles of TBS and what to expect in terms of the separation on final approach. This would be used in the pre-departure briefing and the top of descent briefing.

Notification is required that TBS is being employed on final approach through the terminal information service (D-ATIS) which may need to include the related prevailing wind conditions on final approach.

It has been proposed that the flight deck inform Approach ATC of their intended landing stabilisation speed on first call to Approach ATC so as to enable the application of more consistent and efficient final approach spacing practice by the final approach controller. The R/T and workload consequences are such that in the short term the current procedure with DBS is proposed to be taken forward for the initial deployment. The current DBS procedures consist of applying the approach controller on on-the-job training and experience, supplemented with the ad-hoc flight crew reporting when there is the intention to employ an exceptional landing stabilisation speed for the aircraft type.

The flight deck may need to be able to monitor that the spacing being set up on final approach is appropriate for the reported prevailing wind conditions. A simple procedure may be required for establishing the distance spacing for the TBS rules.

The cautionary wake vortex advisory phraseology may require to be modified so as to be able to be employed with the TBS Concept.

3.2.1.9 Safety Mitigation Elements of the TBS Concept

3.2.1.9.1 Identification of the Safety Mitigation Elements

The SESAR P06.08.01 Safety Assessment [78] and Human Performance Assessment [79] have identified a number of safety mitigation elements associated with the causal factors and outcomes of the identified Hazards resulting from the provision and use of separation indicators:

1. Missing separation indicator (one or more)
2. Sudden loss of separation indicators
3. Separation indicator incorrectly displayed with an incorrect separation
4. Misuse of correctly displayed separation indicator
5. Unanticipated aircraft behaviour

To mitigate against a missing separation indicator an alert is required to be provided to the controllers so that they can revert to applying DBS without a separation indicator. This alert will be required to be provided independently of the displaying of the separation indicators. A candidate option is through the approach arrival sequence display. The approach arrival sequence display will be required to indicate the arrival aircraft in the arrival sequence, those pairs for which a separation indicator distance has been calculated and provide an alert for those pairs for which a separation indicator distance could not be calculated.

When an arrival aircraft is missing from the arrival sequence the options available to the controllers are in order of preference:

1. Create the aircraft entry in the arrival sequence with the corresponding identifiers with the flight data and the surveillance data so that the aircraft is no longer missing from the arrival sequence so that separation indicators can be provided in the normal way.
2. Create a scenario specific gap between the lead aircraft that the missing aircraft is to be inserted behind and the follower aircraft the missing aircraft is to be inserted in front. This gap must be sufficient for the combined DBS wake turbulence separation requirements between the lead aircraft and the missing aircraft and the DBS wake turbulence separation requirements between the missing aircraft and the follower aircraft. The missing aircraft will need to be merged on to final approach by the final approach controller without a reference separation indicator to the required DBS behind the lead aircraft. The follower aircraft behind the missing aircraft can then be merged on to final approach using the separation indicator with the scenario specific gap behind the lead aircraft.
3. Selectively disable the separation indicator between the lead aircraft and the follower aircraft that the missing aircraft is to be slotted in between. The final approach controller will need to merge the missing aircraft and the follower aircraft on to final approach to the required DBS without the aid of separation indicators.

The possible causal factors for a separation indicator distance not being able to be calculated include:

1. Individual aircraft missing from the arrival sequence
2. Missing/unrecognised wake vortex category or aircraft type
3. Incorrect arrival sequence order with an aircraft not yet tracked on intermediate approach
4. Sequence service failure/error
5. TBS tool failure/error (including corrupt/missing data)

The approach arrival sequence display will facilitate the identification of aircraft missing from the arrival sequence, aircraft with a missing/unrecognised wake vortex category or aircraft type, and an incorrect arrival sequence order.

To mitigate against a controller mistaking a missing separation indicator with a displayed separation indicator there is a requirement to alert when the arrival sequence order on intermediate approach is differently ordered to the arrival sequence order displayed to the controllers, and also to alert when the wrong aircraft is turned on to a separation indicator.

A further mitigation is to have a visual indication of the separation indicator / aircraft pairing, through for example a separation indicator label with the follower aircraft callsign (although this may cause too much screen clutter for Heathrow controllers) or for some other visual indication such as colour coding corresponding to the follower wake category.

To mitigate against sudden loss of separation indicators, the controller shall revert to DBS without separation indicator support for new aircraft being turned on to final approach, and to continue with the separation set up for aircraft already established on final approach provided the final approach controller and tower runway controller are satisfied that it is safe to continue with the separation set up.

To mitigate against a TBS tool failure or a sequence service failure an alert is required to be provided to the TMA System Operating Authority and to the Approach and Tower Supervisors of such failures so that the degraded mode procedures are invoked in good time.

To mitigate against a separation indicator being incorrectly displayed with an incorrect separation distance there is a requirement to provide the controllers with a means of checking each separation indicator distance prior to the separation indicator being displayed, and also to quickly check the separation indicator distance once it is displayed. A candidate option for checking the separation indicator distance prior to the separation indicator being displayed is through the approach arrival sequence display. To enable the checking of the TBS distance there is a requirement to provide the controllers with a display of the glideslope wind conditions and associated headwind effects and the associated impact on the TBS distance associated with each wake vortex category pair.

The possible causal factors for a separation indicator distance being incorrectly calculated include:

1. Incorrect arrival sequence order
2. Incorrect wake category or aircraft type
3. TBS tool failure/error
4. Sequence service failure/error
5. Wind service failure/error
6. Incorrect aircraft runway intent (for aircraft nominated for landing on the departure runway)
7. Incorrect final approach separation or runway spacing constraints
8. Incorrect scenario specific spacing requests including incorrect departure gap requests
9. Wrong aircraft turning on to the separation indicator

The approach arrival sequence display will facilitate the identification and correction of the majority of the above possible causal factors prior to the separation indicator being displayed, These include incorrect arrival sequence order, incorrect wake category or aircraft type, incorrect aircraft runway intent, incorrect final approach separation or runway spacing constraints, and incorrect scenario specific spacing requests. This is provided that the aircraft runway intent, the scenario specific spacing and the final approach separation and runway spacing constraints are reflected in the approach arrival sequence display.

To mitigate against the aircraft being delivered out of arrival sequence order or the wrong aircraft being turned on to a separation indicator there is a requirement to alert when the arrival sequence order on intermediate approach is differently ordered to the arrival sequence order displayed to the controllers, and also to alert when the wrong aircraft is turned on to a separation indicator.

To mitigate against TBS tool failure, sequence service failure or wind service failure an alert is required to be provided to the TMA System Operating Authority and to the Approach and Tower Supervisors of such failures so that the degraded mode procedures are invoked in good time.

To mitigate against the misuse of a correctly displayed separation indicator there is a requirement to provide controllers with the means to distinguish between the different types of separation / spacing. Tower runway controllers require to distinguish between wake pairs and minimum radar separation non-wake pairs when the distance spacing compression during landing speed stabilisation is such that cautionary wake advisories are required to be issued to the follower aircraft of wake pairs. Final approach controllers require to distinguish between wake pairs and departure gap pairs for interlaced mode operations.

The possible causal factors of the misuse of a correctly displayed separation indicator include:

1. Using the separation indicator as a target rather than a reference
2. Confusion between separation and spacing constraints for in-trail pairs
3. Confusion between separation and spacing constraints for not-in-trail pairs
4. Inadequate application of spacing practice for managing anticipated distance spacing compression on final approach
5. Unplanned sequence changes due to the wrong aircraft turning on to a separation indicator

To mitigate against inadequate application of spacing practice there is requirement to alert controllers of a distance spacing compression catch-up that is leading to imminent separation infringement, or has caused a separation infringement,

To mitigate against an unplanned sequence change due to the wrong aircraft turning on to a separation indicator there is a requirement to alert when the wrong aircraft is turned on to a separation indicator.

To mitigate against an unplanned change of landing runway intent due to the aircraft being turned on to wrong localiser there is a requirement to alert when an aircraft is merged on to the wrong localiser.

To mitigate against unanticipated aircraft behaviour there is a requirement to alert controllers when an aircraft employs an abnormal indicated airspeed from merging on to final approach until commencing landing speed stabilisation, and to alert controllers of a distance spacing compression catch-up that leading to imminent separation infringement or has caused a separation infringement.

A further mitigation is to incorporate spacing practice support into the TBS tool through providing an indication of the additional spacing that needs to be set up at the start of landing speed stabilisation to compensate for the distance spacing compression that will be experienced between the lead aircraft commencing landing speed stabilisation between 4Nm and 6Nm from the runway landing threshold and crossing the runway landing threshold to land.

3.2.1.9.2 Summary of Identified Safety Mitigation Elements

Note that the mitigations identified are proposals for ways in which associated risk could be managed, without risk classification or analysis to determine which ones are absolutely necessary. Further assessment is needed during V4 and V5 maturity validation activities to determine which subset of proposed mitigations will be required.

It is imperative that the sequence and separation / spacing information provided to the TBS tool is dependable because of the safety implications associated with inducing a severe wake turbulence encounter risk if not. Approach controllers are required to be provided with the means to check and amend the sequence and separation / spacing information and to check the calculated separation indicator distance before each separation indicator is displayed. The following system support mitigation has been identified:

- **Approach Arrival Sequence Display** to facilitate:
  - Identification of individual aircraft not in the arrival sequence.
  - Identification of an incorrect arrival sequence order.
  - Identification / alerting of aircraft without a separation indicator.
  - Coordination and checking of the aircraft landing runway intent for aircraft designated to land on the departure runway.
  - Coordination and checking of the aircraft landing runway intent following a planned or immediate change of arrival runway.

- Coordination and checking of the final approach separation and runway spacing of each runway-in-use including planned or immediate changes of final approach separation or runway spacing constraints.
- Checking and amending of each aircraft wake vortex category and aircraft type.
- Coordination and checking of scenario specific spacing requests including departure gap spacing requests.
- Checking of the separation indicator distance prior to the separation indicator being displayed.

- **Glideslope Wind Conditions and TBS Distance Display** to facilitate:
    - Checking that each TBS distance match the glideslope wind conditions.
    - Checking of the separation indicator distance displayed in the Approach Arrival Sequence Display prior to the separation indicator being displayed.
    - Checking of the separation indicator distance when the separation indicator is displayed prior to the follower aircraft being turned on

Approach controller procedures for checking and updating the arrival sequence order may not be 100% effective. In addition the final approach controller may inadvertently turn the wrong aircraft to merge behind a separation indicator or a pilot may inadvertently act on a turn instruction for another aircraft. The following system support mitigation has been identified:

- **Arrival Sequence Order Monitor** to facilitate:
    - Checking and alerting when the arrival sequence order delivered on intermediate approach mismatches the arrival sequence order in the approach arrival sequence display.
    - This should include the checking of all aircraft on intermediate approach being merged on to final approach and not just the aircraft in the Approach Arrival Sequence Display.
- **Visual Indication of the Separation Indicator / Aircraft Pairing** to facilitate:
    - Controller association to the correct follower aircraft to each separation indicator.
- **Wrong Aircraft Turned on to Separation Indicator Monitor** to facilitate:
    - Checking and alerting for when the wrong aircraft is turned on to a separation indicator.
    - This should include the checking of all aircraft on intermediate approach being merged on to final approach and not just the aircraft in the Approach Arrival Sequence Display.
- **Aircraft Turned on to Wrong Localiser Monitor** to facilitate:
    - Checking and alerting for when an aircraft is merged on to the wrong final approach localiser.

It is imperative in the event of a system failure that there is timely transition to degraded mode operations. The following system support mitigation has been identified:

- **TBS System Monitor** to facilitate:
  - Monitoring and alerting of a TBS System failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.
- **Arrival Sequence Service Monitor** to facilitate:
  - Monitoring and alerting of an Arrival Sequence Service failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.
- **Glideslope Wind Conditions Service Monitor** to facilitate:
  - Monitoring and alerting of a Glideslope Wind Conditions Service failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.

The final approach controller and the tower runway controller require the means to distinguish between the different types of separation / spacing. The following system support has been identified:

- **Separation Indicator Type Support** to facilitate:
  - Providing the controllers the means to visually distinguish between the different types of in-trail separation / spacing including wake separation, minimum radar separation, minimum spacing for visual or runway conditions, and scenario specific spacing including departure gap spacing.
  - Providing the controllers with the means to visually distinguish between the different types of not-in-trail separation / spacing including minimum radar separation, minimum spacing and RNAV procedures separation.

In the event of unanticipated aircraft behaviour the following system support has been identified to facilitate timely controller intervention action:

- **Abnormal Indicated Airspeed Monitor** to facilitate:
  - Monitoring and alerting for abnormal final approach airspeed behaviour that significantly increases the risk of separation infringement.
- **Distance Spacing Compression Monitor** to facilitate:
  - Monitoring and alerting for distance spacing compression that is causing an imminent separation infringement or has caused a separation infringement.

To aid the consistency of the application of additional spacing to compensate for the distance spacing compression experienced during the lead aircraft landing stabilisation phase of final approach, the following system support has been identified:

- **Optimised Runway Delivery Support** to provide:
  - An indication of the additional spacing that needs to be set up behind the lead aircraft prior to commencing landing speed stabilisation in order to compensate for the distance spacing compression that is anticipated during landing speed stabilisation to the lead aircraft crossing the runway landing threshold to land.

3.2.1.9.3 Approach Arrival Sequence Display

The Approach Arrival Sequence Display is required to be provided at the Approach Supervisor, Intermediate Approach Controller, and Final Approach Controller CWPs and the Tower Supervisor and Tower Runway Controller CWPs.

The Approach Arrival Sequence Display is required to display the arrival sequence order with the aircraft runway intent and aircraft wake category / aircraft type out to the working horizon of the intermediate approach controllers coordinating and accepting aircraft into the initial approach fixes.

The Approach Arrival Sequence Display is required to display the planned and immediate changes of runways-in-use, runway modes, and final approach separation and runway spacing constraints and the resulting separation indicator distance between each arrival pair.

The Approach Arrival Sequence Display may be provided through extending the functionality of AMAN to provide a final approach arrival sequence service or may be provided through a new dedicated final approach arrival sequence service which utilises as input the AMAN metering arrival sequence into the initial approach fixes.

The separation indicator distances may either be provided by the TBS tool or may be calculated independently by the final approach arrival sequence service, using the TBS distances provided by the TBS tool so that the TBS distances can be checked prior to the separation indicators being displayed.

The Approach Arrival Sequence Display is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.4 Glideslope Wind Conditions and TBS Distance Display

The Glideslope Wind Conditions and TBS Distance Display is required to be provided at the Approach Supervisor, Intermediate Approach Controller, and Final Approach Controller CWPs and the Tower Supervisor and Tower Runway Controller CWPs.

The Glideslope Wind Conditions and TBS Distance Display is required to display the TBS distances for the wake turbulence separation for the prevailing glideslope wind conditions in such a way that the supervisors and controllers can check the calculated TBS distances.

It should be noted that the mean headwind will vary across the different TBS distances due to the changing boundary layer wind conditions as aircraft descend on the glideslope. Thus an A380 – Light spacing of 189s will have a different mean headwind than a spacing minimum of 60s.

Lead	Follower	TBS Time	TBS Distance	Mean Headwind
J	H	145s	5.4Nm	20kts
	M	167s	6.3Nm	22kts
	L	189s	7.2Nm	23kts
H	H	98s	3.6Nm	17kts
	M	122s	4.5Nm	19kts
	L	145s	5.4Nm	20kts
M	L	122s	4.5Nm	19kts
Spacing Minimum Pairs		60s	2.2Nm	15kts

Table 13: Example Glideslope Wind Conditions and TBS Distance Display

The Glideslope Wind Conditions and TBS Distance Display is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.5 Arrival Sequence Order Monitor

The Arrival Sequence Order Monitor is required to check that the arrival sequence order delivered on intermediate approach matches the arrival sequence order in the Approach Arrival Sequence. This checking should be from prior to the turn on decisions to merge aircraft on to final approach so that the sequence order can be corrected prior to the turn on decisions.

This should include the checking of all aircraft on intermediate approach being merged on to final approach and not just the aircraft in the Approach Arrival Sequence.

The checking should take into account the relative altitudes of the arrival aircraft, where for most of the time the ascending altitude order should match the arrival sequence order. In cases where there is a mismatch in altitude ordering, the relative position on intermediate approach is to be checked to establish whether the aircraft are in a position to be merged on to final approach in the arrival sequence order in the Approach Arrival Sequence.

The alerting of when the arrival sequence order on intermediate approach mismatches the arrival sequence order in the Approach Arrival Sequence may be through the Approach Arrival Sequence Display. The Arrival Sequence Order Monitor is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.6 Wrong Aircraft Turned on to Separation Indicator Monitor

The Wrong Aircraft Turned on to Separation Indicator Monitor is required to check that the aircraft turned on to merge on to final approach behind each separation indicator is the follower aircraft used to calculate the separation indicator distance.

This should include checking of all aircraft merging on to final approach and not just the aircraft in the Approach Arrival Sequence.

The only aircraft that should be within the minimum radar separation of a separation indicator is the follower aircraft in the Approach Arrival Sequence used to calculate the separation indicator distance.

In cases of a gap in the arrival traffic, the nearest aircraft on final approach to the separation indicator should be the follower aircraft in the Approach Arrival Sequence used to calculate the separation indicator distance.

The alerting of when the wrong aircraft has turned on to a separation indicator may be through displaying / highlighting the follower aircraft callsign in the separation indicator label, or through highlighting the follower aircraft in the Approach Arrival Sequence Display, or both. The Wrong Aircraft Turned on to Separation Indicator Monitor is subject to development and validation in the V4 and V5 maturity steps.

When the wrong aircraft is being turned on to a separation indicator there will also be at least one other aircraft out of arrival sequence order with the potential of being turned on to the wrong separation indicator.

3.2.1.9.7 Aircraft Turned on to Wrong Localiser Monitor

The Aircraft Turned on Wrong Localiser Monitor is required to check that each aircraft merges on the final approach localiser of their landing runway intent on the Approach Arrival Sequence that was used to calculate the separation indicator distance and to determine on which final approach localiser centre-line to display the separation indicator.

The alerting of when an aircraft has turned on to the wrong localiser may be through displaying / highlighting the follower aircraft callsign in the separation indicator label, or through highlighting the follower aircraft in the Approach Arrival Sequence Display, or both. The Aircraft Turned on to Wrong Localiser Monitor is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.8 Visual Indication of the Separation Indicator / Aircraft Pairing

A Visual Indication of the Separation Indicator / Aircraft Pairing can be provided by the follower aircraft callsign being displayed in a separation indicator label associated with each separation indicator. This enables the final approach controller to visually / manually check that they are turning on the correct aircraft on to each separation indicator.

This was acceptable to the Stockholm Arlanda approach controllers involved in the EC 6FP RESET project simulation [51]. However the Heathrow approach controllers have rejected this approach because of the screen clutter impact of separation indicator labels.

An alternative approach has been suggested for Heathrow of the colour of the separation indicator being used to provide a visual indication of the wake category of the follower aircraft. The suggestion is to use the same colour coding as per the flight progress strip holders; Heavy yellow, Upper Medium white, Lower Medium, Small and Light blue. This is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.9 TBS System Monitor

The TBS System Monitor is required to actively check the TBS System and associated services and key interoperability interfaces are serviceable.

The TBS System Monitor is required to alert the TMA System Operating Authority and the Approach and Tower Supervisors of TBS System failures so as to facilitate timely transition to degraded mode operations.

This is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.10 Arrival Sequence Service Monitor

The Arrival Sequence Service Monitor is required to actively check the Arrival Sequence Service and key interoperability interfaces are serviceable.

The Arrival Sequence Service Monitor is required to alert the TMA System Operating Authority and the Approach and Tower Supervisors of Arrival Sequence Service failures so as to facilitate timely transition to degraded mode operations.

This is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.11 Glideslope Wind Conditions Service Monitor

The Glideslope Wind Conditions Service Monitor is required to actively check the Glideslope Wind Conditions Service and key interoperability interfaces are serviceable.

The Glideslope Wind conditions Service Monitor is required to alert the TMA System Operating Authority and the Approach and Tower Supervisors of Glideslope Wind Conditions Service failures so as to facilitate timely transition to degraded mode operations.

This is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.12 Separation Indicator Type Support

The Separation Indicator Type Support may be required to provide the controllers with the means to visually distinguish between the different types of in-trail separation / spacing including wake separation, minimum radar separation, minimum spacing for visual or runway conditions, and scenario specific spacing including departure gap spacing.

The tower runway controller may need to easily distinguish between a separation indicator displaying a wake separation and a separation indicator displaying a minimum radar separation or spacing minimum. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation types represented by the separation indicator.

The final approach controller may need to easily distinguish between a separation indicator displaying a wake separation and a separation indicator displaying a departure gap spacing. This is a local adaptation issue which may require the HMI design to visually distinguish between the separation types represented by the separation indicator.

The Separation Indicator Type support may also be required to provide the controllers with the means to visually distinguish between the different types of not-in-trail separation / spacing including minimum radar separation, RNAV procedures separation, and minimum spacing.

The visual distinction may be through the shape, size and colour coding of the separation indicator. More complex shapes than the straight line and chevron shaped indicators may require to be supported. This is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.13 Abnormal Indicated Airspeed Monitor

The Abnormal Indicated Airspeed Monitor is required to monitor for abnormal final approach airspeed behaviour that significantly increases the risk of separation infringement.

Early identification of significant deviations from the procedural airspeed profiles employed on final approach can contribute to consistent and timely intervention before separation infringement occurs.

Automatic monitoring and alerting of deviations from the procedural airspeed profiles employed on final approach has the potential to support consistent and timely intervention before separation infringement occurs.

The current enhanced Mode-S down linked airborne parameters including indicated airspeed (and ground speed) can be utilised for monitoring for non-conformant airspeed behaviour.

The final approach controller can be alerted through the IAS field in the target label. This has been developed and deployed with DBS at Heathrow.

3.2.1.9.14 Distance Spacing Compression Monitor

The Distance Spacing Compression Monitor is required to monitor for ground speed differences between the lead and follower aircraft resulting in distance spacing compression either leading to an imminent separation infringement or has caused a separation infringement.

The separation between aircraft on final approach and the ground speed differences can be monitored using surveillance data.

The Distance Spacing Compression Monitor is required to monitor for separation infringement of the wake separation and minimum radar separation. This includes the TBS distance of the TBS rules.

The Distance Spacing Compression Monitor may be required to monitor for the infringement of spacing minimum and scenario specific spacing including departure gaps.

The controllers shall be alerted of an imminent significant separation infringement or an actual significant separation infringement.

The separation indicator distance calculated by the TBS tool may be used as a reference of the required separation /spacing.

The alert may be in the form of a specialised conflict alert. This has been developed for deployment at Heathrow for DBS and will need to be adapted to TBS. This is subject to development and validation in the V4 and V5 maturity steps.

3.2.1.9.15 Optimised Runway Delivery Support

The Optimised Runway Delivery Support is required to provide an indication of the of the additional spacing that needs to be set up behind the lead aircraft prior to commencing landing speed stabilisation in order to compensate for the distance spacing compression that is anticipated during landing speed stabilisation to the lead aircraft crossing the runway landing threshold to land.

The amount of additional spacing is determined by taking into account the anticipated final approach speed profile of the lead aircraft, and particularly the anticipated landing stabilisation speed profile of the lead aircraft, together with taking into account the anticipated final approach speed profile of the follower aircraft, particularly the anticipated final approach speed profile from the position of the follower aircraft when the lead aircraft commences landing speed stabilisation, to the position of the follower aircraft when the lead aircraft crosses the runway landing threshold.

The additional spacing may be displayed by adding an additional spacing indication to the current separation indicator design, with the separation indicator displaying both the separation or spacing required to be observed to the final approach threshold and the additional spacing that is required to be set up when the lead aircraft commences landing speed stabilisation.

The additional spacing indication is required to be displayed from when the separation indicator is first displayed until the lead aircraft commences landing speed stabilisation and the distance spacing compression commences. Only the separation indicator of the required separation or spacing is required to be displayed once the lead aircraft commences landing speed stabilisation, Optionally the remaining anticipated distance spacing compression may be displayed, which will require the additional spacing to be re-calculated on each track update taking into account the amount of distance spacing compression that has already occurred.

In phase 2 of P06.08.01 the requirements for Optimised Runway Delivery will be investigated with the objective of extending the scope of the TBS tool support to include advice on the additional spacing required between each arrival pair taking into account their respective final approach speed profile intentions or characteristics.

3.2.1.10 Transition into Service Elements of the TBS Concept

The SESAR P06.08.01 Human Performance Assessment [79] has identified the potential requirement to support a stepped introduction of TBS from current DBS operations:

- First step of DBS operations with separation indicator tool support.
- Next step introduce TBS gradually slowly increasing the amount of allowable reduction in the TBS distance compared to DBS
    - For example, limit of 0.5Nm or 10% reduction to start with, increasing to 0.75Nm or 15% reduction, then 1.0Nm or 20% reduction, and so on, as confirming evidence is accumulated of the separation delivery performance of the controllers, and the impact on the pilot reported wake turbulence encounter rate.

3.2.1.11 Reduction of the 2.5Nm Minimum Radar Separation on Final Approach

It is proposed that the current 3Nm and 2.5Nm minimum radar separation on final approach be applied on the initial deployment of the TBS.

However, the 2.5Nm minimum radar separation on final approach constrains the efficiency with which the spacing minimum pairs can be delivered to the TBS on final approach.

For the proposed TBS rule of 60s at the runway threshold for the spacing minimum pairs, the 2.5Nm minimum radar separation represents a mean ground speed of 150kts. When the mean ground speed falls below 150kts during the landing stabilisation phase of final approach to the runway landing threshold, additional time spacing results from adhering to the 2.5Nm minimum radar separation.

For the future it is proposed that a 2Nm minimum radar separation is applied during the landing stabilisation speed phase of final approach to the runway landing threshold.

For the future, it is also proposed that a reduced minimum radar separation below the 2.5Nm minimum radar separation is applied during the procedural airspeed phase of final approach when both the lead and follower aircraft are established on the final approach glideslope.

P06.08.03 is to address reducing the minimum radar separation on final approach.

3.2.1.12 Operational Roles and Responsibilities

The TBS concept operationally impacts Tower ATC, Approach ATC and the Flight Deck.

The Tower Supervisor in coordination with the Approach Supervisor is responsible for ensuring the appropriate separation and spacing constraints, including planned changes to the constraints are specified and maintained through, for example, a separation/spacing mode tool.

The Tower Supervisor and the Approach Supervisor are responsible for ensuring that the flight deck of the arriving aircraft are informed when TBS are being applied on final approach.

The Flight Deck of the arriving aircraft are required to be aware of TBS operation and the ground speed impact of the prevailing wind conditions on the TBS distance on final approach.

The final approach controller is responsible for the safe and efficient processing of arrivals to the runway landing threshold and for consistently and efficiently applying final approach spacing practice when setting up and refining the distance spacing on final approach to each separation indicator.

The Flight Deck of the arriving aircraft are responsible for informing Approach ATC of any non-conformant final approach procedural airspeed issues on first call to Approach ATC, and of optionally informing of when there is an intention to employ an exceptional landing stabilisation speed for the aircraft type.

The final approach controller is responsible for ensuring that the distance spacing set up on final approach accommodates the distance spacing changes due to the respective landing stabilisation speed profiles of the lead and follower aircraft.

The final approach controller and the tower runway controller are responsible for monitoring the changing distance spacing as aircraft descend on the final approach glideslope and for timely intervention when a separation or spacing constraint infringement occurs.

The intermediate approach controller is responsible for ensuring that the appropriate flow of traffic is set up on intermediate approach when TBS are being applied on final approach.

The Approach Supervisor is responsible for ensuring that the demand and capacity balancing arrival flow rate matches the separation and spacing constraints on final approach.

3.2.1.13 Failure Scenarios and Degraded Mode Operations

On a glideslope wind conditions service failure, reversion to separation indicators for DBS is proposed.

On a arrival sequence order service failure or the arrival sequence order integrity not being maintained there will be a need to switch off the separation indicators and revert to using DBS without separation indicators.

On a TBS tool failure and a sudden loss of separation indicators, there will be a need to revert to using DBS without separation indicators. For aircraft already set up on final approach it is proposed to continue with the separation/spacing set up provided the final approach controller and tower runway controller consider it is safe to continue.

3.2.1.14 Other Related Issues

The benefits from the TBS concept will be impacted by the consistency of the arrival flow demand into the initial approach fixes and the flow of arrivals on to intermediate approach. The benefits will also be impacted by the consistency of the expedited runway vacation behaviour of the lead aircraft of spacing minimum pairs.

The intermediate approach controllers require the display of the indicators on their radar displays so as to provide visual feedback on the appropriateness and consistency of the presentation of aircraft on intermediate approach.

There are expected to be requirements to collect sensor data, radar data, weather data, and wake related reports from flight crew and controllers, in order to ensure the continued safe operation of TBS. This may include the requirement for more systematic and system supported monitoring of wake turbulence encounter hazard risks.

3.2.2 Prerequisite

In preparation before the implementation of the concept a number of activities are foreseen such as:

1. Investigation of current wind conditions on all runways and in the arrival sectors to all runways.
2. Investigation of current delay situations and problems.
3. Investigation of aircraft fleet speed behaviour in different headwind conditions during final approach, and in particular the behaviour inside 4Nm from the runway threshold, when landing stabilisation takes place (including behaviour where aircraft start speed reduction to the stabilisation speed before 4nm from the runway threshold).
4. Investigation of current runway occupancy times.

5. Evaluating the wake encounter situation at the airport.
6. Determining the most beneficial implementation scope.
7. Determining and designing the airspace where the concept will be applied.
8. Determining the required system support for the airspace where the concept will be applied.
9. Determining any new required met service support.
10. Set up a new monitoring service that covers all pre- and post- analysis needs (including establishing baseline risks).
11. If not yet available, a tool for calculating "on the day" hourly arrival runway capacity should be introduced.
12. All typical additional spacing scenarios, where extra spacing is required above the time-based separations, shall have predefined estimations (when possible), as a function of time, so as to be available for Tower and TMA supervisors and controllers. Such additional spacing scenarios include: longer runway occupancy times than normal, take-off on the arrival runway, maintenance, low visibility procedures, runway crossing traffic, expected catch-up situations, etc.
13. It is assumed that prior to implementation, an extensive training and awareness campaign, tailored for controllers, airlines and flight crew, will be launched.

3.2.3 Execution

The following TBS operating method is proposed:

1. TBS is to be always available for use. It is a matter for local policy, and the management of overall WVE hazard risk, whether TBS is to replace DBS and be applied 24/7. The controller separation tool support (separation indicators) will always be available for display selection.
2. When TBS is being employed on final approach, the distance separation between arrivals will shorten or lengthen as a function of the headwind or tailwind strength, compared to DBS.
3. Controllers in approach, and in the tower, will use a separation tool when applying TBS. It is assumed that this TBS tool is linked to an approach arrival sequence manager, which can accurately, promptly, and at all times, capture all changes of the approach arrival sequence, and all changes of aircraft landing runway intent.
4. The Tower Supervisor / Approach Supervisor will have access to system support for separation and spacing mode planning. The separation and spacing mode planner may use a predefined dynamic look-up table that contains the appropriate separation and spacing scheme, depending on the surveillance and runway operations separation and spacing constraints.
5. The radar displayed separation indicators shall be provided to the approach controllers and the tower runway controller (used at all times TBS is applied). The TBS tool will use a separation look-up table. The TBS tool will display the correct separation minima for each pair of aircraft. The TBS tool may be connected to approach arrival management procedures and tools.
6. For the final approach controller, the time based separation for each arrival pair will be displayed on the radar screen, as a separation indicator between each arrival pair, displayed on the final approach extended runway centre-line. The separation indicator may incorporate both the separation distance to be respected along the glide path or at the runway threshold, and the appropriate additional spacing to be set up in order to manage the distance spacing compression effects, or either of these, depending on further validation outcomes and local deployment considerations.
7. The tower runway controller monitors the aircraft, and the separation indicators, on the air traffic monitor display, and is responsible for the last part of approach (inside of 4Nm from the runway threshold), in the sense that any foreseen separation infringement needs to be handled by the tower runway controller. If separation is about to be infringed, the tower

runway controller will intervene where required to restore separation, in order to ensure safe continuation of the approach, or order the flight crew to perform a go-around/missed approach, when the continuation of the approach is inappropriate. The tower runway controller is responsible for delivering the landing clearance (for radar minima pairs this is largely dependent on previous landing aircraft's runway occupancy time).

