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SESAR Solution PJ.02-01-04 SPR-INTEROP/OSED for V3 - Part II - Safety Assessment Report

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PJ.02-W2 AART

AIRPORT, AIRSIDE AND RUNWAY THROUGHPUT

This Safety Assessment Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 874477 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document specifies the results of the safety assessments carried out in SESAR 2020 Wave 1 by SESAR Solution PJ.02-01 (Wake Turbulence Separation Optimisation) by EUROCONTROL and ENAIRE. This work continued in Wave 2 as PJ.02.01.04 (Static Pairwise for Arrivals (S-PWS-A concept) and PJ02.01.06 (Static Pairwise for Departures (S-PWS-D concept). This document puts an emphasis on Wave 2 PJ.02.01.04 Static Pairwise Separation for Arrivals concept.

This Safety Assessment Report (SAR) is contributing to the Operational Service and Environment Definition (OSED), Safety and Performance Requirements (SPR), Interoperability (INTEROP) Requirements, Technical Specifications (TS), and Interface Requirement Specifications (IRS).

The PJ.02-01-04 Solution is an extension of the PJ.02-01 arrivals solutions that were developed in SESAR Wave 1 to V3 maturity. PJ.02-01 aimed to optimise wake turbulence separation minima for arrivals to enhance airport runway throughput. It focused on the development and validation of:

- Wake turbulence separations based on static aircraft characteristics and weather dependent reductions;
- Separation delivery support tools for ATCOs.

The purpose of this PJ.02-01-04 OSED as a separate Wave 2 document is to describe the further development of the static pairwise wake separation minima based on an expanded aircraft type matrix.

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1 Executive Summary

This document contains the Specimen Safety Assessment for a typical application of the SESAR Solution 02-01 (Wake Turbulence Separation Optimisation) in capacity constrained Very Large, Large and Medium sized airport operations. The report presents the assurance that the Safety Requirements for the V1-V3 phases are complete, correct and realistic, thereby providing all material to adequately inform the SESAR Solution PJ.02-01 development and validation.

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- Wake turbulence separations based on static aircraft characteristics and weather dependent reductions;
- Separation delivery support tools for ATCOs.

This report is a continuation of the PJ.02.01 SAR [29], adding mainly the developments from SESAR 2020 Wave 2 done by EUROCONTROL for the PJ.02.01.04 S-PWS-A concept.

2 Introduction

This Safety Assessment Report (SAR) is based on the PJ.02.01 SAR [29] and it is addressing the developments brought in SESAR 2020 Wave 2 to the following PJ.02.01 operational improvement steps:

- AO-0306: Wake Turbulence Separations (for arrivals) based on Static Aircraft Characteristics (PWS-A)
- AO-0310: Weather-dependent reductions of Wake Turbulence Separations for final approach (WDS-A)
- AO-0328: Optimised Runway Delivery on Final Approach (ORD)

2.1 Background

For the arrivals concept and the development of ATC support tool prototypes, previous work from Project P06.08.01 and OFA 01.03.01 in SESAR 1 is relevant. SESAR 1 Project P06.08.01 Flexible and Dynamic Use of Wake Turbulence Separations focused on separation delivery of arriving aircraft, which led to the operational deployment of a Time-based Separation(s) (TBS) tool at London Heathrow. Other relevant research is RECAT-EU and RECAT-EU-PWS. RECAT-EU and RECAT-EU-PWS are optimisations of ICAO wake turbulence categories scheme, developed by EUROCONTROL in consultation with European stakeholders.

2.2 General Approach to Safety Assessment

This safety assessment is conducted as per the SESAR Safety Reference Material (SRM) which itself is based on a twofold approach:

- a success approach which is concerned with the safety of the Solution operations in the absence of failure within the end-to-end Solution functional system, encompassing both Normal operation and Abnormal conditions,
- a conventional failure approach which is concerned with the safety of the Solution operations in the event of failures within the end-to-end Solution functional system.

These two approaches are applied to the derivation of safety properties at each of the successive lifecycle stages of the Solution development:

Safety Specification at the Service Level

This is defined as what the new WT separation modes and ATC tools have to achieve at the Air Traffic Management (ATM) Service level in order to satisfy the requirements of the airspace users – i.e. it takes a “black-box” view of the new method of operations and includes what is “shared” between the users (aircraft) and the Air Traffic Service (ATS) Providers.

From a safety perspective, the user requirements are expressed in the form of Safety Criteria (SAC) and the Specification is expressed in the form of Safety Objectives (functionality & performance and integrity/reliability properties), which are derived during the V1 and V2 phases of the development lifecycle. The purpose is to check the completeness of the OSED and identify possible additional

validation objectives to be revealed by the safety analysis in view of their inclusion in the Validation plans.

Safe Design at Design Level

This describes what the operations with the new WT separation modes and ATC tools are actually like internally and includes all those system properties that are not directly required by the users but are implicitly necessary in order to fulfil the specification and thereby satisfy the User requirements. Design is essentially an internal, or "white-box", view of the operations supported by the new WT separation modes and ATC tools. This is more generally called the Design-level Model for the new WT separation modes in terms of human and machine "actors" that deliver the functionality.

From a safety perspective, the Design is expressed in the form of Safety Requirements (sub-divided into functionality & performance and integrity/reliability properties), which are derived during the V2 (initial design safety requirements) and V3 (detailed design safety requirements) phases of the development lifecycle. The purpose here is to feed the SESAR Solution PJ.02-01 SPR-INTEROP/OSED Part I with a complete and correct set of safety requirements. Furthermore, where relevant, the requirements inform the validation exercises with respect to the inclusion of related additional validation objectives for which validation feedback is required.

2.3 Scope of the Safety Assessment

This Safety Assessment Report (SAR) is limited to the scope of SESAR Solution PJ.02-01, concentrating mainly on the Wave 2 sub-concept PJ.02.01.04 S-PWS-A. SESAR Solution PJ.02.01.04 is addressing the Static Pair Wise Separation (PWS), Optimised Runway Delivery (ORD) and Weather Dependent Separation (WDS) concepts for Arrivals.

This safety assessment has not been performed from scratch; it represents an increment of the arrivals-dedicated part of the safety assessment previously performed within SESAR Wave 1 Solution PJ.02-01. The new element brought in by the PJ.02.01.04 S-PWS-A is mainly represented by additional aircraft types included in the RECAT-EU-PWS matrix.

This safety assessment defines the set of Safety Criteria (SAC), Safety Objectives (Sos) and Safety Requirements (SRs) for all the SESAR Solution PJ.02-01 arrivals concepts.

Meanwhile, whilst outlining the strategy employed by SESAR Solution PJ.02-01 for demonstrating the compliance with all SACs, this safety assessment focuses on the design of ATC supporting tools (separation indicators displayed to ATCOs) and working methods/procedures required for the separation delivery with the new WT separation modes, i.e. the correct application of the new WT separation minima for the arrivals concepts.

This safety assessment does not support the Separation design i.e. the definition of new WT separation minima which, if correctly applied in operation, guarantee safe operations on the final approach segment for the arrivals concepts. However, the relevant pieces of safety evidence (mainly in terms of wake turbulence encounter risk assessment) have been produced by P06.08.01 in SESAR 1 and are referenced and summarized within Section 6: Safety Criteria achievability . With regards to S-PWS this evidence is provided by the RECAT-EU-PWS Safety Case submitted to EASA for approval [7] (updated version including the extension of PWS distance minima matrix with new aircraft types – from 96 to 103 types)

This safety assessment covers the design and validation activities, encompassing Safety specification at the Service Level and Design Level.

2.4 Layout of the Document

Section 1 presents the executive summary of the document

Section 2 provides the background of the S-PWS-A concept, the general approach to safety assessment in SESAR and the scope of this safety assessment

Section 3 provides the operational concept overview and the scope of the change, summarises the solution operational environment and key properties together with the stakeholder's expectations and derives the Safety Criteria

Section 4 addresses the safety specification at Service level, through the definition of Sos

Section 5 addresses the safe design of the solution, through the derivation of SRDs and link to validation results

Appendix A presents the consolidated list of Safety Objectives

Appendix B presents the consolidated list of Safety Requirements with traceability to the Safety Objectives

Appendix C presents the list of Assumptions, Issues, Recommendations and Assessment Limitations

Appendix D outlines the Accident Incident Models (AIM) relevant for SESAR Solution 02-01.

Appendix E presents the results of the PJ.02.01 arrivals and departures SAF & HP workshop which took place on the 30th of October 2018 in the frame of SESAR 2020

Appendix F presents the results of the workshop with pilots from Air France and CDG ATCOs which took place on the 28th of January 2019 in the frame of SESAR 2020

Appendix G presents the Risk Classification Schemes for the relevant accident-incident types

Appendix H presents the EATMA models for the arrivals and departures concepts

3 Setting the Scene of the safety assessment

3.1 Operational concept overview and scope of the change

In Wave 2, the concepts are a continuation of those developed in Wave 1. In addition to the work done in Wave 1, Wave 2 proposes to include new/additional a/c types in the S-PWS for arrivals separation minima matrix.

Activities defined in the grant agreement to fulfil the above:

- Aircraft manufacturing data collection campaign to include the following new a/c types in PWS scheme:
  - B748, A35K, B789, B38M, A20N, A21N, BCS1, BCS3 and E195.
- Traffic and radar data collection campaigns to validate separation minima for new/different a/c categories for the safety case (i.e. requires time to fly – radar track data and wind).

No additional RTS was performed in Wave 2 for S-PWS-A concepts.

A SAF and HP screening was done, and no impact was identified on this operational safety assessment by the Wave 2 developments. The Safety Assessment done in Wave 1 is still fully applicable. The additional a/c pairs added to the S-PWS-A separation minima matrix contribute with further evidence to the design SAC (RECAT-EU-PWS-SAC#1), derived within PJ.02.01 and shown in section 3.4 of this document.

3.1.1 Baseline Scenario

3.1.1.1 Current separation schemes

Separation schemes applied in the reference scenarios:

- The distance-based WT separation regulations for arrivals based on WT categories as per e.g. ICAO, RECAT-EU 6 category or UK6 CAT.

Please see PJ.02-01 SPR-INTEROP/OSED [21] section 3 for more information about the ICAO and RECAT-EU distance based WT separation schemes.

3.1.1.2 Current operating method for the arrivals concepts solutions

The standard procedures currently used to transfer an arriving aircraft from En-route airspace through TMA and approach to touchdown are summarized in this sub-section.

MERGE FOR FINAL APPROACH INTERCEPTION

Typically, an aircraft will transition from En-route airspace into the TMA and approach to join the flow for the active landing runway via a Standard Arrival Route (STAR). Within the TMA, the aircraft is first controlled by one or more – dependent on the traffic density and the number of directions aircraft can come from – Approach (radar) controllers. The role of these positions is to merge and descend traffic into a single flow. The names of these controllers and their distribution of tasks may vary from unit to unit. E.g., there may be an initial controller (INI), an intermediate controller (INT) or feeder, and final

controller (FIN) or director (see Figure 1). The majority of alterations to the landing sequence of aircraft occur in the INI and INT controller positions. Unless an emergency or missed approach, event occurs it is rare for the FIN controller to make a change to the sequence flow of arrivals from the INT controller.

The FIN controller vectors the aircraft to the final approach fix on the localizer before transferring to the tower (TWR) or runway controller.

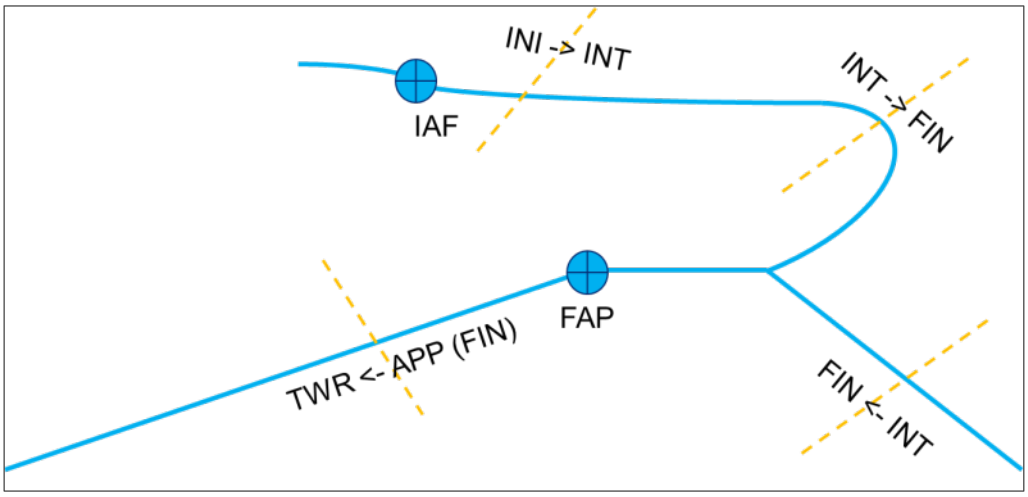


Figure 1: Example approach segments between controller positions

Speed control is defined in many airports' AIP, though the tactical application of this will be subject to variables such as wind and traffic density.

The speed control profile generally outlined is 220 KIAS on base leg until localizer interception, then reduce to 180 KIAS until on glide slope, then reduce to 160 KIAS until the Deceleration Fix at 4 NM from the runway landing threshold. Afterwards, the aircraft adopts its Final Approach Speed (FAS); see Figure 2. Because of differences in Final Approach Points (FAP), varying between approximately 5.5 NM and 13 NM from the runway landing threshold, the length of the segments where a certain speed is controlled may vary.

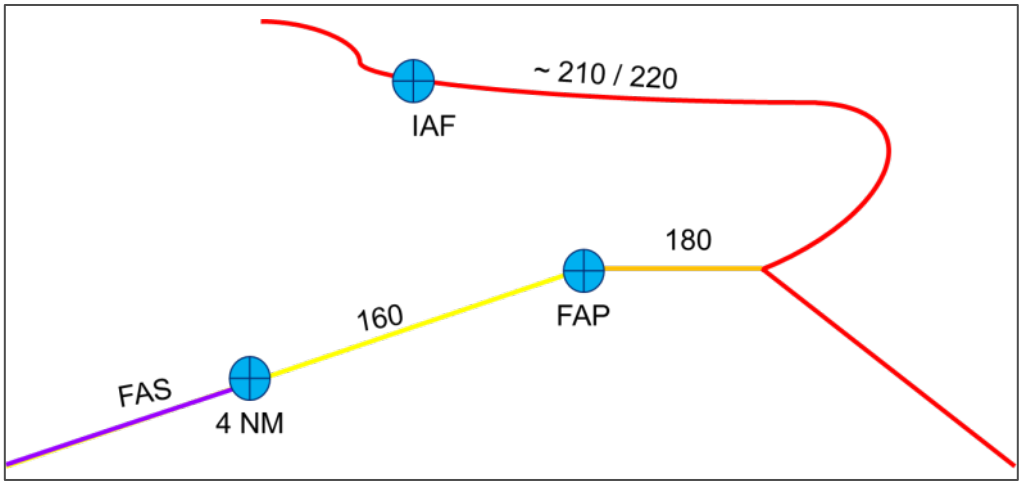


Figure 2: Generic speed control procedure on approach

Variation in ground speed can be about +/- 30 knots, decreasing to +/- 10 knots on the segment after the Deceleration Fix at 4 NM from the runway landing threshold until touchdown. It has furthermore been observed in radar data that the statistical distribution of speed can vary considerably over airports.

The speed profile from the last instructed speed to the Final Approach Speed (FAS), starting from around 6 NM to 4 NM from the runway threshold until touchdown, varies considerably depending on aircraft type, landing weight, stabilization altitude, stabilization mode, weather conditions, and the associated airline operator cockpit procedures (from under 100 KIAS for some Light wake category aircraft types to over 160 KIAS for some Heavy wake category aircraft types). Aircraft starts decelerating at Deceleration Fix (DF) and FAS is reached at Stabilization Fix (SF).

SEPARATION ASSURANCE

Considering the approach path, the location of the FAP, the speed control applied and the wind conditions, the resulting ground speed profile of two succeeding aircraft determines how the **separation** develops on the final approach.

Based on experience, the approach controller(s) will set up the initial separation, taking into account the above-mentioned factors. In addition, the applicable separation minimum (WT or MRS) is considered.

The point until where the defined minimum should be assured is split into two main practices: delivery to threshold (most common) and delivery to the Deceleration Fix at 4 NM from the runway landing threshold. Note that in both cases, ATC is responsible for separation to threshold. In the latter case, WT separation minima are ensured to the Deceleration Fix at 4 NM from the runway landing threshold, taking into account compression after the Deceleration Fix to touchdown.

The separation targeted for, usually includes a certain buffer to account for compression of the distance separation on the last segment of the approach (beyond the Deceleration Fix). The separation buffer applied is primarily based on the experience of the controller, taking into account the actual traffic and wind situation.

Monitoring separation is primarily done using the distance markers on the radar screen as a reference. Next to that, most units have some kind of ‘feeder cursor’ to measure distance between two selected aircraft. At some airports, there is predictive information on how the distance develops, but this seems to be used rarely.

Generally speaking, the TWR controller has few options to directly manage separation. However, in some ATC units the TWR controller has responsibility already from 6 NM or 8 NM before the runway landing threshold and has a radar rating. Otherwise, to resolve a loss of separation, the controller can apply or offer the aircraft visual separation (provided VMC applies), give a go-around instruction, or – and in exceptional cases and when the runway configuration allows – let the aircraft divert to the parallel runway. It is also possible to ask the approach controller to let the following aircraft reduce speed.

The next sub-sections provide a brief description of the TBS, ORD, S-PWS and WDS concepts.

The concepts described here are for segregated mode use only: arrivals on singular runway different from the runway used for departures.

3.1.2 Solution Scenario

3.1.2.1 Static Pair Wise Separation (PWS-A) concept for the Arrivals Concepts Solutions

The PWS-A concept is a wake turbulence scheme which is based upon individual aircraft types rather than grouping aircraft types into wake categories. In a wake category scheme the separations need to be designed to protect the lightest follower aircraft type in a category from the heaviest leader aircraft type in a category. This leads to inefficient separations between other aircraft type pairs which do not need the same amount of protection. The PWS-A WT scheme provides more efficient separations (at a resolution of 0.5 NM) as they can be optimised for each aircraft type pair based upon the static characteristics of each aircraft type.

The PWS-A WT schemes include RECAT-2 (a 96 x 96 aircraft type matrix[1]) together with a 20-CAT matrix (RECAT-EU 6-CAT with 14 sub-categories) which have been developed by EUROCONTROL.

The PWS-A concept could be operated in distance-based mode (DB-PWS-A) or in time-based mode (TB-PWS-A). Both modes of operation involve reduced separations (compared with current day operations) as the WT separations have been optimised at the level of aircraft type pairs. The time-based mode will have further reductions of separation as a function of the headwind conditions.

The concept aims to improve overall runway throughput through using the more efficient WT separations. However, it could also be used to improve runway throughput resilience to delay (assuming no change in declared capacity). In TB-PWS-A mode the concept can be used to improve predictability through improved resilience to headwind conditions.

In either mode a Separation Delivery tool will be required as the controllers will not know the required separation (even in a distance-based operation). The same Separation Delivery tool as is used in the TBS concept can be used to operate the TB-PWS-A concept. This includes the Final Target Distance Indicator (FTD) for providing an indication of the required separation to apply at threshold (or 1 NM) and the Initial Target Distance Indicator (ITD) to provide an indication of the predicted compression. When using TB PWS-A, the FTD will use the same method used in the TBS concept. When using DB-PWS-A the FTD will be defined based on the DB-PWS-A WT scheme. The methods for calculating the ITD remain the same.

A PWS-A concept could be operated only in DB-PWS-A mode in which case there will be no need for mode transition. However if the concept is extended to include the TB-PWS-A mode then there will be a need to support mode transitions, which in case the required wind conditions service (e.g. runway surface and glide path) becomes unavailable, will support the mode switch from TB-PWS-A to DB-PWS-A mode.

Operational constraints which affect TBS which include ROT and MRS will remain applicable in the PWS-A concept.

[1] 96 x 96 aircraft type matrix was developed and Wave 1, and extended further from 96 to 103 types

3.1.2.2 Weather Dependant Separation (WDS-A) concept for the Arrivals Concepts Solutions

WT separation could be reduced as a function of weather. In conditions of sufficient total wind or crosswind, the time separation equivalent to the applicable DBS separation could be reduced by taking advantage of the positive effect of wind on wake decay and transportation.

The key principle of WDS-A is to define the minimum distance in trail separation to apply as a function of weather. This can either be a function of total wind or cross wind.

If it is based on a total wind, then as the magnitude of the total wind increases, the decay rate of wake turbulence increases allowing a reduction of wake turbulence separations. That would allow for a reduction of the time separations compared to the ones observed in low wind conditions between aircraft landing pairs using distance-based separation based on WT categories or PWS-A such that the wake encounter risk is equivalent or lower. There is a need to consider the impact on both IGE and OGE decay rates, particularly as OGE decay rates may not be impacted as much as IGE decay rates.

If it is based on a crosswind, then as the magnitude of the crosswind increases, the probability of the WT to be transported out of the follower aircraft path increases allowing a reduction of wake turbulence separations. When the cross wind exceeds a certain value, the WT can be assured of being crosswind transported out of the path of the follower aircraft within a defined time separation, allowing for the reduction of the WT separation to the defined time separation. Moreover, as for the total wind concept, the crosswind also increases the decay rate of wake turbulence and hence decreases the severity in case of wake turbulence encounter.

The concept achieves the same predictability improvement through improved resilience as is achieved with the TBS concept but can give additional gains due to reduced separations based on the total wind or cross wind.

The WDS-A concept can use as reference for the time separation computation the distance-based separation based on WT categories, in which case the WT separation modes within this safety assessment are abbreviated A-TB-WDS-Tw for total wind and A-TB-WDS-Xw for cross wind.

The WDS-A concept can also be combined with the PWS-A concept, using as reference for the time separation computation the TB-PWS-A, in which case the WT separation modes within this safety assessment are abbreviated A-TB-WD-PWS-Tw for total wind and A-TB-WD-PWS-Xw for cross wind.

The WDS-A time separation minima defined as a function of the respectively total and cross wind shall account for the local wind measurement uncertainty and evolution between computation time and actual separation delivery time.

For that purpose, either a buffer might be added in the design of the time separation or a buffer might be added in the wind threshold definition.

Similarly, to the TBS concept, in case of conditional application of the TB-WDS-A mode, there is a need for mode transitions driven by criteria (wind activation threshold):

- A-TB-WDS-Tw and A-TB-WD-PWS-Tw modes shall be activated only when the reference total wind (as used in the separation minima design) is equal or greater than the A-WDS-Tw threshold (to be determined as function of local conditions).

- A-TB-WDS-Xw and A-TB-WD-PWS-Xw modes shall be activated only when the cross wind (as used in the separation minima design) is equal or greater than the A-WDS-Xw wind threshold.

Either form of the WDS-A concept will use the same HMI that is proposed for the TBS and PWS-A concepts. This includes the FTD for providing the required separation to apply at the separation delivery point and the ITD to provide an indication of the predicted compression (ORD concept). When using the A-WDS-Tw (resp. A-WDS-Xw) modes, the FTD will be computed applying the same method as that used in the TBS concept but using a reduced time separation depending on the total wind (resp. crosswind). The definition of the total wind and crosswind used to define allowed time separation reduction is to be defined locally. It can range from anemometer wind up to full glide path profile.

In either form of WDS-A mode, and as for the TBS mode, the FTD will be based on the largest amongst all operational constraints (i.e. WDS-A WT separation, MRS, ROT or other runway spacing). The methods for calculating the ITD remain the same as for TBS.

The WDS-A concept will need the same headwind forecasting and measuring services as used in TBS for the FTD and ITD computation. However, there will also be other total- or cross- wind forecasting considerations depending on the nature of the WDS-A concept.

For the ECTL TBS concept, the activation threshold only applies at the surface (below 300ft) which means the longer-term forecast (1-2 hours) is only needed for the surface. With regards to the needs for FTD and ITD computation, the GWCS only needs to forecast several minutes ahead.

In addition, if the WDS-A concept is intended to be used strategically to improve airport capacity, then the wind forecasting horizon for the wind thresholds increases to several hours in order to provide the Network Manager sufficient time to plan ahead.

Another consideration is the different components of a wind forecast. You can forecast the wind magnitude and / or the wind direction

As the WDS-A concept is developed the wind forecasting / measuring requirements will be refined and updated accordingly.

3.1.2.3 Optimised Runway Delivery on Final Approach

This section is a summary of section 3.3.2.1.1 from the SPR-INTEROP/OSED[21]. For more details, please see the corresponding section in the OSED.