8. The TBS tool is dependent on a constant high fidelity update of the assumed and planned sequence, in order to at all times, and in all cases, propose the correct separations.
9. An advanced optimisation tool (AMAN/DMAN) for the most efficient sequence of aircraft is believed to enhance the benefit of the concept.
10. Controllers will execute the new separation scheme according to the separation tool provision.
11. Flight crews will be informed about the TBS concept being used in their manuals (AIP).
12. The safe and efficient application of TBS will be monitored by the selection of different data, such as cross checking forecast and real weather parameters, wake monitoring, and radar data, for the purpose of post operation analysis and continuous improvements. Correlation to flight crew wake encounter reports will be incorporated, and if possible, also the collection of FMS data.

3.3 Differences between New and Previous Operating Methods

The objective of the TBS Concept is to provide landing rate resilience to headwind conditions on final approach through:

- Changing the wake turbulence radar separation rules on final approach from distance based separation rules to time based separation rules.
- Providing the final approach controller with separation indicators on their approach radar display so as to enable consistent and accurate delivery to the time based separation rules when merging aircraft on to final approach, and to enable consistent monitoring on final approach.
- Providing the tower runway controller with separation indicators on their air traffic monitor display so as to enable consistent monitoring to the time based separation rules on final approach.
- Changing the final approach controller separation / spacing procedures to be consistent with the separation indicators being the reference for the final approach separation / spacing.
- Changing the tower runway controller separation / spacing procedures to be consistent with the separation indicators being the reference for the final approach separation / spacing.

The approach arrival sequence information is required by the Separation Tool (TBS tool) for calculating each separation indicator distance. To ensure the required integrity of this information the Approach Supervisor and Tower Supervisor and the Approach ATCOs and Tower Runway ATCOs will all use the Approach Arrival Sequence and the associated Approach Arrival Sequence Display as the main coordinating environment for:

- The intended final approach sequence order of the arrival aircraft.
- The landing runway intent of each arrival aircraft.
- The runways-in-use, the runway mode of each runway-in-use, and the surveillance separation and runway spacing constraints to be applied on the final approach for each runway-in-use, included planned and immediate changes.
- The scenario specific spacing requirements.
- The departure gap spacing requirements.
- The resulting required separation distance between each arrival pair.

From accepting aircraft into the initial approach fixes, the Approach Arrival Sequence is continually referenced and checked by each ATCO in order to provide the required integrity assurance (see the scenario flows in Section 5.3).

To enable the checking of the TBS distances a Glideslope Wind Conditions and TBS Distance Display is provided to the Approach Supervisor and Tower Supervisor and the Approach ATCOs and Tower Runway ATCOs. The separation distance is checked in the Approach Arrival Sequence Display prior to each separation indicator being displayed and the separation indicator distance checked when it is first displayed.

To mitigate against the approach controller procedures for checking and updating the arrival sequence order not being 100% effective, or against the wrong aircraft being inadvertently turned on to a separation indicator, system monitor and alerting is provided so as to facilitate timely intervention and correction action by the final approach controller.

To mitigate against unanticipated aircraft airspeed behaviour on final approach or unanticipated distance spacing compression, system monitoring and alerting is provided so as to facilitate timely intervention action by the final approach controller or tower runway controller.

To mitigate against system failure, system monitoring and alerting is provided to facilitate timely reversion to the appropriate degraded mode operations by both Approach ATC and Tower ATC.

The Flight Deck will use easy to assimilate multi-media awareness briefing material on the principles of TBS and on what to expect in terms of the separation on final approach in their pre-departure briefing and top of descent briefing. The terminal information service (D-ATIS) will provide notification that TBS is being employed on final approach and related information on the prevailing glideslope wind conditions.

On first call to Approach ATC the Flight Deck will inform Approach ATC of exceptional approach speed intentions when the aircraft cannot conform to the procedural approach speed profile on final approach, or optionally when the landing stabilisation speed is exceptional for the aircraft type, either exceptionally slow because of landing light, or exceptionally fast because of landing heavy or for other reasons.

The Airport Medium / Short Term Planning Process, the TMA Balance Demand and Capacity Process and Plan Arrival Sequence Process take into account the employment of TBS on final approach and the impact on the resilience of the arrival capacity. This is the anticipated fluctuating arrival capacity taking into account the forecast final approach wind conditions, the forecast visual conditions, the anticipated final approach separation and runway spacing constraints, and the additional spacing delivery performance.

4 Detailed Operational Environment

4.1 Operational Characteristics

4.1.1 General characteristics

4.1.1.1 Separation standards

In today's modern ATM environment, one of the most common ways of separating aircraft in the arrival and departure flows of traffic (in the vicinity of an airport), is the use of horizontal and/or longitudinal separation enabled by radar surveillance. Before final approach, and after the very first phase of climb, this separation is applied as an in trail spacing. Apart from the minimum radar separation that has to be applied in order to avoid collision, the wake turbulence separation rules must also be applied in order to avoid adverse wake vortex encounters (WVE). In order to achieve this, all aircraft have been categorised into groups according to their Maximum Take-Off Weight (MTOW). Additional separation has then been prescribed whenever a less heavy category is following behind an aircraft from a heavier category. This implies that when the traffic at a certain airport contains aircraft from mainly one of the categories, a low penalising effect of wake turbulence separations will appear. On the other hand, whenever the aircraft categories are mixed, there will be efficiency and capacity losses due to the extra separation that has to be applied.

For most European airports, arrivals on final approach are normally separated by applying a 3 Nm or 2.5 Nm radar separation minimum, depending on visibility and radar update rate and performance.

The imposed number of categories, and the granularity of the separation into 1 Nm steps, was part of a design that fitted the ATM-environment some 40 years ago. The system needed to be simple enough for a human to keep in mind the different rules to be applied, without any further tool support. This makes the category system, and the crude separation steps, unnecessarily inefficient. In today's ATM-environment, the possibility to provide adequate controller separation, and separation support tools, that can handle more categories, as well as tailored separation minima, with a more efficient or refined granularity, is one of the enablers for a new concept to be introduced. Also, the delegation of separation responsibilities to the flight deck could potentially require suitable separation tools to be provided on the flight deck.

Figure 28 shows the ICAO Wake Turbulence radar minimum separations, for arrivals and departures, plus the time separations to be applied when taking off. Aircraft combinations that are not in this table can be separated by applying minimum radar separation. *[Ref. ICAO doc 4444 chapter 5 and chapter 8 and ICAO State Letter TEC/OPS/SEP – 08-0294.SLG regarding A380]*

Leading Aircraft	Following Aircraft	Distance-based Wake Turbulence separation	Runway Separation Time for Departures (min)
SUPER	HEAVY	6 NM	2'
SUPER	MEDIUM	7 NM	3'
SUPER	LIGHT	8 Nm	3'
HEAVY	HEAVY	4 NM	-
HEAVY	MEDIUM	5 NM	2'
HEAVY	LIGHT	6 NM	2'
MEDIUM	LIGHT	5 NM	2'

Figure 28: ICAO Wake Turbulence Separations

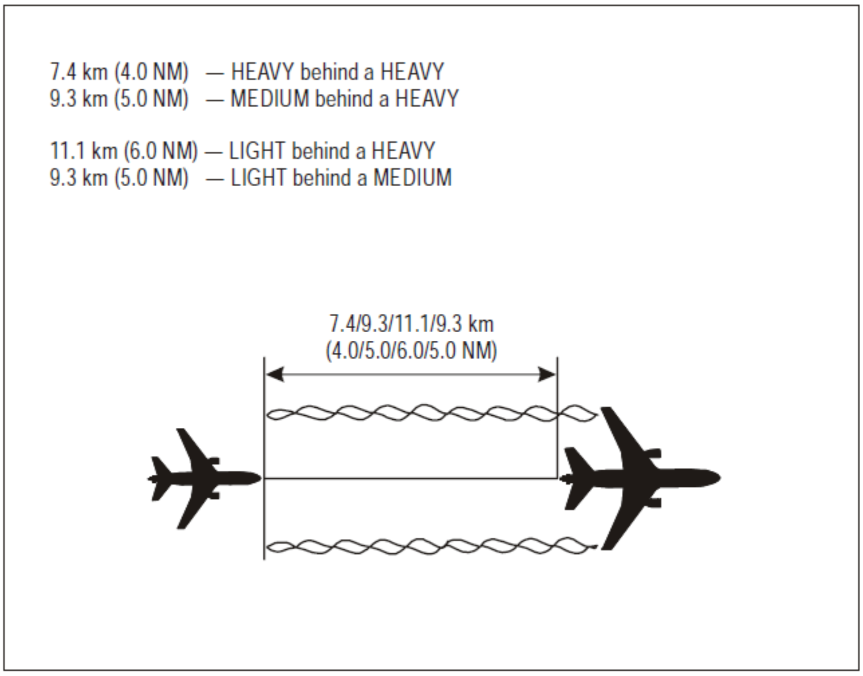


Figure 29: ICAO Wake Turbulence Radar Minima (A380 not included)

4.1.1.2 Aerodrome characteristics

The following typical modes of operations and runway configuration for control of arrival traffic to high-density (see below traffic figures) ECAC airport are considered:

- consecutive arrivals or departures to single runway used in segregated mode
- Consecutive arrivals and departures to dependent parallel runways used in segregated mode. This may be in conjunction with some arrivals being directed to land on the designated departure runway.
- consecutive arrivals or departures to closely spaced parallel runways (CSPR) used in segregated mode
- consecutive arrivals or departures to CSPR used in mixed mode

Note, that if the single runway is operated in mixed mode, the gap created between consecutive arrivals in order to integrate a departure in between, will lead to almost eliminating any likelihood of wake encounters.

4.1.1.3 Traffic characteristics

4.1.1.3.1 Arrival traffic

For arrival traffic, the following traffic mix characteristics of major European airports during peak hours are currently observed. *The missing data on Super Heavy aircraft, and on the medium airport applying the ICAO separation scheme, will be added when available*.

Specimen arrival traffic 1: Major airport applying ICAO separation scheme:

Followers	Super Heavy	Heavy	Medium	Light
Leaders				
Super Heavy	0,05%	0,13%	0,52%	0%
Heavy	0,14%	**2,97%**	**10,32%**	0,01%
Medium	0,53%	**10,54%**	**72,55%**	0,08%
Light	0%	0,01%	0,08%	0,01%

Table 14: Specimen Arrival Traffic for Major Airport Applying ICAO Separation Scheme

Specimen arrival traffic 2: Major airport applying UK separation scheme

Followers	Super Heavy	Heavy	Upper Medium	Lower Medium	Small	Light
Leaders						
Super Heavy	<0.1%	0.38%	<0.1%	0.29%	<0.1%	0%
Heavy	0.37%	**17.22%**	0.63%	**15.51%**	0.47%	0.11%
Upper Medium	<0.1%	0.97%	<0.1%	**1.19%**	0.04%	<0.1%
Lower Medium	0.29%	**14.89%**	**1.5%**	**41.09%**	**1.83%**	0.25%
Small	<0.1%	0.66%	<0.1%	**1.59%**	<0.1%	<0.1%
Light	0%	0.12%	<0.1%	0.25%	<0.1%	<0.1%

Table 15: Specimen Arrival Traffic for Major Airport Applying UK Separation Scheme

Specimen arrival traffic 3: Medium airport applying ICAO separation scheme

Followers	Super Heavy	Heavy	Medium	Light
Leaders				
Super Heavy	0%	0%	0%	0%
Heavy	0%	0,45%	**2,44%**	0,03%
Medium	0%	**2,51%**	**92,59%**	0,71%
Light	0%	0,01%	0,72%	0,10%

Table 16: Specimen Arrival Traffic for Medium Airport Applying ICAO Separation Scheme

Specimen arrival traffic 4: Medium airport applying UK separation scheme

Followers	Super Heavy	Heavy	Upper Medium	Lower Medium	Small	Light
Leaders						
Super Heavy	0%	0%	0%	0%	0%	0%
Heavy	0%	**2.91%**	0.61%	**5.23%**	0.78%	<0.1%
Upper Medium	0%	0.71%	0.77%	**4.54%**	0.39%	<0.1%
Lower Medium	0%	**5.15%**	**4.63%**	**55.82%**	**7.3%**	0.44%
Small	0%	0.74%	0.38%	**7.35%**	**1.48%**	<0.1%
Light	0%	<0.1%	<0.1%	0.42%	<0.1%	<0.1%

Table 17: Specimen Arrival Traffic for Medium Airport Applying UK Separation Scheme

4.1.1.4 Approach characteristics

4.1.1.4.1 Final approach phase of flight

The final approach is the portion of the arrival or descent phase of flight taking place after the intermediate approach phase and before the landing phase.

4.1.1.4.1.1 Instrument final approach profile

Final approach segment is described in ICAO doc 8168 “PANS-OPS” Part 1, Section 4 Chapter 5.

For precision approach, the final approach segment begins at the final approach point (FAP). This is a point in space on the final approach track where the intermediate approach altitude/height intercepts the nominal glide path/microwave landing system (MLS) elevation angle.

Typically, the intermediate approach altitude/height generally intercepts the glide path/MLS elevation angle at heights from 300 m (1 000 ft) to over 1,200 m (4,000 ft) above runway elevation. In this case, for a 3° glide path, interception occurs between 6 km (3 Nm) and 37 km (20 Nm) from the threshold.

In ECAC Terminal Area (TMA) controlled airspace, runway glideslope interception by arrivals can occur up to over 4,000 ft and up to 20 Nm from runway threshold.

Figure 30 provides an illustration of a typical final approach segment with different possible altitudes of glide path interception and approach speeds.

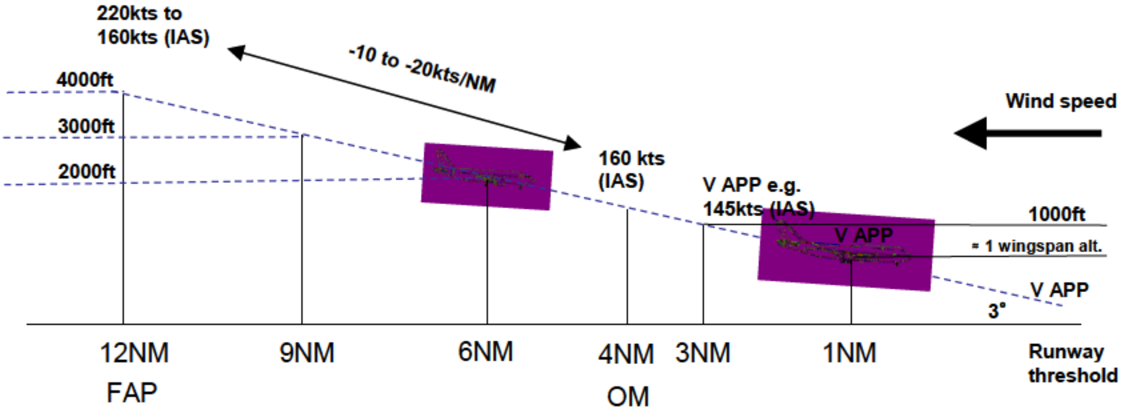


Figure 30: Specimen final approach segment

4.1.1.4.1.2 Flight speed and wind influence on final approach

The flight speed can be expressed by different ways of measurements:

- TAS (true air speed) is the calibrated airspeed corrected for altitude and non-standard temperature.
- IAS (indicated air speed) is the airspeed shown on the flight-deck instrument, obtained by measurements of the external dynamic pressure. At sea level and an atmospheric pressure of 1013.2 mb, and with no wind effect, the airspeed indicated is the true speed of the aircraft relative to the surface. As the aircraft climbs or descents, the air density varies and the IAS will vary in comparison to TAS. However, when it comes to controlling the aircraft, because the flight characteristics of the aircraft also alter with reduction in atmospheric density, the indicated airspeed is of greater importance than the true airspeed
- GS (ground speed) is the speed of an aircraft relative to the ground. Ground speed can be determined by the vector sum of the aircraft's true air speed minus the current wind speed and direction; a headwind subtracts from the ground speed, while a tailwind adds to it.

So, GS = TAS – HWS (headwind component speed)[4]

IAS is used by the Flight Crew (or the FMS) to control flight speed, while IAS & GS is used by ATC (with GS calculated from aircraft surveillance position updates).

Flight speed, being TAS, IAS or GS, will vary on final approach:

- During descent, the speed at interception of the glide path will be reduced to the landing speed that must be achieved, usually at about 1000ft above aerodrome level (aal) to consider the approach to be stabilized, and to continue descent to the runway (typically, the speed reduction is between 10 and 20 kts per Nm).

[4] Note that this equation is an approximation that diverges with increasing crosswind

- The speed at interception depends on the altitude of interception, to allow reduction to the landing speed, and on local airspace management and constraints[5], and on tactical ATC requirements (typically, the speed at interception varies between 220kts to 160kts IAS).
- From the Outer Marker (OM), the aircraft is released from procedural speed control, to reduce speed and stabilise to its landing speed profile.
- The landing IAS profile depends on the aircraft type, the associated landing stabilisation speed mode, and on the flight conditions (weight, landing configuration selected, wind).
- The landing GS profile depends on the aircraft IAS profile and the headwind speed profile.

4.1.2 High level principles, limitations and assumptions

The following high level principles, limitations and assumptions are subject to modification throughout the validation process.

4.1.2.1 Principles

The TBS concept is addressing radar separation minima imposed for WT protection, as wake turbulence separation minima, between consecutive arriving aircraft.

For headwind conditions, the use of consistent time separation minima across all wind conditions, will lead to a reduction of the distance spacing as headwind conditions increase, and so to a recovery of most of the reduction in capacity with distance based separation in headwind conditions.

All else being equal, a reduction in delay during strong headwind conditions, will lead to a reduction in airborne holding, and thus environmental benefits.

All else being equal, a reduction in delay during strong headwind conditions, will reduce flight cancellations, offering economic benefits to airspace users.

Safety benefits are expected by increasing the distance separation in particular headwind conditions (e.g. tailwind conditions), which currently present the highest risk of a severe WT encounter in current day distance based separation operations.

4.1.2.2 Limitations

Benefit is most likely to be significant in peak hours.

Benefit is most likely to be significant for congested airports.

Benefit is most likely to be significant for segregated runway use.

Benefit will be mainly from a reduction of delay, due to the recovery of the reduction in capacity when employing distance based separation in headwind conditions. There is not intended to be an increase in the runway capacity in non-challenging conditions.

Benefit will be limited if a reduction of the minimum radar separation is not enabled by other SESAR projects.

Concept feasibility will depend on the final approach controller’s ability to safely deliver aircraft to time based separations in all wind conditions.

4.1.2.3 Assumptions

The TBS concept is assumed to cover two different Operational Domains:

- TMA (WP5)
- Airport (WP6)

[5] Some Approach Control Unit apply speed restrictions on the final approach segment down to the Outer Marker (OM), before leaving aircraft to stabilise to their respective landing speed

Major changes in the operating method are only expected for final approach.

The TBS concept safety will be assessed by comparing the WT risk under time based separation operations to current day levels observed under distance based separation operations.

4.2 Roles and Responsibilities

Actor	Current Responsibility	Specific/additional role
Tower Supervisor (SUP)	Has overall responsibility for the planning of the tower operation. Monitors operations. Decides on arrival and departure rates. Proposes runway configuration. Gives permission for maintenance, etc.	Is aware of the wind conditions, and for determining and deciding on the application of TBS in consultation with the Approach Supervisor. Responsible for ensuring the duty runways-in-use information, and the separation policy information, and planned changes to these, is available, set up, and maintained consistently in the separation tool support for Tower ATC. Responsible for ensuring runway conditions, and planned and forecast changes to the runway conditions, are reflected in the separation policy information.
Runway Controller (TWR)	In charge of landings.	Uses the separation tool to monitor that separations remain consistent as aircraft descend on final approach, so as to enable timely intervention action to be taken when there is separation infringement. Monitors runway occupancy, and runway conditions, and ensures separation policy is consistently maintained to support the runway conditions, and changes to the runway conditions. Receives, from different sources, and disseminates to the flight deck, critical wake vortex and weather information, when needed.
Intermediate and Final approach controllers	Are in charge of safe and efficient processing of arrivals to the runway	Responsible for ensuring that the arrival aircraft information used by the separation tool to calculate the time based separations is correct. This includes the arrival sequence order intent, and the flight specific aircraft information such as the aircraft type, the landing speed intent, and in the case of parallel active duty runways-in-use, the landing runway intent of each aircraft. Uses the separation tool to ensure final approach separations are set up consistently and efficiently. Uses the separation tool to monitor that separations remain consistent as aircraft descend on final approach, so as to enable timely intervention action to be taken when there is separation infringement.
Flight Crew	Navigates aircraft safely	Is aware of TBS operation and the impact on the distance separation set up on final approach, which is related to the ground speed impact of the prevailing wind conditions. Is informed of when TBS is being employed on final approach, for example, through D-ATIS. Reports critical weather and wake information to ATC.

Actor	Current Responsibility	Specific/additional role
Approach Supervisor	Plans and monitors operation in the TMA	Is aware of the wind conditions, and for deciding and agreeing to the application of TBS, in consultation with the Tower Supervisor. Responsible for ensuring the duty runways-in-use information, and the separation policy information, and planned changes to these, is available, set up, and maintained consistently in the separation tool support for Approach ATC. Responsible for ensuring that flight crew are informed of the application of TBS, for example, through D-ATIS.

New actor	New Task
Safety data analyst	Analyse collected sensor data, radar data, weather data, and wake related reports from flight crews and controllers, in order to develop and ensure the continued safe operation of TBS
Sensor operator	Collects and formats sensor data according to the safety requirements. Could be automated.
Sensor technician	Installs, maintains and supervises the sensor functionality.

4.3 Constraints

Considering the variation in distance of the separation to be applied, controller will not have a simple and single set of distance separation to ensure. A HMI tool **shall** present the controller with a time indicator that represents the horizontal radar separation required in order to maintain the requisite time based separation.

The HMI tool **may** be required by both Runway controllers and Final / Intermediate controllers.

The HMI tool shall show the same separation minimum to both Runway controllers and Final / Intermediate controllers if required.

A wind monitoring and forecasting together with a forecasting of the aircraft speed profile **could** be required for translating time in distance.

If the aircraft speed profile is required, the expected speed profile should be either down linked from the aircraft or deduce from the down linked or static aircraft characteristics:

- If the expected speed profile is based on static table defining, for example, landing speed as a function of the aircraft type, the integrity of the aircraft identification (WT category, Ac type, …) **shall** be ensured
- If the expected speed profile is based on down linked information from the aircraft, the integrity of the provided information **shall** be ensured

The Integrity of the aircraft sequence **shall** be ensured since it will feed the HMI tool in order to set up the separation between aircraft categories correctly (see ADS-B mode S in section 2.5.2 of the High Level OCD).

High integrity aircraft wake turbulence category and aircraft type fields shall be available in the HMI tool.

Pilot awareness about the separation to be applied **shall** be ensured.

Tools may be required to monitor:

- Catch-up between aircraft on final approach
- Aircraft conformance to procedural speeds

- Conformance to the aircraft sequence order

5 Use Cases

5.1 TMA Operational Scenarios

The following operational scenarios are outlined in the WP5 Validation Strategy for Time Based Operations [74].

H/H is a high density, high complexity TMA.

M/M is medium density, medium complexity TMA.

The impact of TBS on the TMA operational scenarios:

- Is addressed in Section 5.3 for the TMA ground solution sub scenarios 1 and 3.
- May be addressed in Section 5.4 in the future for the TMA air solution sub-scenarios 2 and 4.

5.1.1 Sub scenario 1: Implement TMA/APP in H/H environment, ground solution

5.1.1.1 Description of the sub scenario

This sub-scenario is applicable in high density/complexity TMAs (including approach airspace), i.e. TMAs with complex arrivals/departures flows interactions, and significant traffic peaks such that arrival traffic metering in ENR/E-TMA may not be always sufficient to absorb the total arrival management delays.

It is based on a family of techniques aiming at integrating arrival traffic to the runway(s), relying on performance-based navigation (PBN), closed loop vectors and few ATC tactical interventions.

It is expected that due to the traffic density/complexity:

- Level-offs may be required to provide separation between flows (arrivals vs. arrivals or arrivals vs. departures);
- Tactical Lateral interventions for path stretching/shortening may be required in order to integrate the arrival flows to the runway(s).

In the lateral dimension (2D), these techniques will make use of PBN route structures with an embedded path stretching/shortening capability, combined with an operating method involving, in so far as possible, mainly closed loop vectors (e.g. Direct-To) ATC interventions. These will provide a certain degree of strategic separation between traffic flows, while enabling the creation of required spacing between inbound flights from different entry points.

In the vertical dimension (3D) the procedure may include vertical restrictions, and depending on the lateral technique used, and traffic situation, enable CDAs 'by segments' (i.e. that may have to be interrupted with level-off phase(s)).

In the longitudinal dimension (4D), the procedure may include speed restrictions. In-trail spacing will however be maintained by means of tactical ATC speed control.

5.1.1.2 Impact analysis

<u>Notes:</u>

1. This impact analysis considers, as baseline for comparison, the current situation with numerous tactical/open loop ATC interventions i.e. vectors (and generally resulting in inefficient descents).

2. The geometry of route structures will impact the operating method and the trade-off between KPAs (e.g. capacity and predictability vs. flight efficiency and environmental impact).Typical examples of route structures are:

- Hybrid divergence/converging geometries such as “fanned routes”, “trombone routes” (involving S shaped routes, integration along the runway axis and route changes (or in case of high traffic, vectors) between downwind and final);
- Predominantly converging geometries – such as Point Merge Systems (involving traffic integration on a point sequencing legs equi/isodistant from that point, and nominally a single direct to instruction).

The second type of solutions above will result in similar impact, but with potentially higher magnitude, both on benefits and constraints.

Overall, thanks to the use of a route structure with embedded path stretching capability and vertical and/or speed restrictions, there will be less need for ATC interventions, hence fewer instructions, and decrease in ATC workload. This may bring the potential for increased airspace capacity, subject to the exact procedure/route structure used (airspace capacity is expected to be at least maintained, if not increased).

From the controller standpoint, the link / appropriateness between the geometry of the route structure and operating method will also provide a certain degree of standardisation of operations and combined with FL/speed restrictions, homogeneous aircraft behaviour.

For both pilots and controllers, predictability and situation awareness will increase thanks to the use of a route structure and associated operating method/procedure.

Additionally, from the pilot’s perspective, another positive impact is that although not mandatory, it may be possible to use vertical guidance/VNAV.

Predictability will also beneficial to ground tools (increased TP accuracy) and air systems (with aircraft on closed loop, FMS computations can be maintained).

Altogether, these positive impacts have the potential to improve safety. 2D predictability will also in turn improve flight efficiency by enabling segmented CDAs. These will not consist of “full CDAs” though as it is anticipated (see above) that in dense/complex airspace, tactical interventions in the vertical dimension and/or level offs may be required to provide separation between flows, between CDA “segments”. In addition, note that CDA doesn’t equal to ‘idle thrust’ descent. Speed control will still be required to integrate converging flows and provide in trail separation, meaning that certain speed margins will be needed e.g. through constant slope descent segments.

However, the very characteristics that result in structured and more predictable working methods/procedures also have the following drawbacks:

- From the controller’s standpoint, the method of operations will be less flexible than with vectors, being limited in degrees of freedom for tactical interventions;
- Need for monitoring of aircraft behaviour in terms of adherence to published lateral constraints, and vertical or speed restrictions, so as to detect lateral deviations, FL busts or speed overshoots;
- Standardisation and repetitiveness for the controller may induce a risk of loss of vigilance, boredom and/or job satisfaction issues. Systematic reliance on PBN may also induce a risk of vectoring de-skilling.

In addition, the following drawbacks can be identified subject to specific aspects of the considered solution or procedure:

- The fact that published routes are long routes (e.g. with Trombones or Point Merge) may induce the feeling that the track miles will increase; also may have an impact on fuel management;
- From the airborne systems, and procedure/procedure coding perspectives, safety implication of the use of PBN+DCT, when cancelling from the route a point that bears e.g. a vertical restriction;
- Still from the airborne systems perspective, in case the procedure is not followed by using VNAV, additional pilot’s task load to adhere to vertical restrictions.

Important note: The same solutions may be applied in a medium density/complexity environment. However, in the present document, they are not included in the corresponding sub-scenario (medium density/complexity, ground based). Instead they are considered as a variant of the present sub-scenario with the following difference:

- Less dense/complex environment will result in less constrained vertical profiles, and possibly remove the need to recourse to level-off phases to separate flows. Consequently, Flight efficiency/Environmental impact will be further improved in medium density/complexity (through e.g. Point Merge with dissociated sequencing legs and no level-off).

5.1.1.3 Summary

Table 18: Sub-scenario "Implement TMA/APP in H/H environment, ground" – main features

Implement TMA/APP in H/H environment, ground	
Features	**Summary**

Expected benefits	• Controller
	  • (+) Less instructions and standardisation of operations (including use of constraints such as speed or vertical restrictions)
	  • (+) Predictability / situation awareness / homogeneous a/c behaviour
	• Pilot
	  • (+) Predictability/Situation Awareness
	  • (+) Use of vertical guidance information (potential for VNAV)
	• Airspace/route structure: Depends on type of PBN solution
	• Operating method: Depends on type of PBN solution
	• Ground system
	  • (+) Predictability, TP accuracy
	• Air system
	  • (+) Predictability, if closed loop: maintaining FMS calculations (laterally and possibly vertically)
	• ATM /KPA
	  • (+) Predictability (closed loop, standardisation)
	  • (+) Airspace capacity (potential for increase due decrease of ATC workload).
	  • (+) Cost effectiveness (standardisation, training)
	  • (+) Safety
	  • (+) Flight efficiency, environmental impact

Constraints	• Controller
	  • (–) Less flexibility in working method/practices
	  • (–) Risk of constraints overshoot (FL bust/speed overshoot), need for monitoring
	  • (–) Increased risks of loss of vigilance, vectoring deskilling, less job satisfaction
	• Pilot
	  • (–) Published routes = long routes (subjective impact)
	• Airspace/route structure: Depends on type of PBN solution
	• Operating method: Depends on type of PBN solution
	  • (–) PBN+DCT may remove a vertical restriction by cancelling a point bearing the restriction.
	• Air system
	  • (–) CDA vs. Speed margins/speed control
	  • (–) Use of FMS (if we rely on VNAV)
	• ATM
	  • (–) Flexibility / published routes = long routes

5.1.2 Sub scenario 2: Implement TMA/APP in H/H environment, air solution

5.1.2.1 Description of the sub scenario

Similarly to sub-scenario 1 above, this sub-scenario is applicable in high density/complexity TMAs (including approach airspace), i.e. TMAs with complex arrivals/departures flows interactions, and significant traffic peaks such that arrival traffic metering in ENR/E-TMA may not be always sufficient to absorb the total arrival management delays.