This section describes the ORD concept and in particular the Separation Delivery tool that supports and is used by the Controllers in delivering the required separation or spacing on approach to the runway landing threshold. The Separation Delivery tool calculates and displays Target Distance Indicators (TDIs) on the Approach and Tower CWPs. The TDIs include an FTD indicator which displays the required separation / spacing to be delivered to the required delivery point and an Initial Target Distance (ITD) indicator which displays the required spacing to deliver at the DF to support the Controller in delivering the required separation / spacing. The ITD is the FTD plus the predicted compression distance plus any additional buffer (if needed, as safety mitigation to uncertainty in the aircraft speed or wind forecast). The compression distance is the difference between the distance the leader travels from the DF to the point of delivery and the distance the follower travels in the same period of time.

The key steps regarding the calculation and display of these TDIs are as follows:

- Determine the Approach Arrival Sequence;
- Identify all applicable separations / spacing's per arrival pair (includes in-trail and not-in-trail pairs);
- Compute the equivalent distance for any time separations or spacing's;
- Select the maximum applicable separation or spacing which is known as the FTD;
- Compute the ITD by taking into account the effect of compression;
- Determine if the TDI should be displayed;
- Display the TDI on all applicable CWPs.

Target Distance Indications (TDIs) are displayed on the extended runway centreline of the Final Approach controller radar display and the Tower controller Air Traffic Monitor (ATM) display.

The initial arrival sequence could be taken from an AMAN server and input into the separation tool. Alternatively, it can be generated by a dedicated functionality based on actual aircraft position and the expected distance to fly to threshold or it can be taken from the Electronic Flight Progress Strip (EFPS). The controllers shall have the ability to manually alter this sequence using a sequence switching HMI.

TDIs are to be displayed on the extended runway centreline for all leader aircraft that are established on the localiser. The computation and display of ITD and FTD shall start at a moment defined according to a combination of factors relating to an aircraft's position and vector within a defined volume of airspace.

Figure 3 below shows an example of implementation design for the TDIs: in this example, shapes are constraints specific and colours are CWP specific.

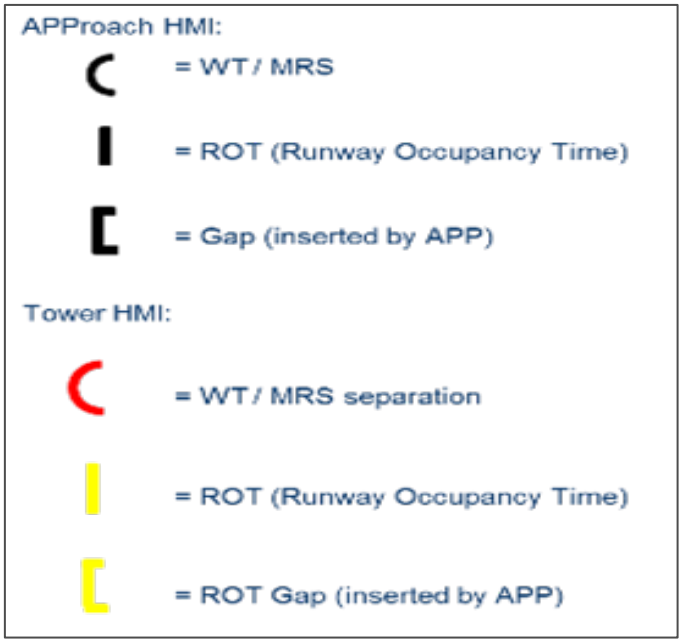


Figure 3: Example of HMI Design for TDIs

MODES OF OPERATION

In case of conditional application of the time-based mode, the concept utilises a wind threshold to provide a safety buffer depending upon the local airport wind variability and the wind forecasting

reliability to ensure that the concept allows for a maximum x seconds of errors in the FTD computation. This means the system requires two modes of operation:

- Distance Based (DBS);
- Time Based (TBS).

In both modes (under normal operating conditions) the same HMI will be used. In DBS mode the FTD will be defined by the distance separations of the selected WT scheme, whilst in TBS mode the FTD will be computed as a function of leader and follower category pair, the time separation from the Pairwise time separation table, the glideslope headwind profile and the follower final approach TAS profile or time-to-fly profile. In both modes the ITD will be computed as a distance added to the FTD, function of leader and follower final approach TAS profile or time-to-fly profile and headwind profile on the glideslope. The controllers and supervisors are shown the current mode of operation through an indication on the HMI.

The decision to switch between DBS mode and TBS mode shall be taken by the Approach and Tower Supervisor on the basis of the information provided by the MET services.

The separations are applied on the basis of wind conditions that may change from the time the separation is computed (at the latest before interception) and the time the aircraft reach the safety critical region of the glide below 300ft, meaning these separations have to be robust to wind conditions variation.

If the glideslope headwind profile is, for example, overestimated by the forecast, the result will be to observe a higher average groundspeed compared to the Separation Delivery Tool expectations and, as a consequence, a lower time separation applied than initially expected by the tool which could increase the risk of WVE.

The decision to activate the TBS mode shall be based on a criterion (total wind threshold) ensuring that whatever the reduction allowed in distance separation, the WVE risk will remain acceptable. As an example, because wake decay is strongly correlated to wind the threshold could be based on the total wind (not only headwind) in the critical region (below 300ft: reasonable worst location on the glide path where separations are designed).

The transition from one mode (TBS or DBS) to the other shall not jeopardize the capability of the ATCO to perform his separation duties. The two different modes share the same HMI and they both have TDIs (unless in case of system failure). The main significant difference with TBS mode active with respect to DBS mode is that the FTD is reduced compared to the DB separations.

A decision on the transition from DBS mode to TBS mode or vice versa shall have been made through a coordination process between the Approach and Tower Supervisor and the MET services. The decision shall be based on information about stable wind conditions and above a pre-defined wind threshold.

Once the decision is taken, both the Approach and Tower controllers are informed, and the requested operations are done in due time in order to have the same mode of operation on all the working positions.

In case of an unexpected drop in the total wind below the minimum threshold a tactical decision to go back to DB mode shall be taken. Once again, the decision is coordinated amongst the Approach and

Tower Supervisors and the MET service. This is however considered as an abnormal mode and should remain a rare event. For avoiding it, a tactical decision (coordinated with MET services) to switch mode can be anticipated or postponed if the weather evolution turns out to deviate from the initial prediction.

HARMONISATION WITH OTHER SEPARATION AND SPACING CONSTRAINTS ON FINAL APPROACH

The separation delivery tool can use different Wake Turbulence scheme to maintain the separations between aircraft pair. The schemes can be the standard reference used nowadays at European airport like ICAO or RECAT-EU or more advanced schemes. Two of these new advanced schemes are part of the PJ.02.01 work: Static Pairwise Separation and Weather Dependent Separations for Arrivals (see sections 3.1.2.1 and 3.1.2.2).

The Separation Delivery Tool factors in the Minimum Radar Separation (3NM or 2.5NM), the runway occupancy time (ROT) or other additional in-trail/not-in-trail separation/spacing constraints (e.g. scenario specific spacing, spacing minimum which may be different from the MRS, specific airborne constraint, etc.).

The Final Target Distance indicator is required to reflect the maximum separation or spacing constraint to be applied between the arrival pair.

3.1.3 Summary of WT separation modes covered by this safety assessment for the arrivals concepts solutions

The following **WT separation modes** of operation based on combinations of the new WT separation concepts outlined in the previous sub-sections are covered in this safety assessment:

Id.	WT separation scheme& associated operation	Concepts involved
DB-PWS-A	Distance Based PWS-A (RECAT-EU-PWS)	PWS-A, ORD
TB-PWS-A	Time Based PWS-A (TB RECAT-EU-PWS)	TB, PWS-A, ORD
A-TB-WDS-Tw	WDS-A Total wind based on conditional reduction of TBS minima	A-WDS-Tw, TB, ORD
A-TB-WDS-Xw	WDS-A Crosswind based on conditional reduction of TBS minima	A-WDS-Xw, TB, ORD
A-TB-WD-PWS-Tw	WDS-A Total wind based on conditional reduction of TB-PWS-A minima	A-WDS-Tw, TB, PWS-A, ORD
TB-WD-PWS-Xw	WDS Cross wind based on conditional reduction of TB-S-PWS minima	A-WDS-Xw, TB, PWS-A, ORD

All WT separation modes are based on the use of Target Distance Indicators (TDI) and as such are supported by the ORD separation delivery tool.

In the current report the DBS and DB-PWS-A modes will be referred to as “Distance Based” (DB) modes whilst the TB-PWS-A, A-TB-WDS-Tw, A-TB-WDS-Xw, A-TB-WD-PWS-Tw and A-TB-WD-PWS-Xw modes will be referred to as “Time Based” (TB) modes. The WDS-A modes represent a sub-category of the

Time-Based modes. The headwind TBS concept applied currently at Heathrow (with no conditional application) is referred to as "TBS".

Note that the safety assessment for the TB and DB modes with indicators has been done in SESAR 1.

3.2 Solution Operational Environment and Key Properties

This section describes the key properties of the Operational Environment that are relevant to the SESAR Solution PJ.02-01 safety assessment (information summarized from SPR-INTEROP/OSED Part I Section 3.2[21]) relevant for the Arrivals Concepts Solutions.

3.2.1 Airspace and Airport characteristics for the Arrivals Concepts Solutions

The Arrivals Concepts Solutions are applicable to capacity constrained Very Large Airports (more than 250k movements per year), Large Airports (between 150k and 250k movements per year) and Medium Airports (between 40k and 150k movements per year). These airports typically operate in Very High, High or Medium Complexity TMA sub-operating environments.

The runway configurations and modes of runway operations employed at European Very Large, Large and Medium Airports include:

- Single runway operating in mixed mode operations
- Independent parallel runways operating in segregated mode operations
- Dependent parallel runways operating in segregated mode operations with the option of some arrival aircraft landing on the designated departure runway
- Closely spaced parallel runways operating in segregated mode operations
- Closely spaced parallel runways operating in mixed mode operations

3.2.2 Types of Airspace – ICAO Classification for the Arrivals Concepts Solutions

Control areas around aerodromes are usually ICAO Class C or D:

- **ICAO Class C:** IFR and VFR flights are permitted, all flights are provided with air traffic control service and IFR flights are separated from other IFR flights and from VFR flights. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights
- **ICAO Class D:** IFR and VFR flights are permitted, and all flights are provided with air traffic control service, IFR flights are separated from other IFR flights and receive traffic information in respect to VFR flights, VFR flights receive traffic information in respect of all other flights.

An ATC clearance is needed and compliance with ATC instructions is mandatory. A speed limit of 250 KIAS applies if the aircraft is below FL 100 (10,000ft) in the UK.

3.2.3 Airspace Users – Flight Rules for the Arrivals Concepts Solutions

The type of traffic permitted at an aerodrome and the associated restrictions is specified in the Aeronautical Information Publication (AIP) for the aerodrome. For example, Heathrow permits IFR traffic and also VFR and SVFR traffic under associated restrictions.

3.2.4 Traffic Levels and complexity for the Arrivals Concepts Solutions

In the Reference Scenarios the level of arrivals traffic in peak hours is as per the current RWY throughput at the respectively Very Large, Large and Medium airports.

In the Solutions Scenarios the level of arrivals traffic in peak hours is as per the increased RWY throughput enabled by the Solutions.

3.2.5 Separation Minima

In Baseline:

- The ICAO radar separation standards for arrivals and departures including MRS, which prevents aircraft collision, and WT separation which is intended to protect aircraft from adverse Wake Turbulence Encounters (WTEs).
- For Arrivals, that involves distance-based WT separations based on WT categories as per e.g. ICAO, RECAT-EU 6 category or UK 6 category schemes.
- For arriving aircraft category pairs with no defined WT separation then the MRS is to be applied. This is typically 3 Nautical Miles (NM) although can be 2.5NM under certain conditions prescribed in ICAO Doc 4444 or as prescribed by the appropriate Air Traffic Services (ATS) authority.

With the Solution Scenarios:

- With PWS-A the ATCOs will apply a separation scheme where separations are based on each aircraft type pair instead of the standard separations scheme where aircraft types are grouped on categories. Additionally, a refined wake category scheme of 20 categories (RECAT-EU 6-CAT plus a further breakdown to an additional 14 refined categories) has been defined for aircraft types not covered by the aircraft type pairwise matrix.
- With WDS-A the WT separations will be reduced thanks to weather conditions (total wind or crosswind) favourable for the concepts. With the crosswind concept there is still a need to provide for sufficient time for the upwind vortex generated by the lead aircraft type to be crosswind transported clear of the downwind wing of the follower aircraft type taking into account the relative lateral navigation performance of the lead and follower aircraft along the extended runway centre-line of the straight-in approach path. For the total wind concept there is still a need to take into account the time separation required for the wake turbulence generated by the lead aircraft to decay so that it is safe to be encountered by the follower aircraft.
- When the runway occupancy time spacing for providing for clearance of the runway by the lead aircraft in time for the follower aircraft to be able to be given clearance to land (ROT Spacing) is the largest separation or spacing constraint then this is required to be applied between the arrival pair. This may be applied as a pre-defined ROT Spacing between wake category pairs where the lead aircraft type has a mean arrival runway occupancy time (aROT) significantly greater than 50s (such as RECAT-EU CAT-A aircraft types of up to around 90s, RECAT-EU CAT-B aircraft types of up to around 75s and RECAT-EU CAT-C aircraft types of up to around 65s), or as Spacing Minimum adjusted dependent on the headwind conditions on final

approach for non-wake pairs where the lead aircraft has a mean aROT of less than 50s (e.g. RECAT-EU CAT-D, CAT-E and CAT-F aircraft types).

3.2.6 Aircraft ATM capabilities for the Arrivals Concepts Solutions

The Aircraft ATM capabilities are as per the Reference Scenario IFR/VFR/SVFR operations at the respectively Very Large, Large and Medium airports. No additional ATM capabilities are envisaged.

The Aircraft ATM Capabilities include the following:

- Transponder (Elementary Mode-S Surveillance (ELS) or Mode A/C)
- Transponder (Enhanced Mode S Surveillance (EHS) (for UK Airports)
- Air-Ground Voice Communication System (VCS)
- Flight Management System (FMS) Capability

3.2.7 Ground ATM capabilities

In the Reference Scenarios:

- Flight Data Processing System
- Arrival Manager
- Departure Manager (for mixed mode)
- Airport Collaborative Decision Making (A-CDM) (for mixed mode)
- Advanced Meteorological Information
- Surveillance System for Surface Movement (e.g. Advanced Surface Movement Guidance and Control System (A-SMGCS))
- Tower CWPs (Airport Tower Supervisor, Tower Runway Controller, Tower Ground Controller, Tower Clearance Delivery Controller or Apron Manager)
    - Electronic Flight Progress Strips
    - Traffic Situation View Display
    - Meteorological Information Display
    - ATC Voice Communications
- TMA CWPs (TMA Supervisor, TMA Planning Controller, TMA Executive Departure Controller, Final Approach Controller)
    - Flight Progress Strips (Either electronic or paper)
    - Radar Situation View Display
    - ATC Voice Communications

With the Solution Scenarios:

Besides the ATCO delivery Tool support for Arrivals which are part of the Change (see details at §2.3.2 in the SAP) the following ground ATM capabilities are considered in the operational environment:

- Local environment weather information and wind forecasting and monitoring capabilities (TBS, ORD, PWS-A and WDS-A concepts rely on wind forecasting and monitoring at the surface and along the final approach path).

- Aircraft performance information in support of ORD concept
- Trajectories information in support of ORD concept.

3.2.8 Terrain Features – Obstacles for the Arrivals Concepts Solutions

There is a requirement to take into account terrain features and obstacles that may impact the wind field when developing and validating the WDS-A concepts. The local topography such as hangar buildings, terminal buildings and high ground in the vicinity of the aerodrome may impact both surface winds and winds aloft on the straight-in approach path.

3.2.9 CNS Aids for the Arrivals Concepts Solutions

No anticipated change from Reference Scenarios for current operations. These include:

- Air-Ground Voice Communication System
- Ground-Ground Voice Communications System
- Instrument Landing System (ILS) and possibly Microwave Landing System (MLS) for some airports
- RNAV / GNSS Navigation Services
- Possibly Ground Based Augmentation System (GBAS) for some airports
- Primary & Secondary Radar Surveillance System for the TMA and Initial, Intermediate and Final Approach
    - Elementary Mode-S Surveillance (ELS) or Mode A/C
    - Enhanced Mode S Surveillance (EHS) (for UK Airports)
- Surveillance System for Surface Movement (e.g. Advanced Surface Movement Guidance and Control System (A-SMGCS)) including some coverage of the landing stabilisation phase of Final Approach.

3.3 Airspace Users Requirements for the Arrivals Concepts Solutions

According to the OSED, the following airspace user requirements are relevant for PJ.02 01:

- Flight Crews shall be briefed on the applicable concept (e.g. PWS-A or WDS-A) to ensure sufficient understanding. Also, they shall be aware of the current mode of operation at the airport which can be achieved through the Digital Automatic Terminal Information Service (D-ATIS).
- Flight Crew shall notify the Approach Controller of an inability to fly the standard procedure or of any non-conformant final approach speeds.
- The aircraft type is an important input into the Separation Delivery tool due to the possible implications of an error. The Flight Crew could be required to confirm aircraft type on first call to allow the Controllers to cross check it. If this is not feasible then an alternative method to reduce the chance of aircraft type errors will need to be found (i.e. via Datalink).
- The cautionary wake vortex advisory phraseology may require to be modified for the applicable concept.
- Additional spacing can be requested by Flight Crew but it is expected to be rare as Flight Crew will be briefed on the applicable concept.

3.4 Safety Criteria

3.4.1 Relevant Pre-existing Hazards for the Arrivals Concepts Solutions

A pre-condition for performing the safety assessment for the introduction of a new concept is to understand the impact it would have in the overall ATM risk picture. The SRM Guidance D and E [2] provide a set of Accident Incident Models (AIM – one per each type of accident) which represent an integrated risk picture with respect to ATM contribution to aviation accidents.

In order to determine which AIMs are relevant for each of the PJ.02.01 Arrivals Concepts Solutions, this sub-section presents the relevant aviation hazards (that pre-exist in the operational environment before any form of de-confliction has taken place) that have been identified within the HP & SAF scoping & change assessment session (using Guidance F.2.2 of [2]).

It has been concluded that the safety-relevant impact of the change brought in by the Arrivals Concepts Solutions is limited to the Interception and Final Approach Path (including initiation of a Missed Approach (Go-Around)). The relevant pre-existing hazards, together with the corresponding ATM-related accident types and AIMs are presented in Table 1 for the Arrivals Concepts Solutions.

Pre-existing Hazards [Hp]	ATM-related accident type & AIM model
Hp#1a "Adverse Wake Encounter on Final Approach"	Wake Turbulence-induced Accident (WTA) on Final Approach Path & associated AIM in Appendix D
Hp#2a "Situation in which the intended 4D trajectories of two or more airborne aircraft are in conflict- Final Approach"	Mid-Air Collision (MAC) on the Final Approach Path & associated AIM in Appendix D
Hp#3 "The preceding landing aircraft are not clear of the runway-in-use"	Runway Collision (RC) & associated AIM in Appendix D

Table 1: Pre-existing hazards relevant for the PJ.02-01 Arrivals Concepts Solutions

3.4.2 Safety Criteria Definition

This section defines the set of Safety Criteria applicable to the operational scenarios for the arrivals concepts solutions.

Safety Criteria (SAC) define the acceptable level of safety (i.e. accident and incident risk level) to be achieved by the Solution under assessment, considering its impact on the ATM/ANS functional system and its operation.

The SAC setting is driven by the analysis of the impact of the Change on the relevant AIM models (models identified at §3.4.1) and it needs to be consistent with the SESAR safety performance targets defined by PJ 19.04 (as per [20]).

For PJ.02-01 the Safety Validation Target is:

"The reduction in the total number of WAKE Final Approach accidents per year of -0.33% and in the total number of RWY Collision accidents per year of -0.53%, due to SESAR 2020 improvements with respect to a hypothetical "do nothing" scenario, in which no changes are made to ATM safety of the

Baseline (2005) while traffic is allowed to increase until it reaches the capacity level targeted for SESAR in 2035."

(note that the safety benefit is the outcome of maintaining the Baseline safety levels whilst accepting the Capacity benefit i.e. traffic increase brought in by the Concept)

Two sets of safety criteria are formulated:

- A first one aimed at ensuring an appropriate Separation design i.e. definition of WT separation minima which, if correctly applied in operation, guarantee safe operations on final approach segment and initial common approach path respectively;
- A second one aimed at ensuring correct Separation delivery i.e. that the defined WT separation minima are correctly applied by ATC.

SEPARATION DESIGN

The following definition will be employed to designate a **pair of aircraft**:

Two consecutive arrivals on the same runway, or on Closely Spaced Parallel RWYs (CSPR), or an arrival following a departure in mixed mode on the same runway or on CSPR.

A SAC is defined for each Arrival WT separation mode within the scope (PWS-A, WDS-A) driven by the applicable WT Accident AIM model (Final Approach – see Appendix D).

- on risk of WT Encounter on Final Approach related to correct application of the WT scheme under consideration (see in AIM WT on Final Approach model Appendix D the outcome of precursor Wake Encounter (WE) 6S "Imminent wake encounter under fault-free conditions" not mitigated by barrier B2 "Wake encounter avoidance")

A-TB-WDS-Tw-SAC#1: The probability per approach of wake turbulence encounter of a given severity for a given traffic pair spaced at WDS Total wind minima on Final Approach segment for any applicable total wind conditions shall not increase compared to the same traffic pair spaced at reference distance WTC-based minima in reasonable worst-case conditions*.

* Reasonable worst-case conditions recognized for WT separation design (as detailed at [7] §4.2.1)

A-TB-WDS-Xw-SAC#1: The probability per approach of wake turbulence encounter of a given severity for a given traffic pair spaced at WDS Cross wind minima on Final Approach segment for any applicable cross wind conditions shall not increase compared to the same traffic pair spaced at reference distance WTC-based minima in reasonable worst-case conditions*.

RECAT-EU-PWS-SAC#1: For an aircraft type pair at RECAT-EU-PWS minima on Final Approach segment, the pair-wise wake turbulence encounter severity shall not be higher than the severity of reference aircraft type pair (selected as acceptable baseline with proven extensive operations) at ICAO minima and in reasonable worst-case conditions*

The **strategy intended for meeting the above SACs** will rely upon the analysis of experimental data (traffic, meteo, wake) possibly combined with modelling. The relevant evidence is provided in Wake Turbulence Re-categorisation and Pair-Wise Separation Minima on Approach and Departure (RECAT-EU-PWS) Safety Case.

Once the Design has met the SAC above, the following safety issue still remains to be addressed:

Safety issue: The frequency of wake turbulence encounters at lower severity levels might increase due to the reduced separation minima. As the frequency of wake turbulence encounters at each level of severity depends on local traffic mix, local wind conditions and proportion of time of application of the concept, there is a need to find a suitable way for controlling the associated potential for WT-related risk increase.

An additional SAC, to be derived on each WT separation mode, is defined in order to cap the safety risk from the case where the correctly defined WT separation minima are not correctly applied, with potential for severe wake encounter higher than if those minima were correctly applied.

- on risk of Imminent wake encounter under unmanaged under-separation (see WE 6F in AIM WTA Final Approach model Appendix D):

  A-SAC#F1: The probability per approach of imminent wake encounter under unmanaged under-separation on Final Approach shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline)

The **strategy** intended for meeting the A-SAC#F1 relies upon qualitatively showing that the use of the tool will involve a significant reduction of the frequency of unmanaged under-separations which will compensate for the risk increase brought in by the higher probability of imminent wake encounter associated to those unmanaged under-separations.

SEPARATION DELIVERY

A set of SACs, to be derived on each WT separation mode, are defined in order to ensure that the defined WT separation minima are correctly applied for separation delivery, i.e. that the right Functional System in terms of People, Procedures, Equipment (e.g. separation delivery tool) is designed such as to enable safe operation in each separation mode.

The correct application of WT separation minima needs to account for the additional separation constraints imposed by the Surveillance separation (during interception and along the final approach path) and the need of preventing RWY collision[2]. For achieving that, the safety risk related to under-separation and its precursors needs to be controlled, driven by the AIM WT on Final Approach models and accounting for constraints imposed by the MRS minima and by the AIM RWY collision model.

- on risk of Unmanaged under-separation (WT) in adequate separation mode during interception and final approach (see WE 7F.1 in AIM WT on Final Approach model Appendix D):

A-SAC#F2: The probability per approach of Unmanaged under-separation (WT) in adequate separation mode during interception & final approach shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline)

- on risk of Unmanaged under-separation induced by inadequate selection & management of separation mode i.e. selection of and transition between any adequate modes of operation i.e. A-WDS-Tw, A-WDS-Xw, DBS (see WE 7F.2 in AIM WT accident on Final Approach model):

A-SAC#F3: The probability per approach of unmanaged under-separation (WT) during interception & final approach shall not increase due to inadequate selection of or transition between any adequate modes of operation

- on risk of Imminent infringement (WT) during interception and final approach (see WE 8 in AIM WT accident on Final Approach model):

A-SAC#F4: The probability per approach of Imminent infringement (WT) during Interception & final approach shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline)

- on risk of Imminent collision during interception and final approach path (see in AIM MAC FAP model MF4):

A-SAC#F6: The probability per approach of Imminent collision during interception and final approach shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline).

- on risk of Imminent infringement (radar separation) during interception and final approach path (see in AIM MAC FAP model MF5.1 and MF7.1):

[2] In case of aircraft inability to recover from a severe wake encounter a wake accident will occur (encompassing loss of control or uncontrolled flight into terrain; that is not related to the Controlled Flight into Terrain accident and associated AIM model)

A-SAC#F7: The probability per approach of Imminent infringement (radar separation) during interception and final approach shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline).

- on risk of Crew/Aircraft induced spacing conflicts (spacing conflicts induced by Crew/Aircraft and not related to ATC instructions for speed adjustment) during interception and final approach (see WE 10/11 in AIM WT accident on Final Approach model):

A-SAC#F5: The probability per approach of Crew/Aircraft induced spacing conflicts during interception & final approach shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline)

- on risk of runway conflict due to conflicting ATC clearances (see in AIM RWY collision model D.2, the precursor RP2.4 which might be caused by e.g. spacing management by APP ATCO without considering ROT constraint or APP ATCO clearing a/c to land while another a/c has been cleared for line-up (applicable only in mixed mode) and which outcome is mitigated by B2: ATC Collision Avoidance involving e.g. last moment detection by TWR ATCO with or without Runway Incursion Monitoring and Conflict Alert System RIMCAS):

A-SAC#R1: The probability per approach of Runway Conflict resulting from Conflicting ATC clearances shall be no greater in operations based on WT scheme under consideration than in current operations applying reference minima (e.g. ICAO or an established operational baseline)

It should be noted that no SAC was derived for the risk of Runway conflict due to premature landing (not cleared by ATCO) or unauthorised RWY entry of ac/vehicle as no change is introduced by the arrivals concepts compared to today's operations.

4 Safety specification at ATS service level

4.1 Overview of activities performed

This section addresses the following activities:

- derivation of Safety Objectives in view of mitigating the relevant risks inherent to aviation in normal conditions of operation– section 4.2
- assessment of the adequacy of the ATS operational services provided by the Solution under abnormal conditions of the Operational Environment & derivation of necessary SOs – section 4.3
- assessment of the adequacy of the ATS operational services provided by the Solution in the case of internal failures and mitigation of the Solution functional system-generated hazards through derivation of SOs – section 4.4

4.2 Mitigation of Risks Inherent to Aviation – Normal conditions

The arrival concepts under assessment are applicable to the final approach operations from merging for interception until the aircraft has landed. Therefore, both Approach Control Service and Aerodrome Control Service are impacted by these concepts. The operational services (i.e. delivered to the Airspace Users) listed in Table 2 have been seen as relevant to these concepts.

ID[3]	Air Navigation Service Objective	Pre-existing Hazard
Airport Operational Scenario Planning Phase		
ACT	Determination and activation of the separation mode (in case of conditional application of the Time-Based modes) Note: only automatic de-activation is possible (TB to DB mode), the activation (DB to TB mode) has to always be done manually by the controllers/supervisors	**Hp#1a** (Wake risk)
GPM	Coordination of pre-planned or tactical GAP management	**Hp#3** (Runway collision risk)
Approach and Landing		
FCF	Facilitate capture of the Final approach	**Hp#1a** (Final Approach wake risk) **Hp#2a** (Final Approach MAC risk)
SP2	Maintain separation between aircraft intercepting different final approach paths (closely spaced parallel runways)	**Hp#1a** (Final Approach wake risk) **Hp#2a** (Final Approach MAC risk)

[3]SP= SeParate aircraft with other aircraft; FCF= Facilitate Capture of the Final approach; ACT = Activation/Transition phase.

SP3	Maintain spacing/separation between aircraft on the same final approach path	**Hp#1a** (Final Approach wake risk) **Hp#2a** (Final Approach MAC risk) **Hp#3** (Runway collision risk)
SP4	Maintain aircraft separation between successive arrivals on the Runway Protected Area (RPA)	**Hp#3** (Runway collision risk)
SP5	Maintain aircraft separation between arrivals and departures in mixed mode (departure behind an arrival vacating or departure in front of arrival) on the Runway Protected Area (RPA)	**Hp#3** (Runway collision risk)

Table 2: Relevant ATM/ANS services and Pre-existing Hazards for the PJ.02-01 Arrivals Concepts Solutions

4.2.1 Safety Objectives at Service level for Normal conditions of operation

The purpose of this section is to derive functionality & performance Safety Objectives (as part of the success approach) in order to mitigate the pre-existing aviation risks under normal operational conditions (i.e. those conditions that are expected to occur on a day-to-day basis) such as to meet the defined Safety Criteria.

To derive the Safety Objectives one needs to interpret, from a safety perspective, the OSED Operational Concept specification (i.e. how the PJ.02-01 concept contributes to the aviation safety) by making use of the European Air Traffic Management Architecture (EATMA) representation as per the Operational layer. More specifically, this means using the OSED Use Cases and their representation through the EATMA Process Models as defined by the PJ.02-01 OSED. The purpose is to derive a complete list of Safety Objectives, allowing to specify the Change involved by the Concept at the operational service level, by considering the PJ.02.01 concepts as a series of continuous processes described through the Use Cases. This allows showing how the Safety Objectives participate in the achievement of the relevant operational services and contribute to safety barriers (in the relevant AIM models) i.e. how they contribute to meeting the Safety Criteria.

The OSED presents the consolidated list of functionality & performance Safety Objectives (SO) under normal operational conditions. The link to the Safety Criteria is shown in the last column for each SO, via the relevant Use Case and operational service that are concerned with the change and allowed the SO derivation.

ID	Safety Objective *(success approach)*	Use Case	Operational Service	Related SAC# (AIM Barrier or Precursor)
	ATC shall be able to apply consistent and accurate DBS, TBS, PWS-A or WDS-A wake turbulence separation rules on final approach (encompassing interception) and landing, through operating under Distance Based modes (DBS, DB-PWS-A) and Time Based modes (TBS, T-PWS-A, A-WDS-Tw and A-WDS-Xw), with the possibility to safely switch between a TB-mode and the corresponding DB-mode. **LIM#005:** Regarding the conditional application of Time-Based modes, in line with the OSED, only the activation and deactivation conditions of each WT separation mode and the switching between each TB-mode and the corresponding DB-mode are covered within this specification and related safety assessment, but not other transitions between modes.	Airport Operational Scenario Planning Phase for PWS, WDS and ORD for Arrivals	ACT: Determination and activation of the separation mode (in case of conditional application of the Time-Based modes)	**SAC#F2** **SAC#F3**
SO 002	In case of conditional application of Time Based (TB) modes, ATC shall apply the correspondent WT separation minima only when the predefined activation criteria for the considered TB-mode are met i.e. specified wind parameter(s) measured against pre-determined wind threshold(s).	As above	As above	**SAC#F3**

ID	Safety Objective *(success approach)*	Use Case	Operational Service	Related SAC# (AIM Barrier or Precursor)
SO 003	In case of conditional application of TB-modes the wind threshold(s) for the activation criteria specific to each TB-mode shall be determined to mitigate the risk of wake vortex encounter due to the uncertainties on the wind profile prediction data and on the aircraft adherence to the generic airspeed profile	As above	As above	**Any mode-A-SAC#F1** **SAC#F3**
SO 004	In case of conditional application of TB- modes, ATC shall apply the corresponding distance-based WT separation mode (DBS or respectively DB-PWS-A) when the activation criteria for TBS, TB-WDS-A modes or respectively TB-PWS-A and A-TB-WD-PWS modes are not met anymore	As above	As above	**SAC#F3**
SO 005	In a given WT separation mode, ATC shall sequence and instruct aircraft to intercept the final approach path such as to establish and maintain applicable separation minima on final approach segment based on the displayed Target Distance Indicators corresponding to that separation mode		FCF: Facilitate capture of the Final approach path SP3: Maintain spacing/separation between aircraft on the same final approach path	**A-SAC#F2** **A-SAC#F4**
SO 006	The Target Distance Indicators shall be calculated and displayed to correctly and accurately represent the greatest constraint out of wake separation minima of the mode under consideration (for all traffic pairs and in the full range of weather and operating conditions pertinent		FCF: Facilitate capture of the Final approach path SP3: Maintain spacing/separation between aircraft on the same final approach path	**A-SAC#F2** **A-SAC#F4** **A-SAC#F6** **A-SAC#F7**

ID	Safety Objective *(success approach)*	Use Case	Operational Service	Related SAC# (AIM Barrier or Precursor)
	for that mode), the MRS, the runway spacing or other spacing constraint (e.g. departure gaps)		GPM: Coordination of pre-planned or tactical GAP management	**A-SAC#R1** **A-SAC#R2**
SO 007	The design of the Separation Delivery Tool and associated operating procedures and practises shall not negatively impact Flight Crew/Aircraft who shall be able to follow ATC instructions in order to correctly intercept the final approach path in the mode under consideration		FCF: Facilitate capture of the Final approach path	**A-SAC#F5**
SO 008	In a given WT separation mode, ATC shall provide correct spacing minima delivery from final approach path acquisition until landing based on separation indicators correctly computed for that separation mode.		SP3: Maintain spacing/separation between aircraft on the same final approach path	**A-SAC#F2** **A-SAC#F4** **A-SAC#F6** **A-SAC#F7** **A-SAC#R1** **A-SAC#R2**
SO 009	ATC and Flight Crew/Aircraft shall ensure that the final approach path is flown whilst respecting the aircraft speed profile (unless instructed otherwise by ATC or airborne conditions require to initiate go around) in order to ensure correctness of the separation indicators		SP2: Maintain separation between aircraft intercepting different final approach path (closely spaced parallel runways) SP3: Maintain spacing/separation between aircraft on the same final approach	**A-SAC#F5**

ID	Safety Objective *(success approach)*	Use Case	Operational Service	Related SAC# (AIM Barrier or Precursor)
SO 010	ATC (and potentially Flight Crew/Aircraft) shall consider the potential for WDS separation infringement due to lateral deviation from final approach path (e.g. dog leg when WDS crosswind is operated)		As above	**A-SAC#F2** **A-SAC#F4** **A-SAC#F5**
SO 011	The runway spacing or other spacing constraint (e.g. departure gaps) shall be input to and accounted for the Separation Delivery Tool (in support of SO 006) It is assumed that landing clearances will be provided in the same manner as per current operations based on WTC scheme		SP4: Maintain aircraft separation between successive arrivals on the Runway Protected Area (RPA) Maintain aircraft separation between arrivals and departures in mixed mode (departure behind an arrival vacating or departure in front of arrival) on the Runway Protected Area (RPA) GPM: Coordination of pre-planned or tactical GAP management	**A-SAC#R1**
SO 012	TWR ATC shall request the insertion of departure gaps from APP ATC, and shall coordinate with APP the modification and cancellation of these gaps as operationally needed		GPM: Coordination of pre-planned or tactical GAP management Maintain aircraft separation between arrivals and departures in mixed mode (departure behind an arrival vacating or departure in front of arrival) on the Runway Protected Area (RPA)	**A-SAC#R1** **A-SAC#R2**

Table 3 PJ.02.01 Safety Objectives (success approach)

4.3 Mitigation of Risks Inherent to Aviation - Abnormal conditions

The purpose of this section is to assess the ability of operations based on the new WT separation modes and ATC tools to work through (robustness), or at least recover from (resilience) any abnormal conditions that might be encountered relatively infrequently (these might be either operational situations/use cases that have not been covered in Section 4.2 or conditions external to the scope of the new System which are not under our control).

4.3.1 Identification of Abnormal Conditions

The following abnormal conditions have been identified in Project 06.08.01 in SESAR 1, also relevant for this iteration.

ID	Abnormal Scenario
1	Change of Aircraft landing runway intent
2	Abnormal procedural aircraft airspeed and/or abnormal stabilized approach speed
3	Lead aircraft go-around
4	Delegation of separation to Flight Crew
5	Actual Wind on final approach different from the wind used for FTD/ITD computation
6	Flight Crew Notification of Aircraft Speed non-conformance
7	Unexpected drop of ground wind below safe threshold
8	Late change of landing runway (not planned)
9	Scenario specific spacing requests (e.g. unforeseen need for RWY inspection)

1/ Change of Aircraft landing runway intent

This situation represents the case of an aircraft changing its runway intent late and requiring to be inserted in the sequence of the “new” runway with a sequence already established.

Two distinct cases need to be addressed:

- Change of aircraft intent before merging towards Final Approach
- Change of aircraft intent after merging towards Final Approach or already established

The second case differs from the first one, as the Approach controllers have less time to handle a late change. The risk is for the aircraft to be inserted in the sequence without updating the arrival sequence, which, if not detected involves the use of incorrect TDIs (corresponding to a different aircraft) with potential for imminent infringement and ultimately large under-separation – mitigation is derived as per SO 103.

2/ Abnormal procedural aircraft airspeed and/or abnormal stabilized approach speed

This situation represents the case of an aircraft not respecting the procedural airspeed before the Deceleration Fix (e.g. respecting 160 KIAS) or the stabilized approach speed specific to the aircraft type (e.g. VAPP) after the Deceleration Fix.

For TB-modes, the risk is that both FTD and ITD are erroneous, as their computation is based on the pre-defined TAS profile for that aircraft type, with potential for imminent infringement and ultimately large under-separation – mitigation is derived as per SO 102, i.e. aircraft speed conformance alert.

For DB-modes, only the precision of ITD is affected, with risk of imminent infringement and need to instruct a missed approach due to compression after the deceleration fix – mitigation as per SO 102

For the affected aircraft pair, ATC either needs to apply speed corrections or to manage compression manually and, if in TB-modes, to apply distance-based WTC separation minima if speed corrections can't be applied.

3/ LEAD AIRCRAFT GO-AROUND

This situation represents the case where the lead Aircraft is executing a missed approach at any point during the final approach (either instructed by ATC or decided by Flight Crew).

The risk is for ATCO to not update the arrival sequence which might involve the use of incorrect TDIs (corresponding to a different aircraft) with potential for imminent infringement and ultimately large under-separation – mitigation is derived as per SO 103.

4/ DELEGATION OF SEPARATION TO FLIGHT CREW

This situation occurs in good visibility conditions, in case the Final APP or TWR ATCO needs to delegate the WT separation to Flight Crew (e.g. in case the FTD is going to be infringed, in order to avoid initiating a go around).

If the Flight Crew accepts the request, the Final Approach ATCO or Tower Runway ATCO shall instruct the Flight Crew to maintain visual separation with the aircraft ahead. In this case the responsibility to maintain separation will be passed to the Flight Crew.

No change compared to current operations based on DBS without indicators.

5/ ACTUAL WIND ON FINAL APPROACH DIFFERENT FROM THE WIND USED FOR FTD/ITD COMPUTATION

Impact on the computed/displayed FTD

For the **Time-Based modes,** if the actual wind conditions on final approach are different from the wind conditions provided by the short term MET prediction and used for FTD computation, the displayed FTD will not provide the right separation minima to be applied and in the worst case the shown distance will be lower than the correct one, with risk of under-separation. More specifically the wind conditions used for the FTD computation are:

- In TB-PWS-A modes: glideslope wind profile,
- In A-TB-WDS-Tw and A-TB-WD-PWS-Tw modes: reference Total wind,
- In A-TB-WDS-Xw and A-TB-WD-PWS-Xw modes: reference Cross wind.

In the current safety assessment, the risk of under-separation induced by the uncertainty in glideslope wind prediction (together with the one induced by uncertainty in the actual final approach speed profile) is mitigated as follows:

- Define time separation buffers for the applicable time separation minima and for various wind conditions; these buffers decrease as the wind increases;

- Select, amongst the considered wind conditions, the one which displays the maximum time separation buffer;
- In case of conditional application, reduce the time separation buffer. The conditional application is expected to be used in many implementations, in order to maintain acceptable performance in terms of resilience and/or throughput (note that at airports where wind conditions are stable adding a separation buffer in the design of separation minima to be used by the FTD will be sufficient to mitigate that risk; however, at airports with changing wind conditions a conjunction of an added separation buffer and the conditional application of the time based modes will be necessary).

However, the above mitigations are not sufficient in the longer term, because if the difference in wind conditions persists the operation will be performed with reduced safety margins and higher exposure to risk of imminent infringement and under-separation. An additional mitigation is derived as per SO 101 i.e. wind conditions monitoring and alerting, whilst specifically considering the **type/component of wind relevant** for each time-based separation concept. If in WDS-Tw/Xw, upon being alerted, the ATCOs shall revert to the correspondent distance-based separation mode (DBS or DB-PWS-A). If in TBS or TB-PWS-A, the tool shall re-compute the TDIs based on the correct wind value.

Note: No impact on FTD in DBS and DB-PWS-A modes.

Impact on the computed/displayed ITD

For **all WT separation modes,** the difference between the actual head wind on the glideslope and the glideslope headwind profile used by the separation delivery tool will impact the accuracy of the ITD and in the worst case the spacing shown will be lower than the correct one with risk for needing to instruct a missed approach due to the non-anticipated compression after the deceleration fix. The mitigation derived above can be re used here – SO 101 (with monitoring of the glideslope wind conditions). Upon being alerted the ATCOs shall manage compression without indicators as per today operations.

Note: The case of wind conditions resulting in a significant difference in the ground speed of aircraft being merged from opposite sides of the extended runway centre-line and a significant change in ground speed as the aircraft turn on to final approach does not involve any change in the way APP ATCO is managing the turn for interception in the current DBS operations without indicators. The Target Distance Indicators are correctly displayed, and ATCO will target them when instructing aircraft to turn for interception whilst accounting for the challenging wind conditions in the same way they do it in current operations.

6/ Flight Crew Notification of Aircraft Speed non-conformance

Flight crew provides notification of approach procedural airspeed non-conformance issues and/or unusually slow or fast landing stabilisation speed for the aircraft type.

In order to mitigate the subsequent risk of not providing adequate spacing to cope with the compression effect, APP ATCO shall take into account, for the merging on to final approach, the notified speed-related aspects to determine the additional spacing that is required to be set up behind the ITD indication – mitigation is derived as per SO 104.

7/ Unexpected drop of reference wind below safe threshold

In case of conditional application of the Time Based modes, when the TB-mode activation criteria is not met anymore (i.e. an unexpected drop of the reference wind below the safe threshold), the TB-mode shall be deactivated (revert to correspondent DB- mode) – see SO 004 (derived in Section 4.2)

8/ LATE CHANGE OF LANDING RUNWAY (NOT PLANNED)

This situation represents the case of a change of the assigned landing runway which was not planned, requiring an establishment of a new arrival sequence for this switched runway.

The risk is for using a not correctly updated arrival sequence which, if not detected involves the use of incorrect TDIs (corresponding to a different aircraft) with potential for imminent infringement and ultimately large under-separation – mitigation is derived as per SO 105.

9/ SCENARIO SPECIFIC SPACING REQUESTS

ATCO shall be able to handle requests for spacing which are specific to scenarios like e.g. unforeseen RWY inspection or temporary blockage or aircraft difficulty for braking. The separation delivery tool shall be able to display TDIs behind the adequate aircraft, based on Controller input, as per SO 106.

The following OSED Use case/Non-nominal flows will be addressed when failure conditions are analysed:

- Insufficient spacing on Final approach
- ITD catch-up alert on Final approach.

4.3.2 Safety Objectives at Service level for Abnormal conditions of operation

The following Safety Objectives considering the abnormal conditions identified above have been derived for arrivals:

ID	Description	Abnormal Scenario	Ref. SAC
SO 101	ATC shall be alerted when the actual wind conditions differ significantly from the wind conditions used for the TDIs computation (wind conditions monitoring alert): for the FTD -glideslope wind in TB-modes only; for the ITD – glideslope wind in all modes (TB and DB).	5	**A-SAC#F2** **A-SAC#F3**
SO 102	ATC shall be alerted when the aircraft speed varies significantly from the procedural airspeed and/or the stabilized approach speed used for the TDIs computation (speed conformance alert) in order to manage compression manually	2	**A-SAC#F5**
SO 103	ATC shall maintain an updated arrival sequence order following a late change of aircraft runway intent or a go-around	1 and 3	**A-SAC#F2** **A-SAC#F4** **A-SAC#F5** **A-SAC#F6** **A-SAC#R1**
SO 104	ATC shall take into account, for the merging on to final approach, the notified approach procedural airspeed non-conformance issues and any notified employment of a slow or fast landing stabilisation speed to	6	**A-SAC#F5**

	determine the additional spacing that is required to be set up behind the ITD indication		
SO 105	The Target Distance Indicators shall be correctly updated in case of late (not planned) change of landing runway Issue 02: In case of a late landing runway change, it should be verified if the arrival sequencing tool can be timely reconfigured in order to display the Approach Arrival Sequence for the switched runway and update the TDIs accordingly.	8	**A-SAC#F2** **A-SAC#F4** **A-SAC#F5** **A-SAC#F6** **A-SAC#R1**
SO 106	ATC shall be able to handle scenario specific spacing requests while using the separation delivery tool	9	**A-SAC#R1** **A-SAC#R2**

Table 4: List of Safety Objectives (success approach) for Abnormal Operations for the PJ.02-01 Arrivals Concepts Solutions

4.4 Mitigation of System-generated Risks (failure conditions)

This section concerns operations in the case of internal failures. Before any conclusion can be reached concerning the adequacy of the safety specification at the OSED level, it is necessary to assess the possible adverse effects that failures internal to the end-to-end Functional System supporting the new WT separation modes and ATC tools might have upon the provision of the relevant operations and to derive safety objectives (failure approach) to mitigate against these effects.

This section provides the list of the identified Operational Hazards, their operational effects, with the mitigation of those effects and the associated severity. The severity classification scheme is based on the Wake Turbulence Accident Model (see Appendix D).

4.4.1 Operational Hazards Identification and Analysis

The list of hazards for arrivals is based on the analysis which was previously done in Project P06.08.01 in SESAR 1. These hazards have been refined further for this iteration.

In SESAR 1, a number of safety workshops for TBS phase 1 took place at NATS premises and were facilitated by NATS safety representatives and involving Approach and Tower Controllers. Hazards, their causes and consequences were identified and assessed during these workshops.

Further on, in TBS phase 2, the Operational Hazards relevant for TB-PWS-A with indicators (corresponding to the TBS separation mode) and DB-PWS-A with indicators (corresponding to DBS separation mode) have been identified and analysed within the TB-PWS-A SAF/HF workshop (Dec 2014) [8], complemented by further safety expert analysis supported by project and operational expertise, and the outcomes have been documented in the TB-PWS-A Safety Assessment Report [8]. This document presents the OHA/HAZID table which led to the identification of the Operational Hazards for TBS and DBS modes, including failure mode, possible causes, preventive mitigations; operational effects and protective mitigations based on workshop and brainstorming activities.

In the frame of P06.08.01, the TB-PWS-A hazard identification and analysis has been further extended by the safety, project and operational experts in order to encompass the newly introduced WT separation modes and ATC tools (based on the use of Target Distance Indicators).

The hazards and mitigations were further refined to reflect the developments of PJ.02.01 during a workshop which took place at EUROCONTROL Bretigny on October 30th, 2018. The workshop was facilitated by SAF and HP experts from EUROCONTROL and it included APP, TWR ATCOs and Supervisors, together with safety, human performance and concept experts. For the full list of participants please see Appendix E. Further, a workshop with pilots from Air France and CDG ATCOs took place on the 28th of January 2019 on the Air France premises at CDG airport. The workshop was facilitated by SAF and HP experts from EUROCONTROL and it included APP and TWR ATCOs from DSNA, pilots from Air France, together with safety, human performance and concept experts from EUROCONTROL. The workshop helped clarifying remaining SAF/HP and concept questions for projects PJ.02.01, PJ.02.02 and PJ.02.03. However, only results from PJ.02.01 and PJ.02.03 were kept in this SAR. For the detailed results of this workshop please see Appendix F.

The Operational Hazards have been identified at operational service level, i.e. aligned to the Safety Objectives in normal conditions and such as to allow their anchoring into the AIM Wake Turbulence Accident model.

It should be noted that hazards Hz#01a, 01b, 02a, 02b, 03a, 03b, 04a, 04b apply in the Reference operations as well (i.e. current operations using DBS minima without indicators), with the same operational effects. Meanwhile most of the means for mitigating the hazard effects are modified by the introduction of the new WT separation modes, as Target Distance Indicators are provided to ATCOs for the application of the separation minima applicable in each mode, whilst ensuring that the severity of the hazard effects is not degraded. Obviously, certain hazard causes and associated preventive mitigations are also changed, but that aspect will be tackled within the failure analysis of the SPR-level design in Section 5.5.1.

The following table provide the consolidated list of the Operational Hazards, with their operational effects, the mitigations protecting against effect propagation and the allocated severity. The severity allocation was based on the severity classification schemes of the relevant Accident Incident Models (AIM) as per the guidance to SRM [2] (Guidance E) and which are included in Appendix D.