It is based on a family of techniques aiming at integrating arrival traffic to the runway(s), relying on performance-based navigation (PBN), closed loop ASAS sequencing and merging lateral trajectory alterations, and ASAS speed control.

It is expected that due to the traffic density/complexity:

- Level-offs may be required to provide separation between flows (arrivals vs. arrivals or arrivals vs. departures);
- Tactical Lateral interventions for path stretching/shortening may be required in order to integrate the arrival flows to the runway(s).

In the lateral dimension (2D), these techniques will make use of PBN route structures with an embedded path stretching/shortening capability, combined with an operating method involving, for suitably equipped aircraft, ASAS sequencing and merging (S&M) manoeuvres. These will provide a certain degree of strategic separation between traffic flows, while enabling the creation of required spacing between inbound flights from different entry points.

In the vertical dimension (3D) the procedure may include vertical restrictions, and depending on the lateral technique used, and traffic situation, enable CDAs ‘by segments’ (i.e. that may have to be interrupted with level-off phase(s)).

In the longitudinal dimension (4D), the procedure may include speed restrictions. Inter aircraft spacing will be maintained by means of ASAS speed control (for suitably equipped aircraft).

5.1.2.2 Impact analysis

Notes:

1. This impact analysis considers, as baseline for comparison, sub-scenario 1 (ground solution for implement in TMA/APP, H/H density/complexity).

2. Similarly to sub-scenario 1, the geometry of route structures will impact the operating method and the trade-off between KPAs (e.g. capacity and predictability vs. flight efficiency and environmental impact).Typical examples of route structures are:

- Hybrid divergence/converging geometries such as “fanned routes”, “trombone routes” (involving S shaped routes, integration along the runway axis and route changes (or in case of high traffic, vectors) between downwind and final);
- Predominantly converging geometries – such as Point Merge Systems (involving traffic integration on a point sequencing legs equi/isodistant from that point, and nominally a single direct to instruction).

The second type of solutions above will result in similar impact, but with potentially higher magnitude, both on benefits and constraints.

Compared with ground solutions from sub-scenario 1, this sub-scenario will result, from the controller’s perspective, in further reduction of ATC interventions (“direct-to” / ”resume navigation” is initiated on board, ASAS speed control instead of ATC speed control) hence less workload. From the pilots’ standpoint, predictability and situation awareness will further increase as target aircraft will be explicitly designated and will appear on the ASAS display.

In terms of operating method, it is anticipated that more consistent inter-aircraft spacing will be obtained through ASAS S&M, which could result in potential for increased capacity (throughput).

Predictability may also increase for the ground systems as target aircraft is explicitly designated and can be known by the system, possibly resulting in better TP accuracy.

From an air system perspective, the use of ASAS S&M will bring the potential for use of managed speed. It will also offer the potential to link speed management with CDA optimisation.

On the other hand, introducing an “airborne-based” solution will result here in the following drawbacks:

- From the controller’s perspective, as separation responsibility does not change, need to radar monitor the spacing between pairs of aircraft under ASAS spacing;
- From the operating method standpoint, and flight efficiency perspective, potentially numerous speed adjustments that may lead to a certain degradation of flight efficiency.

5.1.2.3 Summary

Table 19: Sub-scenario “Implement TMA/APP in H/H environment, air” – main features

Implement TMA/APP in H/H environment, air	
Features	**Summary**

Expected benefits	• Controller
	  • (+) less workload/instructions/ATC interventions (Direct is initiated on board, ASAS speed)
	• Pilot
	  • (+) Predictability/Situation Awareness (designated target a/c)
	• Airspace/route structure: Depends on type of PBN solution
	• Operating method: Depends on type of PBN solution
	  • (+) More consistent spacing
	• Ground system
	  • (+) Predictability/TP accuracy (designated target a/c)
	• Air system
	  • (+) Potential for managed speed, and possible link with CDA optimisation
	• ATM /KPA
	  • (+) Capacity (throughput)

Constraints	• Controller
	  • (–) Need for spacing monitoring
	• Airspace/route structure: Depends on type of PBN solution
	• Operating method: Depends on type of PBN solution
	  • (-) Speed adjustments (potentially numerous)
	• ATM /KPA
	  • (–) Flight efficiency/Environment (fuel consumption/speed adjustments)

Important note: The same solutions may be applied in a medium density/complexity environment. However, in the present document, they are not included in the corresponding sub-scenario (medium density/complexity, air based). Instead they are considered as a variant of the present sub-scenario with the following difference:

Less dense/complex environment will result in less constrained vertical profiles, and possibly remove the need to recourse to level-off phases to separate flows. Consequently, Flight efficiency/Environmental impact will be further improved in medium density/complexity (through e.g. route structure with dissociated sequencing legs and no level-off).

5.1.3 Sub scenario 3: Implement TMA/APP in M/M environment, ground solution

5.1.3.1 Description of the sub scenario

This sub-scenario is applicable in medium density/complexity TMAs (including approach airspace), i.e. TMAs with less complex arrivals/departures flows interactions, route structures enabling a significant level of strategic de-confliction, and assuming that traffic metering in ENR/E-TMA will generally be sufficient to absorb most of the arrival management delays, enabling most of the time subsequent arrival flow integration towards the runway through speed control only.

It is based on a family of techniques aiming at integrating arrival traffic to the runway(s), relying on performance-based navigation (PBN), 2D route allocation, no or few ATC tactical interventions - mainly in the longitudinal dimension i.e. ATC speed control for spacing /separation between in-trail and merging traffic.

It is expected that due to the medium traffic density/complexity, advanced CDAs will be enabled, though possibly with constraints in the form of published vertical restrictions.

5.1.3.2 Impact analysis

Notes:

1. This impact analysis considers, as baseline for comparison, the current situation with numerous tactical/open-loop ATC interventions i.e. vectors (and generally resulting in non efficient descents).

2. The magnitude of positive and negative impacts is expected to be larger than for sub-scenario 1.

The introduction of the techniques considered in this sub-scenario is expected to result in the following positive impacts:

- From the controller's perspective, there will be less need for tactical interventions, hence a decrease in workload, as well as an increase in situational awareness, thanks to allocation of pre-defined and published routes, possibly including vertical restrictions as/if needed.
- For the pilot, the techniques used in that sub-scenario will also provide an improved situational awareness.
- Ground systems and airborne systems will benefit from increased predictability with the potential for e.g. increased TP accuracy.
- Overall, there will be an increase in predictability, flight efficiency and improved environmental impact.

On the other hand, the following drawbacks are anticipated:

- From the controller's perspective, less options will be available in the nominal procedures, hence less flexibility.
- Overall the techniques used here will result in decreased flexibility, and possibly have an adverse impact on traffic throughput.

5.1.3.3 Summary

Table 20: Sub-scenario "Implement TMA/APP in M/M environment, ground" – main features

Implement TMA/APP in M/M environment, ground	
Features	**Summary**

Expected benefits	• Controller
	  • (+) Less interventions
	  • (+) Predictability, situation awareness
	• Pilot
	  • (+) Predictability/Situation Awareness
	• Ground system
	  • (+) Predictability, TP accuracy
	• Air system
	  • (+) Predictability
	• ATM /KPA
	  • (+) Flight efficiency/environmental impact
	  • (+) Predictability

Constraints	• Controller
	  • (–) Less flexibility due to less options
	• Airspace/route structure: Depends on type of PBN solution
	• Operating method: Depends on type of PBN solution
	• ATM
	  • (-) Reduced flexibility, reduced throughput

5.1.4 Sub scenario 4: Implement TMA/APP in M/M environment, air solution

5.1.4.1 Description of the sub scenario

Similarly to sub-scenario 3 above, this sub-scenario is applicable in medium density/complexity TMAs (including approach airspace).

The difference with sub-scenario 3 lies in the fact that ASAS speed control, rather than ATC speed control, will be used to maintain inter-aircraft spacing, for equipped traffic.

5.1.4.2 Impact analysis

Notes:

1. This impact analysis considers, as baseline for comparison, sub-scenario 3 (ground solution for implement in TMA/APP M/M density/complexity).

2. The magnitude of positive and negative impacts is expected to be larger than for sub-scenario 2.

Compared to sub-scenario 3 above, there will be even less ATC interventions, thanks to the use of ASAS speed control. Predictability will be increased thanks to the explicit designation of a target/lead aircraft for ASAS equipped traffic, which will result in increased situational awareness for aircrews and potential for ground systems improvements (e.g. TP accuracy or conflict detection tools).

The airborne systems may offer ASAS implementation through the use of managed speed, and possibly its integration with the management of vertical profiles in the context of CDAs.

Capacity (throughput) is expected to be improved thanks to a more consistent and accurate inter-aircraft spacing.

On the other hand, introducing this “airborne-based” solution will result here in the following drawbacks:

- From the controller’s perspective, as separation responsibility does not change, need to radar monitor the spacing between pairs of aircraft under ASAS spacing;
- From the operating method standpoint, and flight efficiency perspective, potentially numerous speed adjustments that may lead to a certain degradation of flight efficiency.

5.1.4.3 Summary

Table 21: Sub-scenario “Implement TMA/APP in M/M environment, air” – main features

Implement TMA/APP in M/M environment, air	
Features	**Summary**

Expected benefits	• Controller
	• (+) Less workload/instructions/ATC interventions (ASAS speed)
	• Pilot
	  • (+) Predictability/Situation Awareness (designated target a/c)
	• Airspace/route structure: Depends on type of PBN solution
	• Ground system
	  • (+) Predictability/TP accuracy (designated target a/c)
	• Air system
	  • (+) Potential for managed speed, and possible link with CDA optimisation
	• ATM /KPA
	  • (+) Capacity (throughput, through increased spacing accuracy)

Constraints	• Controller
	  • (–) Need for spacing monitoring
	• Operating method: Depends on type of PBN solution
	  • (-) Speed adjustments (potentially numerous)
	• ATM /KPA
	  • (–) Flight efficiency/Environment (fuel consumption/speed adjustments)

5.2 Airport Operational Scenarios

These are the applicable airport operational scenarios from the WP06.02 Airport DOD Step 1 [73].

The focus of this section is the execution phase surface-in operational scenario. The TBS concept impact on clearance to land and runway vacation procedures is included in Section 5.3.

5.2.1 Surface-In OS

The Surface-in scenario describes the processes and interactions that an aircraft encounters from the time when the Flight Crew lands the aircraft (wheels on ground; CDM milestone: ALDT) until the aircraft arrives in-block at the parking stand (CDM milestone: AIBT), for SESAR Concept Story Board Step 1, Service Level 2.

The Scenario starts with touch down, continuing with taxiing in and ends when the aircraft is in-block. In contrast to the definition available in the A-CDM implementation manual, “taxi in” in this document is the section of a BT where the aircraft is leaving the runway and taxiing between the runway and its stand/gate position (in block procedure with chock on included). The Surface-In is part of the execution of a BT and takes place right after the final approach and landing of this BT (Milestone: ALDT = wheels touching the runway after final approach). The scenario ends when the aircraft is parked with chocks on (Milestone: AIBT = stops moving on parking position).

The relevant use cases for time-based separation on final approach are those impacting the landing and runway vacation phases of the Surface-In process.

5.2.1.1 Operations prior to SURFACE-IN Scenario

The Airport Tower Supervisor is continuously aware of changes to the aerodrome capacity e.g. as a result of changes in meteorological conditions, system(s) serviceability etc. and act to maintain a constant balance with demand. Thus, in the nominal case, changes to the Target Landing Time (TLDT) are minor, reflecting a change in sequence priorities and not as a result of over-demand**.**

ATFCM keeps track of changes to the aircraft flight plan / SBT including route changes and diversions to ensure that a dynamic demand/capacity balance is maintained**.**

The ATM System updates the arrival sequence and the TLDT**.**

Based on this information, amongst others, the ATM System plans the aircraft’s routing **[AO-0205]** from the planned runway exit **[AUO-0703]** to the planned aircraft parking stand, as well as the associated taxi time **[AO-0207].**

Before initiation of the approach phase, the ATM system may uplink the planned “runway exit” **[AUO-0703]** and the associated “taxi routing” data to the flight deck **[AUO-0303-A]**. The aircraft may downlink the preferred runway exit, in case it cannot cope with the planned one **[AUO-0703]** but taking into account possible ROT (Runway Occupancy Time) requirements **[AUO-0701]**. The flight crew will “trigger and manage" optimum braking and vacate at the agreed runway exit. Taxi-in route information will be uplinked at the same time in consistency with the agreed runway exit.

The Flight Crew may transmit their preferences/capabilities/limitations for the landing through data link. These data are being considered by the ATM System during its optimisation process. Any update of the runway exit and/or the ground routing is communicated to the Flight Crew either via data link or via voice communication (R/T)[6] **[AUO-0303-A].**

Visually and supported by the ATM System **[AO-208-A],** the Tower Runway Controller monitors the landing runway and adjacent traffic to ensure that the traffic complies with instructions (e.g. separation requirements) **[AO-0303] [AO-0304]** and that the runway is clear. In addition, the Tower Runway controller is informed by the ground system when debris is detected on the surfaces of the runway or connected taxiways. **[AO-0202]**

[6] Voice communication is still possible and valid, but in the description the focus is on data link

The Tower Runway Controller communicates via voice (R/T) the "Landing Clearance" and issues by the ATM system (data link) or by voice the updated runway exit and/or the ground routing to the Flight Crew. The Flight Crew acknowledges receipt of the clearance by communicating via voice (R/T) and lands the aircraft on the assigned runway (the assigned runway can be changed on short notice, e.g. "Swing-over Procedure" in case of parallel or near parallel runways. This can only be done in agreement with the flight crew)**.** Once the speed will be controlled on the runway, the taxi clearance will be uplinked for display on-board.

Communications may be either via Data Link or via voice (R/T): the selection being dependent upon ICAO SARPS and local procedures **[AUO-0303-A].**

5.2.1.2 SURFACE-IN Scenario

Landing

General (UC 6 15)

The Flight Crew lands the aircraft. The Ground System detects touchdown, records the information and makes this information available to other users. **[AUO-0303-A]**

The ATM System identifies and displays the aircraft on all HMIs displaying the airport surface traffic situation. **[AO-0208-A]**

On roll-out the aircraft's automatic braking systems manage the deceleration to achieve the planned runway exit, using BTV-System when available. **[AUO-0703]**

The Flight Crew reports to the Tower Runway Controller that their aircraft has vacated the runway. The Tower Runway Controller verifies, either by using the ATM System **[AO-0208-A]**, or visually, that the aircraft has vacated the runway and instructs the Flight Crew to contact Tower Ground Controller, transferring control of the aircraft. The ATM System records the runway exit taken by the aircraft and that it has vacated the runway.

Optional

Touch and go (UC 6 16)

If, for whatever reason, the aircraft has to perform a touch and go, the general landing procedure starts again (or, in exceptional cases, the aircraft might start the execution of a diversion to an alternate airport).

Go Around (UC 6 17)

If, for whatever reason, the aircraft has to perform a go around, the general landing procedure starts again (or, in exceptional cases, the aircraft might start the execution of a diversion to an alternate airport).

Aircraft not leaving the runway as expected (UC 6 18)

The aircraft did not leave the runway at the planned exit for technical reasons, e.g. speed too high (not intended), a new route has to be recalculated and distributed. **[AO-0205]**

Exits not available (UC 6 19)

Exits might not be available due to blocking by an aircraft / vehicle or short maintenance. That means, aircraft will not be able to exit the runway(s) as usual/ planned, an alternative route has to be recalculated and distributed. **[AO-0205]**

Violation

Unplanned blockage of assigned exit (UC 6 20)

For whatever reason, an assigned exit might be blocked on short notice (on purpose), a new route has to be recalculated and distributed. **[AO-0205]**

5.2.1.3 Use Cases Identified

Use cases describe nominal conditions and topics that deviate from the nominal conditions. The relevant use cases for time-based separation on final approach are those impacting the landing and runway vacation phases of the Surface-In process.

Use Case ID	Use Case Title	Use Case description
UC 6 15	Landing	The Flight Crew lands the aircraft. The Ground System detects touchdown, records the information and makes this information available to other users. The ATM System identifies and displays the aircraft on all HMIs displaying the airport surface traffic situation. On roll-out the aircraft's automatic braking systems manage the deceleration to achieve the planned runway exit, using BTV-System when available. The Flight Crew reports to the Tower Runway Controller that their aircraft has vacated the runway. The Tower Runway Controller verifies, either by using the ATM System, or visually, that the aircraft has vacated the runway and instructs the Flight Crew to contact Tower Ground Controller, transferring control of the aircraft. The ATM System records the runway exit taken by the aircraft and that it has vacated the runway.
UC 6 16	Touch and go	If, for whatever reason, the aircraft has to perform a touch and go, the general landing procedure starts again
UC 6 17	Go around	If, for whatever reason, the aircraft has to perform a go around, the general landing procedure starts again
UC 6 18	Aircraft not leaving the runway as expected	The aircraft did not leave the runway at the planned exit for technical reasons, e.g. speed too high (not intended), a new route has to be planned and distributed
UC 6 19	Exit not available	Exits might be on maintenance that means, aircraft will not be able to exit the runway(s) as usual, an alternative route has to be planned and distributed
UC 6 20	Unplanned blockage of assigned exit	For whatever reason, an assigned exit might be blocked on short notice (on purpose), a new route has to be planned and distributed
UC 6 27	Low visibility procedures	In LVP condition the Tower Ground and Tower Runway Controller will apply appropriate procedures, supported by the Tower Supervisor, according to the AIP.
UC 6-31	Runway incursion	If for whatever reasons an aircraft and/or vehicle enters the protected area of an active runway, the Tower Runway Controller will take all subsequent actions to resolve the runway incursion. If no incident or accident has happened, this situation at least implies a delay for surface-out and surface-in, because the planned traffic has to be re-sequenced
UC 6 38	Runway change	A change of the landing runway may be initiated caused by closures of taxiways or the dimensions of an aircraft might not allow the use of specific taxiways to the assigned stand. That might cause a delay for succeeding flights.
UC 6 39	Runway Inspection	A runway inspection is done on a regular basis, or if requested by Tower Runway Controller or Airport Tower Supervisor. The movement of the inspection car has to be handled as an aircraft movement as long as it moves on the runway or within the safety boundaries of it. This therefore implies a delay on succeeding air-traffic.
UC 6 40	Bird Control on active runway	Bird control is done on a regular basis, or if requested by Tower Runway Controller or Airport Tower Supervisor. The movement of the bird control car has to be handled as an aircraft movement as long as it moves on the runway or within the safety boundaries of it. This therefore implies a delay on succeeding air-traffic.
UC 6 42	Aircraft blocking the active runway due to technical reasons	If an aircraft is unable to vacate the runway (e.g. nose wheel steering is unserviceable), there is a major delay expected, because first technicians have to inspect the aircraft, if it can be towed away and a tow tug has to be ordered and make its way to the aircraft.

Use Case ID	Use Case Title	Use Case description
UC 6 43	Aircraft blocking the active runway with an emergency	Aircraft is blocking the runway, e.g. due to one or more flat tires after touchdown, there is a longer delay expected, because first fire fighters have to secure the aircraft, second technicians have to inspect the aircraft, if it can be lifted up and later be towed away and a tow tug has to be ordered and make its way to the aircraft, etc.
UC 6 44	Major accident on active runway	Aircraft is blocking the runway, e.g. due to one or more flat tires after touchdown, there is a longer delay expected, because first fire fighters have to secure the aircraft, second technicians have to inspect the aircraft, if it can be lifted up and later be towed away and a tow tug has to be ordered and make its way to the aircraft, etc.
UC 6 50	Winter conditions with on- going winter operations (snow/ice removal)	Analysis of a situation of serious winter phenomenon overwhelming winter operations (heavy snow storm, freezing rain) happening on short notice. Analysis of a situation of "medium" winter phenomenon with on-going winter operations triggering restrictions to use certain infrastructures (limitation to some aircraft types) and infrastructures unavailability (intermediate line up taxiway not available, part of taxiways closed, …) and difficulties to enter parking stand etc.

Table 22: Identified Use Cases for Surface-In

5.3 TBS Operational Scenario 1 - Sequence Arrivals Using Time Based Separation Ground Solution

This TBS Operational Scenario is applicable to the following TMA operational Scenarios:

- Sub scenario 1: Implement TMA/APP in H/H environment, ground solution
- Sub scenario 3: Implement TMA/APP in M/M environment, ground solution

H/H is a high density, high complexity TMA.

M/M is medium density, medium complexity TMA.

5.3.1 General Conditions (Scope and Summary)

This Use Case describes in detail the steps involved in sequencing and delivering arrivals aircraft using time based separation on final approach with the aid of separation indicators displayed on the final approach controller radar display and tower runway controller air traffic monitor display.

This Use Case takes place in the Approach Phase of flight and the Surface-In Phase of flight from the arrival aircraft being metered into the initial approach fixes until the arrival aircraft land and vacate the runway,

The Approach Operations in this Use Case is equipped with:

- An Arrival Manager (AMAN) for supporting the metering of the arrival traffic into the initial approach fixes
- An Approach Arrival Sequence Manager for supporting the final approach arrival sequence order, aircraft landing runway intent, and the aircraft separation /spacing reflecting the runways-in-use, the runway mode of each runway-in-use, the final approach separation and runway spacing constraints and the scenario specific spacing requirements including departure gap requirements for interlaced mode runway operations
- An Approach Arrival Sequence Display provided at the Approach Supervisor, Intermediate Approach Controller, Intermediate Support Controller, and Final Approach Controller CWPs
- A Glideslope Wind Conditions Service for each arrival runway-in-use

- A Glideslope Wind Conditions and TBS Distance Display provided at the Approach Supervisor, Intermediate Approach Controller, Intermediate Support Controller and Final Approach Controller CWPs
- A Final Approach Separation Indicator Service provided at the Final Approach Controller and Intermediate Approach Controller CWPs
- An Arrival Sequence Order Monitor Service provided to Intermediate Approach Controller and Final Approach Controller CWPs
- A Wrong Aircraft Turned on to Separation Indicator Monitor Service provided to the Final Approach Controller and Intermediate Approach Controller CWP
- A Aircraft Turned on to Wrong Localiser Service provided to the Final Approach Controller and Intermediate Approach Controller CWP
- A TBS System Monitor Service is provided to the Approach Supervisor CWP and to the TMA System Operating Authority
- An Arrival Sequence Service Monitor Service provided to the Approach Supervisor CWP and to the TMA System Operating Authority
- A Glideslope Wind Conditions Service Monitor Service provided to the Approach Supervisor CWP and to the TMA System Operating Authority
- An Abnormal Indicated Airspeed Monitor Service provided to the Final Approach Controller and Intermediate Approach Controller CWPs
- A Distance Spacing Compression Monitor Service provided to the Final Approach Controller CWP.

The Tower Operations in this Use Case is equipped with:

- An Approach Arrival Sequence Display provided at the Tower Supervisor, and the Tower Runway Controller CWPs
- A Glideslope Wind Conditions and TBS Distance Display provided at the Tower Supervisor, and the Tower Runway Controller CWPs
- A Final Approach Separation Indicator Service provided at the Tower Supervisor, and the Tower Runway Controller CWPs
- A TBS System Monitor Service provided to the Tower Supervisor CWP and to the Tower System Operating Authority
- An Arrival Sequence Service Monitor Service provided to the Tower Supervisor CWP.
- A Glideslope Wind Conditions Service Monitor Service provided to the Tower Supervisor CWP and to the Tower System Operating Authority
- A Distance Spacing Compression Monitor Service provided to the Tower Runway Controller CWP

5.3.2 Pre Conditions

Airport Medium / Short Term Planning and Balance Demand and Capacity have established a flow of arrival aircraft for the aerodrome into the TMA that matches the runway capacity in the prevailing operating conditions.

Plan Arrival Sequence has optimised as far is reasonable the arrival sequence order into the initial approach fixes and that this arrival sequence order is reflected in the AMAN sequence order.

The Approach Arrival Sequence Manager is operational and the Approach Arrival Sequence Display is available at the Approach and Tower ATC CWPs

The Glideslope Wind Conditions Service is operational.

The TBS System and the Final Approach Separation Indicator Service are operational with, separation indicators being available to be selected for display at the Approach and Tower ATC CWPs, and the Glideslope Wind Conditions and TBS Distance Display is available at the Approach and Tower ATC CWPs.

The Arrival Sequence Order Monitor Service, the Wrong Aircraft Turned on Separation Indicator Monitor Service and the Aircraft Turned on to Wrong Localiser Monitor Service are operational.

The TBS System Monitor Service, the Arrival Sequence Service Monitor Service and the Glideslope Wind Conditions Service Monitor Service are operational.

The Abnormal Indicated Airspeed Monitor Service and the Distance Spacing Compression Monitor Service are operational.

The Flight Crew are aware that TBS is being employed on final approach through the pre-departure briefing, the top of descent briefing, and from the D-ATIS notification as the aircraft enters the TMA.

The Flight Crew establish the landing stabilisation speed required for the landing weight, cockpit stabilisation procedures including approach flap setting, and D-ATIS reported surface wind conditions soon after the aircraft enters the TMA.

5.3.3 Post Conditions

The arrival aircraft have landed and vacated the runway.

5.3.4 Actors

Flight Crew

TMA Sector Controllers

Approach Supervisor

Intermediate Approach Controllers & Intermediate Support Controllers

Final Approach Controller

Tower Supervisor

Tower Runway Controller

TMA System Operating Authority

Tower System Operating Authority

5.3.5 Trigger

Coordination of an arrival aircraft into the assigned initial approach fix between the TMA Sector ATCO and the Intermediate Approach ATCO or Intermediate Support ATCO.

5.3.6 Nominal Flow

1. The TMA Sector ATCO coordinates with the Intermediate Approach ATCO or the Intermediate Support ATCO on the flight level for entry into the initial approach fix taking into account holding traffic and occupied holding levels and whether the aircraft will need to hold.
2. The TMA Sector ATCO instructs the Flight Crew to descend to the coordinated flight level for entry into the initial approach fix.
3. The TMA Sector ATCO manage the laddering down of aircraft through the initial approach fix holding levels they are responsible for through instructing the Flight Crew of when to descend to the next level.
4. When aircraft are entering the initial approach fix at a flight level that Approach ATC is responsible for, or have been laddered down to a holding level that Approach ATC are responsible for, the TMA Sector ATCO instructs the Flight Crew to transfer to Approach ATC

and to change RT frequency to the Intermediate Approach ATCO / Intermediate Support ATCO RT frequency.

5. The Flight Crew change RT frequency to the Intermediate Approach ATCO / Intermediate Support ATCO RT frequency.

6. On first call to Approach ATC the Flight Crew confirm the aircraft type / wake category, provide notification of any approach procedural airspeed non-conformance issues, and optionally provide notification if employing an unusually slow or fast landing stabilisation speed for the aircraft type.

7. The Intermediate Approach ATCO / Intermediate Support ATCO checks the aircraft type / wake category on the Flight Progress Strip and the Approach Arrival Sequence Display, and notes any notified approach procedural airspeed non-conformance issues and notes any notified employment of a slow or fast landing stabilisation speed for the aircraft type.

8. The Intermediate Approach ATCO / Intermediate Support ATCO confirm that the arrival aircraft is in the arrival sequence, confirm the aircraft position in the arrival sequence order, and confirm the aircraft landing runway intent, coordinating across the other Intermediate Approach ATCO positions as required. These may be checked using the Approach Arrival Sequence Display.

9. The Intermediate Approach ATCO / Intermediate Support ATCO confirm the separation distance to the aircraft in front in the arrival sequence, taking into account the respective wake categories of the lead and follower aircraft and the respective TBS distance in the prevailing glideslope wind conditions, and also taking into account the final approach separation and runway spacing constraints that are to be applied, and any scenario specific spacing requirements including departure gap requirements. This may be confirmed using the Approach Arrival Sequence Display. The Glide Slope Wind Conditions and TBS Distance Display may be used to maintain awareness of the prevailing wind conditions impact on the TBS distance.

10. For aircraft that are holding at holding levels that Approach ATC are responsible for, the Intermediate Approach ATCO / Intermediate Support ATCO mange the laddering of aircraft down through these holding levels through instructing the Flight Crew as to when to descend to the next holding level, as the aircraft ahead are directed onto initial and intermediate approach and are laddered down through the holding levels.

11. Taking into account the position of the aircraft in the arrival sequence order, the separation / spacing to be delivered on final approach represented by the separation distance, and the aircraft landing runway intent, the Intermediate Approach ATCO determines when to direct the aircraft on initial and intermediate approach such that it will be in a position to be efficiently merged on to final approach respecting the separation / spacing to be delivered. System support advice on the timing of when to direct the aircraft on to initial approach may be provided to the Intermediate Approach ATCO.

12. The Intermediate Approach ATCO instructs the Flight Crew to commence intermediate approach on the appropriate heading or path into the approach radar manoeuvring area, for the landing runway intent, and for aircraft that are holding, the instructions for exiting the hold circuit.

13. The Intermediate Approach ATCO provides the Flight Crew with information to support a CDA (e.g. distance to touchdown advice) and provides altitude clearances as appropriate as aircraft progress on intermediate approach so that the aircraft is at the appropriate altitude for handing over to the Final Approach ATCO.

14. The Intermediate Approach ATCO provides the Flight Crew with the required heading and airspeed instructions in the radar manoeuvring area so as to provide appropriate separation from the other arrival aircraft merging on intermediate approach and so as to set up the appropriate stream of arrival aircraft to the Final Approach ATCO.

15. As the arrival aircraft are approaching the handover position to the Final Approach Controller the Intermediate Approach Controller re-checks the sequence order of the aircraft and the separation distance using the Approach Arrival Sequence Display.

16. The Arrival Sequence Order Monitor Service checks that the position of the aircraft on final approach relative to the aircraft ahead and behind and turning on from the other side of the localiser matches the arrival sequence order in the Approach Arrival Sequence Display.

17. The Intermediate Approach ATCO passes on the Flight Progress Strip to the Final Approach ATCO checking that the Final Approach ATCO Flight Progress Strips are in the order of the Approach Arrival Sequence Display and alerts the Final Approach ATCO of any notified approach procedural airspeed non-conformance issues and any notified employment of a slow or fast landing stabilisation speed.

18. The Intermediate Approach ATCO instructs the Flight Crew to transfer to Final Approach ATCO and to change RT frequency to the Final Approach ATCO

19. The Flight Crew change RT frequency to the Final Approach ATCO and confirm they have transferred frequency.

20. The Final Approach ATCO checks the aircraft order position in the Flight Progress Strips matches the order of the Approach Arrival Sequence Display.

21. The separation indicator for the follower aircraft to turn on behind is displayed on the final approach extended runway centre-line at the Final Approach ATCO CWP and Intermediate Approach ATCO CWP so as to provide a reference for the turn on decisions for merging on to final approach.

22. The Final Approach ATCO and /or the Intermediate Approach ATCO check that the displayed separation indicator distance on the extended runway centre-line matches the separation distance in the Approach Arrival Sequence Display.

23. The Final Approach ATCO takes into account the separation compression on final approach due to the prevailing glideslope wind conditions and the landing stabilisation speed characteristics of both the lead and follower aircraft, including any notified approach procedural airspeed non-conformance issues and any notified employment of a slow or fast landing stabilisation speed to determine the additional spacing that is required to be set up behind the separation indicator as the follower aircraft is merged on to final approach in the zone behind the separation indicator.

24. The Final Approach ATCO judges when to instruct the Flight Crew of when to turn on to base and then when to turn on to intercept so as to merge on to final approach with the appropriate additional spacing behind the separation indicator.

25. When the Final Approach ATCO instructs the Flight Crew to turn on to base they also instruct the Flight Crew to reduce airspeed to the procedural airspeed for merging on to final approach and instruct the aircraft to descend to the appropriate altitude for the position the aircraft are merging on to final approach and the associated altitude of the final approach glideslope.

26. After the aircraft has turned on to intercept to merge on to final approach the Final Approach ATCO assesses the resulting spacing to the aircraft in front and determines the spacing refinement action that is required to set up the appropriate additional spacing behind the separation indicator. In particular the spacing refinement resulting from the timing of the speed reduction instruction to the final steady procedural approach speed on final approach. This may be from before the Flight Crew has confirmed as established on the final approach localiser and usually sometime after the Flight Crew have confirmed as established on the final approach localiser.

27. The Abnormal Indicated Airspeed Monitor monitors the airspeed on the intercept on to final approach.

28. The Wrong Aircraft Turned on to Separation Indicator Monitor monitors that the separation indicator that the aircraft is being turned on behind is the correct separation indicator.

29. The Flight Crew intercept and establish on the final approach localiser and report established to the Final Approach ATCO.

30. The Flight Crew adjust the aircraft descent profile to capture the final approach glideslope.
31. The Final Approach ATCO refines the spacing set up and instructs the Flight Crew to reduce to the final steady procedural airspeed on final approach.
32. The Flight Crew confirm as reducing to the final steady procedural airspeed on final approach.
33. The Abnormal Indicated Airspeed Monitor monitors the airspeed on final approach.
34. The Final Approach ATCO monitors the resulting spacing as the aircraft proceed down final approach.
35. The Distance Spacing Compression Monitor monitors for distance spacing compression resulting in an imminent separation infringement or causing a separation infringement until the lead aircraft commences landing speed stabilisation.
36. When satisfied that an appropriate stable spacing has been set up, the Final Approach ATCO instructs the Flight Crew to transfer to the Tower ATC and to change RT frequency to the Tower Runway ATCO RT frequency.
37. The Flight Crew change RT frequency to the Tower Runway ATCO frequency and confirm identity.
38. The Tower Runway ATCO informs the Flight Crew of the runway surface wind conditions including gusting conditions and confirms the aircraft position with respect to the aircraft ahead on final approach to be given clearance to land.
39. The Flight Crew, where required for the aircraft type, adjust the landing stabilisation speed taking into account the runway surface gusting conditions reported by the Tower Runway ATCO.
40. The Final Approach ATCO continues to monitor the spacing on final approach until the lead aircraft has commenced landing speed stabilisation and is within 4Nm of touchdown.
41. The Tower Runway ATCO checks the spacing set up from when both aircraft are established on the final approach localiser. This includes checking the separation indicator distance from an awareness of the prevailing wind conditions impact on the TBS distance from the Glideslope Wind Conditions and TBS Distance Display.
42. The Tower Runway ATCO monitors the spacing compression and the continued appropriateness of the spacing as the aircraft ahead commences landing speed stabilisation and proceeds down final approach to the runway landing threshold.
43. The Tower ATC variant of the Distance Spacing Compression Monitor monitors the appropriateness of the distance spacing compression during the lead aircraft landing speed stabilisation to the runway landing threshold. The separation indicator is removed from the Final Approach ATCO radar display and the Tower Runway ATCO air traffic monitor display when the lead aircraft crosses the runway landing threshold or enters the radar blanking area if sooner.
44. The Tower Runway ATCO provides clearance to land to the aircraft as per local procedures, with some assurance that the lead aircraft will vacate the runway in time, or to when it has been confirmed that the lead aircraft has vacated the runway.
45. The Tower Runway ATCO monitors the aircraft touching down, rolling out, proceeding to the assigned /appropriate exit taxiway and vacating the runway.

5.3.7 Alternative Flows

[7] Aircraft Type / Wake Category incorrect on Flight Progress Strips

46. The Intermediate Approach ATCO / Intermediate Support ATCO ensure that the aircraft type / wake category is corrected in the system flight plan data.
47. The Intermediate Approach ATCO / Intermediate Support ATCO check that the corrected aircraft type / wake category is propagated through to the Approach Arrival Sequence Display.

48. The Use Case resumes at step 7.

[8] Aircraft not in the Approach Arrival Sequence Display

49. The Intermediate Approach ATCO / Intermediate Support ATCO in coordination with the Approach Supervisor or the other Intermediate Approach ATCO positions determine which procedural option is to be applied to manage the aircraft:
    a. Create the aircraft entry in the arrival sequence with the corresponding identifiers with the flight data and the surveillance data so that the aircraft is no longer missing from the arrival sequence so that separation indicators can be provided in the normal way,
    b. Create a scenario specific gap between the lead aircraft that the missing aircraft is to be slotted in behind and the follower aircraft the missing aircraft is to be slotted in in front. This gap must be sufficient for the combined DBS wake turbulence separation requirements between the lead aircraft and the missing aircraft and the DBS wake turbulence separation requirements between the missing aircraft and the follower aircraft. The missing aircraft will need to be merged on to final approach by the final approach controller without a reference separation indicator to the required DBS behind the lead aircraft. The follower aircraft behind the missing aircraft can then be merged on to final approach using the separation indicator with the scenario specific gap behind the lead aircraft.
    c. Disable the separation indicator between the lead aircraft and the follower aircraft that the missing aircraft is to be slotted in between. The final approach controller will need to merge the missing aircraft and the follower aircraft on to final approach to the required DBS without the aid of separation indicators.
50. If the option chosen is to create the aircraft entry in the arrival sequence, the Intermediate Approach ATCO / Intermediate Support ATCO delegate the creation of the entry to the appropriate APS support role, and when the entry is confirmed as created, check that the aircraft is in the approach position in the Approach Arrivals Sequence Display with correct aircraft type / wake category.
51. If the option chosen is to create a scenario gap between the lead aircraft that the missing aircraft is to be slotted in behind and the follower aircraft the missing aircraft is to be slotted in in front:
    a. The Intermediate Approach ATCO / Intermediate Support ATCO determine the size of the gap required for the respective wake categories of the missing aircraft, the aircraft in front and the aircraft behind, create the scenario specific gap of the required size behind the lead aircraft in the Approach Arrival Sequence.
    b. Check that the scenario specific gap is set up in the Approach Arrivals Sequence Display.
    c. Notes the creation of the gap on the Flight Progress Strips of the lead aircraft and the follower aircraft, and also notes the callsign of the aircraft not in the arrival sequence being turned on in the gap.
52. If the option chosen is to disable the separation indicator behind the lead aircraft:
    a. The Intermediate Approach ATCO / Intermediate Support ATCO disable the separation indicator and check that separation distance in the Approach Arrival Sequence Display is null
    b. Notes the disabling of the separation indicator on the flight progress strips of both the lead and follower aircraft and also notes the callsign of the aircraft not in the arrival sequence being turned on in the gap.
53. The Use Case resumes at step 9.

[9] Aircraft Pair not having a Separation Distance in the Approach Arrival Sequence Display

54. The Intermediate Approach ATCO / Intermediate Support ATCO check whether the aircraft are consecutive aircraft in the same direction of operations. No separation distance is provided when there is a change in the direction of operations.
55. If the aircraft pair are consecutive aircraft in the same direction operations, the Intermediate Approach ATCO / Intermediate Support ATCO check that the aircraft type / wake category of each aircraft are specified and recognisable, and if not amend/correct the unspecified / unrecognised values and check that there is a resulting separation distance in the Approach Arrival Sequence Display.
56. If it is not possible to correct the underlying cause, the Intermediate Approach ATCO / Intermediate Support ATCO:
    a. Selectively disable the separation indicator behind the lead aircraft and check that separation distance in the Approach Arrival Sequence Display is null
    b. Notes the disabling of the separation indicator on the flight progress strips of both the lead and follower aircraft.
57. The Use Case resumes at step 10.

[16] Arrival Sequence Order Monitor Service Alert

58. The Intermediate Approach ATCO checks whether the arrival order in the Approach Arrival Sequence Display matches the arrival order on intermediate approach.
59. If the arrival order in the Approach Arrival Sequence Display is incorrect, the Intermediate Approach ATCO corrects the arrival order and checks the impacted separation distances using the Approach Arrival Sequence Display.
60. The Use Case resumes at step 17.

Anywhere between [1] and [23] Change of Aircraft Landing Runway Intent

61. The Approach Supervisor or Intermediate Approach ATCO updates the aircraft landing runway intent in the Approach Arrivals Sequence.
62. The Approach Supervisor or Intermediate Approach ATCO checks the aircraft landing runway intent is updated in the Approach Arrivals Sequence Display
63. The Approach Supervisor or Intermediate Approach ATCO checks that the separation distance ahead of the aircraft and the separation distance behind the aircraft are both amended to reflect the change in the landing runway intent of the aircraft using the Approach Arrival Sequence Display.
64. If the related separation indicators are being displayed the Intermediate Approach ATCO checks that separation indicator distance reflects the change of aircraft landing runway intent and that the position of the separation indicator ahead of the aircraft is switched to the final approach extended runway centre-line of the switched runway.
65. The Use Case resumes at the step it was invoked between step 1 and step 23.

Anywhere between [1] and [23] Change of Aircraft Arrival Sequence Order Position

66. The Approach Supervisor or Intermediate Approach ATCO updates the aircraft sequence order position in the Approach Arrivals Sequence.
67. The Approach Supervisor or Intermediate Approach ATCO checks the aircraft sequence order position is updated in the Approach Arrivals Sequence Display

68. The Approach Supervisor or Intermediate Approach ATCO checks that the separation distances between the impacted arrival aircraft are amended to reflect the change in the arrival sequence order position of the aircraft using the Approach Arrival Sequence Display.

69. If the related separation indicators are being displayed the Intermediate Approach ATCO checks that each separation indicator distance between each impacted arrival pair has been updated to reflect the change of arrival sequence order position of the aircraft.

70. The Use Case resumes at the step it was invoked between step 1 and step 23.

<u>Anywhere between [1] and [23] New Scenario Specific Spacing Requirement</u>

71. The Tower Supervisor and Approach Supervisor or Arrival Runway ATCO and Final Approach ATCO coordinate on the provision of a new scenario specific spacing requirement between arrival aircraft not yet turned on to merge on to final approach. This may be for several reasons including:

    a. To accommodate a planned runway inspection

    b. To accommodate an emergency flight

    c. To accommodate CAT A or CAT B flight activity in conflict with final approach

    d. To accommodate an arrival flight with a non-standard approach path (e.g. helicopter flight) on to the runway

    e. To accommodate final approach or runway crossing traffic

    f. To accommodate a departure aircraft

72. The Tower Supervisor and Approach Supervisor or Arrival Runway ATCO and Final Approach ATCO negotiate and agree on the position of where the new scenario specific spacing requirement is to be accommodated in the Approach Arrivals Sequence.

73. The Approach Supervisor or Final Approach ATCO set up the request for the new scenario specific spacing requirement in the Approach Arrivals Sequence and check that the scenario specific spacing requirement is reflected in the associated separation distance in the Approach Arrivals Sequence Display. The Final Approach ATCO may delegate responsibility for setting up and checking the scenario specific spacing request to the associated Intermediate Approach ATCO or appropriate support role.

74. The Tower Supervisor or Tower Runway ATCO confirm / check that the new scenario specific spacing requirements have been set up through checking the Approach Arrival Sequence Display.

75. The Use Case resumes at the step it was invoked between step 1 and step 23.

<u>Anywhere between [1] and [23] Amendment of Scenario Specific Spacing Requirement</u>

76. The Tower Supervisor and Approach Supervisor or Arrival Runway ATCO and Final Approach ATCO coordinate on the amendment of a scenario specific spacing requirement between arrival aircraft not yet turned on to merge on to final approach. This may include changing the sequence order position of the scenario specific spacing, amending the scenario specific spacing requirement, or removing the scenario specific spacing requirement.

77. The Tower Supervisor and Approach Supervisor or Arrival Runway ATCO and Final Approach ATCO negotiate and agree on the amendments.

78. The Approach Supervisor or Final Approach ATCO amend the scenario specific spacing requirement in the Approach Arrivals Sequence and check that the amended scenario specific spacing requirement is reflected in the associated separation distances in the Approach Arrivals Sequence Display. The Final Approach ATCO may delegate responsibility for amending and checking the scenario specific spacing request to the associated Intermediate Approach ATCO or appropriate APS support role.

79. The Tower Supervisor or Tower Runway ATCO confirm / check the amended scenario specific spacing requirements through checking the Approach Arrival Sequence Display.
80. The Use Case resumes at the step it was invoked between step 1 and step 23.

Anywhere between [19] and [24] Flight Crew Indicate They Are Not Ready to Proceed with Merging on to Final Approach

81. The Flight Crew Indicate to the Final Approach ATCO that they are not ready to proceed with merging on to Final Approach (e.g. because the cabin is not secure)
82. The Final Approach ATCO determines what action to take to path stretch the aircraft so that it is does not impact the merging of following arrival aircraft on to final approach.
83. The Final Approach ATCO determines what action to take in terms of repositioning the aircraft in the arrival sequence order.
84. The Final Approach ATCO updates the arrival sequence order in the Approach Arrival Sequence and checks that each associated separation distance is update to reflect the amended arrival sequence order using the Arrival Sequence Order Display. This may be delegated to the responsible Intermediate Approach ATCO.
85. The Final Approach ATCO and Intermediate Approach ATCO check that for the related separation indicators that are being displayed, the separation indicator distance between each impacted arrival pair has been updated to reflect the change in arrival sequence order of the aircraft.
86. If the path stretching required is extensive the Final Approach ATCO instructs the flight crew to transfer to the Intermediate Approach ATCO and to change RT frequency to the Intermediate Approach ATCO RT Frequency.
87. If the Flight Crew are instructed to transfer to the Intermediate Approach ATCO, the Flight Crew change RT frequency and confirm identity.
88. The Use Case resumes at the appropriate step between 14 and 23.

Anywhere between [17] and [32] Final Approach ATCO Overloaded with Abnormal Scenario

89. The Intermediate Approach ATCO delays instructing the flight crew to transfer to the Final Approach ATCO and coordinates with the Final Approach ATCO to agree to taking on the responsibility for merging the aircraft on to final approach.
90. The separation indicator for the follower aircraft to turn on behind is displayed on the final approach extended runway centre-line at the Intermediate Approach ATCO CWP and the Final Approach ATCO CWP so as to provide a reference for the turn on decisions for merging on to final approach.
91. The Intermediate Approach ATCO checks that the displayed separation indicator distance on the extended runway centre-line matches the separation distance in the Approach Arrival Sequence Display.
92. The Final; Approach ATCO provides advice on the separation compression on final approach due to the prevailing glideslope wind conditions.
93. The Intermediate Approach ATCO takes into account the separation compression on final approach due to the prevailing glideslope wind conditions and the landing stabilisation speed characteristics of both the lead and follower aircraft, including any notified approach procedural airspeed non-conformance issues and any notified employment of a slow or fast landing stabilisation speed to determine the additional spacing that is required to be set up.
94. The Intermediate Approach ATCO judges when to instruct the Flight Crew of when to turn on to base and then when to turn on to intercept so as to merge on to final approach with the appropriate additional spacing behind the separation indicator.

95. When the Intermediate Approach ATCO instructs the Flight Crew to turn on to base they also instruct to Flight Crew to reduce airspeed to the procedural airspeed for merging on to final approach and instruct the aircraft to descend to the appropriate altitude for the position the aircraft are merging on to final approach and the associated altitude of the final approach glideslope.

96. After the aircraft has turned on to intercept to merge on to final approach the Intermediate Approach ATCO assesses the resulting spacing to the aircraft in front and determines the spacing refinement action that is required to set up the appropriate additional spacing behind the separation indicator. In particular the spacing refinement resulting from the timing of the speed reduction instruction to the final steady procedural approach speed on final approach. This may be from before the Flight Crew has confirmed as established on the final approach localiser and usually sometime after the Flight Crew have confirmed as established on the final approach localiser.

97. The Abnormal Indicated Airspeed Monitor monitors the airspeed on the intercept on to final approach.

98. The Wrong Aircraft Turned on to Separation Indicator Monitor monitors that the separation indicator that the aircraft is being turned on behind is the correct separation indicator.

99. The Flight Crew intercept and establish on the final approach localiser and report established to the Intermediate Approach ATCO.

100. The Flight Crew adjust the aircraft descent profile to capture the final approach glideslope.

101. The Intermediate Approach ATCO refines the spacing set up and instructs the Flight Crew to reduce to the final steady procedural airspeed on final approach.

102. The Flight Crew confirm as reducing to the final steady procedural airspeed on final approach.

103. The Intermediate Approach ATCO instructs the Flight Crew to transfer to Final Approach ATCO and to change RT frequency to the Final Approach ATCO

104. The Flight Crew change RT frequency to the Final Approach ATCO and confirm they have transferred frequency.

105. The Use Case resumes at step 33.

[26] Wrong Aircraft Turned on to Separation Indicator Alert

106. The Final Approach ATCO checks whether it is safe to proceed with merging the impacted aircraft on to final approach and if not breaks the aircraft off from merging on to final approach.

107. If it is safe to proceed, the Final Approach ATCO or responsible Intermediate Approach ATCO amends the arrival order in the Approach Arrival Sequence Display so that it matches the arrival order on intermediate and final approach.

108. If it is safe to proceed, the Final Approach ATCO or responsible Intermediate Approach ATCO checks that the impacted separation distances are amended in the Approach Arrivals Sequence Display and the displayed separation indicator distances are amended.

109. If it is not safe to proceed the Final Approach ATCO decides on the path stretching action to take to separate the aircraft from other traffic and to set up the aircraft such that it can be merged back on to final approach.

110. If it is not safe to proceed and there is any impact on the arrival sequence order on final approach the Final Approach ATCO updates the Approach Arrivals Sequence and checks the associated aircraft arrival sequence order positions have been updated in the Approach Arrivals Sequence Display. This may be delegated to the associated Intermediate Approach ATCO.

111. The Final Approach ATCO and Intermediate Approach ATCO check that each impacted separation indicator distance is updated to reflect the change in arrival sequence order of the aircraft.

112. The Use Case resumes at step 27 when the aircraft continues the approach.

113. The Use Case resumes at the appropriate step between 21 and 24 when the aircraft discontinues the approach.

[25] and [31] Abnormal Indicated Airspeed Alert

114. The Final Approach ATCO assesses the impact of the abnormal indicated airspeed and determines whether and what intervention actions to take.

115. If the abnormal indicated airspeed alert is for an aircraft with an abnormally high airspeed the Final Approach ATCO assesses the impact on the spacing to the aircraft in front.

116. If the abnormal indicated airspeed alert is for an aircraft with an abnormally slow airspeed the Final Approach ATCO assesses the impact on the spacing to the aircraft behind.

117. The Final Approach ATCO carries out the required intervention actions.

118. The intervention actions include airspeed instructions, path stretching instructions and if necessary missed approach instructions, and include managing the impact on subsequent aircraft in the arrival sequence.

119. The Use Case resumes at step 26 and step 32 respectively.

Anywhere between [29] and [44] Final Approach or Tower Runway ATCO Directs Aircraft on to a Missed Approach

120. The Final Approach ATCO or Tower Runway ATO instructs the aircraft to execute a missed approach.

121. The Flight Crew execute the standard missed approach and await further instructions from the Final Approach ATCO or Tower Runway ATCO.

122. The missed approach aircraft is automatically removed from the Approach Arrivals Sequence Display, the separation indicators associated with the missed approach aircraft are automatically removed, and a separation indicator displayed for the separation distance between the resulting new lead aircraft and follower aircraft from ahead and behind the missed approach aircraft.

123. The Final Approach ATCO or Tower Runway ATCO assure appropriate separation from other traffic and instruct the aircraft to turn on to a heading away from the final approach centre-line.

124. The Final Approach ATCO or Tower Runway ATCO instructs the Flight Crew to transfer RT frequency to the responsible Intermediate Approach ATCO RT frequency.

125. The Flight Crew transfer RT frequency to the Intermediate Approach ATCO and confirm they have transferred frequency.

126. The responsible Intermediate Approach ATCO determines where the missed approach aircraft is to be accommodated in the arrival sequence order and amends the arrival sequence order position in the Approach Arrival Sequence and checks that this is reflected into the Approach Arrival Sequence Display and the impacted separation distances are correctly amended.

127. The responsible Intermediate Approach ATCO instructs the aircraft to merge back into the intermediate approach steam at the required position.

128. The Use Case resumes at step13.

Anywhere between [29] and [36] Final Approach ATCO Path Stretches an Aircraft Established on Final Approach

129. The Final Approach ATCO instructs the Flight Crew to turn the aircraft onto a track divergent from the final approach.

130. Once the aircraft has sufficiently path stretched the Final Approach ATCO instructs the Flight Crew to turn on to a heading to intercept and merge back on to final approach.

131. The Flight Crew report re-established on final approach.

132. The Use Case resumes anywhere between [29] and [36].

[34] Insufficient Spacing on Final Approach

133. The Final Approach ATCO assesses the impact of the insufficient spacing and determines what intervention actions to take.

134. The intervention actions include airspeed instructions, path stretching instructions and if necessary missed approach instruction, and include managing the impact on subsequent aircraft in the arrival sequence.

135. The Final Approach ATCO carries out the required intervention actions.

136. The Use Case resumes at step 35 when the aircraft continues the approach.

137. The Use Case resumes at step13 when the aircraft is instructed to execute a missed approach.

[35] Distance Spacing Compression Monitor Alert to the Final Approach ATCO

138. The Final Approach ATCO assesses the impact of the distance compression / separation infringement alert and determines what intervention actions to take.

139. The intervention actions include airspeed instructions, path stretching instructions and if necessary missed approach instructions, and include managing the impact on subsequent aircraft in the arrival sequence.

140. The Final Approach ATCO carries out the required intervention actions.

141. The Use Case resumes at step 36 when the aircraft continues the approach.

142. The Use Case resumes at step13 when the aircraft is instructed to execute a missed approach.

[43] Insufficient Spacing on Final Approach

143. The Tower Runway ATCO assesses the impact of the insufficient spacing and determines what intervention actions to take.

144. The intervention actions include airspeed reduction instructions, path stretching instructions, and providing cautionary wake advisories to the follower aircraft, and if necessary instructing the follower aircraft to execute a missed approach.

145. For an airspeed reduction instruction or a path stretching instruction, the Tower Runway ATCO coordinates with the Final Approach ATCO before issuing the instruction. This is so as to enable the Final Approach ATCO to manage the impact on subsequent aircraft in the arrival sequence.

146. The Tower Runway ATCO carries out the required intervention actions.

147. The Use Case resumes at step 44 when the aircraft continues the approach.

148. The Use Case resumes at step13 when the aircraft is instructed to execute a missed approach.

[43] Distance Spacing Compression Monitor Alert to the Tower Runway ATCO

149. The Tower Runway ATCO assesses the impact of the distance compression / separation infringement alert and determines what intervention actions to take.

150. The intervention actions include airspeed reduction instructions, path stretching instructions, and providing cautionary wake advisories to the follower aircraft, and if necessary instructing the follower aircraft to execute a missed approach.

151. For an airspeed reduction instruction or a path stretching instruction, the Tower Runway ATCO coordinates with the Final Approach ATCO before issuing the instruction. This is so as to enable the Final Approach ATCO to manage the impact on subsequent aircraft in the arrival sequence.

152. The Tower Runway ATCO carries out the required intervention actions.

153. The Use Case resumes at step 43 when the aircraft continues the approach.

154. The Use Case resumes at step13 when the aircraft is instructed to execute a missed approach.

Anywhere Flight Crew Experience a Wake Turbulence Encounter and Continue the Approach

155. The Flight Crew report the Wake Turbulence Encounter to the TMA Sector ATCO, Intermediate Support ATCO, Intermediate Approach ATCO, Final Approach ATCO, or Tower Runway ATCO.

156. The Flight Crew notes the operational circumstances and time of the wake turbulence encounter.

157. The TMA Sector ATCO, or Intermediate Support ATCO, or Intermediate Approach ATCO, or Final Approach ATCO, or Tower Runway ATCO notes the operational circumstances and the time of the wake turbulence encounter.

158. The Use Case resumes at the appropriate step.

159. The Flight Crew subsequently submits a Wake Turbulence Encounter Report as per airline operator procedures.

160. The TMA Sector ATCO, or Intermediate Support ATCO, or Intermediate Approach ATCO, or Final Approach ATCO, or Tower Runway ATCO submits a Wake Turbulence Encounter Report as per local ATC procedures.

Anywhere between [29] and [45] Flight Crew Experience a Wake Turbulence Encounter and Discontinue the Approach

161. The Flight Crew report the Wake Turbulence Encounter to the Final Approach ATCO or Tower Runway ATCO and inform the Final Approach ATCO or Tower Runway ATCO that they are discontinuing final approach on to the standard missed approach.

162. The Flight Crew execute the standard missed approach and await further instructions from the Final Approach ATCO or Tower Runway ATCO.

163. The Flight Crew notes the operational circumstances and time of the wake turbulence encounter.

164. The Final Approach ATCO or Tower Runway ATCO notes the operational circumstances and the time of the wake turbulence encounter.

165. The Missed Approach Use Case is followed.

166. The Use Case resumes at step 13.

167. The Flight Crew subsequently submits a Wake Turbulence Encounter Report as per airline operator procedures.

168. The Final Approach ATCO or Tower Runway ATCO subsequently submits a Wake Turbulence Encounter Report as per local ATC procedures.

Anywhere between [29] and [45] Flight Crew Experience Wind Sheer or Wind Turbulence and Continue the Approach

169. The Flight Crew report the Wind Sheer or Wind Turbulence to the Final Approach ATCO, or Tower Runway ATCO.

170. The Final Approach ATCO or Tower Runway ATCO notes the operational circumstances of the Wind Sheer or Wind Turbulence and informs the Approach Supervisor or Tower Supervisor.

171. The Approach Supervisor and Tower Supervisor ensure that a Wind Sheer or Wind Turbulence warning is issued on D-ATIS.

172. The Final Approach ATCO and Tower Runway ATCO inform subsequent aircraft established on final approach of the Wind Sheer or Wind Turbulence.

173. The Use Case resumes at the appropriate step between 29 and 45.

Anywhere between [29] and [45] Flight Crew Experience Low Level Severe Wind Turbulence and Discontinue the Approach

174. The Flight Crew report low level Severe Wind Turbulence to the Tower Runway ATCO and inform the Tower Runway ATCO that they are discontinuing final approach on to the standard missed approach.

175. The Flight Crew execute the standard missed approach and await further instructions from the Tower Runway ATCO.

176. The Tower Runway ATCO notes the operational circumstances of the low level Severe Wind Turbulence and informs the Tower Supervisor

177. The Tower Supervisor ATCO determines what actions to take to ensure the safety of operations. This may include switching the approach operations to an alternative runway.

178. If operations are to continue on the same runway the Tower Runway ATCO warns subsequent aircraft of the low level Severe Wind Turbulence on final approach.

179. The Tower Supervisor ensures that a Severe Wind Turbulence warning is issued on D-ATIS.

180. The Missed Approach Use Case is followed.

181. The Use Case resumes at step 13.

[44] and [45] Marginal Spacing is Set Up for Clearance to Land on Lead Aircraft Touch Down and Roll Out

182. The Tower Runway ATCO instructs the Flight Crew of the lead aircraft to expedite runway vacation and inform them of the spacing to the follower aircraft.

183. The Flight Crew of the lead aircraft confirm expending runway vacation.

184. The Tower Runway ATCO informs the follower aircraft of the spacing and expedited runway vacation confirmation of the lead aircraft.

185. The Tower Runway ATCO monitors the expedited runway vacation of the lead aircraft and if providing sufficient time for clearance to land provides clearance to land to the follower aircraft.

186. If insufficient time is resulting for clearance to land, the Tower Runway ATCO instructs the Flight Crew to execute a missed approach.

187. The Missed Approach Use Case is followed.

188. The Use Case resumes at step 45 if the aircraft lands.

189. The Use Case resumes at step 13 if the aircraft is directed on to a missed approach.

[44] and [45] Insufficient Spacing is Set Up for Clearance to Land on Lead Aircraft Touch Down and Roll Out

190. The Tower Runway ATCO instructs the Flight Crew to execute a missed approach.

191. The Missed Approach Use Case is followed.

192. The Use Case resumes at step 13.

[44] and [45] Extended Runway Occupancy of the Lead Aircraft Resulting in the Lead Aircraft Not Vacating the Runway in Time for Clearance to Land

193. The Tower Runway ATCO instructs the Flight Crew to execute a missed approach.

194. The Missed Approach Use Case is followed.

195. The Use Case resumes at step 13.

[44] and [45] Aircraft Does Not Vacate Runway in Time for Clearance to Land to Follower Aircraft

196. The Tower Runway ATCO instructs the follower aircraft to execute a missed approach.

197. The Missed Approach Use Case is followed.

198. The Use Case resumes at step 13 for the follower aircraft.

Anywhere between [24] and [44] New Tactical Scenario Specific Spacing Requirement

199. The Tower Runway ATCO and Final Approach ATCO or the Tower Supervisor and Approach Supervisor coordinate on the provision of a new scenario specific spacing requirement between arrivals pairs already merged on to final approach or merging on to final approach. This may be for several reasons including an immediate runway inspection or to immediately accommodate crossing traffic.

200. The Tower Runway ATCO and Final Approach ATCO or the Tower Supervisor and Approach Supervisor agree on sequence position where the new scenario specific spacing requirement is to be accommodated in Approach Arrivals Sequence.

201. The Final Approach ATCO or Approach Supervisor set up the request for the new scenario specific spacing requirement in the Approach Arrivals Sequence and check that the scenario specific spacing requirement is reflected in the associated separation distances in the Approach Arrivals Sequence Display. The Final Approach ATCO may delegate responsibility for setting up and checking the scenario specific spacing request to the associated Intermediate Approach ATCO or appropriate APS support role.

202. The Tower Runway ATCO or Tower Supervisor confirms / checks that the new scenario specific spacing requirement has been set up through checking the Approach Arrival Sequence Display.

203. The Final Approach ATCO and the Tower Runway ATCO check that the new scenario specific spacing requirement is reflected in the associated displayed separation indicator distance.

204. The Final Approach ATCO and the Tower Runway ATCO assess the impact of the new scenario specific request and determines what actions to take to accommodate the request.

205. The new tactical scenario specific spacing may be able to be achieved through the path stretching of follower aircraft on base or intercept by taking the aircraft through the final approach extended centre-line and merging on to final approach from the other side of the centre-line.

206. The new tactical scenario specific spacing may be able to be achieved by tactically adjusting the spacing between aircraft already established on final approach through speed instructions or tactical vectoring.

207. The new tactical scenario specific spacing may only be able to be achieved by directing of one or more aircraft established on final approach after the new scenario specific spacing request to carry out a late switch on to a parallel runway or to carry out a missed approach.

208. The Use Case resumes at the step it was invoked between 24 and 45.

Anywhere between [24] and [45] Blocked Runway, Aircraft Able to Establish on Alternative Parallel Runway

209. The Tower Runway ATCO informs the Final Approach ATCO of the blocked runway.

210. The Tower Runway ATCO or the Final Approach ATCO informs the next aircraft to land on final approach of the blocked runway and directs the aircraft on to a missed approach if already beyond being able to switch to the alternative parallel runway.

211. For the each subsequent arrival aircraft on final approach in turn, the Final Approach ATCO determines whether there is the option to switch to the alternative runway, verifies whether the pilot accepts a visual switch to the alternative parallel runway, and either instructs the aircraft to carry out the visual switch or a missed approach.

212. The Tower Supervisor and Approach Supervisor coordinate on the estimated duration of the blocked runway and the alternative runway provision including either the switching of the delivery of arrival aircraft already committed on intermediate approach on to the alternative parallel runway, or either holding in orbits or at a designated holding fix on intermediate approach, or directed back to hold at an initial approach fix.