ID	Hazard Description	High Level Causes (derived from Success SO)	Operational Effects	Mitigations protecting against propagation of effects	Severity *(most probable effect)*
		Inadequate ATCO instruction Inadequate ATCO-pilot communication	When applying WDS for example, ATCO may be drawn into reducing to the new separation minima before the current transition procedures (e.g. from 3 to 2.5NM or 1000ft) allow, especially when the Separation Delivery Tool is used, due to the ATCO being drawn in delivering to the TDI. This means an imminent infringement, i.e. spacing is eroded with risk for temporary and limited under-separation (e.g. less than 0.5 NM) during separation establishment on	**Protective Mitigations** Resolve situation by vectoring, level instructions or go-around WAKE FAP B3 Management of Imminent Infringement MAC FAP B3 ATC Collision Avoidance	WK-FA-SC3b MAC-FA-SC3

[4] Example: LOC overshoot resulting in the follower catching-up the leader that performed the overshot; one cause might be the wrong or untimely ATCO heading instruction; a second cause might be the late Pilot response.

			Final App or later during Final App can happen.		
	Separation not being recovered following imminent infringement of A/C pair instructed by ATC to merge on the Final Approach interception	(e.g. Go around, break off etc- depends on the triggering event) ATCO failure to instruct timely the separation recovery action before the imminent infringement is evolving to a large under-separation Pilot failure to timely execute the separation recovery instruction	Large under-separation (of more than e.g. 0.5 NM) occurs during separation establishment on Final App or later during Final App.	**Protective Mitigations** With respect to WTE risk: Follower within WV influence area, WV survival in the flight path (F6) – this is degraded with MRS 2NM (compared to MRS 2.5NM) The **use of tool is expected to mitigate** that risk increase by contributing to the reduction of separation infringements thanks to the increased separation delivery accuracy. WAKE FAP F6 Wake Decay & Transport MAC FAP B2 ACAS Warning	WK-FA-SC3a MAC-FA-SC2b
	Inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach	Unanticipated pilot/aircraft behaviour during interception (overshoot; a/c lateral, vertical or speed deviation;	Spacing is eroded with risk for temporary and limited under-separation (e.g. less than 0.5 NM) during separation establishment on	**Protective Mitigations** ATC recovery from imminent infringement by adequate action (vectoring, level instructions or go-around)	WK-FA-SC3b MAC-FA-SC3

	interception profile without ATC instruction given	wrong a/c turns on the indicator)	Final App or later during Final App	WAKE FAP B3 Management of Imminent Infringement MAC FAP B3 ATC Collision Avoidance	
	Separation not being recovered following imminent infringement due to aircraft deviation from Final Approach interception profile without ATC instruction given				
	Inadequate separation management of an aircraft pair naturally catching-up as instructed by ATC on the Final Approach	Inadequate use of separation indicators by the APP ATCO when a/c is established on final Lack/loss of indicator for one aircraft on Final App	Imminent infringement, i.e. spacing is eroded with risk for temporary and limited under-separation (e.g. less than 0.5 NM) the Final App	**Protective Mitigations** ATCO detects the missing indicator and: Aircraft established on Final approach stabilized with 160kts IAS and behind ITD is allowed to continue the approach,	WK-FA-SC3b MAC-FA-SC3

				otherwise initiate Go around WAKE FAP B3 Management of Imminent Infringement MAC FAP B3 ATC Collision Avoidance	
	Separation not being recovered following imminent infringement by an aircraft pair instructed by ATC on the Final Approach				
	Inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach profile without ATC instruction given		Spacing is eroded with risk for temporary and limited under-separation (e.g. less than 0.5 NM) on the Final App	**Protective Mitigations** Supported by catch-up warning; Re-clear a/c to fly a different speed if possible OR Go-around; WAKE FAP B3 Management of Imminent Infringement MAC FAP B3 ATC Collision Avoidance	WK-FA-SC3b MAC-FA-SC3

	Separation not being recovered following imminent infringement due to aircraft deviation from Final Approach profile without ATC instruction given				
	One or multiple separation minima infringements due to undetected corruption of separation indicator	Corruption of one or multiple separation indicators	Large under-separation (of more than e.g. 0.5 NM) occurs for one or multiple aircraft pairs on the Final App	**Protective Mitigations** Partial mitigation: Buffer for ITD and FTD take margins on the wind computation. In DB-mode: ATCO will realise that the tool is using incorrect wind reference because successive aircraft separated correctly using the indicators will have the tendency to infringe the correct FTD as the leader decelerates, triggering a go-around by the TWR controller. In TB-modes: It is difficult for the ATCO to realise that the tool is	WK-FA-SC3a MAC-FA-SC2b *However, because multiple aircraft might be affected before failure is detected, a Safety Objective more demanding than the corresponding hazard severity will be allocated via an impact modification factor IM=20*

				using incorrect wind reference. The a/c will be separated according to a wrong FTD, i.e. wake separation infringement. *For the incorrect separation indicator in relation to speed non-conformance:* go-around of the follower (because TDI might be wrong) WAKE FAP F6 Wake Decay & Transport MAC FAP B2 ACAS Warning	
	One or multiple imminent infringements due to lack/loss of separation indicator for multiple or all aircraft		One or multiple imminent infringements, i.e. spacing is eroded with risk for temporary and limited under-separation (e.g. less than 0.5 NM) on the Final App	**<u>Protective Mitigations</u>** ATCO detects the missing indicators and reverts to Baseline DBS (a supporting DBS table is required, especially in TB PWS with multiple categories) Aircraft established on Final approach stabilized with 160kts IAS and behind ITD are allowed to continue the approach All other aircraft – either not established on Final or not at	WK-FA-SC3b MAC-FA-SC3 *However, because multiple aircraft might be affected before failure is detected, a Safety Objective more demanding than the corresponding hazard severity will be allocated via an impact*

				stabilized IAS 160kts or not behind ITD: - Initiate Go-around or break off - Establish ICAO DBS asap WAKE FAP B3 Management of Imminent Infringement MAC FAP B3 ATC Collision Avoidance	*modification factor IM=10*
	One or multiple separation minima infringements induced by ATC through inadequate selection & management of the separation mode		Large under-separation (of more than e.g. 0.5 NM) occurs for one or multiple aircraft pairs during separation establishment on Final App or later during the Final App	WAKE FAP F6 Wake Decay & Transport MAC FAP B2 ACAS Warning	WK-FA-SC3a MAC-FA-SC2b *However, because multiple aircraft might be affected before failure is detected, a Safety Objective more demanding than the corresponding hazard severity will be allocated via an impact modification factor IM=20*
	Runway conflict due to landing	Inappropriate line-up instruction given by	The situation when an arrival aircraft is landing on a	**Preventive Mitigations:**	RWY-C SC3

	clearance in conflict with another landing (ROT not respected) or with cleared line-up/take-off (GAP not respected)	controller (not enough time for take-off without infringing separation with landing aircraft) Lack or wrong coordination with APP ATCO regarding the gap in front of the arrival Pilot slow in executing line-up/take-off results in consuming the arrival gap ATCO delayed instruction for take-off ATCO not compliant with correct ROT Wrong sequence planning information Loss or corruption of the sequence list tool	runway which is being used by a departing aircraft, the two aircraft being thus in conflict, but where the situation is solved by the corrective action of the TWR ATCO (e.g. initiate go-around).	A wrong Sequence planning information is systematically detected by ATCO (via his situation awareness & own view of the correct sequence and possible use of a gap) A failure, loss or corruption of the sequence list tool will have an impact on the ATCO performance, but is safely mitigated by ATCO keeping full awareness of the sequence in the short term. ATCO will apply a more conservative strategy (e.g. instruct 2 departures in a gap instead of the 3 initially planned), will estimate the departures fitting in the arrival gaps by himself. **Protective Mitigations** Go around timely instructed & executed (RWY Col AIM Barrier B2)	
	Runway Conflict not prevented by ATCO involving		The situation when an arrival aircraft is landing on a runway which is being used by a departing aircraft, the		

	unauthorised AC/vehicle		two aircraft being thus in conflict, but where the situation is solved by the corrective action of the TWR ATCO (e.g. initiate go-around).	

Table 5: System-Generated Hazards and Analysis for the PJ.02-01 Arrivals Concepts Solutions

During the 06.08.01 TB-PWS HP/SAF workshop [9], the separation minima infringement (Wake turbulence separation or MRS) was discussed and the outcome of the discussion was the following:

- Approaching the separation indicator ("FTD") with potential for over-passing it, is seen as an imminent infringement (considered a hazard) that requires a separation recovery action (e.g. speed adjustment, Go around as appropriate). In case, whilst waiting for the separation recovery action to become effective, the aircraft temporarily over-passes the FTD with no more than 0.5 NM, that occurrence remains at the same severity level as an imminent infringement.
- If the separation recovery is not timely or not effective, that is an even higher severity hazard (corresponding to a Large under-separation in the Wake Turbulence Accident AIM).
    - Passing more than 0.5 NM in front of the separation indicator ("FTD") is a significant safety occurrence that is required to be recorded & analysed.

Based on this discussion:

- A spacing conflict induced by Crew/Aircraft (i.e. due to aircraft deviation from interception or Final Approach profile) and adequately managed by ATC (no imminent infringement) is classified with a severity SC3b (WAKE FAP) and SC3 (MAC FAP).
- An imminent infringement (encompassing situations where separation minima is temporarily infringed of no more than 0.5 NM, waiting for the separation recovery action to become effective) is classified with a severity SC3b (WAKE FAP) and SC3 (MAC FAP).
- A separation minima infringement of more than 0.5 NM (Large under-separation) is classified with a severity SC3a (WAKE FAP) and SC2b (MAC FAP).

It should be noted that, in the Wake Turbulence Accident AIM, an imminent infringement which is correctly recovered (which might involve a temporary separation infringement of no more than 0.5 NM) is considered to have the same potential for wake encounter as any traffic correctly separated according to the rule.

4.4.2 Safety Requirements at ATS Service level (SRS) associated to failure conditions

Safety Objectives (addressing integrity/reliability) are formulated to limit the frequency at which the operational hazards identified in the previous section could be allowed to occur using the Risk Classification Scheme defined in Appendix G.

Table 6 lists the failure Safety Objectives (integrity/reliability) to be considered during the design phase for arrivals.

Even though all the hazards identified previously have been allocated two severities since they impact both WAKE FAP and MAC FAP, quantitative figures have been assigned only for the WAKE FAP severities. This is because there were no figures for the severity classification scheme of the MAC FAP model at the creation of this safety assessment report. When the figures for the MAC FAP model will be available, the two severities (MAC and WAKE) will have to be compared and the most stringent should be applied for the Safety Objectives in Table 6.

SO ref (hazard severity)	Safety Objectives (integrity/reliability)
Safety Objectives relative to the Final Approach interception phase	
SO 201 Hz#01a (WK-FA SC-3b MAC-FA-SC3)	The frequency of occurrence of the inadequate separation management of a pair of aircraft instructed by ATC to merge on the Final Approach interception (which is nevertheless recovered by ATC i.e. SMI[5]≤0.5NM), shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)* ***Explanation:*** *Computation of the Safety Objective:* $SO = \frac{MTFoO}{N*IM} = \frac{1E-02}{5*1}$ *= 2E-03 occurrences per approach* *Computation of the no of occurrences per day: 2E-03*135000/365 = 0.74* *Which comes to 2 occurrences every 3 days*
SO 202 Hz#01b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement of A/C pair instructed by ATC to merge on the Final Approach interception (SMI>0.5NM) shall not be greater than 4x10-5/ approach *(4x10-5/approach means 6 occurrence per year for an airport with 135,000 landings per year)*
SO 203 Hz#02a (WK-FA SC-3b MAC-FA-SC3)	The frequency of occurrence of the inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach interception profile without ATC instruction given (which is nevertheless recovered by ATC i.e. SMI≤0.5NM), shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)*
SO 204 Hz#02b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement due to aircraft deviation from Final Approach interception profile without ATC instruction given (SMI>0.5NM) shall not be greater than 4x10-5/approach *(4x10-5/approach means 6 occurrence per year for an airport with 135,000 landings per year)*
Safety Objectives relative to the Final Approach phase	
SO 205 Hz#03a (WK-FA SC-3b MAC-FA-SC3)	The frequency of occurrence of the inadequate separation management of an aircraft pair naturally catching-up as instructed by ATC on the Final Approach (which is nevertheless recovered by ATC i.e. SMI≤0.5NM) shall not be greater than 2x10-3 /approach

[5] SMI stands for Separation Minima Infringement (WT or MRS)

	(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)
SO 206 Hz#03b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement by an aircraft pair instructed by ATC on the Final Approach (SMI>0.5NM) shall not be greater than 4x10-5/approach *(4x10-5/approach means 6 occurrences per year for an airport with 135,000 landings per year)*
SO 207 Hz#04a (WK-FA SC-3b MAC-FA-SC3)	The frequency of occurrence of the inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach profile without ATC instruction given (which is nevertheless recovered by ATC i.e. SMI≤0.5NM) shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)*
SO 208 Hz#04b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement due to aircraft deviation from Final Approach profile without ATC instruction given (SMI>0.5NM) shall not be greater than 4x10-5/approach *(4x10-5/approach means 6 occurrences per year for an airport with 135,000 landings per year)*
Safety Objectives relative to Interception and Final Approach (common mode failures)	
SO 209 Hz#05 (WK-FA-SC3a MAC-FA-SC2b; IM=20)	The frequency of occurrence of one or multiple separation minima infringements due to undetected corruption of separation indicator (SMI>0.5NM) shall not be greater than 2x10-6/approach *(2x10-6/approach means 1 occurrences every 4 years for an airport with 135,000 landings per year)* *Explanation:* *Computation of the no of occurrences per year: 2E-6*135000/365 = 7.4E-04* *Which comes to 1 occurrence every 1350 days which represents 1 occurrence every 3.7 years (rounded to 1 occurrence every 4 years)*
SO 210 Hz#06 (WK-FA-SC3a MAC-FA-SC2b; IM=10)	The frequency of occurrence of one or multiple imminent infringements due to lack/loss of separation indicator for multiple or all aircraft (which are nevertheless recovered by ATC i.e. SMI≤0.5NM) shall not be greater than 2x10-4 /approach *(2x10-4/approach means 1 occurrence every 15 days for an airport with 135,000 landings per year)*
Safety Objectives relative to the management of the separation mode	
SO 211 Hz#07 (WK-FA-SC3a MAC-FA-SC2b; IM=20)	The frequency of occurrence of one or multiple separation minima infringements induced by ATC through inadequate selection or management of a separation mode shall not be greater than 2x10-6/approach *(2x10-6/approach means 1 occurrences every 4 years for an airport with 135,000 landings per year)*
Safety Objectives relative to mixed mode of operations	
SO 212 Hz#08	The frequency of occurrence of a runway conflict due to conflicting ATC clearances shall not be greater than 10-7/movement.

(RWY-C SC3)	(10-7/movement means 2,6x10-4/day) It should be noted that **2,6x10-4/day** is **too stringent** for this type of operational hazard. This value will be updated once the Severity Classification Scheme for the Runway Collision Model is updated.

Table 6: Safety Objectives (integrity/reliability) for the PJ.02-01 Arrivals Concepts Solutions

Figure 4 depicts the structure relating the different Safety Objectives as determined by the causal links between the corresponding hazards, respectively for the interception phase (IA) and during the final approach (FA). The safety objectives corresponding to the hazards based on common modes failures (addressing both phases) are stand-alone (no link to other hazards). This structure will be further detailed in 5.5.1.1 within the causal analysis of each hazard, based on Fault Trees.

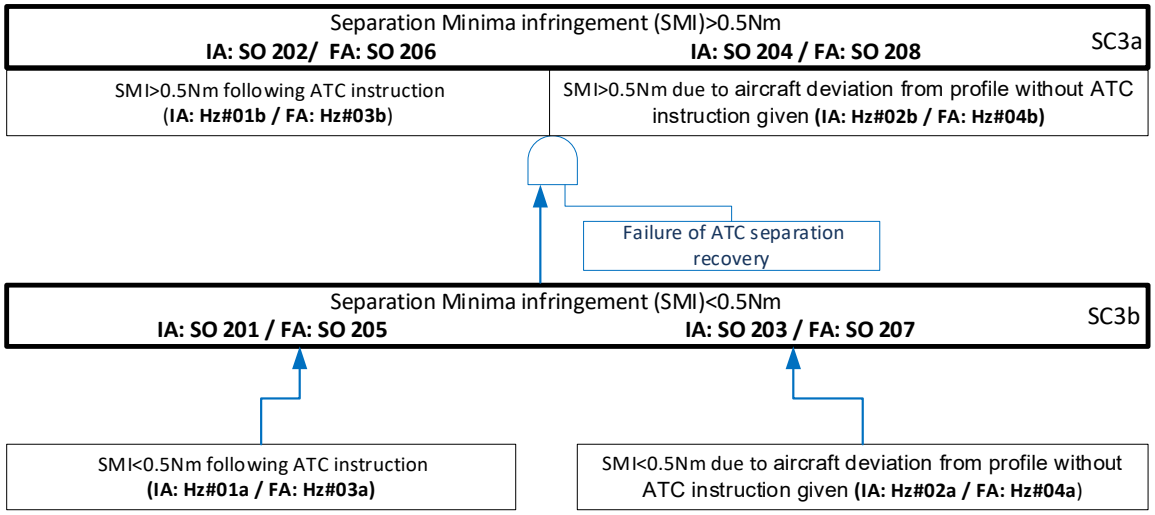


Figure 4: Safety Objectives with Hazards associated to: The Interception of the Final Approach (IA) respectively the Final Approach until delivery at the threshold (FA) for the Arrivals Concepts Solutions

5 Safe Design of the Solution functional system

5.1 Overview of activities performed

This section addresses the following activities:

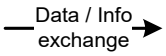
- Section 5.2 - introduction of the design model (initial or refined) of the Solution functional system
- Section 5.3 - derivation of Safety Requirements (functionality & performance) at Design level (SRD) in normal conditions of operation from the SOs (functionality & performance) of section 4.2 and supported by the analysis of the initial or refined design model above
- Section 5.4 - derivation of Safety Requirements (functionality & performance) at Design level (SRD) in abnormal conditions of operation from the SRS (functionality and performance) of section 4.3 and supported by the analysis of the operation of the initial or refined design under abnormal conditions of operation
- Section 5.5 - assessment of the adequacy of the design (initial or refined) in the case of internal failures and mitigation of the Solution operational hazards (identified at section 4.4) through derivation from SOs (integrity/ reliability) of Safety Requirements (functionality & performance) and Safety Requirements (integrity&reliability) at Design level (SRD)
- Section 5.6 - realism of the refined safe design (i.e. achievability and “testability” of the SRD)
- Section 5.7 - safety process assurance at the initial or refined design level

5.2 Design model of the Solution functional system

The Arrivals Concepts Solutions SPR-level Model in this context is a high-level architectural representation of the Solution System design. This model is the equivalent of the SESAR 2020 NSV-4 EATMA diagram (shown in section 1 and in Appendix H) and it is entirely independent of the eventual physical implementation of the design. The SPR-level Model describes the main human tasks, machine functions and airspace design. In order to avoid unnecessary complexity, human-machine interfaces are not shown explicitly on the model – rather they are implicit between human actors and machine-based functions.

5.2.1.1 Description of SPR-level Model for the Arrivals Concepts Solutions

The symbols used in the model are as follows:

	Human actor – ground-based
	Equipment function – ground-based
	Human actor – airborne
	Equipment function – airborne
	External influence (outside ATM control domain)
	Main data / information flow

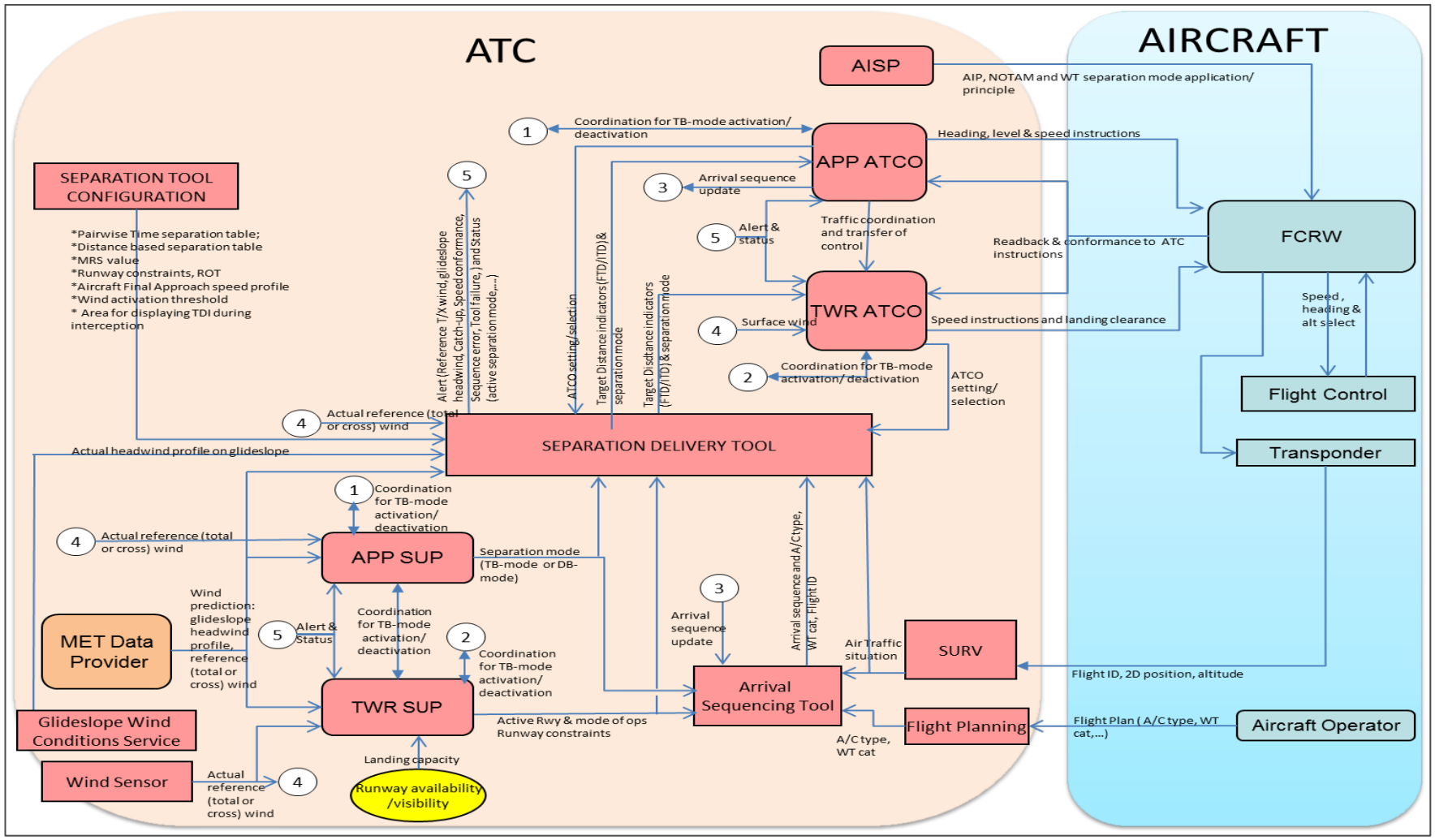


Figure 5: The SPR-level Model for the PJ.02.01 Arrivals Concepts Solutions

5.2.1.1.1 Human Actors in the Model

Actor	Current Responsibility	Specific/additional role
Approach ATC supervisor (APP SUP)	Plans, monitors and supervises tactical traffic management in the TMA	Is aware of the wind conditions for deciding and agreeing to the application of TB-modes or DB-modes, in consultation with the Tower ATC supervisor. Responsible to activate and de-activate TB-mode in collaboration with the Tower supervisor and informing controllers of change in mode of operations (e.g. via HMI or verbally). Responsible for ensuring the duty runways-in-use information, and the separation policy information, and planned changes to these, are available, set up, and maintained consistently in the Separation Delivery and Arrival Sequencing tools supporting Approach ATC. Responsible for ensuring that flight crew are informed of the application of the WT separation mode, for example, through ATIS.
Intermediate and Final approach controllers (APP ATCO)	Are in charge of safe and efficient processing of arrivals to the runway	Responsible for ensuring that a correct arrival sequence order is provided to the separation tool. This requires maintaining an up to date sequence order in the Arrival Sequencing tool in line with the actual sequence changes. Responsible to instruct the aircraft in order to intercept properly the final approach and to monitor the trajectory following these instructions. Uses the Separation Delivery tool to ensure final approach separations are set up consistently and efficiently. Uses the Separation Delivery 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 imminent separation infringement. Interacts manually with the Separation Delivery tool to e.g. select parameters or display mode (ATCO setting and selection).
Flight Crew (FCRW)	Conduct the approach safely	The Flight Crew remains ultimately responsible for the safe and orderly operation of the flight in compliance with the ICAO Rules of the Air, other relevant ICAO and EASA provisions, and within airline standard operating procedures. The Flight Crew ensures that the aircraft operates in accordance with ATC clearances and instructions. The Flight Crew is aware of WT separation mode and the impact on the distance separation set up on final approach. Is informed of what WT separation mode is being employed on final approach, for example, through ATIS. Reports critical weather and wake information to ATC.

Actor	Current Responsibility	Specific/additional role
Tower ATC supervisor (TWR 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 runway maintenance, etc.	Is aware of the wind conditions for determining and deciding on the application of TB-modes or DB-modes in consultation with the Approach ATC supervisor. Responsible to activate and de-activate TB-mode in collaboration with the Approach supervisor and informing controllers of change in mode of operations (e.g. via HMI or verbally). Responsible for ensuring the duty runways-in-use information, runway constraints and the separation policy information, and planned changes to these are available, set up and maintained consistently in the Separation Delivery and Arrival Sequencing tools. Responsible for ensuring that the runway conditions, and planned and forecast changes to the runway conditions, are reflected in the separation policy information.
Tower controller (TWR ATCO)	In charge of landings.	Uses the Separation Delivery 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 imminent 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. Responsible to provide the landing clearance. Interacts manually with the Separation Delivery tool to e.g. select parameters or display mode (ATCO setting and selection).
Aircraft Operator	Responsible for the aircraft operation. Responsible to file flight plan.	Flight plan includes the A/C type which is essential for any WT separation mode.
MET Data Provider	Measure, predict and provides the relevant weather information for the TB-modes.	Provides wind prediction (glideslope headwind profile, reference -total or cross- wind) to APP and TWR supervisor to plan operation in TB-modes or DB-modes. Provides short term wind prediction (glideslope headwind profile, reference -total or cross- wind) to the Separation Delivery tool for computing the FTD in TBS and TB-PWS-A modes and the ITD in any mode.
AISP	Provides Aeronautical Information (AIP, approach charts NOTAMs, etc.).	Aeronautical information includes information regarding operations in WT separation modes.

Table 7: Human Actors for the new WT Separation Modes of the PJ.02.01 Arrivals Concepts Solutions

5.2.1.1.2 Machine-based elements in the Model

Equipment / Tool	Current relevant function	Specific/additional function
Flight Planning	Provides the information for arrival traffic identification, A/C type and its WT category	A/C type and WT category are essential for the TB-PWS-A concept.
Transponder	MANDATORY: ELS (Elementary Surveillance) Provides the aircraft identification and position.	
	OPTIONAL: EHS (Enhanced Surveillance) Airborne parameters from the aircraft (Magnetic Heading, Indicated Airspeed, Roll Angle, Rate of Turn, Vertical rate, True Track angle, Ground Speed, Selected Altitude, True Airspeed, True Track Angle, Roll Angle/Rate of Turn) can be downlinked	The downlinked EHS airborne parameters (IAS, GS) could be used for enhancing the approach speed profile monitoring. The downlinked actual wind direction & speed extracted by the surveillance system might be used to validate MET data and for deriving the glideslope headwind profile on final approach (vector difference between the air vector -airspeed and heading- and the ground vector -ground speed and track angle) if that information is shown to be sufficiently accurate at low altitude.
Flight Control	Control the flight to support planned and tactical navigation to destination.	
Ground surveillance (SURV)	MANDATORY: ELS (Elementary Surveillance) SURV provides the aircraft Identification, Position and Altitude information to the Controller Working Positions.	Provides the aircraft Identification, Position and Altitude information to the Separation Delivery and Arrival Sequencing tools.
	OPTIONAL: EHS (Enhanced Surveillance) SURV could provide actual Wind direction & speed and GS/IAS for a given aircraft.	See “Transponder” above.
Wind sensors	Measure the prevailing wind speed and direction at the runway surface level.	Measure the actual reference (total or cross) wind and provide it to the Separation Delivery tool in order to trigger alert for TB-mode deactivation (in case of conditional application of TB-mode).
Glideslope Wind Conditions Service (GWCS)		Determine the actual headwind on the glideslope from the ground until the localizer altitude interception and provides it to the Separation Delivery tool in view of the glideslope headwind monitoring function and alert for TBS or TB-PWS-A mode deactivation (case of conditional

Equipment / Tool	Current relevant function	Specific/additional function
		application of TB-mode) and for managing compression without ITD. Note: Might be used in complement or replacement of glideslope headwind profile prediction from MET Data.
Arrival Sequencing Tool		Provide an optimized arrival sequence for the Separation Delivery tool considering: • runways-in-use • final approach separation and runway spacing constraints that are required to be applied on each runway-in-use • scenario for specific spacing (e.g. runway inspection spacing) • departure gap spacing requirements for a runway supporting interlaced/mixed mode operations
Separation Delivery tool		Computes and displays the separation indicators (FTD and ITD) to ATCO for separation provision: • Final Target Distance (FTD) which is the minimum distance in trail separation to be maintained down to the point of separation delivery. • Initial Target Distance (ITD) which is the distance to be applied at x NM from the threshold to ensure the follower meets the FTD when the leader reaches the point of separation delivery. The ITD considers the compression effect that will take place in the last x NM of the approach. The Separation Delivery tool operates in TB-modes or DB-modes, with possibility of transition between these modes in case of conditional application of TB-modes. The initial and final target distance “indicators” are proposed to be displayed on the extended runway centre-line as soon as the lead aircraft enters a locally defined zone. The Separation Tool warns ATCOs and Supervisors in case of failure or abnormal situations (alerts for Reference total or cross wind, glideslope headwind, Catch-up, Speed conformance, Sequence error, Tool failure) and provides them Status information (active WT separation mode).
Separation Delivery tool Configuration		Configuration module for the Separation Delivery tool with parameters fine-tuned for the local environment. This configuration is essential for the Separation Delivery tool computation by providing the following: the Pairwise time separation table; the distance-based

Equipment / Tool	Current relevant function	Specific/additional function
		pairwise separation table, the MRS value applicable for the final approach; the Runway constraints per runway end, optionally the ROT per A/C category; the aircraft type approach speed profile; the wind activation threshold; the defined volume in the interception area where a leader inside this zone will have Target Distance Indicators displayed on the extended runway centreline.

Table 8: Machine-based elements for the new WT Separation Modes of the PJ.02.01 Arrivals Concepts Solutions

5.2.1.2. SESAR 2020 SPR level Model (EATMA NSV-4 Diagram)

Figure 6 shows the EATMA NSV4 diagram, which is the equivalent of the SPR-level Model in PJ.02.01. This diagram was used to check the completeness of the high level and the refined safety requirements against the latest developments of PJ.02.01:

Note that, at the time when this report was written, the EATMA NSV-4 Diagrams for Arrivals were still being updated. Therefore, please refer to the NSV-4 stored in EATMA in the PJ.02.01 Folder for the latest version of the EATMA NSV-4 Use Cases for arrivals.

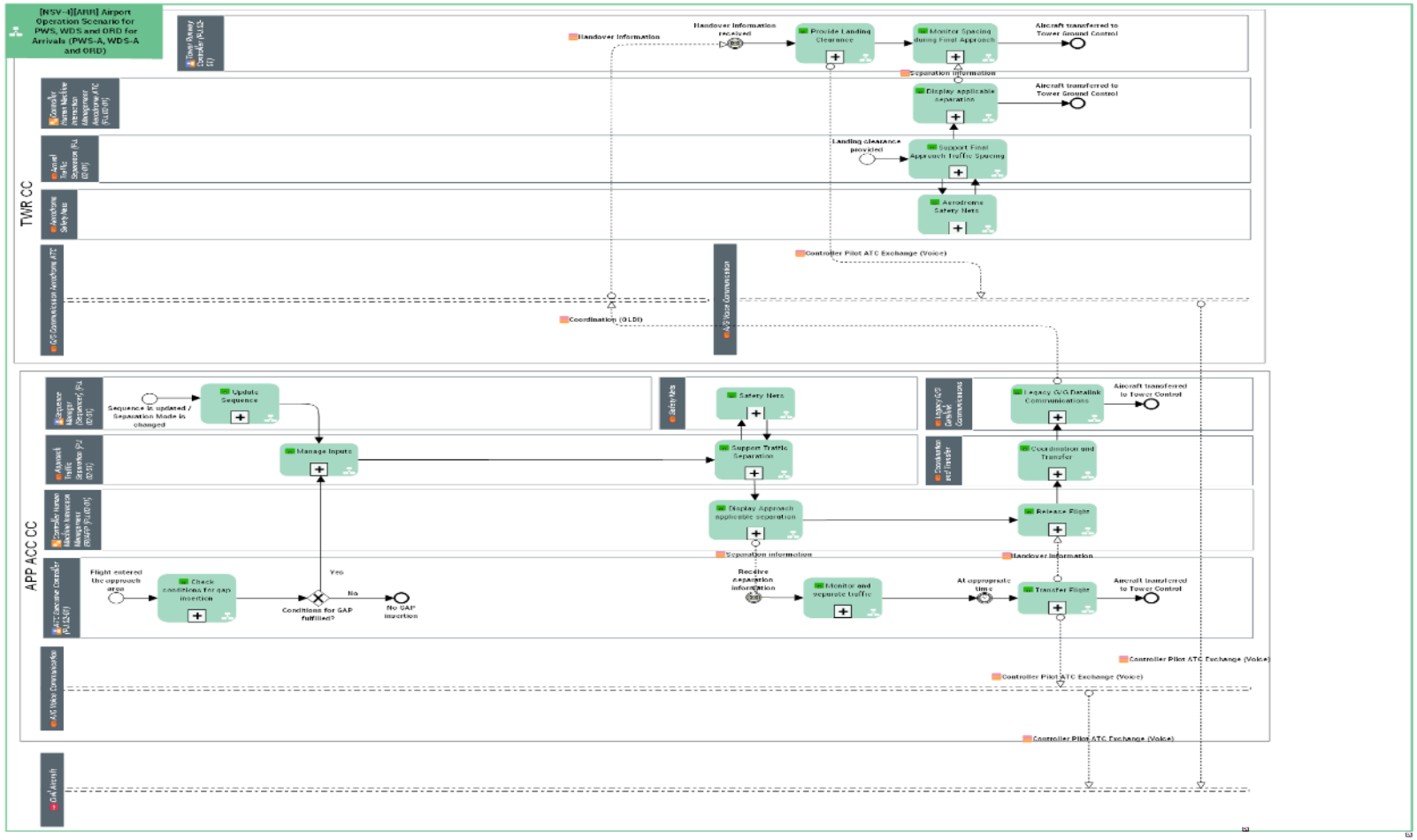


Figure 6: NSV-4 Diagram for PWS-A, WDS-A and ORD for Arrivals

5.3 Deriving Safety Requirements at Design level for Normal conditions of operation

5.3.1 Safety Requirements at Design level (SRD) – Normal conditions of operation

Table 9 below shows how the Safety Objectives (Functionality and Performance) derived in Section 4 map on to the Safety Requirements. All provisions from ICAO Annexes and procedures in Doc 4444 PANS-ATM still apply as operational baseline.

The safety requirements address the ATM changes related to the new WT separation modes and ATC tools (with indicators) made possible by the TBS, ORD, PWS-A and WDS for Arrivals and Departures concepts. The fact that a Safety Requirement addresses only one or a sub-set of WT separation modes is indicated in the requirement text, otherwise the requirement is considered as relevant for all the WT separation modes.

SO Description	SRs	SR Description
SO 001 ATC shall be able to apply consistent and accurate DBS, TBS, PWS-A or WDS-A wake turbulence separation rules on final approach (encompassing interception) and landing, through operating under Distance Based modes (DBS, DB-PWS-A) and Time Based modes (TBS, T-PWS-A, A-WDS-Tw and A-WDS-Xw), with the possibility to safely switch between a TB-mode and the corresponding DB-mode.	SR1.002 REQ-02.01-SPRINTEROP-ARR0.0100	The tool shall operate under Distance Based modes (DB-modes: DBS, S-PWS) and Time Based modes (TB- modes: TB S-PWS, TB-WDS-Tw, TB-WDS-Xw, TB-WD-PWS-TW, TB-WD-PWS-XW), with the possibility to switch between DB-modes and corresponding TB- modes.
	SR1.007 REQ-02.01-SPRINTEROP-ARR0.1030	The Approach or Tower Controller shall be able to safely perform their separation duties during transition between separation modes.

	SR1.008 REQ-02.01-SPRINTEROP-ARR0.1080	The frequency of separation mode switches shall be done in a way that would avoid controller confusion and unnecessary workload.
	SR1.009 REQ-02.01-SPRINTEROP-ARR0.1120	The mode of operation shall be clearly displayed to the controllers (Tower and Approach) and Supervisors (Tower and Approach) at all times.
	SR1.010 REQ-02.01-SPRINTEROP-ARR0.1390	Consideration shall be given to the impact of mode changes on external systems and processes such as AMAN and flow management.
	SR1.011 REQ-02.01-SPRINTEROP-ARR0.0530	The system architecture shall ensure all applicable Controller Working Positions (e.g. per runway) operate in the same mode(s).
	SR1.120 REQ-02.01-SPRINTEROP-ARR0.1040	All licenced Approach and Tower controllers (and Supervisors) shall be fully trained to switch between the time based and distance based modes of operation.
	SR1.123 REQ-02.01-SPRINTEROP-ARR0.1290	Regular trainings shall ensure ATCOs maintain sufficient competency to safely revert to and manage air traffic in DBS operations without Target Distance Indicators (i.e. implementation of the separation tool shall not adversely affect the controller's air traffic- vectoring skills- using DBS WT Category without Target Distance Indicators).
	SR1.126 REQ-02.01-SPRINTEROP-ARR0.1021	The transition tasks (activation and deactivation of TB modes) shall be defined for all actors involved, for both a spontaneous transition (e.g. sudden change of wind conditions, etc.) as well as for a planned transition, where a collaborative approach for the ATCO and SUPs in APP and TWR shall apply.
	SR1.127 REQ-02.01-SPRINTEROP-ARR0.1031	Mode transitions (planned) should take place outside peak hours.
	SR1.128 REQ-02.01-SPRINTEROP-ARR2.1222	Timely reversion from conditional mode to standard mode of operations shall be triggered by the Supervisor or automatically by the system depending on the local implementation. The possibility for the ATCOs

		spontaneous reversal (e.g. in case of sudden loss of indicators) shall be locally defined.
SO 002 In case of conditional application of Time Based (TB) modes, ATC shall apply the correspondent WT separation minima only when the predefined activation criteria for the considered TB-mode are met i.e. specified wind parameter(s) measured against pre-determined wind threshold(s).	SR1.012 REQ-02.01-SPRINTEROP-ARR2.1060	For TB- modes the Approach and Tower Supervisors shall collaboratively decide when the conditional (TB) mode should be activated or de activated based on meteorological data information and predefined activation criteria and on prior coordination with Controllers. Note: Activation of a WT separation mode encompasses both starting operations at the beginning of the day and transition to a different WT separation mode during the day.
	SR1.013 REQ-02.01-SPRINTEROP-ARR0.0980	The Tower Supervisor in coordination with the Approach Supervisor (and occasionally the Tower and Approach Controllers - in line with defined local procedures) shall determine the final approach separation mode and runway spacing constraints that are to be applied at any time by the separation delivery tool.
	SR1.015 REQ-02.01-SPRINTEROP-ARR0.1222	The Approach and Tower Supervisors shall inform the respective Controller when the conditional (TB) mode will be activated or de activated by indicating the first aircraft in the arrival sequence to be separated according to the new mode. (e.g. at least 2 min before interception- to be locally defined)
	SR1.017 REQ-02.01-SPRINTEROP-ARR0.1223	The ATCOs and the Supervisors shall always have a clear indication in the CWP from which aircraft in the sequence the new mode of operations or the reversion to standard mode are applied.
	SR1.020 REQ-02.01-SPRINTEROP-ARR2.1170	The Wind Forecast Service shall be provided to the users to plan or execute WDS-A (Xw or Tw) concept operations. The service shall include standard meteorological information and WDS-A (Xw or respectively Tw) concept specific information with respect to wind nowcast and forecast, wind speed, direction and trends, in particular the crosswind component (glide-slope and surface cross winds) or respectively the total wind (glide-slope and

		surface total winds) with respect to each runway direction.
	SR1.023 REQ-02.01-SPRINTEROP-ARR2.1160	In order to enable the modes activation/deactivation, the Tower Supervisor and the Approach supervisor shall be provided with a meteorological situation picture that includes the nowcast and forecast data regarding the wind speed and direction at different locations and altitudes covering the area encompassing the final approach phase of arrival flights. Such information shall in particular display the relevant wind component for the application of WDS-A concept reduced wake separations.
	SR1.027 REQ-02.01-SPRINTEROP-ARR0.1110	The Approach and Tower Runway ATCO shall continue to use the TDIs that are already displayed (as per the previous separation mode) for the aircraft in the arrival sequence preceding the first one to be separated according to the new mode.
SO 003 In case of conditional application of TB-modes the wind threshold(s) for the activation criteria specific to each TB-mode shall be determined to mitigate the risk of wake vortex encounter due to the uncertainties on the wind profile prediction data and on the aircraft adherence to the generic airspeed profile	SR1.003 REQ-02.01-SPRINTEROP-ARR0.0131	For the time based separation modes (TB-modes i.e. TBS, TB-PWS-A, TB-WDS-A or A-TB-WD-PWS), for which FTD (Final Target Distance standing for the separation indication) is computed based on a time separation, the risk of under-separation induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated.
	SR1.004 REQ-02.01-SPRINTEROP-ARR0.0132	• For the Time based separation modes the risk of under-separation induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated by one or a combination of the following means: • Adding a time separation buffer in the design of the FTD indicators displayed to Controllers. These buffers may vary depending on the considered applicable separation minima and wind conditions

		• The conditional application of any TB- mode (e.g. WDS shall be locally pre-determined and used as a wind-based criterion for the activation of that mode • For the TB- mode, taking a buffer in the design of TBS minima (e.g. higher headwind conditions when selecting reference baseline minima) • The selection of most appropriate mean(s) shall be based on the local operational conditions, local wind behaviour, wind profile and aircraft speed profile prediction system accuracy
	SR1.005 REQ-02.01-SPRINTEROP-ARR3.0151	For all separation modes, for which an ITD (Initial Target Distance standing for the compression indication) is used, the risk of under-separation after Deceleration Fix induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated.
	SR1.006 REQ-02.01-SPRINTEROP-ARR3.0152	For all separation modes, for which an ITD is used, the risk of under-separation after Deceleration Fix induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated by adding a time separation buffer in the design of the ITD indicators displayed to Controllers. These buffers may vary depending on the considered applicable separation minima and wind conditions.
	SR1.018 REQ-02.01-SPRINTEROP-ARR2.1130	The WDS-TW mode shall be activated only when the runway surface and glide-slope reference total wind (as used in the separation minima design) is equal or greater than the WDS-Tw threshold
	SR1.019 REQ-02.01-SPRINTEROP-ARR2.1140	The WDS-Xw mode shall be activated only when the runway surface and glide-slope reference cross wind (as used in the separation minima design) is equal or greater than the WDS-Xw threshold
	SR1.021 REQ-02.01-SPRINTEROP-ARR2.1150	The WDS-Tw and WDS-Xw activation thresholds shall be determined to mitigate the risk of wake vortex encounter due to the uncertainties on the wind prediction data and on the lateral aircraft deviation from RWY extended centreline.
SO 004 In case of conditional application of TB-	SR1.007 REQ-02.01-	The Approach or Tower Controller shall be able to safely perform their separation duties during transition between separation modes.

modes, ATC shall apply the corresponding distance-based WT separation mode (DBS or respectively DB-PWS-A) when the activation criteria for TBS, TB-WDS-A modes or respectively TB-PWS-A and A-TB-WD-PWS modes are not met anymore	SPRINTEROP-ARR0.1030	
	SR1.008 REQ-02.01-SPRINTEROP-ARR0.1080	The frequency of separation mode switches shall be done in a way that would avoid controller confusion and unnecessary workload.
	SR1.009 REQ-02.01-SPRINTEROP-ARR0.1120	The mode of operation shall be clearly displayed to the controllers (Tower and Approach) and Supervisors (Tower and Approach) at all times.
	SR1.014 REQ-02.01-SPRINTEROP-ARR0.1070	Supervisor must reconsider the mode of operation if they receive WTE reports from Pilots over a short period of time via Controllers. Rationale: Several WTE reports in a short space of time may mean the incorrect mode of operation is activated hence Supervisors should reassess the decision.
	SR1.016 REQ-02.01-SPRINTEROP-ARR0.1090	In case the reversion from a TB mode is triggered automatically by the Separation Delivery Tool (e.g. due to the wind falling below the applicable minima), the Separation Delivery Tool shall indicate to the ATCO the aircraft to be separated according to the new separation mode. A notification shall indicate to the Controller and the Supervisor the change and preferably the reason behind it.
	SR1.017 REQ-02.01-SPRINTEROP-ARR0.1223	The ATCOs and the Supervisors shall always have a clear indication in the CWP from which aircraft in the sequence the new mode of operations or the reversion to standard mode are applied.
	SR1.020 REQ-02.01-	The Wind Forecast Service shall be provided to the users to plan or execute WDS-A (Xw or Tw) concept operations. The service shall include standard meteorological information and WDS-A (Xw or respectively Tw) concept

	SPRINTEROP-ARR2.1170	specific information with respect to wind nowcast and forecast, wind speed, direction and trends, in particular the crosswind component (glide-slope and surface cross winds) or respectively the total wind (glide-slope and surface total winds) with respect to each runway direction.
	SR1.023 REQ-02.01-SPRINTEROP-ARR2.1160	In order to enable the modes activation/deactivation, the Tower Supervisor and the Approach supervisor shall be provided with a meteorological situation picture that includes the nowcast and forecast data regarding the wind speed and direction at different locations and altitudes covering the area encompassing the final approach phase of arrival flights. Such information shall in particular display the relevant wind component for the application of WDS-A concept reduced wake separations.
	SR1.024 REQ-02.01-SPRINTEROP-ARR0.1760	In case of conditional application in TB-modes, the Supervisors (Tower and Approach) and Controllers (Tower and Approach) shall be alerted automatically in advance when the predefined activation criteria will not be met anymore hence the imminent need to transition from one separation mode to another, in order to temporarily limit or regulate the flow of inbound traffic (e.g. through metering) prior to the switch of separation mode in order to manage the change and controllers workload
	SR1.025 REQ-02.01-SPRINTEROP-ARR2.1190	If the Wind Forecast service detects WDS-A concept suspension, the information shall be transmitted to the Separation Delivery tool and a corresponding alert shall be displayed to the CWPs of the Controllers and Supervisors.
	SR1.026 REQ-02.01-SPRINTEROP-ARR0.1100	Upon reversion to (activation of) a new separation mode, the separation delivery tool shall display the adequate FTD (separation indication) and ITD (compression indications) to the Approach ATCO for all aircraft starting with the first aircraft in the arrival sequence to be separated according to the new mode.
	SR1.027 REQ-02.01-SPRINTEROP-ARR0.1110	The Approach and Tower Runway ATCO shall continue to use the TDIs that are already displayed (as per the previous separation mode) for the aircraft in the arrival sequence preceding the first one to be separated according to the new mode.
SO 005 In a given WT separation mode, ATC shall sequence and instruct aircraft to	SR1.001 REQ-02.01-	The Intermediate Approach, Final Approach and Tower Controllers shall be provided with a Separation Delivery Tool displaying Target Distance Indicators (TDI) to enable consistent and accurate application of TBS, PWS-A, DBS

intercept the final approach path such as to establish and maintain applicable separation minima on final approach segment based on the displayed Target Distance Indicators corresponding to that separation mode	SPRINTEROP-ARR0.0050	and/or WDS-A wake turbulence separation rules on final approach and landing.
	SR1.022 REQ-02.01-SPRINTEROP-ARR0.0670	Local implementation shall define the latest time that a stable TDI is required by the Controller for spacing, so that the FTD and ITD indicators may be re-calculated due to changing glideslope wind conditions
	SR1.028 REQ-02.01-SPRINTEROP-ARR0.0300	The approach arrival sequence information shall be provided to the Separation Delivery tool.
	SR1.029 REQ-02.01-SPRINTEROP-ARR0.0910	The separation delivery tool shall be given the arrival runway intent including eventual updates for each aircraft such that it is considered for the computation of the Target Distance Indicators
	SR1.030 REQ-02.01-SPRINTEROP-ARR0.0920	The runway final approach sequence order shall be displayed on the HMI so that it is visible to the Approach, Tower and Supervisor positions.
	SR1.032 REQ-02.01-SPRINTEROP-ARR0.0550	If there is a change to the sequence order or runway intent, the Approach Controller should check that each indicator for each affected aircraft pair has been updated.
	SR1.033 REQ-02.01-SPRINTEROP-ARR0.0940	In case of a change of the arrival sequence order position of an aircraft, the Approach controller shall check that the arrival sequence order has been updated to reflect the change
	SR1.034 REQ-02.01-SPRINTEROP-ARR0.0941	The sequence manager shall ensure that for the change of the sequence order there is no overlap (or lack of awareness) between the actions taken by the Intermediate Approach Controller and the Final Approach Controller, by allowing only one change at a time.