213. The Approach Supervisor changes the runways-in-use and the runway modes and associated final approach separation and spacing constraints to reflect any change in runway-in-use.

214. The Approach Supervisor and Tower Supervisor check that the change in runway-in-use is reflected in the Approach Arrival Sequence Display and the appropriate separation distance is set up between each aircraft being delivered on to the alternative parallel runway.

215. The responsible Intermediate Approach ATCO determines where each missed approach aircraft is to be accommodated in the arrival sequence order and amends the arrival sequence order position in the Approach Arrival Sequence and checks that this is reflected into the Approach Arrival Sequence Display and the impacted separation distances are correctly amended.

216. The Approach Supervisor and Tower Supervisor determine the runway mode for the available runway or runways for the continued operation of the airport for the duration of the blocked runway.

217. The Approach Supervisor changes the runways-in-use and the runway modes and associated final approach separation and spacing constraints to reflect the change in runway-in-use.

218. The Approach Supervisor and Tower Supervisor check that the change in runway-in-use is reflected in the Approach Arrival Sequence Display and the appropriate separation distance is set up between each aircraft being delivered on to the alternative parallel runway.

219. The Use Case resumes at the step between 24 and 45.

Anywhere between [24] and [45] Blocked Runway, Aircraft Unable to Establish on Alternative Parallel Runway

220. The Tower Runway ATCO informs the Final Approach ATCO of the blocked runway.

221. The Tower Runway ATCO or Final Approach ATCO informs the next aircraft to land on final approach of the blocked runway and directs the aircraft on to a missed approach

222. For the each subsequent arrival aircraft on final approach in turn, the Final Approach ATCO instructs the aircraft to carry out a missed approach, timing the instruction such that the appropriate separation is set up between each aircraft on intermediate approach.

223. The Intermediate Approach ATCO directs the aircraft already committed on intermediate approach to hold in orbits or at a designated holding fix on intermediate approach, or directed back to hold at an initial approach fix.

224. The Tower Supervisor and Approach Supervisor coordinate on the estimated duration of the blocked runway and determine what actions to take with the arrival traffic including diversion to alternative aerodromes.

225. The Use Case ends.

Anywhere between [1] and [15] Planned Change of Runway-In-Use

226. The Tower Supervisor and Approach Supervisor coordinate on the need for and the timing for a planned change of runway in use.

227. The Approach Supervisor adds the planned change of runway-in-use to the Approach Arrivals Sequence / AMAN Arrivals Sequence and checks that it is reflected into the Approach Arrivals Sequence Display from the sequence position of the planned change.

228. The Approach Supervisor and Tower Supervisor check that the planned change of runway-in-use is reflected into the aircraft runway intent of the arrival aircraft in the Approach Arrivals Sequence from the sequence position of the planned change.

229. The Approach Supervisor checks that for the new runway-in-use, the runway mode and the associated final approach separation and runway spacing constraints are set up appropriately from the sequence position of the planned change of runway use.

230. If the runway mode and associated final approach separation and runway spacing constraints need to be changed, the Approach Supervisor adds the planned change of runway mode and associated changes to the final approach separation and runway spacing constraints from the sequence position of the planned change of runway use.

231. If the runway mode and associated final approach separation and runway spacing constraints are changed the Approach Supervisor checks that the planned change of runway mode and the associated final approach separation and runway spacing constraints are reflected in the Approach Arrivals Sequence / AMAN Arrivals Sequence from the sequence position of the planned change of runway.

232. The Approach Supervisor and Tower Supervisor check that the runway mode and associate final approach separation and runway spacing constraints are correctly reflected in the separation distance between each arrival pair from the sequence position of the planned change of runway-in-use using the Approach Arrival Sequence Display.

233. For aircraft already directed from the initial approach fix into on to intermediate approach the Intermediate Approach ATCO appropriately modify the initial approach path so that the aircraft are set up appropriately for the change of landing runway.

234. The Use Case resumes at the appropriate step between 1 and 15.

Anywhere between [17] and [44] Unplanned or Immediate Change of Runway-In-Use

235. The Tower Supervisor and Approach Supervisor and the Tower Runway ATCO and Final Approach ATCO coordinate on the need for and the timing for an unplanned or immediate change of runway in use.

236. The Tower Runway ATCO and the Final Approach ATCO determine which aircraft can continue the approach and which aircraft need to discontinue the approach.

237. For aircraft established on final approach that need to discontinue the approach, in the order of the aircraft on final approach, the Tower Runway ATCO and the Final Approach ATCO direct each aircraft on to a missed approach.

238. The Approach Supervisor adds the unplanned or immediate change of runway-in-use to the Approach Arrivals Sequence / AMAN Arrivals Sequence and checks that the change of runway-in-use is reflected into the Approach Arrivals Sequence Display from the sequence position of the unplanned or immediate change.

239. The Approach Supervisor and Tower Supervisor check that the unplanned or immediate change of runway-in-use is reflected into the aircraft runway intent of the arrival aircraft in the Approach Arrivals Sequence / AMAN Arrivals Sequence from the sequence position of the unplanned or immediate change.

240. The Approach Supervisor checks that for the new runway-in-use, the runway mode and the associated final approach separation and runway spacing constraints are set up appropriately from the sequence position of the of the unplanned or immediate change of runway use.

241. If the runway mode and associated final approach separation and runway spacing constraints need to be changed, the Approach Supervisor adds the planned change of runway mode and associated changes to the final approach separation and runway spacing constraints from the sequence position of the unplanned or immediate change of runway use.

242. If the runway mode and associated final approach separation and runway spacing constraints are changed the Approach Supervisor checks that the planned change of runway mode and the associated final approach separation and runway spacing constraints are reflected in the Approach Arrivals Sequence from the sequence position of the planned change of runway.

243. The Approach Supervisor and Tower Supervisor check that the runway mode and associate final approach separation and runway spacing constraints are correctly reflected in the separation distance between each arrival pair from the sequence position of the unplanned or immediate change of runway-in-use using the Approach Arrival Sequence Display. For each aircraft directed on to missed approach the Missed Approach Use Case is followed with the Intermediate Approach ATCO streaming the aircraft appropriately for the change of landing runway.

244. For aircraft not established on final approach that need to discontinue the approach, the Final Approach ATCO vectors the aircraft appropriately back on to intermediate approach and instructs the Flight Crew to transfer RT frequency to the responsible Intermediate Approach ATCO RT frequency.

245. The Flight Crew transfer RT frequency to the Intermediate Approach ATCO and confirm they have transferred frequency.

246. The Intermediate Approach ATCO determines where the aircraft is to be accommodated in the arrival sequence order and amends the arrival sequence order position in the Approach Arrival Sequence and checks that this is reflected into the Approach Arrival Sequence Display and the impacted separation distances are correctly amended.

247. The responsible Intermediate Approach ATCO instructs the aircraft to merge back into the intermediate approach steam at the required position for the change of landing runway.

248. The Use Case resumes at the appropriate step.

Anywhere between [1] and [15] Planned Change of Runway Mode or Final Approach Separation or Runway Spacing Constraint

249. The Tower Supervisor and Approach Supervisor coordinate on the need for and the timing for a planned change of runway mode or final approach separation or runway spacing constraint for a runway-in-use.

250. The Approach Supervisor adds the planned change of runway mode or final approach separation or runway spacing constraint to the Approach Arrivals Sequence / AMAN Arrivals Sequence and checks that it is reflected into the Approach Arrivals Sequence Display from the sequence position of the planned change.

251. The Approach Supervisor checks that the planned change of runway mode or final approach separation or runway spacing constraint are reflected in the Approach Arrivals Sequence Display / AMAN Arrivals Sequence Display from the sequence position of the planned change.

252. The Approach Supervisor checks that the runway mode or final approach separation or runway spacing constraint is correctly reflected in the separation distance between each arrival pair from the sequence position of the planned change using the AMAN Sequence Display or the Approach Arrival Sequence Display.

253. The Use Case resumes at the appropriate step between 1 and 15.

Anywhere between [17] and [44] Unplanned or Immediate Change of Runway Mode or Final Approach Separation or Runway Spacing Constraint

254. The Tower Supervisor and Approach Supervisor or the Tower Runway ATCO and Final Approach ATCO coordinate on the need for and the timing for an unplanned or immediate change of runway mode or final approach separation or runway spacing constraint for a runway-in-use.

255. The Tower Runway ATCO and the Final Approach ATCO determine which aircraft are impacted and identify any aircraft that need to discontinue the approach.

256. For aircraft established on final approach that need to discontinue the approach, in the order of the aircraft on final approach, the Tower Runway ATCO and the Final Approach ATCO direct each aircraft on to a missed approach.

257. For each aircraft directed on to missed approach the Missed Approach Use Case is followed.

258. The Approach Supervisor or Final Approach ATCO adds the unplanned or immediate change of runway mode or final approach separation or runway spacing constraint for the runway-in-use to the Approach Arrivals Sequence. The Final Approach ATCO may delegate this to an Intermediate Approach ATCO.

259. The Approach Supervisor or Final Approach ATCO and the Tower Supervisor or Tower Runway ATCO check that the unplanned or immediate change of runway mode or final approach separation or runway spacing constraint for the runway-in-use is reflected into the Approach Arrivals Sequence Display.

260. The Approach Supervisor or Final Approach ATCO and the Tower Supervisor or the Tower Approach ATCO check that the unplanned or immediate change of runway mode or final approach separation or runway spacing constraint is reflected into the separation distance of the arrival pairs in the Approach Arrivals Sequence from the aircraft position of the unplanned or immediate change.

261. The Use Case resumes at the appropriate step.

5.3.8 Failure and Recovery Flows

Anywhere between [17] and [43] Separation Indicator Display Failure on the Final Approach ATCO Radar Display

262. There is a Separation Indicator Display Failure with the Separation Indicators being suddenly removed from the Final Approach ATCO radar display

263. The Final Approach ATCO continues with the separation / spacing set up on final approach for arrival pairs already merged on to final approach as long as satisfied that it is safe to continue with the spacing set up.

264. For arrival pairs where the Final Approach ATCO is not satisfied that it is safe to continue with the spacing set up, the Final Approach ATCO directs the follower aircraft on to a missed approach and the Missed Approach Use Case is followed.

265. The Final Approach ATCO reverts to distance based separation without separation indicator support for merging aircraft on to final approach and de-selects the displaying of separation indicators to prevent any disruption from any possible recovery in the displaying of the separation indicators.

266. The Final Approach ATCO informs the Tower Runway ATCO of the failure and the reversion to distance based separation without separation indicator support.

267. The Final Approach ATCO informs the Approach Supervisor of the Separation Indicator Display Failure and the de-selection of the displaying of the separation indicators.

268. The Approach Supervisor coordinates the reversion to distance based separation and the de-selection of the displaying of the separation indicators across all the Approach ATCO positions.

269. The Approach Supervisor informs the Tower Supervisor of the Separation Indicator Display Failure and the reversion to distance based separation without separation indicator support.

270. The Tower Supervisor coordinates the reversion to distance based separation and the de-selection of the displaying of the separation indicators across all the Tower ATCO positions.

271. The Approach Supervisor informs the TMA System Operating Authority of the failure.

272. The TMA System Operating Authority instigates investigation and recovery from the system failure.

273. The Use Case ends.

Anywhere between [17] and [43] Separation Indicator Display Failure on the Tower Runway ATCO Air Traffic Monitor Display

274. There is a Separation Indicator Display Failure with the Separation Indicators being suddenly removed from the Tower Runway ATCO air traffic monitor display

275. The Tower ATCO continues with the separation / spacing set up on final approach for arrival pairs already merged on to final approach as long as satisfied that it is safe to continue with the spacing set up.

276. The Tower Runway ATCO informs the Final Approach ATCO of the failure and the need for reversion to distance based separation.

277. The Tower Runway ATCO reverts to distance based separation without separation indicator support for merging aircraft on to final approach and de-selects the displaying of

separation indicators to prevent any disruption from any possible recovery in the displaying of the separation indicators.

278. For arrival pairs where the Tower Runway ATCO is not satisfied that it is safe to continue with the spacing set up, the Tower Runway ATCO directs the follower aircraft on to a missed approach and the Missed Approach Use Case is followed.

279. The Final Approach ATCO reverts to distance based separation for merging aircraft on to final approach and determines whether to revert to distance based separation without separation indicator support or to revert to distance based separation with separation indicator support.

280. The Final Approach ATCO continues with the separation / spacing set up on final approach for arrival pairs already merged on to final approach as long as satisfied that it is safe to continue with the spacing set up.

281. For arrival pairs where the Final Approach ATCO is not satisfied that it is safe to continue with the spacing set up, the Final Approach ATCO directs the follower aircraft on to a missed approach and the Missed Approach Use Case is followed.

282. The Tower Runway ATCO informs the Tower Supervisor of the Separation Indicator Display Failure.

283. The Tower Supervisor coordinates the reversion to distance based separation without separation indicator support across the Tower ATCO positions.

284. The Tower Supervisor informs the Approach Supervisor of the Separation Indicator Display Failure and the reversion to distance based separation without separation indicator support.

285. The Approach Supervisor determines whether to revert to distance based separation without separation indicator support or to revert to distance based separation with separation indicator support, and coordinates the reversion to appropriate distance based separation across all the Approach ATCO positions.

286. The Tower Supervisor informs the Tower System Operating Authority of the failure

287. The Approach Supervisor informs the TMA System Operating Authority of the failure.

288. The TMA System Operating Authority in coordination with the Tower System Operating Authority instigate investigation and recovery from the system failure.

289. The Use Case ends.

<u>Anywhere TBS System Failure</u>

290. A TBS System failure occurs and the TBS System Monitor alerts the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor of the TBS System failure.

291. The Approach Supervisor informs the Approach ATCOs of the TBS System failure and to switch to degraded mode operations with DBS without separation indicators.

292. The Final Approach ATCO reverts to distance based separation without separation indicator support for merging aircraft on to final approach and de-selects the displaying of separation indicators to prevent any disruption from any possible recovery in the displaying of the separation indicators

293. The Tower Supervisor informs the Tower Runway ATCO of the TBS System failure and to switch to degraded mode operations with DBS without separation indicators.

294. The Tower Runway ATCO reverts to distance based separation without separation indicator support and de-selects the displaying of separation indicators to prevent any disruption from any possible recovery in the displaying of the separation indicators.

295. The Final Approach ATCO and the Tower Runway ATCO continues with the separation / spacing set up on final approach for arrival pairs already merged on to final approach as long as satisfied that it is safe to continue with the spacing set up.

296. For arrival pairs where the Final Approach ATCO or the Tower Runway ATCO are not satisfied that it is safe to continue with the spacing set up, the Final Approach ATCO or Tower Runway ATCO directs the follower aircraft on to a missed approach and the Missed Approach Use Case is followed.

297. The Approach Supervisor informs the TMA System Operating Authority of the TBS System failure.

298. The TMA System Operating Authority instigates investigation and recovery from the TBS System failure.

299. The Use Case ends.

Anywhere TBS System Recovery

300. The TMA System Operating Authority informs the Approach Supervisor that the TBS System has been restored into service.

301. The Approach Supervisor informs the Tower Supervisor of the TBS System restoration into service.

302. The Approach Supervisor coordinates with the Tower Supervisor on when to resume TBS operations.

303. The Approach Supervisor informs the Approach ATCOs of the intention of resuming TBS operations.

304. The Approach Supervisor and Approach ATCOs ensure that the Approach Arrival Sequence is up to date and fully representative of the actual and planned arrival sequence order, the runways-in-use and runway modes, and the runway separation and spacing constraints that are to be applied.

305. The Approach Supervisor informs the Tower Supervisor of the readiness to resume TBS operations.

306. The Approach Supervisor coordinates the resumption of TBS operations across the Approach ATCO positions.

307. The Approach ATCO positions enable the displaying of the separation indicators.

308. The Tower Supervisor coordinates the resumption of TBS operations across the Tower ATCO positions.

309. The Tower ATCO positions enable the displaying of the separation indicators.

310. The Use Case ends.

Anywhere Glideslope Wind Conditions Service Interruption of Service

311. The Glideslope Wind Conditions Service is unable to maintain the glideslope wind profile to the required service performance (e.g. interruption of up-to-date information because of a gap in the arrivals traffic on final approach).

312. The Glideslope Wind Conditions Server informs the TBS Server of the interruption in the Glideslope Wind Conditions Service

313. For aircraft already established on final approach the TBS Server continues with the calculated TBS distances.

314. For aircraft yet to be merged on to final approach the TBS Server reverts to applying DBS for the separation indicators.

315. The TBS Tool informs the Approach Supervisor and the Approach ATCOs of the Glideslope Wind Conditions Service interruption of service and the switch to degraded mode operations applying DBS with the separation indicators.

316. The Approach Supervisor informs the Tower Supervisor of the switch to degraded mode operations applying DBS with the separation indicators.

317. The Tower Supervisor informs the Tower Runway ATCO of the switch to degraded mode operations applying DBS with the separation indicators.

318. The Use Case ends.

Anywhere Glideslope Wind Conditions Service Resumption from Interruption of Service

319. The Glideslope Wind Conditions Service resumes maintaining the glideslope wind profile to the required service performance (e.g. resumption of up-to-date information because of resumption of arrivals traffic on final approach).

320. The Glideslope Wind Conditions Server informs the TBS Server of the resumption from the interruption of the Glideslope Wind Conditions Service

321. For aircraft already established on final approach the TBS Server continues with the calculated DBS distances.

322. For aircraft yet to be merged on to final approach the TBS Server reverts to applying TBS for the separation indicators.

323. The TBS Tool informs the Approach Supervisor and the Approach ATCOs of the resumption of the Glideslope Wind Conditions Service and the resumption of TBS mode operations applying TBS with the separation indicators.

324. The Approach Supervisor informs the Approach ATCOs of the resumption of the Glideslope Wind Conditions Service and the resumption of TBS mode operations applying TBS with the separation indicators.

325. The Approach Supervisor informs the Tower Supervisor of the switch to TBS mode operations applying TBS with the separation indicators.

326. The Tower Supervisor informs the Tower Runway ATCO of the resumption of the Glideslope Wind Conditions Service and the resumption of TBS mode operations applying TBS with the separation indicators.

327. The Use Case ends.

Anywhere Glideslope Wind Conditions Service Failure

328. A Glideslope Wind Conditions Service failure occurs and the Glideslope Wind Conditions Service Monitor alerts the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor of the Glideslope Wind Conditions Service failure.

329. The Glideslope Wind Conditions Server Monitor informs the TBS Server of the failure of the Glideslope Wind Conditions Service

330. For aircraft already established on final approach the TBS Server continues with the calculated TBS distances.

331. For aircraft yet to be merged on to final approach the TBS Server reverts to applying DBS for the separation indicators.

332. The TBS Tool informs the Approach Supervisor and the Approach ATCOs of the Glideslope Wind Conditions Service failure and the switch to degraded mode operations applying DBS with the separation indicators.

333. The Approach Supervisor informs the Tower Supervisor of the switch to degraded mode operations applying DBS with the separation indicators.

334. The Tower Supervisor informs the Tower Runway ATCO of the switch to degraded mode operations applying DBS with the separation indicators.

335. The Approach Supervisor informs the TMA System Operating Authority of the Glideslope Wind Conditions Service failure.

336. The TMA System Operating Authority instigates investigation and recovery from the Glideslope Wind Conditions Service failure.

337. The Use Case ends.

Anywhere Glideslope Wind Conditions Service Recovery

338. The Glideslope Wind Conditions Service resumes the Glideslope Wind Conditions Service.

339. The Glideslope Wind Conditions Server informs the TBS Server of the resumption of the Glideslope Wind Conditions Service

340. For aircraft already established on final approach the TBS Server continues with the calculated DBS distances.

341. For aircraft yet to be merged on to final approach the TBS Server reverts to applying TBS for the separation indicators.

342. The TBS Tool informs the Approach Supervisor and the Approach ATCOs of the resumption of the Glideslope Wind Conditions Service and the switch to TBS mode operations applying TBS with the separation indicators.

343. The Approach Supervisor informs the Approach ATCOs of the resumption of the Glideslope Wind Conditions Service and the resumption of TBS mode operations applying TBS with the separation indicators.

344. The Approach Supervisor informs the Tower Supervisor of the switch to TBS mode operations applying TBS with the separation indicators.

345. The Tower Supervisor informs the Tower Runway ATCO of the resumption of the Glideslope Wind Conditions Service and the resumption of TBS mode operations applying TBS with the separation indicators.

346. The Use Case ends.

Arrival Sequence Service Failure

347. An Arrival Sequence Service failure occurs and the Arrival Sequence Service Monitor alerts the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor of the Arrivals Sequence Service failure.

348. The Approach Supervisor informs the Approach ATCOs of the Arrival Sequence Service failure and to switch to degraded mode operations with DBS without separation indicators.

349. The Final Approach ATCO reverts to distance based separation without separation indicator support for merging aircraft on to final approach and de-selects the displaying of separation indicators to prevent any disruption from any possible recovery in the displaying of the separation indicators

350. The Tower Supervisor informs the Tower Runway ATCO of the Arrival Sequence Service failure and to switch to degraded mode operations with DBS without separation indicators.

351. The Tower Runway ATCO reverts to distance based separation without separation indicator support and de-selects the displaying of separation indicators to prevent any disruption from any possible recovery in the displaying of the separation indicators.

352. The Final Approach ATCO and the Tower Runway ATCO continues with the separation / spacing set up on final approach for arrival pairs already merged on to final approach as long as satisfied that it is safe to continue with the spacing set up.

353. For arrival pairs where the Final Approach ATCO or the Tower Runway ATCO are not satisfied that it is safe to continue with the spacing set up, the Final Approach ATCO or Tower Runway ATCO directs the follower aircraft on to a missed approach and the Missed Approach Use Case is followed.

354. The Approach Supervisor informs the TMA System Operating Authority of the Arrival Sequence Service failure.

355. The TMA System Operating Authority instigates investigation and recovery from the Arrival Sequence Service failure.

356. The Use Case ends.

Arrival Sequence Order Service Recovery

357. The TMA System Operating Authority informs the Approach Supervisor and the Tower Supervisor that the Arrivals Sequence Service has been restored into service.

358. The Approach Supervisor coordinates with the Tower Supervisor on when to resume TBS operations.

359. The Approach Supervisor informs the Approach ATCOs of the intention of resuming TBS operations.

360. The Approach Supervisor and Approach ATCOs ensure that the Approach Arrival Sequence is up to date and fully representative of the actual and planned arrival sequence order, the runways-in-use and runway modes, and the runway separation and spacing constraints that are to be applied.

361. The Approach Supervisor informs the Tower Supervisor of the readiness to resume TBS operations.

362. The Approach Supervisor coordinates the resumption of TBS operations across the Approach ATCO positions.

363. The Approach ATCO positions enable the displaying of the separation indicators.

364. The Tower Supervisor coordinates the resumption of TBS operations across the Tower ATCO positions.

365. The Tower ATCO positions enable the displaying of the separation indicators.

366. The Use Case ends.

5.4 TBS Operational Scenario 2 - Sequence Arrivals Using Time Based Separation Air Solution

This TBS Operational Scenario is applicable to the following TMA operational Scenarios:

- Sub scenario 2: Implement TMA/APP in H/H environment, air solution
- Sub scenario 4: Implement TMA/APP in M/M environment, air solution

H/H is a high density, high complexity TMA.

M/M is medium density, medium complexity TMA.

This Air Solution is being developed under P05.06.06.

6 Requirements

Select hidden text to display the full specification of each requirement.

6.1 Operational Requirements for P06.08.01 Time Based Separation for Final Approach

6.1.1 Time Based Separation for Final Approach Concept Proposal

Identifier	REQ-06.08.01-OSED-OPS1.0001
Requirement	The TBS operational concept shall apply on final approach, from when both the lead and follower aircraft establish on the final approach localiser, until the lead aircraft crosses the runway landing threshold to touchdown.

Identifier	REQ-06.08.01-OSED-OPS1.0002
Requirement	The time based separation concept shall apply time based wake turbulence radar separation rules on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0003
Requirement	The final approach controller and the tower runway controller shall be provided with the necessary TBS tool support to enable consistent and accurate delivery and monitoring to time based wake turbulence radar separation rules on final approach. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0100 REQ-06.08.01-OSED-OPS1.0101

Identifier	REQ-06.08.01-OSED-OPS1.0100
Requirement	The final approach controller shall be provided with the necessary TBS tool support to enable consistent and accurate delivery and monitoring to time based wake turbulence radar separation rules on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0101
Requirement	The tower runway controller shall be provided with the necessary TBS tool support to enable consistent and accurate delivery and monitoring to time based wake turbulence radar separation rules on final approach.

6.1.2 TBS Tools Support for Visualisation of the Required Separation or Spacing

Identifier	REQ-06.08.01-OSED-OPS1.0004
Requirement	To provide for the consistent and accurate delivery and monitoring to time based wake turbulence separation rules the final approach controller and tower runway controller require visualisation of the TBS distance separation of the TBS rules. This is to at least a distance separation step resolution of 0.1NM. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0200 REQ-06.08.01-OSED-OPS1.0201

Identifier	REQ-06.08.01-OSED-OPS1.0200

Requirement	The system shall provide visualisation of the TBS distance separation to the final approach controller to at least a distance separation step resolution of 0.1Nm.

Identifier	REQ-06.08.01-OSED-OPS1.0201
Requirement	The system shall provide visualisation of the TBS distance separation to the tower runway controller to at least a distance separation step resolution of 0.1Nm.

Identifier	REQ-06.08.01-OSED-OPS1.0005
Requirement	The system shall display a separation indicator on the final approach centre-line of the follower aircraft, behind the lead aircraft target position on the radar display.

Identifier	REQ-06.08.01-OSED-OPS1.0006
Requirement	The system shall display a separation indicator on the extended runway centre-line of not-in-trail follower aircraft in dependent parallel runway operations.

Identifier	REQ-06.08.01-OSED-OPS1.0007
Requirement	The separation indicator position shall reflect the maximum separation or spacing constraint that is required to be applied between the arrival pair.

Identifier	REQ-06.08.01-OSED-OPS1.0008
Requirement	The separation indicator position shall be updated in synchronisation with the track position updates of the lead and follower aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0009
Requirement	The system shall provide the final approach controller with a visual reference of the required separation or spacing constraint for supporting the setting up and refining of the spacing when turning aircraft on from intermediate approach and establishing on the final approach localiser.

Identifier	REQ-06.08.01-OSED-OPS1.0010
Requirement	The separation indicator shall be first displayed to the final approach controller while the follower aircraft is on intermediate approach, before the turn on decisions that sets up the initial distance spacing on merging on to final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0202
Requirement	The system shall support displaying of the separation indicator from at least 25Nm from the landing runway threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0011
Requirement	The final approach controller and the tower runway controller require a visual reference of the required separation or spacing constraint when monitoring for separation infringement as the arrivals descend on the final approach glideslope to the runway landing threshold. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0203 REQ-06.08.01-OSED-OPS1.0204

Identifier	REQ-06.08.01-OSED-OPS1.0203
Requirement	The final approach controller shall be provided with a visual reference of the required separation or spacing constraint as the aircraft descend on the final approach glideslope to the runway landing threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0204
Requirement	The tower runway controller shall be provided with a visual reference of the required separation or spacing constraint as the aircraft descend on the final approach glideslope to the runway landing threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0012
Requirement	The separation indicator shall be first displayed to the tower runway controller when both the lead and follower aircraft are establish on their respective extended runway centre-lines.

Identifier	REQ-06.08.01-OSED-OPS1.0013
Requirement	The TBS distance for an arrival pair shall only be re-calculated up to the lead aircraft turning on to intercept the final approach localiser. Note that the proposal to stabilise the TBS distance after the lead aircraft has turned on to intercept the localiser is subject to analysis of the consequences on the management of the wake turbulence encounter risk in changeable wind conditions. This is subject to V4 and V5 maturity validation confirmation.

Identifier	REQ-06.08.01-OSED-OPS1.0014
Requirement	A separation indicator shall be displayed behind each lead aircraft established on final approach when the follower aircraft is confirmed through approach tracking as on intermediate or final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0015
Requirement	An indicator is required to be displayed for lead aircraft on intercept to final approach within a specified distance of the extended runway centre-line that they are merging on to. These include aircraft on intercept that have flow through the extended runway centre-line and are merging back from the other side of the centre-line. These indicators are to be positioned the required separation or spacing behind the indicator ahead when there is no gap between the indicator ahead and the aircraft on intercept to final approach. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0205 REQ-06.08.01-OSED-OPS1.0206

Identifier	REQ-06.08.01-OSED-OPS1.0205
Requirement	A separation indicator shall only be displayed behind lead aircraft on intercept and base when the follower aircraft is confirmed through approach tracking as on intermediate or final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0206
Requirement	For an aircraft on intercept and base, the separation indicator shall be positioned at the required separation or spacing behind the separation indicator ahead when there is no gap between the separation indicator ahead and perpendicular projected position of the target position of the aircraft on to the extended runway centre-line it is turning on to. A gap between a separation indicator and the aircraft being turned on occurs when the perpendicular projected position of the target position of the aircraft being turned on is behind the separation indicator further from the runway landing threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0016
Requirement	Just sufficient separation indicators shall be displayed for that required to support the turn on decisions of the final approach controller.

Identifier	REQ-06.08.01-OSED-OPS1.0017
Requirement	When an indicator is required to be displayed behind aircraft on intermediate approach that have yet to be turned on to intercept to merge on to final approach, the indicator is to be positioned at the required separation or spacing behind the indicator ahead when there is no gap between the indicator ahead and the aircraft on intermediate approach. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0205 REQ-06.08.01-OSED-OPS1.0206

Identifier	REQ-06.08.01-OSED-OPS1.0018
Requirement	When there is a gap between the indicator and follower aircraft being turned on when the follower aircraft is on base or intercept and within the specified distance of the extended runway centre-line, the indicator behind the follower aircraft is to be positioned the required separation or spacing behind the perpendicular projection of the target position of the follower aircraft being turned on. In parallel runway operations and not-in-trail aircraft the perpendicular projection is on to the extended runway centre-line of landing runway intent of the follower aircraft. A gap between an indicator and the follower aircraft being turned on occurs when the perpendicular projection of the target position of the follower aircraft being turned on is behind the indicator further from the runway landing threshold. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0207

Identifier	REQ-06.08.01-OSED-OPS1.0207
Requirement	For an aircraft on intercept or base, the separation indicator shall be positioned at the required separation or spacing behind the perpendicular projected position of the target position of the aircraft on to the extended runway centre-line of the follower aircraft, when there is a gap between the separation indicator ahead and the perpendicular projected position of the target position of the aircraft on to the extended runway centre-line it is turning on to. A gap between a separation indicator and the aircraft being turned on occurs when the perpendicular projected position of the target position of the aircraft being turned on is behind the separation indicator further from the runway landing threshold

Identifier	REQ-06.08.01-OSED-OPS1.0019
Requirement	The final approach controller and the tower runway controller remain responsible for monitoring for separation infringement and for timely intervention action. There is a significant potential for separation infringement scenarios on final approach because of the diversity of approach speed profiles being employed during landing speed stabilisation and the resulting uncertainties about the amount of distance spacing change and time spacing change that will be experienced between each arrival pair on final approach. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0208 REQ-06.08.01-OSED-OPS1.0209

Identifier	REQ-06.08.01-OSED-OPS1.0208
Requirement	The final approach controller shall remain responsible for monitoring for separation infringement and for timely intervention action.

Identifier	REQ-06.08.01-OSED-OPS1.0209
Requirement	The tower runway controller shall remain responsible for monitoring for separation infringement and for timely intervention action.