	SR1.037 REQ-02.01-SPRINTEROP-ARR0.0110	The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that needs to be delivered after considering all in-trail and if applicable not-in-trail constraints.
	SR1.038 REQ-02.01-SPRINTEROP-ARR3.0120	If the ORD concept is considered, the Separation Delivery tool shall provide to ATCOs a visualisation (ITD indicator) of the required spacing on final approach to be delivered at the deceleration fix in order to deliver the required minimum separation / spacing at the delivery point.
	SR1.039 REQ-02.01-SPRINTEROP-ARR0.0890	The separation delivery tool shall support ATCOs in the delivery of wake separations that are allowed only when leader and follower aircraft are aligned on the centreline.
	SR1.040 REQ-02.01-SPRINTEROP-ARR0.0190	There shall be surveillance coverage down to the separation delivery point to allow the separation tool to display Target Distance Indicators on the runway extended centreline including the last part of the final approach.
	SR1.045 REQ-02.01-SPRINTEROP-ARR0.0690	TDI display shall be robust to ensure they do not keep switching on and off as aircraft perform normal manoeuvres
	SR1.046 REQ-02.01-SPRINTEROP-ARR0.0490	The follower TDI shall be linked to the actual aircraft position of the leader: • If the leader is aligned with the runway axis, then the follower TDIs are to be displayed behind the actual leader position; • If the leader is not yet aligned with the runway axis and the perpendicular projected position on the runway extended centreline is behind its own ITD then the follower TDIs are to be displayed behind the perpendicular projected position on the runway extended centreline; • If the leader is not yet aligned with the runway axis and the perpendicular projected position on the runway extended centreline is ahead its own ITD, then the follower TDIs are to be displayed behind the position of ITD ahead. In case several aircraft have not yet intercepted the glide, this leads to a train of ITDs, each one being attached to the

		previous one and all moving at the speed of the last aircraft on the extended runway centreline.
	SR1.047 REQ-02.01-SPRINTEROP-ARR0.0480	The TDIs shall be displayed to the Intermediate and Final Approach Controllers sufficiently early in order to allow correct interception
	SR1.048 REQ-02.01-SPRINTEROP-ARR0.0630	Criteria to determine the time for displaying indicators for each CWP shall be specified depending upon the local operation's needs.
	SR1.049 REQ-02.01-SPRINTEROP-ARR0.0470	The Separation Delivery tool and associated procedures shall support the Controller decision to turn onto final approach.
	SR1.050 REQ-02.01-SPRINTEROP-ARR3.1000	If the ORD concept is implemented, the Final Approach Controller shall maintain the aircraft on or behind the ITD on the final approach and reduce to the final approach procedural airspeed until the transfer to the Tower controller.
	SR1.051 REQ-02.01-SPRINTEROP-ARR3.0170	If the ORD concept is implemented, the Approach controller shall vector the follower aircraft so that it stays on or behind the corresponding ITD.
	SR1.052 REQ-02.01-SPRINTEROP-ARR0.0710	The tool shall automatically display the FTD (if not already displayed) if the aircraft comes within a defined distance of the computed FTD. This distance shall be configurable within the tool.
	SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)
	SR1.058 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed

		according to the rules defined for the high priority separation and low priority spacing indicators)
	SR1.059 Example of REQ-02.01-SPRINTEROP-ARR0.0796	For the APP HMI, if the second and/or third most constraining ITD is no longer infringed, the corresponding FTDs shall be hidden by the system
	SR1.060 REQ-02.01-SPRINTEROP-ARR0.0850	The HMI design shall allow ATCO to hide/unhide indicators for a specific aircraft pair, and current and forthcoming alerts/warnings for that aircraft as a follower (e.g. infringement, catch-up, speed,..)
	SR1.061 REQ-02.01-SPRINTEROP-ARR0.0900	Following the ATCO action to suppress the TDIs for specific aircraft the tool shall: • remove any information on the spacing/separation (ITD and FTD) • remove its ongoing or not display the forthcoming Separation Delivery Tool alerts (e.g. Catchup/Speed/SeqNumber/Infringement)
	SR1.062 REQ-02.01-SPRINTEROP-ARR0.0720	The Approach controller shall be able to remove the FTD from the radar display, but not when the FTD has been automatically displayed by the System.
	SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.
	SR1.064 REQ-02.01-SPRINTEROP-ARR0.0870	The Approach controller shall maintain applicable surveillance separation minima at any point during approach. This includes the case of a leader aircraft established on the final approach axis and a follower not yet established
	SR1.065 REQ-02.01-SPRINTEROP-ARR0.1340	The current operational procedures for transitioning from intermediate separations (3NM) to final approach separations (e.g. 2.5NM MRS) shall continue to apply.
	SR1.066 REQ-02.01-SPRINTEROP-ARR3.0500	Once the follower aircraft has been positioned w.r.t ITD and before the leader reaches its deceleration point, the Controller shall apply speed instructions in accordance to the reference glide slope air speed used for ITD calculation.

	SR1.097 REQ-02.01-SPRINTEROP-ARR0.0970	If ORD is not implemented, the Final Approach Controller shall maintain the aircraft behind the FTD with sufficient buffer due to the effect of compression caused by different leader and follower groundspeed profiles, and shall reduce aircraft's speed to the final approach procedural airspeed.
	SR1.098 REQ-02.01-SPRINTEROP-ARR0.0167	If both the FTD and ITD are available, the ITD indication ("compressions indicator") shall be the main indicator to be used by the final approach controller.
	SR1.099 REQ-02.01-SPRINTEROP-ARR0.0651	In case the ITD is the main display on the final approach, the ATCOs shall be able to display the FTD , depending upon the local operation's needs.
	SR1.114 REQ-02.01-SPRINTEROP-ARR0.0166	Clear guidelines with regard to the list of possible actions to be made in the case of an FTD infringement (in the APP and in the TWR) shall be described per position for the local implementation.
	SR1.117 REQ-02.01-SPRINTEROP-ARR0.1250	Approach and Tower Controllers shall be fully trained to apply the procedures for the new separation modes and to use of the Separation Delivery Tool and supporting systems (e.g. alerts) with indicators prior to deployment.
	SR1.118 REQ-02.01-SPRINTEROP-ARR0.1260	All Approach and Tower controllers and Supervisors shall be fully trained in the operating procedures for the new WT separation modes prior to deployment.
	SR1.129 REQ-02.01-SPRINTEROP-ARR0.1351	In a dual approach arrival environment, ATCOs shall have supporting alert, for identifying vertical and horizontal infringements for the crossing aircraft (e.g. North runways to South runways)
SO 006 The Target Distance Indicators shall be calculated and displayed to correctly and accurately represent the greatest constraint out of wake separation minima of the mode under consideration (for all traffic pairs and in the full range of weather	SR1.031 REQ-02.01-SPRINTEROP-ARR0.0570	If there is a change to the separation / spacing constraint (e.g. Gap) the TDI for the affected aircraft pair shall be re-computed.

and operating conditions pertinent for that mode), the MRS, the runway spacing or other spacing constraint (e.g. departure gaps)		
	SR1.035 REQ-02.01-SPRINTEROP-ARR0.0139	TDIs shall be displayed on the extended runway centreline behind each lead aircraft established on final approach and shall be linked to the actual lead aircraft position along the runway axis.
	SR1.036 REQ-02.01-SPRINTEROP-ARR0.0133	TDI position shall provide the accurate information about the required separation/spacing for each aircraft pair
	SR1.067 REQ-02.01-SPRINTEROP-ARR0.0080	In DB- modes the separation delivery tool shall be provided with a range of wake turbulence distance-based separation rules based on ICAO Aircraft Type (e.g. ICAO, RECAT-EU, RECAT-EU-PWS) depending upon the airport needs.
	SR1.068 REQ-02.01-SPRINTEROP-ARR0.0230	All applicable Minimum Radar Separation (MRS) rules shall be provided to the Separation Delivery tool.
	SR1.069 REQ-02.01-SPRINTEROP-ARR0.0251	The separation delivery tool shall provide ATCOs the possibility to manage gap spacing between consecutive arrival flights.
	SR1.070 REQ-02.01-SPRINTEROP-ARR0.0240	All applicable runway-related spacing rules other than those related to runway configuration shall be provided to the Separation Delivery tool.
	SR1.072 REQ-02.01-SPRINTEROP-ARR0.0253	The separation delivery tool shall provide confirmation to ATCO that the gap spacing insertion is successful or not.
	SR1.073 REQ-02.01-SPRINTEROP-ARR0.0254	The ATCOs shall be able to insert automatic gap spacing based on pre-defined scenarios in the sequence manager

	SR1.074 REQ-02.01-SPRINTEROP-ARR0.0255	The tool shall provide ATCOs the ability to update and cancel any gap spacing previously inserted.
	SR1.075 REQ-02.01-SPRINTEROP-ARR0.0310	An expected aircraft speed or time-to-fly profile model on the final approach glide-slope shall be provided to the Separation Delivery tool for the FTD calculation.
	SR1.076 REQ-02.01-SPRINTEROP-ARR1.0320	An expected aircraft speed or time-to-fly profile model on the final approach glide-slope shall be provided to the Separation Delivery tool for the ITD calculation.
	SR1.077 REQ-02.01-SPRINTEROP-ARR0.0060	In TBS mode, the separation delivery tool shall be provided with time separation rules.
	SR1.078 REQ-02.01-SPRINTEROP-ARR1.0070	S-PWS wake separation rules shall be provided to the Separation Delivery tool.
	SR1.079 Example of REQ-02.01-SPRINTEROP-ARR2.0030	In TB-modes where WDS is applied (WDS-Xw and WDS-Tw) the separation delivery tool shall be provided with time separation tables (for each cross-wind and respectively total wind value and each aircraft pair category) derived from: • the time required for a sufficient vortex decay • the time required for the vortex to be transported away from the path of the follower aircraft • the reference speed profile for the leader and follower aircraft
	SR1.080 REQ-02.01-SPRINTEROP-ARR0.0130	In TB mode, the FTD computed by the tool to indicate the wake separation applicable at the delivery point shall take into consideration: • The time separation from the wake turbulence separation table (for WDS the separation tables might be more than one depending on the total/cross wind values); • The aircraft pair (from the arrival sequence list); • The glideslope headwind profile;

		• The follower time-to-fly profile obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction
	SR1.081 REQ-02.01-SPRINTEROP-ARR0.0161	The spacing constraint computation shall take into consideration the same inputs as for the ITD and FTD plus: • The time separation value representing the spacing constraint (ROT, GAP, scenario specific spacing, etc.)
	SR1.082 REQ-02.01-SPRINTEROP-ARR0.0321	Aircraft time-to-fly profiles used in the FTD and ITD calculations shall be based on a time-to-fly model representative of nominal aircraft speed behaviour on final approach, in the local environment.
	SR1.083 REQ-02.01-SPRINTEROP-ARR3.0150	The ITD computed by the tool for all separation and spacing constraints (wake separation in DB and TB modes, MRS, ROT and other spacing constraints) shall take in consideration: • The FTD for the considered aircraft pair • The glideslope headwind profile • The leader and follower time-to-fly profiles obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction
	SR1.084 REQ-02.01-SPRINTEROP-ARR3.0163	If the ITD calculation is smaller than the FTD (e.g. pull away scenario) then it shall be changed to the same value as the FTD.
	SR1.085 REQ-02.01-SPRINTEROP-ARR0.0220	Aircraft identifier, ICAO aircraft type and wake category for all arrival aircraft, including subsequent updates to this information, shall be provided to the Separation Delivery tool.
	SR1.086 REQ-02.01-SPRINTEROP-ARR0.0280	The Separation Delivery tool shall be provided with the predicted headwind profile on the glideslope (ideally from ground to the published localiser interception altitude) to compute the ITD in all modes and the FTD in TB-modes. The used profiles shall ensure smooth temporal evolution of the ITD on the final approach.

	SR1.087 REQ-02.01-SPRINTEROP-ARR0.0290	If in a local implementation the tool is required to consider the actual runway surface wind conditions, then the runway surface wind conditions shall be provided to the Separation Delivery tool.
	SR1.088 REQ-02.01-SPRINTEROP-ARR2.0141	In WDS modes (total wind/cross wind) the Separation Delivery tool shall use the relevant separation table for the FTD computation based on the measured total/cross wind
	SR1.089 REQ-02.01-SPRINTEROP-ARR0.0162	The tool in any mode shall display TDIs representing the greatest constraint out of all applicable in-trail or not in-trail separation constraints. The constraints can be the high priority separation (e.g. Wake and MRS) and the low priority runway spacing (ROT) and other spacing constraints (e.g. departure GAP, runway inspections, etc.).
	SR1.090 REQ-02.01-SPRINTEROP-ARR0.0691	The Controllers shall be able to visually distinguish (via colour or symbol) if Target Distance Indicators are relative to WT, MRS or ROT (or other spacing constraint).
	SR1.091 REQ-02.01-SPRINTEROP-ARR0.0580	The display option for the indicator shall be configurable depending on the type of separation / spacing.
	SR1.092 REQ-02.01-SPRINTEROP-ARR0.0681	The design of the TDIs shall be made in order to ensure they are easy to read and interpret, being in line with the design philosophy (shape, colour etc.) of the other ATC tools used in the local environment.
	SR1.093 REQ-02.01-SPRINTEROP-ARR0.0800	The HMI design shall allow Controllers to identify the aircraft associated with each displayed indicator.
	SR1.098 REQ-02.01-SPRINTEROP-ARR0.0167	If both the FTD and ITD are available, the ITD indication (“compressions indicator”) shall be the main indicator to be used by the final approach controller.
	SR1.099 REQ-02.01-SPRINTEROP-ARR0.0651	In case the ITD is the main display on the final approach, the ATCOs shall be able to display the FTD , depending upon the local operation's needs.

	SR1.100 REQ-02.01-SPRINTEROP-ARR0.0590	TDIs shall be displayed on all applicable ATCO and SUP CWPs (Tower Runway, Final Approach and Intermediate Approach), according to the local implementation rules.
	SR1.101 REQ-02.01-SPRINTEROP-ARR0.0700	Approach and Tower shall have access to consistent information (on their CWP HMI) relating to separation delivery to be able to communicate effectively with each other.
	SR1.102 REQ-02.01-SPRINTEROP-ARR0.0770	The displayed indicator distance and shape shall be consistent between all applicable CWPs.
	SR1.104 REQ-02.01-SPRINTEROP-ARR0.0650	The Approach controller shall have the possibility to globally select the display of the FTD, however the FTD shall automatically be displayed when some alerts are active (e.g. risk of imminent FTD infringement).
	SR1.105 REQ-02.01-SPRINTEROP-ARR0.0164	The FTD indicator shall be the main TDI to be used by the Tower Controller.
	SR1.106 REQ-02.01-SPRINTEROP-ARR3.0660	The Tower controller shall have the possibility to globally select the display of the ITD (in addition to FTD which shall always be displayed).
	SR1.107 REQ-02.01-SPRINTEROP-ARR3.0160	Before the Leader reaches its Deceleration Fix (DF), the ITD shall be “static” (i.e. the separation distance between the Leader position and the displayed ITD shall be static, the ITD shall hence move at the leader speed). It shall be computed accounting for the compression/ pull-away effect for the aircraft pair expected from the leader DF until the separation delivery point. After the Leader passes the DF, the ITD shall move towards the FTD, accurately account for compression/pull-away effect for the aircraft pair expected from the actual leader position until the separation delivery point.
	SR1.108 REQ-02.01-SPRINTEROP-ARR0.0140	Before the Leader reaches the separation delivery point, the FTD shall be “static” (i.e. the separation distance between the Leader position and the displayed FTD shall be static, the FTD shall hence move at the Leader speed). It shall be computed accounting for the expected time-to-fly of the Follower aircraft until the separation delivery point. After the Leader passes the separation delivery

		point and until the Follower reaches the separation delivery point, the FTD shall be disconnected from the Leader (e.g. move at the expected Follower speed to reach zero when the Follower is expected to reach the delivery point).
	SR1.111 REQ-02.01-SPRINTEROP-ARR0.0200	All applicable runway configuration spacing rules shall be provided to the Separation Delivery tool.
	SR1.112 REQ-02.01-SPRINTEROP-ARR0.0270	The tool shall allow the runway occupancy time (ROT) constraints to be configurable for each aircraft based on multiple parameters.
	SR1.115 REQ-02.01-SPRINTEROP-ARR0.0441	In case of a change of runway configuration, the Approach and/or Tower supervisors shall coordinate prior to inserting the new arrival runway into the tool.
	SR1.116 REQ-02.01-SPRINTEROP-ARR0.0440	In case of a change of runway configuration, the Approach and/or Tower supervisors shall be able to input to the separation tool the new arrival runway to be considered for Target Distance Indicators computation. ISSUE 2: In case of a late landing runway change, it should be verified if the arrival sequencing tool can be timely reconfigured in order to display the Approach Arrival Sequence for the switched runway and update the TDIs accordingly.
	SR1.121 REQ-02.01-SPRINTEROP-ARR0.0370	Local implementation shall ensure that roles and responsibilities are clearly defined regarding the management of data inputs into the Separation Delivery tool including runway policy, runway spacing constraints, visibility conditions and runway conditions.
	SR1.122 REQ-02.01-SPRINTEROP-ARR0.0180	The Surveillance system shall provide the Separation Delivery Tool with aircraft position and altitude for all arrival aircraft.
SO 007 The design of the Separation Delivery Tool and associated operating procedures and practises shall not	SR1.094 REQ-02.01-SPRINTEROP-ARR0.1410	The Flight Crew shall be made aware of the locally applied separation mode and minima via appropriate means (e.g. from ATIS, AIP, NOTAM, information campaigns).

negatively impact Flight Crew/Aircraft who shall be able to follow ATC instructions in order to correctly intercept the final approach path in the mode under consideration		
	SR1.095 REQ-02.01-SPRINTEROP-ARR0.1421	Information campaigns shall familiarise the flight crew/ airspace users with all novel concepts associated to the implementation of reduced separations.
	SR1.096 REQ-02.01-SPRINTEROP-ARR0.1400	An overview of the key principles of the TBS, S-PWS, WDS and / or ORD concept of operations (ConOps) shall be published in AIP.
SO 008 In a given WT separation mode, ATC shall provide correct spacing minima delivery from final approach path acquisition until landing based on separation indicators correctly computed for that separation mode.	SR1.001 REQ-02.01-SPRINTEROP-ARR0.0050	The Intermediate Approach, Final Approach and Tower Controllers shall be provided with a Separation Delivery Tool displaying Target Distance Indicators (TDI) to enable consistent and accurate application of TBS, PWS-A, DBS and/or WDS-A wake turbulence separation rules on final approach and landing.
	SR1.037 REQ-02.01-SPRINTEROP-ARR0.0110	The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that needs to be delivered after considering all in-trail and if applicable not-in-trail constraints.
	SR1.038 REQ-02.01-SPRINTEROP-ARR3.0120	If the ORD concept is considered, the Separation Delivery tool shall provide to ATCOs a visualisation (ITD indicator) of the required spacing on final approach to be delivered at the deceleration fix in order to deliver the required minimum separation / spacing at the delivery point.
	SR1.039 REQ-02.01-	The separation delivery tool shall support ATCOs in the delivery of wake separations that are allowed only when leader and follower aircraft are aligned on the centreline.

	SPRINTEROP-ARR0.0890	
	SR1.040 REQ-02.01-SPRINTEROP-ARR0.0190	There shall be surveillance coverage down to the separation delivery point to allow the separation tool to display Target Distance Indicators on the runway extended centreline including the last part of the final approach.
	SR1.041 REQ-02.01-SPRINTEROP-ARR0.0730	The TDIs corresponding to the high priority MRS separation constraint shall remain visible on the radar display until the leader aircraft reaches the separation delivery point.
	SR1.042 REQ-02.01-SPRINTEROP-ARR0.0740	The TDIs corresponding to the high priority Wake separation constraint shall remain visible on the radar display until the leader aircraft reaches the separation delivery point.
	SR1.043 REQ-02.01-SPRINTEROP-ARR0.0750	The TDIs corresponding to the low priority Runway Occupancy Time constraint shall remain visible on the radar display until the leader aircraft reaches the separation delivery point.
	SR1.044 REQ-02.01-SPRINTEROP-ARR0.0760	The TDIs corresponding to the low priority Gap spacing constraint shall remain visible on the radar display until the follower aircraft reaches the separation delivery point.
	SR1.045 REQ-02.01-SPRINTEROP-ARR0.0690	TDI display shall be robust to ensure they do not keep switching on and off as aircraft perform normal manoeuvres
	SR1.050 REQ-02.01-SPRINTEROP-ARR3.1000	If the ORD concept is implemented, the Final Approach Controller shall maintain the aircraft on or behind the ITD on the final approach and reduce to the final approach procedural airspeed until the transfer to the Tower controller.
	SR1.051 REQ-02.01-SPRINTEROP-ARR3.0170	If the ORD concept is implemented, the Approach controller shall vector the follower aircraft so that it stays on or behind the corresponding ITD.
	SR1.052 REQ-02.01-SPRINTEROP-ARR0.0710	The tool shall automatically display the FTD (if not already displayed) if the aircraft comes within a defined distance of the computed FTD. This distance shall be configurable within the tool.