Identifier	REQ-06.08.01-OSED-OPS1.0020
Requirement	The final approach controller and the tower runway controller need to be able to clearly and consistently recognise at a glance the spatial relationship between each indicator displayed and the target position of the follower aircraft when both are in close proximity and overlapping. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0210 REQ-06.08.01-OSED-OPS1.0211

Identifier	REQ-06.08.01-OSED-OPS1.0210
Requirement	The final approach controller shall be able to clearly and consistently recognise at a glance the spatial relationship between a separation indicator and the target position of the follower aircraft when both are in close proximity and overlapping.

Identifier	REQ-06.08.01-OSED-OPS1.0211
Requirement	The tower runway controller shall be able to clearly and consistently recognise at a glance the spatial relationship between a separation indicator and the target position of the follower aircraft when both are in close proximity and overlapping.

Identifier	REQ-06.08.01-OSED-OPS1.0021
Requirement	The HMI design (i.e. shape, colour, size and display priority) of the indicator shall harmoniously integrate into the final approach controller radar display and the tower runway controller air traffic monitor display respectively. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0212 REQ-06.08.01-OSED-OPS1.0213

Identifier	REQ-06.08.01-OSED-OPS1.0212
Requirement	The HMI design (e.g. shape, colour, size and display priority) of each type of separation indicator shall harmoniously integrate into the final approach controller radar display.

Identifier	REQ-06.08.01-OSED-OPS1.0213
Requirement	The HMI design (e.g. shape, colour, size and display priority) of each type of separation indicator shall harmoniously integrate into the tower runway controller air traffic monitor display.

Identifier	REQ-06.08.01-OSED-OPS1.0022
Requirement	A separation indicator shall be consistently displayed on the extended runway centre-line of the follower aircraft when the lead aircraft laterally drifts off their extended runway centre-line.

Identifier	REQ-06.08.01-OSED-OPS1.0023
Requirement	A separation indicator shall be consistently displayed on the extended runway centre line of the follower aircraft when controller vectoring intervention is used to increase the spacing between the lead aircraft and the aircraft in front by vectoring the lead aircraft away from the centre-line and back on to the centre-line

Identifier	REQ-06.08.01-OSED-OPS1.0024

Requirement	For not-in-trail pairs for parallel runway operations there may also be an in-trail aircraft in front of the follower aircraft. The indicator displayed is to be for the maximum of the not-in-trail or in-trail separation or spacing constraints. There is a need for a clear indication of whether the separation or spacing constraint for the displayed indicator is a not-in-trail constraint or an in-trail constraint because of the impact on the controller action when there is a risk of separation infringement. When the not-in-trail and in-trail constraints are close together there may be a requirement for both the not-in-trail indicator and the in-trail indicator to be displayed. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0214 REQ-06.08.01-OSED-OPS1.0215 REQ-06.08.01-OSED-OPS1.0216

Identifier	REQ-06.08.01-OSED-OPS1.0214
Requirement	The separation indicator shall clearly distinguish whether the separation or spacing constraint displayed is a not-in-trail constraint or an in-trail constraint.

Identifier	REQ-06.08.01-OSED-OPS1.0215
Requirement	When a follower aircraft has both an in-trail and a not-in-trail separation constraint, the separation indicator shall show the maximum of the constraints.

Identifier	REQ-06.08.01-OSED-OPS1.0216
Requirement	When a follower aircraft has both an in-trail and not-in-trail separation constraint, and for which the constraints are close together (e.g. 0.5Nm), both the in-trail separation indicator and the not in trail separation indicator shall be displayed.

Identifier	REQ-06.08.01-OSED-OPS1.0217
Requirement	The in-trail separation indicator displayed to the tower runway controller may need to clearly distinguish between a separation indicator for wake separation and a separation indicator for minimum radar separation or spacing minimum. This is a local adaptation issue subject to V4 and V5 maturity validation confirmation.

Identifier	REQ-06.08.01-OSED-OPS1.0218
Requirement	The in-trail separation indicator displayed to the final approach controller may need to clearly distinguish between a separation indicator for wake separation and a separation indicator for departure gap spacing. This is a local adaptation issue subject to V4 and V5 maturity validation confirmation.

Identifier	REQ-06.08.01-OSED-OPS1.0025
Requirement	During the transition between the extended runway centre-lines of a late runway switch, separation indicators shall continue to be updated on the extended runway centre-line on which they are being displayed until the aircraft switching landing runway establishes on the extended runway centre-line of the switched runway.

Identifier	REQ-06.08.01-OSED-OPS1.0026
Requirement	When an aircraft undergoing a late runway switch establishes on the centre-line of the switched runway, the impacted separation indicators shall be re-calculated and their display positions updated.

Identifier	REQ-06.08.01-OSED-OPS1.0027
Requirement	A separation indicator behind a lead aircraft shall usually be automatically removed when the lead aircraft crosses the runway landing threshold, or when the target of the aircraft is removed from being displayed if sooner.

Identifier	REQ-06.08.01-OSED-OPS1.0219
Requirement	The tower runway controller may require selective removal of the separation indicators between spacing minimum pairs as the lead aircraft crosses 4DME with just the separation indicators for wake pairs requiring to be displayed until the lead aircraft crosses the runway landing threshold. This is subject to local preferences and V4 and V5 maturity validation confirmation.

Identifier	REQ-06.08.01-OSED-OPS1.0220
Requirement	The final approach controller may require the separation indicator to be displayed until 6Nm or 4Nm, from the runway landing threshold, which for separation indicator distances of 6Nm or more, or 4Nm or more, is after the lead aircraft has crossed the runway landing threshold and been removed from display. This is subject to local preferences and V4 and V5 maturity validation confirmation.

Identifier	REQ-06.08.01-OSED-OPS1.0028
Requirement	The indicator for an aircraft that transitions from final approach on to a missed approach is to be automatically removed and the TBS re-calculated and the indicator position updated in front of the arrival aircraft following the missed approach aircraft. A missed approach is characterised by an altitude divergence of 1000ft or greater above the glideslope or by a sustained climb of 20s or more. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0221 REQ-06.08.01-OSED-OPS1.0222

Identifier	REQ-06.08.01-OSED-OPS1.0221
Requirement	The separation indicators associated with an aircraft that transitions on to a missed approach shall be automatically removed and the separation indicator calculated and displayed between the preceding and follower aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0222
Requirement	A missed approach shall be characterised by the local ATC procedures (e.g. an altitude divergence of 1000ft or greater above the glideslope, a sustained climb of 20 seconds a sustained lateral divergence from the localiser for 20 seconds or more, or a lateral divergence from the localiser of more than 1Nm).

Identifier	REQ-06.08.01-OSED-OPS1.0223
Requirement	An aircraft shall be defined as on base when the track is +/- 40 degrees to the perpendicular to the extended runway centre-line within the turn on region of final approach and at turn on altitudes for merging on to final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0224
Requirement	An aircraft shall be defined as on intercept when the track is +/- 20 degrees of a closing track of 30 degrees to the extended runway centre-line within the turn on region of final approach and at turn on altitudes for merging on

	to final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0225
Requirement	An aircraft shall be defined as having captured final approach when the track is +/- 10 degrees of the extended runway centre-line, is stable with the aircraft not turning, and is within the localiser capture region of final approach and at localiser capture altitudes for final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0226
Requirement	For departure gap spacing from when the lead aircraft crosses 4DME; the final approach controller may require the separation indicator to be updated at the ground speed resulting from the follower aircraft conforming to the reference airspeed profile to 4DME, until the indicator is updated to either 6Nm or 4Nm, from the runway landing threshold. This is subject to local preferences and V3 maturity validation confirmation in the P06.08.04 validation exercises.

Identifier	REQ-06.08.01-OSED-OPS1.0227
Requirement	For departure gap spacing when the separation indicator to be updated at the ground speed resulting from the follower aircraft conforming to the reference airspeed profile to 4DME, when this results in distance spacing compression that reduces the spacing distance between the separation indicator and lead aircraft target position to the wake turbulence separation that is required between the lead and follower aircraft, the separation indicator type shall be changed to a wake separation indicator type with the corresponding wake separation distance. This is subject to local preferences and V3 maturity validation confirmation in the P06.08.04 validation exercises.

Identifier	REQ-06.08.01-OSED-OPS1.0228
Requirement	The system shall provide the means for the Approach Supervisor and the Approach ATCOs to selectively suppress the displaying of a separation indicator between an arrival pair in the approach arrival sequence. This is subject to local preferences and V3 maturity validation confirmation in the P06.08.04 validation exercises.

Identifier	REQ-06.08.01-OSED-OPS1.0029
Requirement	The TBS distance shall be re-calculated and the separation indicator position updated when the separation or spacing constraints change behind a lead aircraft displaying a separation indicator.

Identifier	REQ-06.08.01-OSED-OPS1.0030
Requirement	The TBS distance shall be re-calculated and the separation indicator position updated when the follower aircraft changes behind a lead aircraft displaying an indicator.

Identifier	REQ-06.08.01-OSED-OPS1.0031
Requirement	The separation indicators associated with an aircraft that is removed from the arrival sequence (e.g. because of a late diversion to a different aerodrome) shall be automatically removed and separation indicators calculated and displayed between the preceding and follower aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0032
Requirement	Separation Indicators shall be displayed on the radar displays of the intermediate approach controllers.

6.1.3 Final Approach Spacing Practice

Identifier	REQ-06.08.01-OSED-OPS1.0033
Requirement	The final approach controller and the flight deck will be required to adopt procedures and practices to ensure that the variations in the distance spacing changes and the time spacing changes on final approach are consistently managed. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0300 REQ-06.08.01-OSED-OPS1.0301

Identifier	REQ-06.08.01-OSED-OPS1.0300
Requirement	The final approach controller shall adopt procedures and practices to ensure that the variations in the distance spacing changes and the time spacing changes on final approach are consistently managed.

Identifier	REQ-06.08.01-OSED-OPS1.0301
Requirement	The flight deck shall adopt procedures and practices to ensure that the variations in the distance spacing changes and the time spacing changes on final approach are consistently managed.

Identifier	REQ-06.08.01-OSED-OPS1.0034
Requirement	The final approach controller shall set up and refine the distance spacing on establishing on the localiser such that the required separation or spacing constraints are observed on final approach to the runway landing threshold to touchdown.

Identifier	REQ-06.08.01-OSED-OPS1.0035
Requirement	The separation indicator shall display the stable distance separation of the separation or spacing constraint that is required to be observed by the follower aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0036
Requirement	The final approach controller shall set up distance spacing with the additional spacing required to maintain appropriate spacing between the lead aircraft and follower aircraft to the runway landing threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0037
Requirement	The efficiency of the final approach spacing practice shall be ensured with respect to the additional spacing applied with the TBS distance represented by the separation indicator.

Identifier	REQ-06.08.01-OSED-OPS1.0038
Requirement	The flight deck may inform Approach ATC of their intended landing stabilisation speed on first call to Approach ATC.

6.1.4 Time Based Wake Turbulence Radar Separation Rules

Identifier	REQ-06.08.01-OSED-OPS1.0039
Requirement	The time based wake turbulence radar separation rules (TBS rules) shall be derived from the distance based wake turbulence separation rules (DBS rules) in the reference low headwind conditions when the achieved arrival capacity with the DBS rules are currently acceptable to busy capacity constrained arrival runway operations.

Identifier	REQ-06.08.01-OSED-OPS1.0040
Requirement	The TBS rules shall be derived from the DBS rules using a ground speed

	profile conversion, where the ground speed profile conversion is derived based on the reference airspeed profile over the distance based separation to the final approach threshold in the reference low headwind conditions.

Identifier	REQ-06.08.01-OSED-OPS1.0041
Requirement	The reference airspeed profile shall be aligned to a standard reference landing stabilisation speed profile to the final approach threshold such that sufficient time separation results for follower aircraft with landing stabilisation airspeeds above 150kts.

Identifier	REQ-06.08.01-OSED-OPS1.0042
Requirement	The reference airspeed profile shall be aligned to local approach speed profile procedures prior to landing speed stabilisation.

Identifier	REQ-06.08.01-OSED-OPS1.0400
Requirement	The reference low headwind conditions shall be a mean headwind profile on the glideslope over the spacing to the final approach threshold of a minimum of 5kts.

Identifier	REQ-06.08.01-OSED-OPS1.0043
Requirement	The chosen standard procedural airspeed profile for the conversion of the ICAO DBS rules to the TBS rules to the runway landing threshold is a standard procedural speed of a steady 170kt to 6Nm from the runway landing threshold (6DME), with an airspeed reduction of 20kts per Nm to a steady landing stabilisation speed of 150kt IAS to the runway landing threshold.

6.1.5 Calculating the TBS Distance

Identifier	REQ-06.08.01-OSED-OPS1.0044
Requirement	The TBS distance shall be derived from applying the TBS rules in the prevailing wind conditions on final approach over the spacing to the final approach threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0045
Requirement	The TBS distance shall be applied as a stable distance separation equivalent of the TBS rules independent of the actual airspeed and ground speed profiles of the lead aircraft or follower aircraft on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0046
Requirement	The TBS distance shall be converted from the TBS rules using the reference airspeed profile applied in the context of the final approach wind conditions forecast to be experienced by the follower aircraft over the distance separation to the final approach threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0047
Requirement	A glideslope wind conditions service shall be provided over the distance separation to the final approach threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0048
Requirement	The final approach glideslope wind conditions that the follower aircraft is forecast to experience shall be the wind conditions at the time the follower aircraft flies the separation to the final approach threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0049
Requirement	The glideslope wind conditions over the distance separation in stable winds may be represented by the latest measured mean wind conditions from a

	wind profiler or the last aircraft to fly final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0050
Requirement	In changing wind conditions on final approach, the final approach glideslope wind conditions applied by the system may be required to allow for some contingency provision to ensure a sufficient TBS distance is calculated.

6.1.6 Harmonisation with Other Separation and Spacing Constraints on Final Approach

Identifier	REQ-06.08.01-OSED-OPS1.0051
Requirement	The TBS rules and the TBS distance shall be applied in the context of all of the other separation and spacing constraints on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0052
Requirement	The other surveillance and runway operations constraints impacting final approach including: o Wake turbulence separation constraints options o DBS and TBS (WDS and PWS in the future) o Radar surveillance constraints o In-trail final approach radar separation minimum o Not-in-trail final approach radar separation minimum for dependent parallel runway operations o Runway operations constraints o VIS2 and LVP constraints o Runway occupancy minimum spacing constraints impacted by runway surface braking and conditions and exit taxiway serviceability ▪ Spacing minimum behind all pairs ▪ Spacing minimum behind Heavy aircraft types ▪ Spacing minimum behind Super Heavy aircraft types o Overload/Staffing/Equipment minimum spacing constraints o Night time operations minimum spacing constraints o Airborne procedures constraints o RNAV procedures separation constraints for in-trail separation on final approach o RNAV procedures separation constraints for not-in-trail separation for dependent parallel runway operations o Mixed mode runway operations departure gap constraints o Standard departure gap size for a single and multiple (2, 3,more) departure aircraft o Additional departure gap spacing behind Heavy and Super Heavy arrival aircraft types (to accommodate the longer arrival aircraft runway occupancy times) o Closely spaced parallel runway operations constraints. o Converging and crossing runway constraints o Specific tailored separation requirements between an arrival pair, for example, for o Runway inspection spacing o Runway crossing spacing o Airborne emergency spacing This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0600 to REQ-06.08.01-OSED-OPS1.0631

Identifier	REQ-06.08.01-OSED-OPS1.0600
Requirement	The system shall provide support for the wake turbulence radar separation minimum DBS rules applied on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0601
Requirement	The system shall provide adaptation support for national / local aerodrome variants of the wake turbulence radar separation minimum DBS rules applied on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0602
Requirement	The system shall provide support for the wake turbulence radar separation minimum TBS rules applied on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0603
Requirement	The system shall provide adaptation support for national / local aerodrome variants of the wake turbulence radar separation minimum TBS rules applied on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0604
Requirement	The system shall provide adaptation support for the evolution of the wake turbulence radar separation minimum DBS rules to the RECAT Phase 1 (RECAT EU) DBS rules.

Identifier	REQ-06.08.01-OSED-OPS1.0605
Requirement	The system shall provide adaptation support for the evolution of the wake turbulence radar separation minimum TBS rules to the TBS rules derived from the RECAT Phase 1 (RECAT EU) DBS rules.

Identifier	REQ-06.08.01-OSED-OPS1.0606
Requirement	The system shall provide adaptation support for the evolution of the wake turbulence radar separation minimum DBS rules to the RECAT Phase 2 / Pair Wise Separation (PWS) DBS rules.

Identifier	REQ-06.08.01-OSED-OPS1.0607
Requirement	The system shall provide adaptation support for the evolution of the wake turbulence radar separation minimum TBS rules to the TBS rules derived from the RECAT Phase 2 / Pair Wise Separation (PWS) DBS rules.

Identifier	REQ-06.08.01-OSED-OPS1.0608
Requirement	The system shall be adaptable to support Weather Dependent Separation (WDS) where the wake turbulence radar separation minimum DBS rules may be dynamically reduced due to the meteorological conditions impact on the transport or decay of the wake turbulence generated by the lead aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0609

Requirement	The system shall be adaptable to support Weather Dependent Separation (WDS) where the wake turbulence radar separation TBS rules may be dynamically reduced due to the meteorological conditions impact on the transport or decay of the wake turbulence generated by the lead aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0610
Requirement	The system shall provide support for the in-trail distance based minimum radar separation applied between in-trail aircraft on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0611
Requirement	The system shall provide adaptation support for national / local aerodrome variants of the in-trail distance based minimum radar separation applied between in-trail aircraft on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0612
Requirement	The system shall provide support for a runway operations related distance based spacing minimum applied behind all lead aircraft of in-trail pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0613
Requirement	The system shall provide support for a runway operations related distance based spacing minimum applied behind all Heavy wake category lead aircraft of in-trail arrival pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0614
Requirement	The system shall provide support for a runway operations related distance based spacing minimum applied behind all Super Heavy wake category lead aircraft of in-trail arrival pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0615
Requirement	The system shall provide support for a runway operations related time based spacing minimum applied behind all lead aircraft of in-trail pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0616
Requirement	The system shall provide support for a runway operations related time based spacing minimum applied behind all Heavy wake category lead aircraft of in-trail arrival pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0617
Requirement	The system shall provide support for a runway operations related time based spacing minimum applied behind all Super Heavy wake category lead aircraft of in-trail arrival pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0618
Requirement	The system shall provide support for a scenario specific distance based spacing constraint to be specified behind identified lead aircraft of in-trail

	arrival pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0619
Requirement	The system shall provide support for a scenario specific time based spacing constraint to be specified behind identified lead aircraft of in-trail arrival pairs on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0620
Requirement	The system shall provide support for specifying the standard distance based departure gap spacing required for interleaving a single departure aircraft, between in-trail arrival pairs under interlaced / mixed mode operations.

Identifier	REQ-06.08.01-OSED-OPS1.0621
Requirement	The system shall provide support for specifying the standard distance based departure gap spacing required for interleaving two departure aircraft, between in-trail arrival pairs under interlaced / mixed mode operations.

Identifier	REQ-06.08.01-OSED-OPS1.0622
Requirement	The system shall provide support for specifying the additional distance based departure gap spacing required behind Heavy wake category lead arrival aircraft to accommodate the runway occupancy times of Heavy wake category lead aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0623
Requirement	The system shall provide support for specifying the additional distance based departure gap spacing required behind Super Heavy wake category lead arrival aircraft to accommodate the runway occupancy times of Super Heavy wake category lead aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0624
Requirement	The system shall provide support for specifying the standard time based departure gap spacing required for interleaving a single departure aircraft, between in-trail arrival pairs under interlaced / mixed mode operations.

Identifier	REQ-06.08.01-OSED-OPS1.0625
Requirement	The system shall provide support for specifying the standard time based departure gap spacing required for interleaving two departure aircraft, between in-trail arrival pairs under interlaced / mixed mode operations.

Identifier	REQ-06.08.01-OSED-OPS1.0626
Requirement	The system shall provide support for specifying the additional time based departure gap spacing required behind Heavy wake category lead arrival aircraft to accommodate the runway occupancy times of Heavy wake category lead aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0627
Requirement	The system shall provide support for specifying the additional time based departure gap spacing required behind Super Heavy wake category lead

	arrival aircraft to accommodate the runway occupancy times of Super Heavy wake category lead aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0628
Requirement	The system shall provide support for the not-in-trail distance based minimum radar separation applied between not-in-trail aircraft established on separate localisers of dependent or closely spaced parallel runways.

Identifier	REQ-06.08.01-OSED-OPS1.0629
Requirement	The system shall provide adaptation support for national / local aerodrome variants of the not-in-trail distance based minimum radar separation applied between not-in-trail aircraft established on separate localisers of dependent or closely spaced parallel runways.

Identifier	REQ-06.08.01-OSED-OPS1.0630
Requirement	The system shall provide support for a distance based spacing minimum applied between not-in-trail aircraft established on dependent or closely spaced parallel final approach localisers.

Identifier	REQ-06.08.01-OSED-OPS1.0631
Requirement	The system shall provide support for specific not-in-trail airborne procedure separation constraints for identified aircraft; for example the 2.5NM not-in-trail separation constraint ahead of and behind aircraft performing an RNAV intermediate approach on to final approach,

Identifier	REQ-06.08.01-OSED-OPS1.0053
Requirement	The Tower Supervisor in coordination with the Approach Supervisor shall determine the final approach separation and runway spacing constraints that are to be applied at any time.

Identifier	REQ-06.08.01-OSED-OPS1.0632
Requirement	The Tower Runway Controller in coordination with the Final Approach Controller may change the final approach separation and runway spacing constraints that are to be applied at any time.

Identifier	REQ-06.08.01-OSED-OPS1.0054
Requirement	The minimum separation or spacing to be set up on final approach shall be at least that of the maximum separation or spacing constraint that is required to be applied.

Identifier	REQ-06.08.01-OSED-OPS1.0055
Requirement	The separation indicator position shall reflect the maximum separation or spacing constraint to be applied between the arrival pair.

Identifier	REQ-06.08.01-OSED-OPS1.0056
Requirement	The separation and spacing constraints need to be specified for each runway-in-use, and need to include both the current constraints and planned changes to the constraints. The planned changes to the constraints should be specified with reference to an identified lead arrival aircraft. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0633 REQ-06.08.01-OSED-OPS1.0634

	REQ-06.08.01-OSED-OPS1.0635

Identifier	REQ-06.08.01-OSED-OPS1.0633
Requirement	The separation and spacing constraints shall be specified for each runway-in-use.

Identifier	REQ-06.08.01-OSED-OPS1.0634
Requirement	The separation and spacing constraints shall include both the current constraints and planned changes to the constraints.

Identifier	REQ-06.08.01-OSED-OPS1.0635
Requirement	The planned changes to the constraints shall be specified with reference to an identified lead arrival aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0057
Requirement	An immediate change in the separation or spacing constraints shall apply from behind the next arrival aircraft to cross the runway landing threshold.

Identifier	REQ-06.08.01-OSED-OPS1.0058
Requirement	The Tower Supervisor in coordination with the Approach Supervisor shall specify and maintain the separation and spacing constraints.

Identifier	REQ-06.08.01-OSED-OPS1.0636
Requirement	The Tower Runway Controller in coordination with the Final Approach Controller may need to maintain / change the separation and spacing constraints.

Identifier	REQ-06.08.01-OSED-OPS1.0059
Requirement	The surveillance and runway operations separation and spacing constraints shall be specified and maintained through, for example, a separation/spacing mode tool.

Identifier	REQ-06.08.01-OSED-OPS1.0060
Requirement	The Tower ATC Supervisor in coordination with the Approach ATC Supervisor shall specify and maintain the other separation and spacing constraints. Duplicate of REQ-06.08.01-OSED-OPS1.0058

Identifier	REQ-06.08.01-OSED-OPS1.0061
Requirement	All of the final approach separation and spacing constraints need to be taken into account when establishing the minimum required separation or spacing between each arrival pair. The other surveillance and runway operations separation and spacing constraints need to be taken into account alongside the dynamically calculated TBS distance. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.0637 REQ-06.08.01-OSED-OPS1.0638

Identifier	REQ-06.08.01-OSED-OPS1.0637
Requirement	All final approach separation and spacing constraints shall be taken into account when establishing the minimum required separation or spacing between each arrival pair.

Identifier	REQ-06.08.01-OSED-OPS1.0638
Requirement	All other surveillance and runway operations separation and spacing constraints shall be taken into account alongside the dynamically calculated

	TBS distance for the applicable wake turbulence radar separation minimum.

Identifier	REQ-06.08.01-OSED-OPS1.0062
Requirement	The AMAN sequence order with landing runway intent with the incorporation of late sequence order and landing runway intent changes shall provide a reliable final approach arrival order and landing runway intent for each aircraft.

Identifier	REQ-06.08.01-OSED-OPS1.0063
Requirement	For interlaced / mixed mode operations, the combined AMAN and DMAN sequence order with the incorporation of late changes of arrival sequence order or interlaced departure intent shall provide reliable interlaced sequence information for arrivals and departures.

6.1.7 Airspace User Considerations

Identifier	REQ-06.08.01-OSED-OPS1.0700
Requirement	The TBS Concept shall be developed so as to have a manageable impact on airspace users.

Identifier	REQ-06.08.01-OSED-OPS1.0701
Requirement	The TBS Concept shall be developed so as to have a minimum impact on airframe equipage requirements.

Identifier	REQ-06.08.01-OSED-OPS1.0702
Requirement	TBS Concept multi-media awareness briefings shall be developed and provide to the airspace users.

Identifier	REQ-06.08.01-OSED-OPS1.0703
Requirement	The flight crew shall be provided with notification of when TBS is being employed on final approach through the aerodrome information service.

Identifier	REQ-06.08.01-OSED-OPS1.0704
Requirement	The aerodrome information service shall provide sufficient information on the prevailing glideslope wind conditions or the TBS distances such the flight crew are able to retain awareness of the separation distances that apply on final approach for the prevailing wind conditions.

Identifier	REQ-06.08.01-OSED-OPS1.0705
Requirement	The flight crew shall inform Approach ATC of their aircraft type / wake category on first call.

Identifier	REQ-06.08.01-OSED-OPS1.0706

Requirement	The flight crew shall inform Approach ATC of intended non-conformance to the airspeed procedures on intermediate or final approach on first call.

Identifier	REQ-06.08.01-OSED-OPS1.0707
Requirement	The flight crew shall inform Approach ATC of the intended employment of an exceptional landing stabilisation speed for the aircraft type on first call.

Identifier	REQ-06.08.01-OSED-OPS1.0708
Requirement	The cautionary wake vortex advisory phraseology shall be modified so as to be able to be employed with the TBS Concept.

6.1.8 Safety Mitigation Elements for the TBS Concept

Identifier	REQ-06.08.01-OSED-OPS1.0800
Requirement	The system shall provide an Approach Arrivals Sequence Display to the Approach Supervisor, Intermediate Approach Controller, Intermediate Support Controller and Final Approach Controller

Identifier	REQ-06.08.01-OSED-OPS1.0801
Requirement	The system shall provide an Approach Arrivals Sequence Display to the Tower Supervisor and Tower Runway Controller.

Identifier	REQ-06.08.01-OSED-OPS1.0802
Requirement	The Approach Arrivals Sequence Display shall display the arrival sequence order with aircraft runway intent and aircraft wake category / aircraft type out to the working horizon of the Intermediate Approach Controller / Intermediate Support Controller coordinating and accepting aircraft into the initial approach fixes.

Identifier	REQ-06.08.01-OSED-OPS1.0803
Requirement	The Approach Arrivals Sequence Display shall display planned and immediate changes of runways-in-use, runway modes, and final approach separation and runway spacing constraints.

Identifier	REQ-06.08.01-OSED-OPS1.0804
Requirement	The Approach Arrivals Sequence Display shall display the separation distance between each arrival pair.

Identifier	REQ-06.08.01-OSED-OPS1.0805
Requirement	The Approach Arrivals Sequence Display shall support the alerting of when a separation distance could not be calculated for an arrival pair.

Identifier	REQ-06.08.01-OSED-OPS1.0806
Requirement	The system shall provide a Glideslope Wind Conditions and TBS Distance Display to the Approach Supervisor, Intermediate Approach Controller, Intermediate Support Controller and Final Approach Controller

Identifier	REQ-06.08.01-OSED-OPS1.0807
Requirement	The system shall provide a Glideslope Wind Conditions and TBS Distance Display to the Tower Supervisor and Tower Runway Controller.

Identifier	REQ-06.08.01-OSED-OPS1.0808
Requirement	The system shall provide an Arrival Sequence Order Monitor to check that

	the arrival sequence order delivered on intermediate approach matches the arrival sequence order in the Approach Arrival Sequence Display.

Identifier	REQ-06.08.01-OSED-OPS1.0809
Requirement	The Arrival Sequence Order Monitor shall check for all aircraft on intermediate approach being merged on to final approach and not just aircraft in the Approach Arrival Sequence.

Identifier	REQ-06.08.01-OSED-OPS1.0810
Requirement	The Arrival Sequence Order Display shall support an Arrival Sequence Order Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0811
Requirement	The Approach Radar Display shall support an Arrival Sequence Order Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0812
Requirement	The system shall provide a visual indication of the separation indicator / aircraft pairing.

Identifier	REQ-06.08.01-OSED-OPS1.0813
Requirement	The system shall support a separation indicator label with the callsign of the follower aircraft in order to provide a visual indication of the separation indicator / aircraft pairing.

Identifier	REQ-06.08.01-OSED-OPS1.0814
Requirement	The system shall provide a TBS System Monitor to actively check the TBS System and associated services and key interoperability interfaces are serviceable.

Identifier	REQ-06.08.01-OSED-OPS1.0815
Requirement	The TBS System Monitor shall provide an alert of a TBS System failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.

Identifier	REQ-06.08.01-OSED-OPS1.0816
Requirement	The system shall provide an Arrival Sequence Service Monitor to actively check the Arrival Sequence Service and associated key interoperability interfaces are serviceable.

Identifier	REQ-06.08.01-OSED-OPS1.0817
Requirement	The Arrival Sequence Service Monitor shall provide an alert of an Arrival Sequence Service failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.

Identifier	REQ-06.08.01-OSED-OPS1.0818
Requirement	The system shall provide a Glideslope Wind Conditions Service Monitor to actively check the Glideslope Wind Conditions Service and associated key interoperability interfaces are serviceable.

Identifier	REQ-06.08.01-OSED-OPS1.0819
Requirement	The Glideslope Wind Conditions Service Monitor shall provide an alert of a Glideslope Wind Conditions Service failure to the TMA System Operating Authority, the Approach Supervisor and the Tower Supervisor.

Identifier	REQ-06.08.01-OSED-OPS1.0820
Requirement	The system shall provide separation indicator type support to provide the controllers with the means to distinguish between the different types of in-

	trail separation / spacing.

Identifier	REQ-06.08.01-OSED-OPS1.0821
Requirement	The system shall support the following separation indicator types for in-trail separation / spacing: 1. Minimum radar separation 2. Wake separation 3. Spacing minimum 4. Scenario specific spacing 5. Departure gap spacing

Identifier	REQ-06.08.01-OSED-OPS1.0822
Requirement	The system shall provide separation indicator type support to provide the controllers with the means to distinguish between the different types of not-in-trail separation / spacing.

Identifier	REQ-06.08.01-OSED-OPS1.0823
Requirement	The system shall support the following separation indicator types for not-in-trail separation / spacing: 1. Minimum radar separation 2. Spacing minimum 3. Specific airborne procedure separation

Identifier	REQ-06.08.01-OSED-OPS1.0064
Requirement	The system shall provide an Abnormal Indicated Airspeed Monitor to monitor and alert for abnormal final approach airspeed behaviour.

Identifier	REQ-06.08.01-OSED-OPS1.0824
Requirement	The Approach Radar Display shall support an Abnormal Indicated Airspeed Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0065
Requirement	The system shall provide a Distance Compression Monitor to monitor and alert for separation infringement scenarios through monitoring for ground speed differences between the lead and follower aircraft resulting in distance spacing compression either leading to an imminent separation infringement or causing a separation infringement.

Identifier	REQ-06.08.01-OSED-OPS1.0825
Requirement	The Approach Radar Display shall support a Distance Compression Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0826
Requirement	The Tower Air Traffic Monitor Display shall support a Distance Compression Monitor alert to the Tower Runway Controller.

Identifier	REQ-06.08.01-OSED-OPS1.0066
Requirement	The system shall provide a Wrong Aircraft Turned on to Separation Indicator Monitor to check that the correct aircraft is turned on to each separation indicator and to alert when the wrong aircraft is turned on to a separation indicator.

Identifier	REQ-06.08.01-OSED-OPS1.0827
Requirement	The Wrong Aircraft Turned on to Separation Indicator Monitor shall check for all aircraft on intermediate approach being merged on to final approach and not just aircraft in the Approach Arrival Sequence.

Identifier	REQ-06.08.01-OSED-OPS1.0828

Requirement	The Arrival Sequence Order Display shall support the Wrong Aircraft Turned on to Separation Indicator Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0829
Requirement	The Approach Radar Display shall support the Wrong Aircraft Turned on to Separation Indicator Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0067
Requirement	The system shall provide an Aircraft Turned on to Wrong Localiser Monitor to check and alert for an aircraft not being turned on to the intended final approach localiser, i.e. different than the Approach Arrival Sequence intended landing runway.

Identifier	REQ-06.08.01-OSED-OPS1.0830
Requirement	The Approach Radar Display shall support the Aircraft Turned on to Wrong Localiser Monitor alert to the Approach Controllers.

Identifier	REQ-06.08.01-OSED-OPS1.0831
Requirement	The system shall provide optimised runway delivery support for the additional spacing that needs to be set up behind the lead aircraft prior to the lead aircraft commencing landing speed stabilisation in order to compensate for the distance spacing compression that is anticipated during landing speed stabilisation

Identifier	REQ-06.08.01-OSED-OPS1.0832
Requirement	The system shall provide separation indictor support for displaying the optimised runway delivery addition spacing to be set up behind the lead aircraft prior to lead aircraft commencing landing speed stabilisation.

6.1.9 Transition into Service Elements of the TBS Concept

Identifier	REQ-06.08.01-OSED-OPS1.0900
Requirement	The system shall provide support for the wake turbulence radar separation minimum DBS rules applied on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.0901
Requirement	The system shall provide support for a transition stepped introduction of the TBS rules through supporting the specification of a minimum TBS distance for each wake vortex pair in the TBS rules.

6.1.10 Reduction of the 2.5Nm Minimum Radar Separation on Final Approach

Identifier	REQ-06.08.01-OSED-OPS1.1000
Requirement	The system shall provide support for the in-trail minimum radar separation on final approach to be reduced to below the current 2.5Nm minimum radar separation.

6.1.11 Failure Scenarios and Degraded Mode Operations

Identifier	REQ-06.08.01-OSED-OPS1.1100
Requirement	On a glideslope wind conditions service failure the system shall support

	automatic reversion from separation indicators for TBS to separation indicators for DBS while maintaining the continuity of the TBS separation indicators of aircraft pairs established on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.1101
Requirement	On a glideslope wind conditions service recovery the system shall support automatic reversion from separation indicators for DBS to separation indicators for TBS while maintaining the continuity of the DBS separation indicators of aircraft pairs established on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.1102
Requirement	On an arrival sequence order service failure the system shall support reversion to DBS without separation indictors while maintaining the continuity of the separation indicators of aircraft pairs established on final approach.

Identifier	REQ-06.08.01-OSED-OPS1.1103
Requirement	On an arrival sequence order service recovery the system shall support a controlled reversion back to the use of separation indicators under Approach Supervisor procedures.

Identifier	REQ-06.08.01-OSED-OPS1.1104
Requirement	On a TBS tool failure the system shall support reversion to DBS without separation indictors with the separation indicators turned off.

Identifier	REQ-06.08.01-OSED-OPS1.1105
Requirement	On a TBS tool service recovery the system shall support a controlled reversion back to the use of separation indicators under Approach Supervisor procedures.

6.1.12 Other Related Issues

Identifier	REQ-06.08.01-OSED-OPS1.0068
Requirement	There are expected to be requirements to collect sensor data, radar data, weather data, and wake related reports from flight crew and controllers, in order to ensure the continued safe operation of TBS. This may include the requirement for more systematic and system supported monitoring of wake turbulence encounter risks. This requirement has been superseded by the following: REQ-06.08.01-OSED-OPS1.1200 REQ-06.08.01-OSED-OPS1.1201 REQ-06.08.01-OSED-OPS1.1202 REQ-06.08.01-OSED-OPS1.1203

Identifier	REQ-06.08.01-OSED-OPS1.1200
Requirement	Sensor data on the strength of the wake turbulence of aircraft on final approach shall be collected and analysed for TBS operations.

Identifier	REQ-06.08.01-OSED-OPS1.1201
Requirement	Radar data on the separation / spacing delivery performance on final

	approach in the context of the separation indicator distance shall be collected and analysed.

Identifier	REQ-06.08.01-OSED-OPS1.1202
Requirement	Meteorological data and the associated calculated TBS distances shall be collected and analysed.

Identifier	REQ-06.08.01-OSED-OPS1.1203
Requirement	Wake related reports from flight crews and controllers shall be collected and analysed.

6.2 Functional / System Requirements for P06.08.01 Time Based Separation for Final Approach

6.2.1 Calculating the TBS Distance

Identifier	REQ-06.08.01-OSED-FUNC.0001
Requirement	The system shall start calculating the TBS distance and the separation / spacing distance for each separation indicator when aircraft are on intermediate approach.

Identifier	REQ-06.08.01-OSED-FUNC.0100
Requirement	The system shall start calculating the TBS distance and separation distance between each arrival pair for displaying the Approach Arrival Sequence Display out to the working horizon of the Intermediate Approach Controller / Intermediate Support Controller accepting aircraft from the TMA Sector Controllers.

Identifier	REQ-06.08.01-OSED-FUNC.0101
Requirement	The system shall calculate and maintain the TBS distance for each wake vortex pair for displaying in the Glideslope Wind Conditions and TBS Distance Display.

Identifier	REQ-06.08.01-OSED-FUNC.0002
Requirement	The system shall look up the required time based wake turbulence radar separation for the arrival pair using the predefined TBS rules table, taking into account the respective wake turbulence categories of the lead and follower aircraft.

Identifier	REQ-06.08.01-OSED-FUNC.0003
Requirement	The system shall establish the ground speed profile resulting from applying the reference airspeed profile over the separation to the final approach threshold in the wind conditions on the glideslope at the time the follower aircraft is forecast to fly the separation to the final approach threshold.

Identifier	REQ-06.08.01-OSED-FUNC.0004
Requirement	The system shall calculate the TBS distance by applying the ground speed profile over the required time based wake turbulence radar separation.

Identifier	REQ-06.08.01-OSED-FUNC.0005
Requirement	The system shall apply the following process for establishing the ground speed profile in [REQ-06.08.01-OSED-FUNC.0003]: ○ Establishing the reference IAS profile from the final approach threshold out to 9NM or 10NM from the final approach threshold on

	the glideslope. ○ Establishing the TAS profile corresponding to the reference IAS profile, taking into account the runway elevation above mean sea level, the glideslope angle, and the glideslope elevation above the runway landing threshold. ○ Establishing the mean TAS for each 0.5NM or 1NM segment of the final approach glideslope ○ Establishing the mean headwind component of the wind conditions profile for each 0.5NM or 1NM segment of the final approach glideslope. ○ Establishing the mean ground speed for each 0.5NM or 1NM segment of the final approach glideslope by subtracting the mean headwind component from the mean TAS for each 0.5NM or 1NM segment. ○ *Second order crosswind effects on the ground speed are small and do not need to be taken into account. In headwind conditions these the crosswind effect will marginally reduce the mean ground speed (~5kt reduction in a 40kt headwind) which will marginally reduce the TBS. Not including the crosswind effect results in the distance separation of the TBS being marginally increased.* This requirement has been superseded by the following: REQ-06.08.01-OSED-FUNC.0102 REQ-06.08.01-OSED-FUNC.0103

Identifier	REQ-06.08.01-OSED-FUNC.0102
Requirement	The system shall establish the ground speed profile over the separation to the final approach threshold in 0.5Nm or 1Nm segments by subtracting the wind effect from the TAS profile for each segment over the separation.

Identifier	REQ-06.08.01-OSED-FUNC.0103
Requirement	The system shall establish the TAS profile over the separation to the final approach threshold in 0.5Nm or 1Nm segments by converting from the IAS profile for each segment over the same separation taking into account the runway elevation above mean sea level, the glideslope angle, and the glideslope elevation above the runway landing threshold.

Identifier	REQ-06.08.01-OSED-FUNC.0006
Requirement	The system shall calculate the TBS distance by converting the TBS rule using the ground speed profile for each 0.5Nm or 1Nm segment over the separation to the final approach threshold.

Identifier	REQ-06.08.01-OSED-FUNC.0007
Requirement	The system may determine the mean wind effect over the separation to the final approach threshold using enhanced Mode S down linked airborne parameters, real-time measurements from glideslope wind conditions aloft profilers, and a forecast wind conditions aloft profile.

Identifier	REQ-06.08.01-OSED-FUNC.0008

Requirement	The system shall establish the mean wind effect for each 0.5Nm or 1Nm segment over the separation distance to the landing runway threshold (or the local separation delivery threshold).

Identifier	REQ-06.08.01-OSED-FUNC.0009
Requirement	The following forecasting requirements shall be considered if a forecast wind conditions aloft profile is to be used: ○ There will be a need to develop a forecast wind conditions aloft profile for the local aerodrome with suitable performance. ○ There will be a need for area resolution to distinguish between the wind conditions on each final approach glideslope in order to be adequately responsive to changing wind conditions. ○ There will be a need for vertical resolution so as to distinguish the wind conditions effects on the ground speed down to potentially each ½ NM of distance spacing on the glideslope. ○ There will be a need for temporal resolution so as to distinguish between the timing of successive aircraft on the final approach glideslope with down to 60s time separation and where the flying time over each ½ NM of distance spacing is around 10s to 15s. ○ The forecast is to be applied over a time horizon of 7 to 10 minutes in the future, the time it takes for aircraft being turned from intermediate approach to merge on to final approach to descend on the final approach glideslope to the final approach threshold. This requirement has been superseded by the following: REQ-06.08.01-OSED-FUNC.0104 REQ-06.08.01-OSED-FUNC.0105 REQ-06.08.01-OSED-FUNC.0106 REQ-06.08.01-OSED-FUNC.0107 REQ-06.08.01-OSED-FUNC.0108

Identifier	REQ-06.08.01-OSED-FUNC.0104
Requirement	The system shall develop a forecast wind conditions aloft profile for the local aerodrome with suitable performance.

Identifier	REQ-06.08.01-OSED-FUNC.0105
Requirement	The system shall provide area resolution by distinguishing between the wind conditions on each final approach glideslope in order to be adequately responsive to changing wind conditions.

Identifier	REQ-06.08.01-OSED-FUNC.0106
Requirement	The system shall provide vertical resolution by distinguishing between the wind conditions effects on ground speed down to potentially each ½ Nm of distance spacing on the glideslope.

Identifier	REQ-06.08.01-OSED-FUNC.0107
Requirement	The system shall provide temporal resolution by distinguishing between the timing of successive aircraft on the final approach glideslope with down to 60 seconds time separation and where the flying time over each ½ Nm of

	distance is around 10 to 15 seconds.

Identifier	REQ-06.08.01-OSED-FUNC.0108
Requirement	The system shall forecast wind conditions aloft over a time horizon of 7 to 10 minutes into the future.

Identifier	REQ-06.08.01-OSED-FUNC.0010
Requirement	The TBS distance for an arrival pair shall only be re-calculated up to the lead aircraft turning on to intercept the final approach localiser.

Identifier	REQ-06.08.01-OSED-FUNC.0011
Requirement	The system shall re-calculate the TBS between an arrival pair impact by a missed approach, by a late switch of landing runway, by a late change in arrival sequence order or by a late change of landing runway intent. A late change is after the lead aircraft has turned on to intercept to merge on to final approach. This requirement has been superseded by the following: REQ-06.08.01-OSED-FUNC.0109 REQ-06.08.01-OSED-FUNC.0110 REQ-06.08.01-OSED-FUNC.0111 REQ-06.08.01-OSED-FUNC.0112

Identifier	REQ-06.08.01-OSED-FUNC.0109
Requirement	The system shall re-calculate the TBS distance between an arrival pair impacted by a missed approach.

Identifier	REQ-06.08.01-OSED-FUNC.0110
Requirement	The system shall re-calculate the TBS distance between an arrival pair impacted by a switch of landing runway after the lead aircraft has turned on to intercept to merge on to final approach.

Identifier	REQ-06.08.01-OSED-FUNC.0111
Requirement	The system shall re-calculate the TBS distance between an arrival pair impacted by a change in arrival sequence after the lead aircraft has turned on to intercept to merge on to final approach.

Identifier	REQ-06.08.01-OSED-FUNC.0112
Requirement	The system shall re-calculate the TBS distance between an arrival pair impacted by a change of landing runway intent after the lead aircraft has turned on to intercept to merge on to final approach.

6.2.2 Management of Other Separation and Spacing Constraints on Final Approach

Identifier	REQ-06.08.01-OSED-FUNC.0012
Requirement	The system shall provide support for the wake turbulence and other surveillance and runway operations separation and spacing constraints on

	final approach to be specified and maintained through, for example, a separation/spacing mode tool by the Tower ATC Supervisor in coordination with the Approach ATC Supervisor. This requirement has been specified in the corresponding Operational Requirements in Section6.1.6.

Identifier	REQ-06.08.01-OSED-FUNC.0013
Requirement	The system shall provide support for the current and planned changes to separation and spacing constraints to be specified for each runway-in-use. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.6.

Identifier	REQ-06.08.01-OSED-FUNC.0014
Requirement	The system shall provide support for the planned changes to the final approach separation / runway spacing constraints to be specified with reference to an identified lead arrival aircraft. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.6.

Identifier	REQ-06.08.01-OSED-FUNC.0015
Requirement	The system shall provide support to an immediate change of a separation or spacing constraint to be applied to all arrival pairs. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.6.

Identifier	REQ-06.08.01-OSED-FUNC.0016
Requirement	The system shall provide support for the following separation and spacing constraints to be specified for each runway-in-use: ○ **Wake turbulence separation minimum** – TBS or DBS (including RECAT, WDS and PWS in the future). ○ **Minimum radar separation** – 2.5NM or 3NM final approach in-trail minimum radar separation ○ **Spacing minimum** – 2.5NM, 3NM, 3.5NM, 4NM, 5NM, 6NM or greater (up to 12NM) final approach runway operations related spacing applied across all in-trail arrival pairs. ○ **Dependent or closely spaced parallel approach minimum radar separation** – 2NM, 2.5NM or 3NM diagonal not-in-trail minimum radar separation for arrival pairs established on separate extended runway centre-lines. ○ **Specific Heavy spacing minimum** – 5NM or 6NM runway operations related spacing constraint behind Heavy aircraft. ○ **Specific Super Heavy spacing minimum** – 4NM, 5NM, 6NM, or greater (up to 20NM) runway operations related spacing

	constraint behind Super Heavy aircraft. ○ **Specific spacing constraint behind identified lead aircraft** – For example runway inspection spacing, runway crossing spacing and additional spacing (e.g. 15NM) behind an emergency aircraft ○ **Specific airborne procedure spacing constraints for identified aircraft** – For example the 2.5NM not-in-trail separation constraint ahead of and behind aircraft performing an RNAV intermediate approach on to final approach. ○ **Mixed mode interlaced spacing minimum** – Standard gap spacing for interleaving a single departure, and for interleaving multiple departures (2, 3 or more), between arrival pairs. ○ **Mixed mode specific Heavy additional spacing** - Additional departure gap spacing behind Heavy arrival aircraft types to accommodate the longer arrival aircraft runway occupancy times ○ **Mixed mode specific Super Heavy additional spacing** - Additional departure gap spacing behind Super Heavy arrival aircraft types to accommodate the longer arrival aircraft runway occupancy times This requirement has been specified in the corresponding Operational Requirements in Section 6.1.6.

6.2.3 Establishing the Required Separation or Spacing Between Each Arrival Pair

Identifier	REQ-06.08.01-OSED-FUNC.0017
Requirement	The system shall establish the in-trail required separation or spacing for consecutive arrival aircraft on the same final approach localiser taking into account the wake turbulence category of each aircraft and all separation and spacing constraints.

Identifier	REQ-06.08.01-OSED-FUNC.0018
Requirement	The system shall establish the not-in-trail required separation or spacing for arrival pairs on dependent or closely spaced parallel final approaches taking into account the not-in-trail approach minimum radar separation and specific airborne procedure constraints for identified aircraft.

Identifier	REQ-06.08.01-OSED-FUNC.0019
Requirement	The system shall utilise dependable arrival and departure sequence order information with dependable landing runway intent, wake category and aircraft type information when establishing the required separation or spacing between each arrival pair.

6.2.4 General Separation Indicator Display Requirements

Identifier	REQ-06.08.01-OSED-FUNC.0020
Requirement	The separation indicator shall be first displayed to the final approach controller while the follower aircraft is on intermediate approach, before the turn on decisions that sets up the initial distance spacing on merging on to final approach.

Identifier	REQ-06.08.01-OSED-FUNC.0021
Requirement	A separation indicator shall be displayed behind each lead aircraft on final approach

Identifier	REQ-06.08.01-OSED-FUNC.0022
Requirement	A separation indicator shall be displayed for lead aircraft on intercept to final approach within a specified distance of the extended runway centre-line that they are merging on to.

Identifier	REQ-06.08.01-OSED-FUNC.0023
Requirement	The specified distance from the extended runway centre line for lead aircraft on intercept shall be an adaptable parameter with a default value of 6Nm.

Identifier	REQ-06.08.01-OSED-FUNC.0024
Requirement	Just sufficient separation indicators shall be displayed for that required to support the turn on decisions of the final approach controller.

Identifier	REQ-06.08.01-OSED-FUNC.0025
Requirement	The maximum displayable position of the separation indicator on the final approach centre-line from the runway threshold shall be an adaptable parameter with a default value of 25Nm.

Identifier	REQ-06.08.01-OSED-FUNC.0026
Requirement	The maximum number of additional aircraft behind the last aircraft on final approach or on intercept within the specified distance of the extended runway centre-line that they are merging on to shall be an adaptable parameter with a default value of 3.

Identifier	REQ-06.08.01-OSED-FUNC.0027
Requirement	The separation indicator shall be first displayed to the tower runway controller when both the lead and follower aircraft are establish on their respective extended runway centre-lines.

Identifier	REQ-06.08.01-OSED-FUNC.0028
Requirement	The separation indicator position shall reflect the separation or spacing constraint to be applied between the arrival pair.

Identifier	REQ-06.08.01-OSED-FUNC.0029
Requirement	A separation indicator shall consist of an indicator symbol placed at the required separation or spacing behind the lead aircraft target position.

Identifier	REQ-06.08.01-OSED-FUNC.0030
Requirement	A separation indicator shall always be displayed on the final approach centre-line of the designated landing runway of the follower aircraft for not-in-trail arrival pairs on parallel approaches.

Identifier	REQ-06.08.01-OSED-FUNC.0031
Requirement	A separation indicator position shall be updated as the lead and follower aircraft target positions are updated, with no discernible delay as perceived by the final approach controller.

Identifier	REQ-06.08.01-OSED-FUNC.0032
Requirement	The final approach controller and the tower runway controller need to be able to clearly and consistently recognise at a glance the spatial relationship between each indicator displayed and the target position of the follower aircraft when both are in close proximity and overlapping. This requirement has been superseded by the following: REQ-06.08.01-OSED-FUNC.0400 REQ-06.08.01-OSED-FUNC.0401

Identifier	REQ-06.08.01-OSED-FUNC.0400
Requirement	The final approach controller shall be able to clearly and consistently recognise at a glance the spatial relationship between a separation indicator and the target position of the follower aircraft when both are in close proximity and overlapping.

Identifier	REQ-06.08.01-OSED-FUNC.0401
Requirement	The tower runway controller shall be able to clearly and consistently recognise at a glance the spatial relationship between a separation indicator and the target position of the follower aircraft when both are in close proximity and overlapping.

Identifier	REQ-06.08.01-OSED-FUNC.0033
Requirement	The HMI design (i.e. shape, colour, size and display priority) of the indicator shall harmoniously integrate into the final approach controller radar display and the tower runway controller air traffic monitor display respectively This requirement has been superseded by the following: REQ-06.08.01-OSED-FUNC.0402 REQ-06.08.01-OSED-FUNC.0403

Identifier	REQ-06.08.01-OSED-FUNC.0402
Requirement	The HMI design (e.g. shape, colour, size and display priority) of each type of separation indicator shall harmoniously integrate into the final approach controller radar display

Identifier	REQ-06.08.01-OSED-FUNC.0403
Requirement	The HMI design (e.g. shape, colour, size and display priority) of each type of separation indicator shall harmoniously integrate into the tower runway controller air traffic monitor display.

Identifier	REQ-06.08.01-OSED-FUNC.0404
Requirement	For in-trail separation indicators the system shall provide the means for the controllers to visually distinguish between the differ types of in-trail separation / spacing including wake separation, minimum radar separation, spacing minimum, scenario specific spacing and departure gap spacing.

Identifier	REQ-06.08.01-OSED-FUNC.0034
Requirement	When a follower aircraft has both an in-trail and a not-in-trail separation constraint, the separation indicator shall show the maximum of the constraints.

Identifier	REQ-06.08.01-OSED-FUNC.0035
Requirement	The separation indicator shall clearly distinguish whether the separation or spacing constraint displayed is a not-in-trail constraint or an in-trail constraint.

Identifier	REQ-06.08.01-OSED-FUNC.0036
Requirement	When a follower aircraft has both an in-trail and not-in-trail separation constraint, and for which the constraints are close together (e.g. 0.5Nm), both the in-trail separation indicator and the not in trail separation indicator shall be displayed.

Identifier	REQ-06.08.01-OSED-FUNC.0405
Requirement	For not-in-trail separation indicators the system shall provide the means for the controllers to visually distinguish between the differ types of not-in-trail separation / spacing including minimum radar separation, spacing minimum, and specific airborne procedures separation.

Identifier	REQ-06.08.01-OSED-FUNC.0037
Requirement	A separation indicator behind a lead aircraft shall usually be automatically removed when the lead aircraft crosses the runway landing threshold, or when the target of the aircraft is removed from being displayed if sooner.

Identifier	REQ-06.08.01-OSED-FUNC.0406
Requirement	For the Tower Runway Controller the system shall provide the means for selective removal of the separation indicators between spacing minimum and other non-wake pairs as the lead aircraft crosses 4DME such that only the separation indicators of wake pairs are displayed until the lead aircraft crosses the runway landing threshold.

Identifier	REQ-06.08.01-OSED-FUNC.0407
Requirement	For large separation / spacing distances the system shall provide selectable support for the displaying and updating of the position of the separation indicator until the follower aircraft has reached a defined position of final approach (e.g. 6DME or 4DME) irrespective of the lead aircraft having crossed the runway landing threshold and landed,

Identifier	REQ-06.08.01-OSED-FUNC.0408
Requirement	When displaying and updating the separation indicator after the lead aircraft has crossed the runway landing threshold, the system shall use the final approach reference airspeed profile to establish the ground speed profile to be applied in the prevailing glideslope wind conditions for updating / coasting the separation indicator position.

Identifier	REQ-06.08.01-OSED-FUNC.0409
Requirement	For departure gap spacing the system shall provide selectable support for coasting of each departure gap separation indicator from when the lead aircraft crosses 4DME and commences landing speed stabilisation until the separation indicator crosses 6DME or 4DME.

Identifier	REQ-06.08.01-OSED-FUNC.0410
Requirement	When providing support for coasting of each departure gap separation indicator, the system shall use the final approach reference airspeed profile to establish the ground speed profile to be applied in the prevailing glideslope wind conditions for updating / coasting the separation indicator position.

Identifier	REQ-06.08.01-OSED-FUNC.0411
Requirement	When providing support for coasting of each departure gap separation indicator, when this coasting results in distance spacing compression that reduces the spacing distance between the separation indicator and the lead aircraft target position to the wake turbulence separation that is required between the lead and follower aircraft, the system shall change the separation indicator to a wake separation indicator type with the corresponding wake separation distance, and the coasting stopped.

Identifier	REQ-06.08.01-OSED-FUNC.0412
Requirement	The system shall support selective suppression of the displaying of the separation indicator between an arrival pair.

Identifier	REQ-06.08.01-OSED-FUNC.0038
Requirement	The separation indicators associated with an aircraft that transitions on to a missed approach shall be automatically removed and separation indicators calculated and displayed between the preceding and follower aircraft.

Identifier	REQ-06.08.01-OSED-FUNC.0039
Requirement	Separation Indicators shall be displayed on the radar displays of the intermediate approach controllers.

Identifier	REQ-06.08.01-OSED-FUNC.0040
Requirement	The display of indicators shall be selectable and de-selectable by the final approach controller, the intermediate approach controllers and the tower runway controller positions so as to be able to support reversion procedures to DBS without separation tool support. This requirement has been superseded by the following: REQ-06.08.01-OSED-FUNC.0413 REQ-06.08.01-OSED-FUNC.0414

Identifier	REQ-06.08.01-OSED-FUNC.0413
Requirement	The display of separation indicators shall be selectable and de-selectable at each Approach Controller CWP.

Identifier	REQ-06.08.01-OSED-FUNC.0414
Requirement	The display of separation indicators shall be selectable and de-selectable at each Tower Controller CWP.

6.2.5 General Separation Indicator HMI Design Requirements

Identifier	REQ-06.08.01-OSED-FUNC.0041

Requirement	The default shape for the in-trail separation indicator shall be a marker line perpendicularly oriented to the extended runway centre-line.

Identifier	REQ-06.08.01-OSED-FUNC.0042
Requirement	An alternative shape for the separation indicators shall be a chevron of two lines at an angle of 140 degrees, with the indictor position defined as the point where the two chevron lines meet, and the orientation being in the direction aircraft move down the final approach centre-line of the landing runway (including curved approaches).

Identifier	REQ-06.08.01-OSED-FUNC.0043
Requirement	The separation indicator symbol shall be configurable for size and line width with default settings.

Identifier	REQ-06.08.01-OSED-FUNC.0044
Requirement	The separation indicator symbol shall be configurable for colour and intensity with default settings, which are compatible with other local uses of colour coding and display intensity on the final approach controller display and the tower runway controller display.

Identifier	REQ-06.08.01-OSED-FUNC.0045
Requirement	The target symbol shall be displayed over the separation indicator when the separation indicator and target symbol overlap on the display.

Identifier	REQ-06.08.01-OSED-FUNC.0046
Requirement	The default shape and colour for the not-in-trail separation indicator shall be easily distinguishable from the in-trail separation indicator.

Identifier	REQ-06.08.01-OSED-FUNC.0047
Requirement	The separation indicator may be accompanied with an indicator label with the callsign of the aircraft to be turned on to the separation indicator.

Identifier	REQ-06.08.01-OSED-FUNC.0048
Requirement	The separation indicator label may display the previous IAS and Ground Speed of the lead aircraft at the position of the separation indicator in the indicator label. Deleted as not required for fixed distance separation indicators.

Identifier	REQ-06.08.01-OSED-FUNC.0049
Requirement	The separation indicator label shall be selectable for display.

Identifier	REQ-06.08.01-OSED-FUNC.0050
Requirement	Individual fields within the separation indicator label shall be selectable for display.

	Deleted as not required for fixed distance separation indicators.

6.2.6 General Separation Indicator Display Positioning Requirements

Identifier	REQ-06.08.01-OSED-FUNC.0051
Requirement	The separation indicator shall be displayed at the required separation or spacing behind the lead aircraft target position when the lead aircraft is on the final approach centre-line.

Identifier	REQ-06.08.01-OSED-FUNC.0052
Requirement	When the lead aircraft is on intercept to final approach and within a specified distance of the extended runway centre-line it is merging on to, the separation indicator shall be displayed behind the separation indicator ahead when there is no gap between the separation indicator ahead and the aircraft on intercept to final approach.

Identifier	REQ-06.08.01-OSED-FUNC.0053
Requirement	When the lead aircraft is on intermediate approach and has yet to be turned on to intercept to merge on to final approach or which has been turned on to intercept and is more than the specified distance from the extended runway centre-line that it is merging to, the separation indicator shall be displayed behind the separation indicator ahead when there is no gap between the separation indicator ahead and the aircraft on intermediate approach.

Identifier	REQ-06.08.01-OSED-FUNC.0054
Requirement	When there is a gap between the separation indicator ahead and the follower aircraft being turned on when the follower aircraft is on base or intercept and within the specified distance of the extended runway centre-line, the separation indicator behind the follower aircraft shall be positioned the required separation or spacing behind the perpendicular projection of the target position of the follower aircraft being turned on.

Identifier	REQ-06.08.01-OSED-FUNC.0055
Requirement	The system shall display a separation indicator on the extended runway centre-line of not-in-trail follower aircraft in dependent parallel runway operations.

Identifier	REQ-06.08.01-OSED-FUNC.0056
Requirement	An aircraft shall be defined as on base when the track is +/- 40 degrees to the perpendicular to the extended runway centre-line within the turn on region of final approach and at turn on altitudes for merging on to final approach. This requirement has been specified in the corresponding Operational Requirements in Section6.1.2.

Identifier	REQ-06.08.01-OSED-FUNC.0057
Requirement	An aircraft shall be defined as on intercept when the track is +/- 20 degrees

	of a closing track of 30 degrees to the extended runway centre-line within the turn on region of final approach and at turn on altitudes for merging on to final approach. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.2.

Identifier	REQ-06.08.01-OSED-FUNC.0058
Requirement	An aircraft shall be defined as having captured final approach when the track is +/- 10 degrees of the extended runway centre-line, is stable with the aircraft not turning, and is within the localiser capture region of final approach and at localiser capture altitudes for final approach. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.2.

6.2.7 Automatic Monitoring and Alerting of Non-Conformant Final Approach Airspeed Behaviour

Identifier	REQ-06.08.01-OSED-FUNC.0059
Requirement	The system shall provide support for the automatic monitoring and alerting of deviations from the procedural airspeed profiles employed on final approach. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

Identifier	REQ-06.08.01-OSED-FUNC.0060
Requirement	The system shall provide support for alerting the final approach controller through the IAS field in the target label. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

6.2.8 Automatic Monitoring and Alerting of Separation Infringement

Identifier	REQ-06.08.01-OSED-FUNC.0061
Requirement	The system shall provide support for the automatic monitoring and alerting for separation infringement on final approach utilising radar surveillance data. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

Identifier	REQ-06.08.01-OSED-FUNC.0062
Requirement	The system shall provide support for alerting the final approach controller through a specialised final approach separation infringement conflict alert.

	This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

6.2.9 Automatic Monitoring and Alerting of the Wrong Aircraft Being Turned on to the Indicator

Identifier	REQ-06.08.01-OSED-FUNC.0063
Requirement	The system shall provide support for the automatic monitoring and alerting for the wrong aircraft being turned on to a separation indicator. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

Identifier	REQ-06.08.01-OSED-FUNC.0064
Requirement	The system shall provide support for alerting the final approach controller by displaying the indicator label, with the callsign of the correct follower aircraft to be turned on to the indicator being displayed in the indicator label. A simpler alternative may be to pulse the indicator. The alert is ended when the arrival sequence order is correct and the correspondence has been corrected between the aircraft being turned on and the indicator. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

6.2.10 Automatic Monitoring and Alerting for an Aircraft not being Turned on to the Intended Final Approach Centre-Line

Identifier	REQ-06.08.01-OSED-FUNC.0065
Requirement	The system shall provide support for the automatic monitoring and alerting for aircraft not being turned on the intended final approach centre-line. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

Identifier	REQ-06.08.01-OSED-FUNC.0066
Requirement	The system shall provide support for alerting the final approach controller by pulsing the indicator. The alert is ended when the aircraft captures the correct final approach centre-line or the landing runway intent is corrected to reflect the final approach centre-line that the aircraft has been turned on to. This requirement has been specified in the corresponding Operational Requirements in Section 6.1.8.

6.3 Safety Requirements for P06.08.01 Time Based Separation for Final Approach

6.3.1 Safety Integrity Requirements

Identifier	REQ-06.08.01-SPR-SIR1.0001
Requirement	The frequency of a FDPS failure to provide flight data inputs to the TBS tool for one arrival aircraft shall be low.

Identifier	REQ-06.08.01-SPR-SIR1.0002
Requirement	The frequency of a FDPS failure to provide flight data inputs to the TBS tool for several arrival aircraft in a row shall be very low.

Identifier	REQ-06.08.01-SPR-SIR1.0003
Requirement	The frequency of a MET system failure to provide wind data inputs to the TBS tool for one aircraft shall be low.

Identifier	REQ-06.08.01-SPR-SIR1.0004
Requirement	The frequency of a MET system failure to provide wind data inputs to the TBS tool for several aircraft in a row shall be very low.

Identifier	REQ-06.08.01-SPR-SIR1.0005
Requirement	The frequency of an AMAN system failure to provide sequence and runway in-use inputs to the TBS tool for one aircraft shall be low.

Identifier	REQ-06.08.01-SPR-SIR1.0006
Requirement	The frequency of an AMAN system failure to provide sequence and runway in-use inputs to TBS tool for several aircraft in a row shall be very low.

Identifier	REQ-06.08.01-SPR-SIR1.0007
Requirement	In case of missing input data, no TBS indication shall be provided to the Approach Controller, together with a visual warning of this lack of TBS indication. This requirement has been superseded by the following: REQ-06.01.01-SPR-SIR1.0100 REQ-06.01.01-SPR-SIR1.0101

Identifier	REQ-06.01.01-SPR-SIR1.0100
Requirement	The approach controller shall not have a TBS indication when there is missing input data.

Identifier	REQ-06.01.01-SPR-SIR1.0101
Requirement	The approach controller shall be provided with a visual warning when there is no TBS indication.

Identifier	REQ-06.08.01-SPR-SIR1.0008
Requirement	In case of no TBS indication is available for one or several aircraft and/or a warning of this, Approach Controller shall revert to DBS minima application for this aircraft. This requirement has been superseded by the following: REQ-06.01.01-SPR-SIR1.0102 REQ-06.01.01-SPR-SIR1.0103

Identifier	REQ-06.01.01-SPR-SIR1.0102
Requirement	The approach Controller shall revert back to DBS minima when there is no TBS indication for an aircraft.

Identifier	REQ-06.01.01-SPR-SIR1.0103
Requirement	The approach controller shall revert back to DBS minima when there is a warning for no TBS indication.

Identifier	REQ-06.08.01-SPR-SIR1.0009
Requirement	In case of lack of information on aircraft type or WT category, the Approach Controller shall ask on first call with the Flight Crew and shall apply DBS minima for this aircraft.

Identifier	REQ-06.08.01-SPR-SIR1.0010
Requirement	The frequency of an ATC system and a TBS tool failure to provide TBS indication for one aircraft shall be low.

Identifier	REQ-06.08.01-SPR-SIR1.0011
Requirement	A TBS tool back-up shall be available for switching over in case of failure of primary tool.

Identifier	REQ-06.08.01-SPR-SIR1.0012
Requirement	Approach Supervisor and Approach Controller shall be made aware of planned maintenance on TBS tool, and revert to DBS in case of TBS tool sudden failure or planned stop.

Identifier	REQ-06.08.01-SPR-SIR1.0013
Requirement	AMAN software processes providing inputs to the TBS tool shall comply with SWAL 4.

Identifier	REQ-06.08.01-SPR-SIR1.0014
Requirement	The Approach Controller shall ask for confirmation of the aircraft type and wake turbulence category on first call with the Flight Crew when there is doubt about the correctness of the displayed separation indicator.

Identifier	REQ-06.08.01-SPR-SIR1.0015
Requirement	Wind data shall be supplied from multiple sources.

Identifier	REQ-06.08.01-SPR-SIR1.0016
Requirement	Forecasted wind conditions shall be used to anticipate significant wind variations.

Identifier	REQ-06.08.01-SPR-SIR1.0017
Requirement	Contingency shall be built into the TBS tool to allow for a degree of variability in the wind conditions when calculating the TBS distance.

Identifier	REQ-06.08.01-SPR-SIR1.0018
Requirement	The separation indicator shall not be displayed if checks regarding the realism of the aircraft speed information are failed. Deleted because the impacted separation indicators are required to enable the final approach controller and tower runway controller to monitor the resulting distance spacing compression impact on the separation.

Identifier	REQ-06.08.01-SPR-SIR1.0019
Requirement	The Approach Controllers (INT and FIN) shall be provided with the

	approach arrival sequence on the traffic display.

Identifier	REQ-06.08.01-SPR-SIR1.0020
Requirement	Any change in the arrival sequence before the lead aircraft is established on the final approach path (related to spacing management, aircraft trajectory deviation) shall be timely input into the Arrival Manager system, and TBS system. This requirement has been superseded by the following: REQ-06.01.01-SPR-SIR1.0104 REQ-06.01.01-SPR-SIR1.0105

Identifier	REQ-06.01.01-SPR-SIR1.0104
Requirement	The arrival manager system shall be updated with any change in the arrival sequence before the lead aircraft is established on the final approach path.

Identifier	REQ-06.01.01-SPR-SIR1.0105
Requirement	The TBS system shall be updated with any change in the arrival sequence before the lead aircraft is established on the final approach path.

Identifier	REQ-06.08.01-SPR-SIR1.0021
Requirement	TBS tool software processes shall comply with SWAL 3.

Identifier	REQ-06.08.01-SPR-SIR1.0022
Requirement	The TBS tool shall be revalidated for operational use after maintenance has taken place.

Identifier	REQ-06.08.01-SPR-SIR1.0023
Requirement	Approach Supervisor and Controllers shall be briefed on the TBS concept of operations.

Identifier	REQ-06.08.01-SPR-SIR1.0024
Requirement	Approach Controllers shall be trained for TBS operations and the use of TBS tool.

Identifier	REQ-06.08.01-SPR-SIR1.0025
Requirement	Approach Supervisor and Controllers shall be briefed on the safety requirements for TBS operations.

Identifier	REQ-06.08.01-SPR-SIR1.0026
Requirement	The system shall provide automatic monitoring and alerting of separation infringement.

Identifier	REQ-06.08.01-SPR-SIR1.0027
Requirement	The system shall provide automatic monitoring and alerting for an aircraft not being turned on to the intended final approach localiser, i.e. different than the AMAN intended landing runway.

Identifier	REQ-06.08.01-SPR-SIR1.0028
Requirement	An overview of the key principles of the TBS concept of operations shall be published in the AIP.

Identifier	REQ-06.08.01-SPR-SIR1.0029
Requirement	Pilots shall be briefed on the TBS concept of operations.

Identifier	REQ-06.08.01-SPR-SIR1.0030
Requirement	Pilots shall timely comply with ATC instructions on final approach.

Identifier	REQ-06.08.01-SPR-SIR1.0031
Requirement	Pilots shall timely notify ATC of an inability to fly the standard approach procedure.

Identifier	REQ-06.08.01-SPR-SIR1.0032
Requirement	Approach Controllers shall be alerted by an automatic warning tool in case of abnormal approach speed.

Identifier	REQ-06.08.01-SPR-SIR1.0033
Requirement	Approach Controllers shall check the consistency of the TBS indication for an unusual aircraft type.

Identifier	REQ-06.08.01-SPR-SIR1.0034
Requirement	ATC units shall coordinate for any unusual ATC instruction on final approach.

Identifier	REQ-06.08.01-SPR-SIR1.0035
Requirement	Approach Controllers shall maintain their knowledge of aircraft characteristics and behaviour on final approach.

Identifier	REQ-06.08.01-SPR-SIR1.0036
Requirement	The system shall provide automatic monitoring and alerting of non-conformant final approach airspeed behaviour.

6.3.2 Effect Risk Mitigation Requirements

Identifier	REQ-06.08.01-SPR-ESR1.0001
Requirement	DBS operations shall remain available in case of TBS being unserviceable.

Identifier	REQ-06.08.01-SPR-ESR1.0002
Requirement	In case missing inputs to compute a TBS indication, a safety mitigation function shall display by default the DBS rule applicable behind the lead aircraft, and the Controller shall be informed that the DBS rule is displayed. The requirement has been superseded by the following: REQ-06.08.01-SPR-ESR1.0100 REQ-06.08.01-SPR-ESR1.0101

Identifier	REQ-06.08.01-SPR-ESR1.0100
Requirement	A DBS rule shall be displayed when there are missing inputs to calculate a TBS indication.

Identifier	REQ-06.08.01-SPR-ESR1.0101
Requirement	The controller shall be informed when a DBS rule is displayed.

Identifier	REQ-06.08.01-SPR-ESR1.0003
Requirement	In case of missing inputs to compute a TBS indication behind a lead aircraft before turn-on, to facilitate a timely detection by the Controller of this missing TBS indication, a safety mitigation function (e.g. visual alert) should be provided. In that case, the Controller shall revert to and apply DBS rule. This requirement has been superseded by: REQ-06.08.01-SPR-ESR1.0102 REQ-06.08.01-SPR-ESR1.0103

Identifier	REQ-06.08.01-SPR-ESR1.0102
Requirement	A safety mitigation function shall be provided when there is missing inputs to compute a TBS indication behind a lead aircraft before turn on.

Identifier	REQ-06.08.01-SPR-ESR1.0103
Requirement	A controller shall revert to and apply DBS rule when a safety mitigation function is provided.

Identifier	REQ-06.08.01-SPR-ESR1.0004
Requirement	In case of sudden loss of TBS indication, the Controller shall revert to DBS rule and re-establish DBS rule spacing as soon as feasible, and ensure that possible on-going catch-up situations are closely monitored and resolved. If catch-up situation are not possible to be resolved, Controllers shall instruct follower aircraft to go-around. This requirement has been superseded by the following: REQ-06.08.01-SPR-ESR1.0104 REQ-06.08.01-SPR-ESR1.0105

Identifier	REQ-06.08.01-SPR-ESR1.0104
Requirement	In the case of sudden loss of the separation indicator the controller shall revert to DBS rules and establish DBS rules spacing as soon as feasible.

Identifier	REQ-06.08.01-SPR-ESR1.0105
Requirement	In case of sudden loss of the separation indicator Controllers shall closely monitor and resolve any catch-up situations, and instruct aircraft to go-around if a catch-up situation cannot be resolved.

Identifier	REQ-06.08.01-SPR-ESR1.0005
Requirement	Controllers shall check that the provided separation indicator looks consistent with displayed aircraft types and WT category.

Identifier	REQ-06.08.01-SPR-ESR1.0006
Requirement	Controllers shall maintain an awareness of the distance separation minima to be applied between the WT categories.

Identifier	REQ-06.08.01-SPR-ESR1.0007
Requirement	Controllers' competency for DBS operations shall not be degraded by the implementation of TBS operations.

Identifier	REQ-06.08.01-SPR-ESR1.0008
Requirement	A visual alert shall be provided to the Approach Controller when the aircraft instructed to turn-on is not the one as planned in the arrival sequence.

Identifier	REQ-06.08.01-SPR-ESR1.0009
Requirement	A visual alert shall be provided when abnormal indicated airspeed is detected.

Identifier	REQ-06.08.01-SPR-ESR1.0010
Requirement	A visual alert shall be provided in case of catch-up.

Identifier	REQ-06.08.01-SPR-ESR1.0011
Requirement	The separation indicator shall provide information to indicate which follower aircraft it is intended for.

Identifier	REQ-06.08.01-SPR-ESR1.0012
Requirement	The separation indicator shall look different for WT and for MRS separation.

Identifier	REQ-06.08.01-SPR-ESR1.0013
Requirement	Procedure shall be developed to handle traffic with missing indicators and Controllers shall be trained on scenarios with missing indicators. This requirement has been superseded by the following: REQ-06.08.01-SPR-ESR1.0107 REQ-06.08.01-SPR-ESR1.0108

Identifier	REQ-06.08.01-SPR-ESR1.0107
Requirement	Procedure shall be developed to handle traffic with missing separation indicators.

Identifier	REQ-06.08.01-SPR-ESR1.0108
Requirement	Controllers shall be trained on scenarios with missing separation indicators.

Identifier	REQ-06.08.01-SPR-ESR1.0014
Requirement	Approach and Tower Controllers shall be provided with look-up tables for DBS minima to support DBS operations when necessary.

6.4 Information Exchange Requirements

Within the timescales of P06.08.01 Phase 1 an Industrial Based Platform (IBP) was not available. Therefore both the VP-303 simulation and the VP-302 simulation [76] [77] were conducted using NATS developed TBS prototypes for the Swanwick TC Approach Simulator and the Heathrow Tower Simulator respectively.

Given that an IBP was not available, Information Exchange Requirements have not been addressed in this phase of the project. It is currently planned that verification of a TBS IBP will be conducted in Q1 2014, at which time the Information Exchange Requirements should be addressed by the P10.04.04 and P12.02.02 in coordination with P06.08.01.

7 References

7.1 Applicable Documents

This OSED complies with the requirements set out in the following documents:

[1] IS SESAR SEMP 2.0

[2] EUROCONTROL ATM Lexicon https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

[3] Template Toolbox 03.00.00 https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[4] Requirements and V&V Guidelines 03.00.00 https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[5] Templates and Toolbox User Manual 03.00.00 https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

7.2 Reference Documents

The following documents were used to provide input/guidance/further information/other:

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[7] B4.2 WPB4.2 – D08 Processes and Services, dated 12/09/2010

[8] ED-78A Guidelines for Approval of the provision and use of Air Traffic Services supported by Data Communications

[9] OATA Operational Scenario and Use Case Guide V1.0

[10] ICAO Document 4444

[11] 06.08.01, High Level Operational Concept Description for Flexible and Dynamic Use of Wake Turbulence Separations, D03, Edition 00.01.00, 2010-10-29

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[14] London Terminal Control (Swanwick) – MATS Part 2 Edition 2/10, 2010-11-29

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[22] Eurocontrol TBS Project: TIME BASED SEPARATIONS: Detailed specifications for rapid prototyping, version 1.0, 2004-09-14

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[28]Eurocontrol TBS Project: Wake Vortex Safety Assessment of Time Based Separation, revision 1, 2005-03-18

[29]NATS Landing Rate Resilience Project, March 2005 Workshop Report, P2972, 2005-07

[30]NATS Landing Rate Resilience Project, July 2005 Workshop Report, P3045, 2005-09

[31]NATS Landing Rate Resilience Project, System Modelling Report, P3045, 2005-10

[32]NATS Landing Rate Resilience Project, Wake Vortex Safety Assessment, P3045, 2005-11

[33]NATS Landing Rate Resilience Project, Go-Around Safety Assessment, P3045, 2005-012

[34]NATS Advanced Separation Criteria Project, Vortex Wake Separation Requirements, 4ABT ASC, 2005-04

[35]Eurocontrol TBS Project, TIME BASED SEPARATION: Safety Plan, 2006-03

[36]Eurocontrol European Wake Vortex Mitigation Benefits Study: Work Package 4: Detailed Study of the Implementation of TBS and Crosswind Reduced Separations at Heathrow, 2006—06

[37]NATS Advanced Separation Criteria Project, Approach System Modelling of Spacing Minimum Aircraft Pairs at Heathrow, 6ABT ASC, 2006-08

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[39]Eurocontrol TBS Project, CDG Real-Time Simulation Results, EEC Note No.17/06, 2006-11

[40]Eurocontrol TBS Project, TIME BASED SEPARATION: Generic Safety Assessment, version 0.1, 2007-01-05

[41]Eurocontrol TBS Project, Time Based Separation – Safety Plan, 2007-03

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[58]NATS TBS Project, TBS Workshop, September 2010 Validation Plan, TBS/PLN/01, Issue 1, 2010-06

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[61]EC 6FP RESET Project, Elicitation of experts on potential mitigating measures for high ranking hazards, 2010-07-30

[62]EC 6FP RESET Project, D7.4 Preliminary Safety Case Part 3 Time Based Separations, 2010-07

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[70]SESAR P06.08.01, NATS TBS User Group 9 Minutes, 2011-05-27

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[73]SESAR WP6 Airport Detailed Operational Description (DOD) Step 1, Edition 01.00.01, 20/02/2012

[74]SESAR WP5 Validation Strategy for Concept Step 1 – Time Based Operations, Edition 00.00.05, 10/12/2012

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[77]SESAR P06.08.01 D10 Validation Report (VALR) for Time Based Separation (TBS), Edition 00.01.01, 28/02/2013

[78]SESAR P06.08.01 D11 Time Based Separation for Arrivals (TBS) – Safety Assessment Report (SAR), Edition 00.00.06, 01/02/2013

[79]SESAR P06.08.01 D11 Internal Exercise Report – Appendix 1: HP Report, Edition 00.01.00, 28/02/2013

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[81]SESAR P06.02 Airport Validation Strategy Step 1, Edition 00.03.00, 23/12/2011

Appendix A Justifications

Not applicable to P06.08.01 Phase 1.

Appendix B Heathrow Approach

B.1 Time Based Wake Turbulence Radar Separation Rules

The Heathrow DBS rules applied on final approach to 4Nm from the runway threshold (4DME) are presented in Table 10 below.

		Follower					
		Super Heavy	**Heavy**	**Upper Medium**	**Lower Medium**	**Small**	**Light**
Leader	**Super Heavy** A380 (560T)	4Nm	6Nm	7Nm	7Nm	7Nm	8Nm
	Heavy More than 162T	4Nm	4Nm	5Nm	5Nm	6Nm	7Nm
	Upper Medium 104T – 162T	SM	SM	3Nm	4Nm	4Nm	6Nm
	Lower Medium 40T – 104T	SM	SM	SM	SM	3Nm	5Nm
	Small 17T – 40T	SM	SM	SM	SM	3Nm	4Nm
	Light 17T or less	SM	SM	SM	SM	SM	SM

Table 23: Heathrow DBS rules on final approach

Note: Although no wake turbulence separation is required for a 'Super' following either a 'Super' or 'Heavy', a minimum spacing of 4Nm will be used to allow for the runway occupancy time of the lead aircraft.

SM equates to the spacing minimum on final approach to be applied to 4DME. A standard spacing minimum of 3Nm is applied in Terminal Control (TC) airspace. On final approach at Heathrow the spacing minimum may be reduced to 2.5Nm outside of 4DME under specific conditions [London Terminal Control (Swanwick) MATS Part 2 [14]]:

- The Tower Arrivals controller *(runway controller)* is able to provide reduced separation in the vicinity of the aerodrome when the follower aircraft passes 6.5 Nm from touchdown.
  - It is inevitable that under most circumstances the final approach spacing established by the radar controller *(final approach controller)* will reduce as the lead aircraft passes 4DME and reduces to final approach speed (landing stabilisation speed)
- Braking action and runway occupancy times are nominal.
  - The final approach spacing outside of 4DME should not be reduced below 3Nm if reports of adverse Braking Action have been received, or runway occupancy times are adversely affected by runway contaminants such as slush, snow or ice.
- The second aircraft of any given pair is within 20Nm of the runway threshold

- The radar source being used *(by the final approach controller)* must have an update rate of 5 seconds or less.
- Appropriate wake turbulence separation is not required between the specific individual pairs of aircraft
- The specific individual pairs of aircraft are closely monitored and when necessary speed adjusted by the FIN controller *(final approach controller)* to ensure that spacing does not erode below the minimum radar separation of 2.5Nm.

In the UK AIP for London Heathrow [15] the local traffic regulations for the use of runways and aircraft separation states:

- In certain weather conditions 2.5Nm spacing minimum may be applied on final approach. The conditions when this spacing minimum may be utilised are:
    - Visibility and cloud ceiling equal to or better than 10km and 1500ft with a minimum recommended headwind component of 10kt.
    - Braking action is good.
    - When aircraft involved in the procedure are being operated normally. It is the pilot's responsibility to inform ATC if they are operating their aircraft in other than a normal manner.
    - Speed on final approach and 2.5Nm separation from the preceding traffic must be stabilised by 8Nm.

The ground speed profile conversion will be based on a reference airspeed profile over the distance based separation to the start of landing speed stabilisation at 4DME.

At Heathrow the standard procedural airspeed profile to the start of landing speed stabilisation at 4DME is a steady 160kt IAS. This is to be applied in low headwind conditions on the final approach glideslope to 4DME such that the ground speed equates to the indicated airspeed.

For non-wake spacing minimum pairs, a 60s time separation minimum is proposed to reflect the average runway occupancy profiles of the lead aircraft of non-wake spacing minimum pairs being under 50s at Heathrow. This is provided that appropriate spacing practice can be applied across 4DME.

[It has been proposed that this is increased to 65s because a number of Medium, Small and Light aircraft types have slow landing stabilisation speed profiles that result in excessive distance spacing compression inside of 4DME, and because the follower aircraft of spacing minimum pairs are usually heavier with faster landing stabilisation speed profiles than the lighter lead aircraft.]

This results in the Heathrow TBS rules on final approach to 4DME in Table 11.

		Follower					
		Super Heavy	**Heavy**	**Upper Medium**	**Lower Medium**	**Small**	**Light**
Leader	**Super Heavy** A380 (560T)	90s	135s	158s	158s	158s	180s
	Heavy More than 162T	90s	90s	113s	113s	135s	158s
	Upper Medium 104T – 162T	60s	60s	68s	90s	90s	135s
	Lower Medium 40T – 104T	60s	60s	60s	60s	68s	113s
	Small 17T – 40T	60s	60s	60s	60s	68s	90s
	Light 17T or less	60s	60s	60s	60s	60s	60s

Table 24: Heathrow TBS rules on final approach

The range of TBS in Table 12 result from the mean ground speed profiles impact of the range of wind conditions experienced over the separation to 4DME at Heathrow.

Mean Ground Speed	60s (SM)	67.5s (3Nm)	90s (4Nm)	112.5s (5Nm)	135s (6Nm)	157.5s (7Nm)	180s (8Nm)
180kt	3.0Nm	3.4Nm	4.5Nm	5.6Nm	6.8Nm	7.9Nm	9.0Nm
170kt	2.8Nm	3.2Nm	4.2Nm	5.3Nm	6.4Nm	7.4Nm	8.5Nm
160kt	2.7Nm	3.0Nm	4.0Nm	5.0Nm	6.0Nm	7.0Nm	8.0Nm
150kt	2.5Nm	2.8Nm	3.8Nm	4.7Nm	5.6Nm	6.6Nm	7.5Nm
140kt	2.3Nm	2.6Nm	3.5Nm	4.4Nm	5.3Nm	6.1Nm	7.0Nm
130kt	2.2Nm	2.4Nm	3.3Nm	4.1Nm	4.9Nm	5.7Nm	6.5Nm
120kt	2.0Nm	2.3Nm	3.0Nm	3.8Nm	4.5Nm	5.3Nm	6.0Nm

Table 25: TBS for mean ground speed profiles over the separation to 4DME

When the standard spacing minimum of 3Nm is required to be outside of 4DME on final approach the entries in orange and red in Table 12 must be adjusted to the 3Nm standard radar separation.

When the 2.5Nm spacing minimum is applied outside of 4DME on final approach the entries on red in Table 11 must be adjusted to the 2.5Nm spacing minimum.

B.2 Calculating the TBS

The Heathrow TBS rules are converted to the TBS by applying the 160kt reference airspeed profile to 4DME, in the final approach glideslope wind conditions that the lead aircraft is forecast to experience over the separation to 4DME.

B.3 Separation Constraints between Arrival Pairs on Final Approach

Wake Turbulence Separation Constraints

Reversion to DBS

With the introduction of the time based wake turbulence separation rules there will be a need to manage the potential reversion back to the distance based wake turbulence separation rules:

- There will be a need to indicate when TBS are to be applied and when DBS are to be applied
- The reversion to DBS may be either to indicator supported DBS or current non-indicator supported DBS
    - The display of the indicators shall be selectable and de-selectable

Operational Deployment Transition to TBS

In the operational deployment transition to the indicator supported time based wake turbulence separation rules:

- There may be a need to support a transition to indicator supported DBS
- There may be a need to support a gradual transition to the TBS, restricting the distance spacing reduction below the DBS for a period of time, before gradually relaxing this restriction:
    - For example, initially restricting the distance spacing reduction to 0.5Nm below the DBS, either for all wake turbulence pairs, or for selected wake turbulence pairs.

Spacing Minimum Constraints outside of 4DME

2.5Nm Spacing Minimum

This can only be applied when reduced separation in the vicinity of the aerodrome can be applied under the specified conditions in the Heathrow Airport MATS Part 2 [13] and the UK AIP for London Heathrow [15].

In addition there is a need to ensure that appropriate time spacing for clearance to land is set up as the follower aircraft approaches the runway threshold. This usually requires a minimum of a 10kt runway surface headwind.

- There will be a need to indicate when the 3Nm spacing minimum is to be applied and when the 2.5Nm spacing minimum is to be applied.

3Nm Spacing Minimum

When the 3Nm spacing minimum radar separation is to be applied outside of 4DME, the 2.5Nm minimum radar separation applies inside of 4DME to touchdown.

VIS2/LVP with ILS Safeguarding Procedures – Spacing Minimum Requirements

The operation types for VIS2 / LVP with ILS Procedures and the associated spacing minimum that are required to be supported for Heathrow [13] are shown in Table 13.

Operation Type	Weather Conditions	Lead Aircraft Must Be	Landing Clearance Given By	Spacing Minimum
Normal Operations	**Good weather** (Any weather conditions better than VIS2)	**Off the runway** (Or "Land After" permitted if the criteria are met)	(No minimum range)	**3Nm**
VIS2	**Relevant runway exits not visible to the Tower runway controller** (No fixed weather criteria)	**Assessed as having passed the line equivalent to the CAT I holding point (107.5m) displayed on A-SMGCS**	(No minimum range)	**4Nm** **5Nm behind Heavy**
LVP using ILS	**Touchdown RVR less than 600m** or **Cloud ceiling less than 200ft**	**Clear of the Localiser Safeguarding Area**	**2Nm** **EXCEPTIONALLY** **1Nm**	**6Nm**
Safeguarding	**Fog warning received** or **Touchdown RVR 1000m and expected to fall below 600m** or **Cloud ceiling 300ft and expected to fall to 200ft**	CAT II/III holds in use Operational procedures dependent on the type of operation being conducted		

Table 26: Heathrow VIS2/LVP with ILS Safeguarding Procedures - Summary of Requirements

In parallel runway operations the relevant runway exits may not be visible for one runway and visible for the other runway, and thus VIS2 procedures will just apply to the impacted runway.

Non-Nominal Runway Occupancy Spacing Constraints

When a key exit taxiway becomes unserviceable increased spacing may be required because of the impact on runway occupancy times.

This may impact all aircraft, and so the spacing minimum behind all aircraft will need to be increased above the minimum radar separation.

This may impact specific lead aircraft types that rely on the exit taxiway for expedited runway vacation, for example Heavy and/or Super Heavy aircraft wake categories, and so the spacing minimum behind these wake categories will need to be increased.

When the runway becomes contaminated such that runway occupancy times are impacted increased spacing may be required.

Equipment Failure Spacing Constraints

For particular operational equipment failures increased spacing may be required because of the extra controller workload caused by the equipment failure.

This will impact all aircraft, and so the spacing minimum behind all aircraft will need to be increased above the minimum radar separation.

Night Shift Spacing Constraints

In night shift operations the minimum spacing procedures are change to reflect the low traffic levels. This coordinated between the Tower ATC and Approach and may be 6Nm spacing for the end of evening traffic and 12Nm spacing for the residual overnight traffic.

Emergency Landing Traffic Spacing Constraints

For emergency landing traffic, due to the requirement for a runway surface inspection following an aircraft with a known emergency condition, a gap needs to be provided behind the emergency traffic. A gap of 15Nm is required to be created between the emergency landing traffic and the next aircraft to land on that runway.

Dependent Parallel Runway Separation Constraints

Successive aircraft on adjacent parallel extended final approach centre-lines can be separated by 2Nm diagonally subject to both aircraft being established on their respective final approach localiser, and priority lines between the final approach controller and the Tower runway controller are serviceable.

Both runways-in-use are used to service arrival delivery when the gates open at the start of the day until the first departure rotation commences. During this period there is a stream of arrival traffic on both final approach localisers and so there is a need to ensure that each follower aircraft respects both the diagonal parallel runway separation constraints and the in-trail separation constraints to the arrival aircraft ahead.

Tactical enhanced arrival management may be used throughout the day to land a restricted number of arrival aircraft on the departure runway-in-use. There may be more than one arrival aircraft on the departure runway-in-use final approach localiser and so there is a need to ensure that each follower aircraft respects both the diagonal parallel runway separation constraints and the in-trail separation constraints to the arrival aircraft ahead.

If the priority lines between the final approach controller and the Tower runway controller are not serviceable, or for other reasons, the dependent parallel runway separation constraints may be required to be increased to, for example, the 2.5Nm or 3Nm minimum radar separation.

B.4 Managing the Separation and Spacing Constraints

These are applied across 4DME at Heathrow.

B.5 Establishing the Required Separation or Spacing Between Each Arrival Pair

These are established across 4DME at Heathrow.

B.6 TBS Tool Support for the Visualisation of the Final Approach Separation or Spacing

There are no specific additional Heathrow requirements.

B.7 Final Approach Spacing Practice

At Heathrow it has been accepted that it is operationally difficult to apply wake turbulence separation in the latter stages of final approach when the rate at which individual aircraft reduce separation is not known to ATC. The Heathrow DBS are applied with acceptance of some distance spacing compression when the lead aircraft is inside of 4DME, and with the associated procedures and practices associated with an acceptable level of distance spacing compression.

The same final approach spacing practice for Heathrow DBS will also need to apply to the TBS, with improved consistency.

B.8 Safety Mitigation Elements of the TBS Concept

There are no specific additional Heathrow requirements.

B.9 Reduction of the 2.5Nm Radar Separation Minimum on Final Approach

There are no specific additional Heathrow requirements.

B.10 Roles and Responsibilities

There are no specific additional Heathrow requirements.

B.11 Other Related Issues

There are no specific additional Heathrow requirements.

Appendix C New Information Elements

Within the timescales of P06.08.01 Phase 1 an Industrial Based Platform (IBP) was not available. Therefore both the VP-303 simulation and the VP-302 simulation [76] [77] were conducted using NATS developed TBS prototypes for the Swanwick TC Approach Simulator and the Heathrow Tower Simulator respectively.

Given that an IBP was not available, Information Exchange Requirements have not been addressed in this phase of the project. It is currently planned that verification of a TBS IBP will be conducted in Q1 2014, at which time the Information Exchange Requirements should be addressed by the P10.04.04 and P12.02.02 in coordination with P06.08.01.

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