	SR1.053 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0792	For the TWR HMI, if the first most constraining ITD corresponding to a high priority separation indicator (e.g. WAKE or MRS) is infringed, then its already displayed corresponding FTD shall be accompanied by the distance countdown to the FTD of the corresponding aircraft such that the TWR controller is aware that a high priority ITD has been infringed Note this countdown to the FTD applies only to the high priority separation indicators (WAKE and MRS). The scope of this distance is to show the TWR ATCO when an ITD has been infringed keeping in mind that the ITD is not displayed by default for the TWR controller.
	SR1.054 Example of REQ-02.01-SPRINTEROP-ARR0.0792	For the TWR HMI, if the second most constraining ITD corresponding to a high priority separation is infringed, the system shall display the corresponding FTD accompanied by the distance countdown to the FTD, in addition to the already displayed first most constraining FTD such that the TWR controller is aware that a high priority ITD has been infringed (FTD displayed according to the rules defined for the high priority separation indicators)
	SR1.055 Example of REQ-02.01-SPRINTEROP-ARR0.0793	For the TWR HMI, if the high priority ITD is no longer infringed: • In case the FTD corresponding to this high priority ITD is the first most constraining FTD the corresponding countdown distance to the FTD shall be hidden by the system and • In case the FTD corresponding to this high priority ITD is the second most constraining FTD, the FTD shall be hidden together with the countdown to the FTD
	SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)
	SR1.058 Example of	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority

	REQ-02.01-SPRINTEROP-ARR0.0795	spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed according to the rules defined for the high priority separation and low priority spacing indicators)
	SR1.059 Example of REQ-02.01-SPRINTEROP-ARR0.0796	For the APP HMI, if the second and/or third most constraining ITD is no longer infringed, the corresponding FTDs shall be hidden by the system
	SR1.060 REQ-02.01-SPRINTEROP-ARR0.0850	The HMI design shall allow ATCO to hide/unhide indicators for a specific aircraft pair, and current and forthcoming alerts/warnings for that aircraft as a follower (e.g. infringement, catch-up, speed,..)
	SR1.061 REQ-02.01-SPRINTEROP-ARR0.0900	Following the ATCO action to suppress the TDIs for specific aircraft the tool shall: • remove any information on the spacing/separation (ITD and FTD) • remove its ongoing or not display the forthcoming Separation Delivery Tool alerts (e.g. Catchup/Speed/SeqNumber/Infringement)
	SR1.062 REQ-02.01-SPRINTEROP-ARR0.0720	The Approach controller shall be able to remove the FTD from the radar display, but not when the FTD has been automatically displayed by the System.
	SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.
	SR1.064 REQ-02.01-SPRINTEROP-ARR0.0870	The Approach controller shall maintain applicable surveillance separation minima at any point during approach. This includes the case of a leader aircraft established on the final approach axis and a follower not yet established
	SR1.066 REQ-02.01-SPRINTEROP-ARR3.0500	Once the follower aircraft has been positioned w.r.t ITD and before the leader reaches its deceleration point, the Controller shall apply speed instructions in accordance to the reference glide slope air speed used for ITD calculation.
	SR1.097 REQ-02.01-	If ORD is not implemented, the Final Approach Controller shall maintain the aircraft behind the FTD with sufficient

	SPRINTEROP-ARR0.0970	buffer due to the effect of compression caused by different leader and follower groundspeed profiles, and shall reduce aircraft's speed to the final approach procedural airspeed.
	SR1.098 REQ-02.01-SPRINTEROP-ARR0.0167	If both the FTD and ITD are available, the ITD indication ("compressions indicator") shall be the main indicator to be used by the final approach controller.
	SR1.099 REQ-02.01-SPRINTEROP-ARR0.0651	In case the ITD is the main display on the final approach, the ATCOs shall be able to display the FTD , depending upon the local operation's needs.
	SR1.103 REQ-02.01-SPRINTEROP-ARR0.0165	The Tower Controller shall monitor and ensure that there is no infringement of the FTD.
	SR1.105 REQ-02.01-SPRINTEROP-ARR0.0164	The FTD indicator shall be the main TDI to be used by the Tower Controller.
	SR1.114 REQ-02.01-SPRINTEROP-ARR0.0166	Clear guidelines with regard to the list of possible actions to be made in the case of an FTD infringement (in the APP and in the TWR) shall be described per position for the local implementation.
	SR1.117 REQ-02.01-SPRINTEROP-ARR0.1250	Approach and Tower Controllers shall be fully trained to apply the procedures for the new separation modes and to use of the Separation Delivery Tool and supporting systems (e.g. alerts) with indicators prior to deployment.
	SR1.118 REQ-02.01-SPRINTEROP-ARR0.1260	All Approach and Tower controllers and Supervisors shall be fully trained in the operating procedures for the new WT separation modes prior to deployment.
	SR1.124 REQ-02.01-SPRINTEROP-ARR2.0971	The Tower Controller shall ensure that the actual spacing behind the leader aircraft is not infringing the FTD and in case of imminent infringement he shall apply adequate corrective action like delegating visual separation to Flight Crew or instructing go-around.
	SR1.125 REQ-02.01-	The Approach and Tower Runway Controllers shall remain responsible for monitoring for separation infringements

	SPRINTEROP-ARR0.0990	and for timely intervention actions to resolve or prevent them.
	SR1.129 REQ-02.01-SPRINTEROP-ARR0.1351	In a dual approach arrival environment, ATCOs shall have supporting alert, for identifying vertical and horizontal infringements for the crossing aircraft (e.g. North runways to South runways)
SO 009 ATC and Flight Crew/Aircraft shall ensure that the final approach path is flown whilst respecting the aircraft speed profile (unless instructed otherwise by ATC or airborne conditions require to initiate go around) in order to ensure correctness of the separation indicators	SR1.109	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), the APP and TWR Controllers shall be made aware with respect to the impact on the TDIs correctness when actual aircraft speed profile is different from the pre-defined TAS profile used by the separation delivery tool.
	SR1.110 REQ-02.01-SPRINTEROP-ARR0.1420	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), Flight Crew shall be briefed and reminded (e.g. via information campaigns) on the importance to respect on the Final Approach path the ATC speed instructions until the start of the deceleration and/or the published procedural airspeed on final approach and to notify Controller in a timely manner in case of inability to conform to one of those.
SO 010 ATC (and potentially Flight Crew/Aircraft) shall consider the potential for WDS separation infringement due to lateral deviation from final approach path (e.g. dog leg when WDS crosswind is operated)	SR1.113 REQ-02.01-SPRINTEROP-ARR0.1430	With regards to WDS modes (total wind or cross wind) Flight Crew shall be briefed and reminded on the importance to respect the Final Approach path in terms of lateral deviation from the glide path and to notify Controller in a timely manner in case of inability to conform to it.
SO 011 The runway spacing or other spacing constraint (e.g. departure gaps)	SR1.013 REQ-02.01-	The Tower Supervisor in coordination with the Approach Supervisor (and occasionally the Tower and Approach Controllers - in line with defined local procedures) shall determine the final approach separation mode and

shall be input to and accounted for the Separation Delivery Tool (in support of SO 006)	SPRINTEROP-ARR0.0980	runway spacing constraints that are to be applied at any time by the separation delivery tool.
	SR1.089 REQ-02.01-SPRINTEROP-ARR0.0162	The tool in any mode shall display TDIs representing the greatest constraint out of all applicable in-trail or not in-trail separation constraints. The constraints can be the high priority separation (e.g. Wake and MRS) and the low priority runway spacing (ROT) and other spacing constraints (e.g. departure GAP, runway inspections, etc.).
	SR1.121 REQ-02.01-SPRINTEROP-ARR0.0370	Local implementation shall ensure that roles and responsibilities are clearly defined regarding the management of data inputs into the Separation Delivery tool including runway policy, runway spacing constraints, visibility conditions and runway conditions.
SO 012 TWR ATC shall request the insertion of departure gaps from APP ATC, and shall coordinate with APP the modification and cancellation of these gaps as operationally needed	SR1.031 REQ-02.01-SPRINTEROP-ARR0.0570	If there is a change to the separation / spacing constraint (e.g. Gap) the TDI for the affected aircraft pair shall be re-computed.
	SR1.044 REQ-02.01-SPRINTEROP-ARR0.0760	The TDIs corresponding to the low priority Gap spacing constraint shall remain visible on the radar display until the follower aircraft reaches the separation delivery point.
	SR1.072 REQ-02.01-SPRINTEROP-ARR0.0253	The separation delivery tool shall provide confirmation to ATCO that the gap spacing insertion is successful or not.
	SR1.073 REQ-02.01-SPRINTEROP-ARR0.0254	The ATCOs shall be able to insert automatic gap spacing based on pre-defined scenarios in the sequence manager
	SR1.074 REQ-02.01-SPRINTEROP-ARR0.0255	The tool shall provide ATCOs the ability to update and cancel any gap spacing previously inserted.

Table 9: Mapping of Safety Objectives to Safety Requirements for the PJ.02.01 Arrivals Concepts Solutions

5.3.2 Static analysis of the functional system behaviour – Normal conditions of operation

No additional requirements were found as a result of the static analysis of the functional system behaviour.

5.3.3 Dynamic Analysis of the functional system behaviour – Normal conditions of operation

No additional requirements were found as a result of the dynamic analysis of the functional system behaviour.

5.3.4 Effects on Safety Nets – Normal conditions of operation

The new WT separation modes and ATC tools do not impact the safety net associated to ground collision avoidance (e.g. MSAW, TAWS); since obstacle clearances are not modified with these concepts.

The application of the new separation modes is reducing the distance separation between aircraft therefore it might impact STCA, ACAS, RIMCAS or ASMGCS level 2. However, the Safety Requirement **SR1.089** specifies that the TDIs display the greatest constraint out of the applicable separation minima's and other applicable constraints, which includes the minimum radar separation, ROT and other runway constraints. Therefore the performance of STCA, ACAS, RIMCAS and ASGCMS level 2 should not be impacted by the new WT separation modes. See also SR1.064 during the interception phase.

5.4 Deriving Safety Requirements at Design level for Abnormal conditions of operation

5.4.1 Safety Requirements at Design level (SRD) for Abnormal conditions of operation

This section ensures that the Arrivals Concepts Solutions SPR-level Design is complete, correct and internally coherent with respect to the Safety Requirements (Functionality and Performance) derived for the abnormal operating conditions that were used to derive the corresponding Safety Objectives (success approach) in Section 4.3.

5.4.1.1 Scenarios for Abnormal Conditions for the Arrivals Concepts Solutions

Table 10 below recalls the different scenarios relative to the abnormal conditions identified in Section 4.3.1 and for which new Safety Objectives have been derived in Section 4.3.2, analyses the causal factors or possible influences and presents the risk mitigation.

ID	Scenario	Possible influences or causal factors	Mitigation
1	Change of Aircraft landing runway intent.	Pilot's request.	Inform Arrival Sequencing (and thus the Separation Delivery) tool about late

			change of the sequence order in order to have correct separation indications.
2	Abnormal procedural aircraft airspeed and/or abnormal stabilized approach speed.	Pilot basic airmanship not respected. Aircraft problem.	Detect abnormal airspeed (through alerting), manage compression manually and, in TB-modes, apply adequate corrective actions for the affected pairs: airspeed instructions, path stretching instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary, missed approach instruction.
3	Lead aircraft go-around.	Loss of separation on final. Severe Wake Encounter. Runway not in sight at minima. Loss of ILS guidance in IFR. Insufficient spacing between successive landings. Landing runway occupied. Late landing clearance. Unstable approach below 500ft.	Inform separation tool about the sequence order change due to the missed approach (if not automatic) in order to have correct separation indications.
4	Delegation of separation to Flight Crew.	Final APP or TWR ATCO needs to delegate the WT separation to Flight Crew (e.g. in case the FTD is going to be infringed, in order to avoid initiating a go around).	Request Flight Crew if they can apply a visual separation. Upon acceptance, the responsibility to maintain separation will be passed to the Flight Crew.
5	Actual Wind on final approach different from the wind used for FTD/ITD computation.	External influence, not under ATM managerial control.	Ensure anticipation of change in wind conditions by forecast and monitoring Detect change in wind condition (through wind condition monitoring and alerting) and revert to the correspondent DB- mode (in case of change in glideslope wind, ITDs will be inhibited and compression managed as per today operations).
6	Flight Crew Notification of Aircraft Speed non-conformance.	Pilot reasons. Aircraft problem detected by Pilot.	ATCO takes into account, for the merging on to final approach, the notified speed-related aspects to determine the additional spacing that is required to be set up behind the ITD indication.

7	Unexpected drop of reference wind below safe threshold.	External influence, not under ATM managerial control.	TB-mode is deactivated (revert to correspondent DB- mode).
8	Late change of landing runway (not planned).	Runway blocked.	Ensure coordination, update landing runway in Separation Delivery and Arrival Sequencing tools in order to get updated arrival sequence and separation indicators.
9	Scenario specific spacing requests.	Unplanned Runway inspection. Pilot reporting difficulty to brake.	Allow individual definition of spacing constraint and display of associated TDIs.

Table 10: Operational Scenarios Analysis – Abnormal Conditions for the PJ.02.01 Arrivals Concepts Solutions

5.4.1.2 Derivation of Safety Requirements (Functionality and Performance) for Abnormal Conditions for the Arrivals Concepts Solutions

Table 11 below, uses the outcome of the previous sub-section (Table 10) and the Safety Objectives from Section 4.3 to derive the corresponding Safety Requirements (Functionality and Performance).

SO	SO Description	SRs	SR Description
SO 101	ATC shall be alerted when the actual wind conditions differ significantly from the wind conditions used for the TDIs computation (wind conditions monitoring alert): for the FTD -glideslope wind in TB-modes only; for the ITD – glideslope wind in all modes (TB and DB).	SR1.208	In WDS total wind modes (A-TB-WDS-Tw), the Approach and Tower Controllers and Supervisors shall be alerted by the total wind monitoring function about a significant difference between actual reference total wind and the reference total wind used for the TB computation, i.e. when the predicted allowed time separation (based on the total wind prediction used for Target Distance Indicator computation) compared to the actual allowed time separation (based on the actual total wind measurement) exceeds a threshold to be determined locally.
		SR1.209	In WDS cross wind modes (A-TB-WDS-Xw), the Approach and Tower Controllers and Supervisors shall be alerted by the cross wind monitoring function about a significant difference between actual reference cross wind and the reference cross wind used for the TB computation, i.e. when the predicted allowed time separation (based on the cross wind prediction used for Target Distance Indicator computation) compared to the actual allowed time-separation (based on the actual cross wind

		measurement) exceeds a threshold to be determined locally.
	SR1.210	In WDS total wind modes (A-TB-WDS-Tw), in case of total wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.
	SR1.211 REQ-02.01-SPRINTEROP-ARR2.1680	In WDS crosswind modes (WDS-Xw), in case of cross wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode, using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.
	SR1.212	In TBS and TB-PWS-A modes, in case there is a significant difference between actual glideslope headwind profile and the glideslope headwind profile used for the TDI computation, the Separation Delivery Tool shall re-compute the TDIs based on the correct headwind value and inform the ATCO about the re-computation.
	SR1.213 REQ-02.01-SPRINTEROP-ARR2.1690	The triggering values of the headwind, total wind and cross wind monitoring alerts shall be determined on the basis of the used buffers in the TDI computation
SO 102 ATC shall be alerted when the aircraft speed varies significantly from the procedural airspeed and/or the stabilized approach speed used for the TDIs computation (speed conformance alert) in order to manage compression manually	SR1.214 REQ-02.01-SPRINTEROP-ARR0.1500	The Approach and/or Tower controller shall be alerted by the speed conformance alert function when the actual aircraft speed differs by more than a locally-defined threshold from the aircraft speed profile used for the TDIs computation.
	SR1.215 REQ-02.01-SPRINTEROP-ARR0.1700	In TB-modes, in case of speed conformance alert before the stabilisation fix, the Final Approach or Tower Controllers shall check whether the actual spacing behind the leader aircraft is below the distance-based WTC separation minima and if positive shall apply adequate corrective actions: airspeed instructions, path stretching instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary,

		missed approach instruction, and shall manage the impact on subsequent aircraft in the arrival sequence.
	SR1.217 REQ-02.01-SPRINTEROP-ARR0.1710	For all modes, in case of speed conformance alert the Final Approach and Tower Controllers shall be aware that ITD indicators are no longer accurate if the same speed is kept until the deceleration fix (ITD computation impacted by pre-defined glideslope airspeed profile of both follower and leader) thus shall manage compression without indicators as per today operations.
	SR1.218 REQ-02.01-SPRINTEROP-ARR0.1510	The triggering value used for the speed conformance alert shall be determined on the basis of the used buffers in the TDI computation. The region on the glideslope where the alert is active shall be defined locally (e.g. 8 NM from RWY threshold).
SO 103 ATC shall maintain an updated arrival sequence order following a late change of aircraft runway intent or a go-around	SR1.200 Example of REQ-02.01-SPRINTEROP-ARR0.0852	The Intermediate and Final Approach controllers shall be the masters of the Final Approach arrival sequence and shall be able in a simple and timely way to update the sequence, insert or remove an aircraft and amend the sequence when there is a go-around in accordance with their strategy for the interception with no adverse impact on workload.
	SR1.201 REQ-02.01-SPRINTEROP-ARR0.0560	For every change in the arrival sequence (aircraft swapping positions, aircraft removed or missed approach, late change of the runway intent, etc.) the tool shall immediately re-compute all affected TDIs and reflect the change on the HMI accordingly.
	SR1.204 REQ-02.01-SPRINTEROP-ARR0.0851	Local procedures shall define the procedures related to the use of the TDIs and the specific instances in which they can be removed.
	SR1.205 REQ-02.01-SPRINTEROP-ARR0.0960	The Target Distance Indicators associated to a leader aircraft executing a go-around shall be removed from the sequence and new Target Distance Indicators shall be computed for the following a/c, considering the new arrival pairs created due to this go-around. The aircraft could be removed from the sequence manually by the ATCO or automatically.
SO 104 ATC shall take into account, for the merging on to final approach, the notified approach procedural	SR1.216 REQ-02.01-SPRINTEROP-ARR0.1370	Pilots shall notify ATC of an inability to fly the standard approach procedure, and of any non-conformant final approach procedural airspeed issues, in a timely manner.

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 ITD indication	SR1.219 REQ-02.01-SPRINTEROP-ARR0.1360	The Approach Controller shall take into account any notified inability to fly the standard approach procedure and any non-conformant final approach procedural airspeed issues when setting up the spacing on final approach.
SO 105 The Target Distance Indicators shall be correctly updated in case of late (not planned) change of landing runway	SR1.202 REQ-02.01-SPRINTEROP-ARR0.0561	For a late change of the runway intent, the tool shall immediately re-compute all affected TDIs and reflect the change on the HMI accordingly (i.e. the TDIs corresponding to the affected aircraft disappear from the extended runway centreline of the old runway and is displayed on the extended runway centreline of the new runway).
	SR1.203 REQ-02.01-SPRINTEROP-ARR0.0950	When the aircraft is already inserted into the sequence with a runway intent and there is a change of aircraft landing runway intent, the Approach controller shall check that Target Distance Indicators reflect the change of aircraft landing runway intent
SO 106 ATC shall be able to handle scenario specific spacing requests while using the separation delivery tool	SR1.206 REQ-02.01-SPRINTEROP-ARR0.0250	Scenario specific spacing gaps between aircraft pairs shall be provided to the Separation Delivery tool.
	SR1.220 REQ-02.01-SPRINTEROP-ARR0.1380	Procedures shall be locally defined for the handling of scenario specific spacing requests and runway changes.

Table 11: Safety Requirements or Assumptions to mitigate Abnormal Conditions for the PJ.02.01 Arrivals Concepts Solutions

5.5 Safety Requirements at Design level addressing Internal Functional System Failures

5.5.1 Design analysis addressing internal functional system failures

The objective of this analysis consists in determining how the system architecture (encompassing people, procedures, equipment) designed for the new WT separation modes and ATC tools can be made safe in presence of internal system failures. For that purpose, the method consists in apportioning the Safety Objectives of each hazard into Safety Requirements to elements of the system driven by the analysis of the hazard causes.

Fault tree analysis is used to identify the causes of hazards and combinations thereof, accounting for safeguards already specified in the current standards and for any indication on their effectiveness but also accounting for the safety requirements derived during the design analysis in normal and abnormal conditions.

Quantitative Safety Requirements will not be derived in this safety assessment. This will however need to be done by the industry in the validation stages prior to implementation (i.e. V4 onwards).

Fault tree analysis is also used to identify additional mitigations to reduce the likelihood that specific failures occur or would propagate up to the Hazard (i.e. operational level). These mitigations are then captured as additional Qualitative Safety Requirements (Functionality and Performance).

5.5.1.1 Causal Analysis for the Arrivals Concepts Solutions

For each system-generated hazard (see Section 4.4), a top-down identification of internal system failures that could cause the hazard was conducted. The hazards are:

- Hazards applicable to Interception and Final Approach (based on common mode failures):
  - **Hz#05**: One or multiple imminent infringements not detected and not recovered due to undetected corruption of separation indicator
  - **Hz#06**: One or multiple imminent infringements due to lack of separation indicator for multiple or all aircraft
- Hazards relative to the approach interception and associated to ATC instructions:
  - **Hz#01b**: Separation not being recovered following imminent infringement of A/C pair instructed by ATC to merge on the Final Approach interception
  - **Hz#01a**: Inadequate separation management of a pair of aircraft instructed by ATC to merge on the Final Approach interception
- Hazards relative to the approach interception and originated by Crew/Aircraft:
  - **Hz#02b**: Separation not being recovered following imminent infringement due to aircraft deviation from Final Approach interception profile without ATC instruction given
  - **Hz#02a**: Inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach interception profile without ATC instruction given
- Hazards during the Final Approach and associated to ATC instructions:
  - **Hz#03b**: Separation not being recovered following imminent infringement by an aircraft pair instructed by ATC on the Final Approach

- **Hz#03a**: Inadequate separation management of an aircraft pair naturally catching-up as instructed by ATC on the Final Approach
- Hazards during the Final Approach and originated by Crew/Aircraft:
  - **Hz#04b**: Separation not being recovered following imminent infringement due to aircraft deviation from Final Approach profile without ATC instruction given
  - **Hz#04a**: Inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach profile without ATC instruction given
- Hazard applicable to the management of separation mode:
  - **Hz#07:** Large under-separation induced by ATC through inadequate selection & management of the separation mode
- Hazard applicable to mixed mode of operations:
  - **Hz#08:** Runway conflict due to landing clearance in conflict with another landing (ROT not respected) or with cleared line-up/take-off (GAP not respected)

The purpose of the causal analysis is to increase the detail of risk mitigation strategy through the identification of all possible causes. This way it will be possible to identify the corresponding Safety Requirements to meet the Safety Objective of the Operational Hazard under consideration.

A fault tree is produced for each selected hazard that provides a detailed overview of the contribution of all domains to that hazard. Fault trees are elaborated by decomposing the hazard in a combination of failures (i.e. Basic Causes and failure of mitigations) linked by different gates: "AND" gates and "OR" gates. Once the fault tree is built, the safety objective assigned to the hazard is apportioned among the failures identified and safety requirements are allocated.

Existing mitigations (i.e. already captured as safety requirements) are identified and, where necessary, additional mitigation means are proposed in order to reduce the likelihood of occurrence of the Operational Hazard. The additional mitigation means are formalized as Safety Requirements.

5.5.1.1.1 Hz#05 (SO 209): One or multiple separation minima infringements due to undetected corruption of separation indicator

This hazard affects both the Final approach interception and the Final Approach down to separation delivery at RWY threshold. It is caused by the undetected corruption of the separation indicator (for one or multiple aircraft) which is a common mode failure impacting all the Wake AIM barriers up to and including the B3a: ATC separation recovery. Multiple aircraft might be impacted and exposed to large under-separation before the failure is detected (significant exposure time). Consequently, the residual risk of wake alive ahead is significantly higher compared to the occurrence of a single large under-separation (as per Hz#01b, 02b, 03b, 04b), thus a more demanding SO has been allocated via an impact modification factor IM=20.

The basic causes of this hazard are captured in the Hz#05 Fault Tree (See Figure 7).

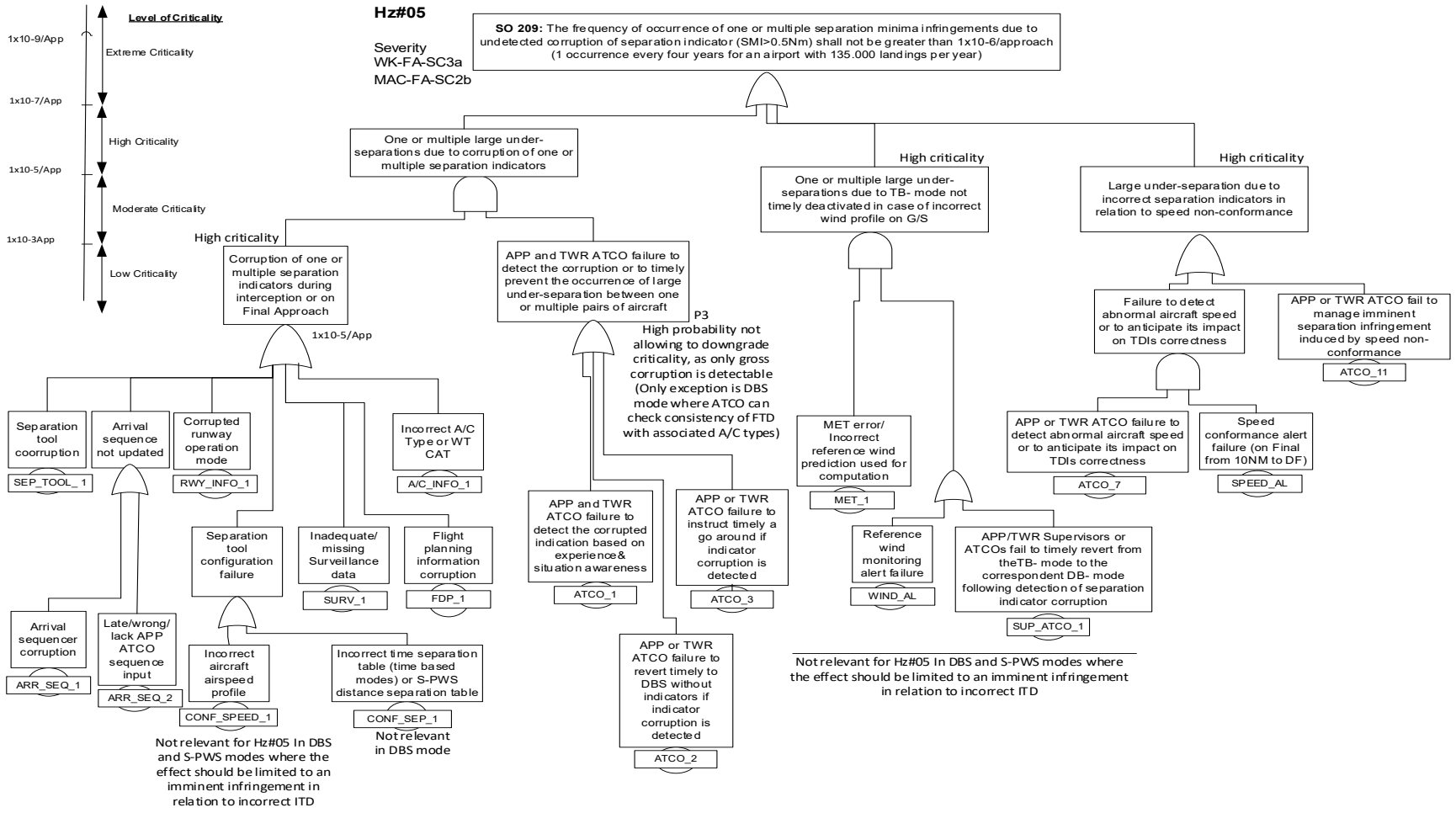


Figure 7: Hz#05 Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#05 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Corruption of one or multiple separation indicators during interception or on Final Approach			
Separation Tool corruption.	SEP_TOOL_1	The separation tool despite correct inputs computes corrupted separation indicator(s) (for one or multiple aircraft).	Mitigated through the software assurance process which defines the acceptably safe level of confidence in the separation delivery tool prior to implementation. **SR1.317:** The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment
Arrival sequencer corruption.	ARR_SEQ_1	The arrival sequencer does not provide the correct sequence to the separation delivery tool despite the arrival sequence displayed to the controller is correct.	**SR1.028, SR1.201**, “normal and abnormal conditions” Also mitigated through the software assurance process which defines the acceptably safe level of confidence in the arrival sequence service prior to implementation. **SR1.317:** The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment
Late, Wrong or Lack of arrival sequence input by the APP controller.	ARR_SEQ_2	The approach controller does not timely update the arrival sequence following a change in the sequence (according to his strategy for the interception, late change of aircraft landing runway intent, missed approach etc.) or makes a mistake when	**SR1.300, SR1.032, SR1.034, SR1.093 and SR1.033** “normal conditions”. **SR1.200** “abnormal conditions”

		she/he updates the sequence or does not update the sequence in the tool whilst considering an order different from the one provided by the tool.	
Corrupted runway operation mode.	RWY_INFO_1	The information about the active runway and/or mode of operation (segregated or mixed mode) sent to the arrival sequencer are corrupted.	No specific SR for the new concepts because it is assumed that this failure will be detected by the tower and/or the approach supervisor before aircraft are vectored to the final approach.
Incorrect aircraft airspeed profile. Not relevant for Hz#05 in DBS and S-PWS modes where the effect should be limited to an imminent infringement.	CONF_SPEED_1	The aircraft speed profile used by the separation delivery tool to compute separation indicator is incorrect. In DBS and DB-PWS-A modes the effect should be limited to an imminent infringement, as the TWR ATCO would initiate a Go Around to manage the compression effect (ITD is computed using the wind profile on the glideslope therefore the indication could be corrupted but FTD will remain correct).	**SR1.080** "normal conditions". **SR1.320:** Separation delivery tool verification shall be carried-out after modification of the time-to-fly/airspeed profile configuration file (new A/C types or modification of existing A/C speed profiles) before the system returns in operational service **SR1.319:** A quality assurance process shall be put in place to validate the separation time table configuration file (in TB- modes) or the distance separation table configuration file of the separation delivery tool **SR1.318:** Separation delivery tool verification shall be carried-out after modification of the separation time table configuration file (in TB- modes) or the distance separation table configuration file before the system returns in operational service **SR1.317:** The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment

Incorrect time separation table (time-based modes) or S-PWS distance separation table. Not relevant in DBS mode.	CONF_SEP_1	The separation time table in time-based modes (that correspond to the application of equivalent distance-based separations either DBS or DB-PWS-A) or the DB-PWS distance separation table in DB-PWS-A mode, which are used by the separation delivery tool to compute separation indicator are incorrect. Not relevant in DBS mode.	**SR1.077, SR1.078, SR1.088, SR1.079** "normal conditions". **SR1.319:** A quality assurance process shall be put in place to validate the separation time table configuration file (in TB- modes) or the distance separation table configuration file of the separation delivery tool **SR1.317:** The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment **SR1.318:** Separation delivery tool verification shall be carried-out after modification of the separation time table configuration file (in TB- modes) or the distance separation table configuration file before the system returns in operational service
Inadequate/missing surveillance data.	SURV_1	Surveillance information sent to the arrival sequencer is corrupted including flight ID information.	No specific SR because reliability of the surveillance system is considered sufficient for all the WT separation modes and ATC tools considered.
Flight planning information corruption. Incorrect A/C Type or WT CAT.	FDP_1 A/C_INFO_1	Fight plan information sent to the arrival sequencer and the separation delivery tools is corrupted or incorrect. This includes incorrect aircraft types and/or the Wake Turbulence Categories.	**SR1.085** "normal conditions". **SR1.315:** It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust. Aircraft type and wake turbulence category are essential parameters for all the concepts using the separation delivery tool:

			SR1.316: At the first contact with the Approach, the flight crew shall provide the Aircraft type or alternatively this information could be provided to the Approach Controller via data link and the Approach Controller shall cross check this information with the information displayed on the CWP. **SR1.304:** Wake category and aircraft type information shall be always available in the aircraft labels so that this information remains visible for Controllers. **SR1.321:** When a flight data input error (e.g. missing or wrong ICAO aircraft type or wake category) is detected, it shall be possible to update the corresponding information into the input for the separation delivery tool. **SR1.330:** Approach control shall check the validity of Flight Plan information displayed on the CWP (ICAO aircraft type, wake category) Note the following assumption is conservatively taken: **A015:** Controllers cannot have detailed knowledge of separations for each pair of aircraft in all modes except for DBS therefore checking that Target Distance indications are consistent with the associated aircraft types and WT category is not realistic
TWR and APP ATCO failure to detect the corruption or to timely prevent the occurrence of large under-separation between one or multiple pairs of aircraft			

APP and TWR ATCO failure to detect the corrupted indication.	ATCO_1	APP and TWR ATCO do not detect the corrupted indication: • low probability in DBS mode where ATCO can check consistency of FTD with associated A/C types or WTC, • high probability in all other modes where only large errors can be detected by checking consistency of FTD with associated A/C types or WTC	**SR1.322:** In TB modes, relevant wind information shall be displayed on Approach / Tower Controller working positions for awareness purposes (e.g. to enable significant discrepancy check with the displayed TDI). Note the following assumption is conservatively taken: **A015:** Controllers cannot have detailed knowledge of separations for each pair of aircraft in all modes except for DBS therefore checking that Target Distance indications are consistent with the associated aircraft types and WT category is not realistic
APP or TWR ATCO failure to revert timely to DBS without indicators if indicator corruption is detected.	ATCO_2	APP or TWR ATCO does not revert timely to DBS minima without indicators when indicator corruption is detected.	**SR1.123** in “normal conditions” **SR1.304:** Wake category and aircraft type information shall be always available in the aircraft labels so that this information remains visible for Controllers **SR1.323:** Approach and Tower Controllers shall be provided with look-up tables for DBS minima to support DBS operations with no TDIs when necessary. **SR1.324:** ATCOs shall continue to have a 'click and drag' distance measuring tool so they can accurately measure inter a/c spacing when required (e.g. for building confidence in the tool or during degraded modes).

APP or TWR ATCO failure to instruct timely a go around if indicator corruption is detected	ATCO_3	APP or TWR ATCO does not instruct timely a go around in case the indicator(s) corruption has been detected (e.g. corruption involving gross error). Given the detection latency, the probability is nevertheless higher than when indicators are correctly displayed (see APP_ATCO_10 during interception and ATCO_6 on Final approach).	No specific SR because it is assumed that this is a normal ATCO procedure considering that the problem is detected.
One or multiple large under-separations due to Time-based mode not timely deactivated in case of incorrect wind profile on G/S			
MET error/ Incorrect reference wind prediction used for computation. Not relevant for DBS and DB-PWS-A modes.	MET_1	The reference wind prediction used for the separation computation (glideslope headwind profile In TBS and TB-PWS-A, total wind in A-WDS-Tw and crosswind in A-WDS-Xw modes) is different from the actual reference wind. The respective wind monitoring alerts specific to each of the TB-modes have been derived as mitigation during Abnormal modes analysis, allowing the reversion to the correspondent distance-based separation mode (for WDS) or a re-computation of the TDIs (for TBS and TB-PWS-A). For DBS and DB-PWS-A modes only relevant for ITD computation (if problem is detected, ATCO need to manage compression manually but FTD continues to be correct).	**SR1.086** “normal conditions”. **SR1.207, SR1.208, SR1.209, SR1.210, SR1.211, SR1.212** and **SR1.213** in “abnormal conditions”
Reference wind monitoring alert failure.	WIND_AL	The reference wind monitoring alert fails to timely detect and trigger warning about the significant discrepancy between the reference wind prediction used for the computation and the actual reference wind (glideslope headwind profile in TBS and TB-PWS-A, total wind in A-TB-WDS-Tw and cross wind in A-TB-WDS-Xw modes) Not relevant for DBS and DB-PWS-A modes.	**SR1.325:** Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)

APP/TWR Supervisors or ATCOs fail to timely revert from the time-based mode to the correspondent distance-based mode following detection of separation indicator corruption.	SUP_ATCO_1	APP/TWR Supervisors or ATCOs fail to timely revert from the time-based mode to the correspondent distance-based mode following wind monitoring alert when in WDS (error in detection of the alert, coordination or correct and timely execution of the mode reversion). Not relevant for DBS and DB-PWS-A modes.	**SR1.210, SR1.211** "abnormal conditions".
APP or TWR ATCO failure to detect abnormal aircraft speed or to anticipate its impact on TDIs correctness.	ATCO_7	APP or TWR ATCO does not detect that one of the aircraft involved in an imminent infringement situation is not respecting the instructed or procedural speed, or they do not anticipate the impact of the Follower speed non-conformance on the TDIs correctness. In case the follower speed is higher than the value used for TDIs computation (e.g. 160 KIAS) on the last part of the Final Approach (e.g. last 10 NM) the FTD indicator is incorrect in TB-modes and the ITD indicator is incorrect in all modes. That might involve the follower getting too close to the leader with risk for loosing separation as the compression would not have been correctly anticipated and managed.	**SR1.109, SR1.124 and SR1.110** "normal conditions". **SR1.214, SR1.215, SR1.217, SR1.218** "abnormal conditions". It is assumed that the approach and the tower controller verify the actual speed of the aircraft and the speed trend when aircraft are established on the final approach.
Speed conformance alert failure.	SPEED_AL	In case APP or TWR ATCO do not detect that one of the aircraft involved in an imminent infringement situation is not respecting the procedural speed instructions or any other ATC speed	**SR1.306:** Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.

		instructions, the speed conformance alert warns in case actual Follower air speed is different from the air speed profile used by the separation tool computation. The current event is the speed conformance alert failing to timely detect and trigger the warning about the follower aircraft speed non-conformance (too fast).	
APP or TWR ATCO fail to manage imminent separation infringement induced by speed non-conformance	ATCO_11	APP or TWR ATCO fail to manage imminent separation infringement induced by speed non-conformance, via speed adjustment, delegation of visual separation to Flight Crew or instructing go around.	**SR1.215, SR1.124** “abnormal and normal conditions”.

Table 12: Derivation of Mitigation/Safety Requirements for Hazard Hz#05 for the PJ.02.01 Arrivals Concepts Solutions

5.5.1.1.2 Hz#06 (SO 210): One or multiple imminent infringements due to lack/loss of separation indicator for multiple or all aircraft

This hazard affects both the Final approach interception and the Final Approach down to separation delivery at RWY threshold. It is caused by the lack or loss (initially displayed and subsequently removed) of the separation indicator (for multiple or all concerned aircraft) which is a common mode failure impacting the barriers B3 to B5 (dealing with separation management of aircraft pairs merging to the Final Approach or naturally catching up on the Final Approach, or with spacing conflicts due to A/C deviation).

Given the need for ATCOs to manage the unplanned reversion to DBS minima without indicators for multiple or all aircraft it is assumed, as a worst effect, that for at least a pair of aircraft the separation management as per barriers B3 to B5 fails. Nevertheless, the barrier B3a: ATC separation recovery will mitigate this hazard, as ATCOs will be able to detect the problem and revert to DBS minima without indicators, before large under-separation would occur.

However, given the expected occurrence of multiple imminent infringements the risk is considered higher compared to the lack of a single separation indicator (addressed in Hz#01a, Hz#03a), thus a more demanding SO has been allocated via an impact modification factor IM=10.

The basic causes of this hazard are captured in the Hz#06 Fault Tree (See Figure 8).

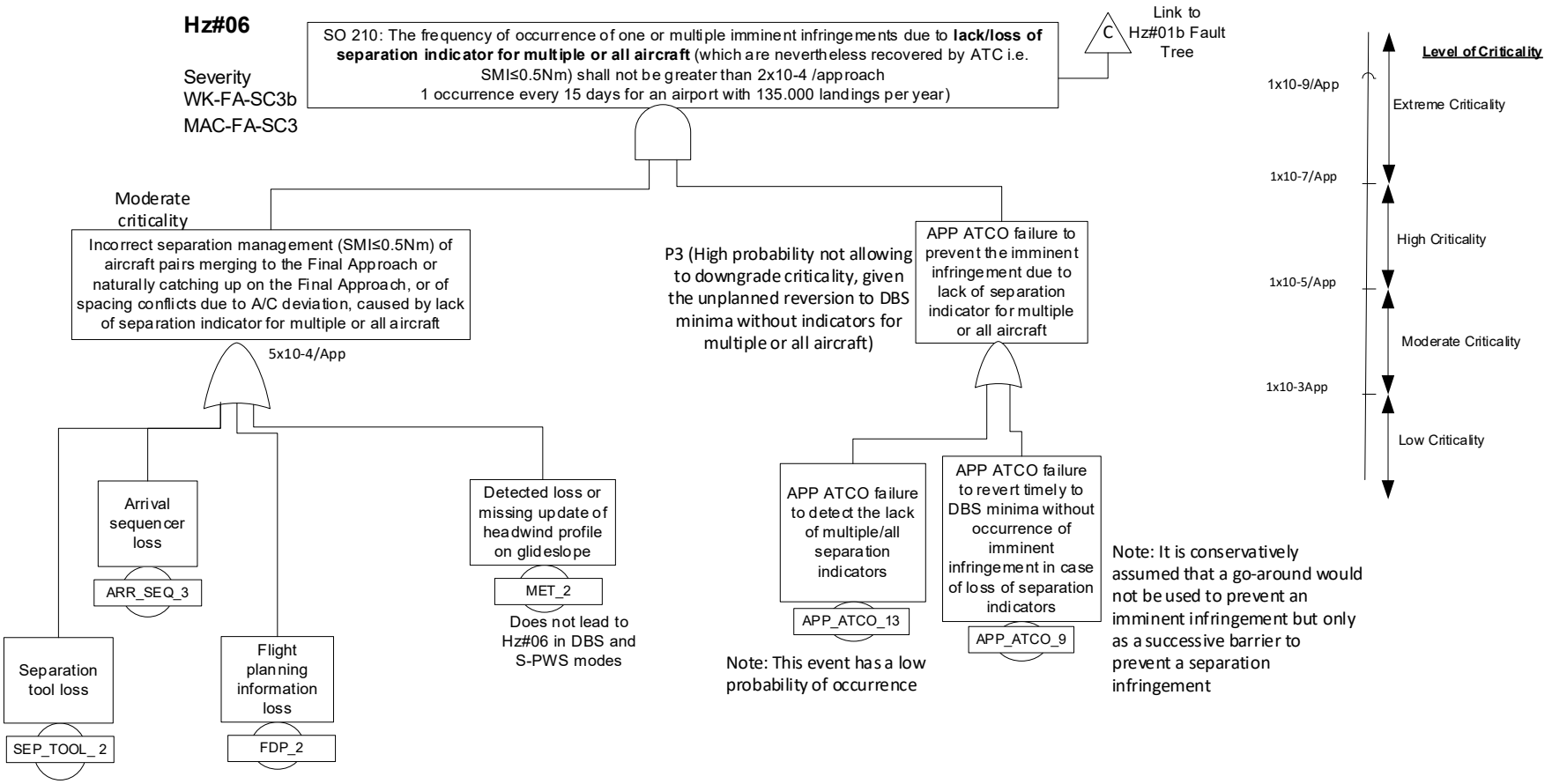


Figure 8: Hz#06 Fault tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#06 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective:

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Incorrect separation management (SMI≤0.5NM) of aircraft pairs merging to the Final Approach or naturally catching up on the Final Approach, or of spacing conflicts due to A/C deviation, caused by lack of separation indicator for multiple or all aircraft			
Separation Tool loss.	SEP_TOOL_2	The separation tool does not display multiple or all the separation indicators or display them too late for the interception of the final approach. ATCOs need to revert to DBS minima without indicators; however, one or several imminent infringements might occur in relation to the high workload peak.	**SR1.048 and SR1.037** "normal conditions". **SR1.123, SR1.323, SR1.324, SR1.304** (reversion to DBS minima without indicators, as specified at Hz#05 for ATCO_2). **SR1.331**: In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off) **SR1.327:** In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure **SR1.306:** Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.
Arrival sequencer loss.	ARR_SEQ_3	The arrival sequencer does not provide information to the separation tool for multiple or all aircraft despite inputs are correct (e.g. sequence frozen). ATCOs need to revert to DBS minima without	**SR1.028** "normal conditions". **SR1.123, SR1.323, SR1.324, SR1.304** (reversion to DBS minima without indicators, as specified at Hz#05 for ATCO_2) **SR1.300:** Controllers shall be trained to check the aircraft landing runway intent and that the aircraft order is correct and coherent with the arrival sequence list. They shall check if and that the aircraft order is displayed in the arrival sequence list and/or if the aircraft sequence number is displayed in the radar label in accordance with their intended sequence.

		indicators; however, one or several imminent infringements might occur in relation to the high workload peak.	**SR1.314:** If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft **SR1.306:** Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.
Flight planning information loss.	FDP_2	Fight plan information sent to the arrival sequencer and the separation delivery tool is missing. This includes aircraft types and/or the Wake Turbulence Categories. ATCOs need to revert to DBS minima without indicators; however, one or several imminent infringements might occur in relation to the high workload peak.	**SR1.085** in "normal conditions" **SR1.313**: If there is insufficient information to calculate a TDI then that TDI shall not be provided, together with a visual warning. **SR1.306:** Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative. **SR1.123, SR1.323, SR1.324, SR1.304** (reversion to DBS minima without indicators, as specified at Hz#05 for ATCO_2). No specific SR associated to the flight plan system because its current availability is considered sufficient for the new WT separation modes.
Detected loss or missing update of Headwind Profile on Glideslope. (Does not lead to Hz#06 in DBS and DB-PWS=A)	MET_2	Headwind profile on the Glideslope is lost or is not updated, but that is alerted according to SRs proposed in the mitigation column. In TB-modes the reversion to correspondent DB- mode	**SR1.305**: For all modes, in case of loss of glideslope headwind profile input to the separation tool, the alert for loss of glideslope headwind profile service shall be displayed to the Controllers and Supervisors. **SR1.325**: Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)

		is coordinated between Supervisors and ATCOs and can be performed smoothly; however, a certain risk of imminent infringement is pessimistically assumed, which is lower than the one related to an abrupt reversion needed in case of loss of separation tool. Not relevant for this hazard in DBS and DB-PWS-A modes (ITD is computed using the wind profile on the glideslope therefore the indication could be lost but it cannot lead to a spacing conflict because FTD is correctly displayed in such case). Meanwhile in these modes the Approach Controller shall use FTD only for the turn-on decision for merging on to final approach, vectoring the follower aircraft to intercept the	**SR1.308**: In DB- modes, in the degraded situation where glideslope headwind profile input is missing, the Approach Controller shall use only the FTD for the turn-on decision for merging on to final approach (whilst ITDs shall no more be displayed), vectoring the follower aircraft to intercept the final approach and further spacing management during interception whilst adding extra buffer to the FTD to manually account for compression or shall revert to an acceptably safe DB-mode with ITD and FTD computed using a conservative wind profile (until the glideslope headwind profile is available again) **SR1.307:** In TB-modes, in the degraded situation where glideslope headwind profile input is missing: - The Controllers shall revert to the correspondent DB- mode (DBS or S-PWS) with use of FTDs only whilst ITDs shall no more be displayed (manual management of compression) or shall revert to an acceptably safe TB-mode with ITD and FTD computed using a conservative wind profile (until the glideslope headwind profile is available again); OR - The Separation Delivery Tool shall automatically revert to the correspondent DB-mode or to an acceptably safe TB-mode (FTD and ITD computed using a conservative wind profile). A notification of the automatic switch shall be provided to the ATCOs and Supervisors.

		final approach and further spacing management during interception whilst adding extra buffer to the FTD to account for compression.	
APP ATCO failure to prevent the imminent infringement due to lack of separation indicator for multiple or all aircraft			
APP ATCO failure to detect the lack of multiple/all separation indicators.	APP_ATCO_13	APP ATCO failure to detect the lack of multiple/all separation indicators (low probability of occurrence).	No specific mitigation required.
APP ATCO failure to revert timely to DBS minima without occurrence of imminent infringement in case of loss of separation indicators.	APP_ATCO_9	APP ATCO failure to revert timely to DBS minima without occurrence of imminent infringement in case of loss of separation indicators. ATCO will easily detect the lack of indicators for the new arrivals (see above), but his decision to revert to DBS without indicators might be delayed if a clear information about the	**SR1.327:** In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure **SR1.326**: In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point. **SR1.331:** In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off) **SR1.303:** Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.

		tool failure is not available.	**SR1.329:** Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.) **SR1.123, SR1.323, SR1.324, SR1.304** (reversion to DBS minima without indicators, as specified at Hz#05 for ATCO_2).

Table 13: Derivation of Mitigation/Safety Requirements for Hazard Hz#06 for the PJ.02.01 Arrivals Concepts Solutions

5.5.1.1.3 Hz#01b (SO 202): Separation not being recovered following imminent infringement of A/C pair instructed by ATC to merge on the Final Approach interception

This hazard occurs during the Final Approach interception and its basic causes have been captured in the Hz#01b Fault Tree (See Figure 9).

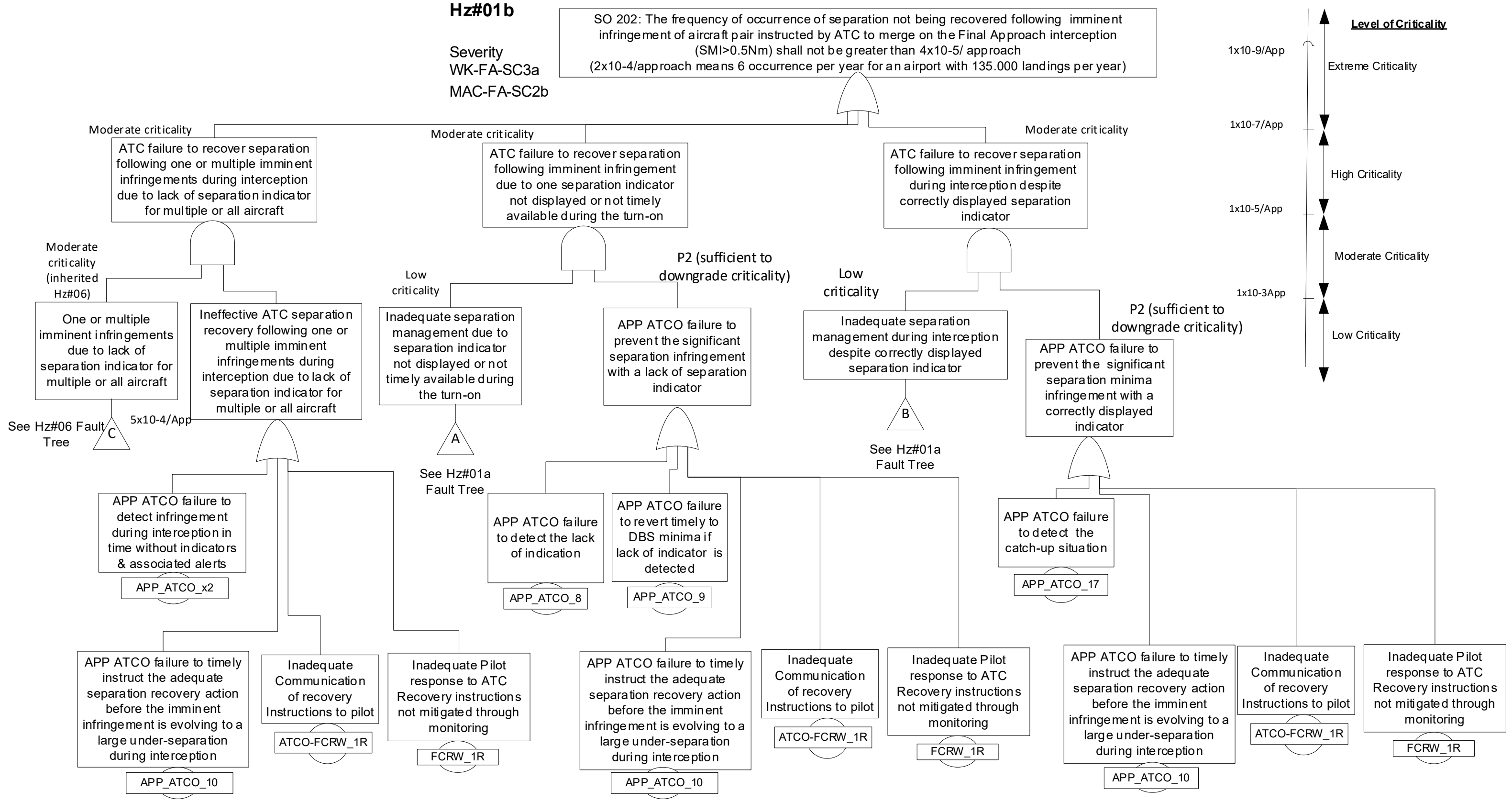


Figure 9: Hz#01b Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#01b Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
ATC failure to recover separation following one or multiple imminent infringements during interception due to lack of separation indicator for multiple or all aircraft			
One or multiple imminent infringements due to lack of separation indicator for multiple or all aircraft	See Hz#06 Fault Tree (ref C)	See Hz#06 table One or multiple imminent infringements due to lack of separation indicator for multiple or all aircraft, if not timely managed by ATC, evolve into large under-separation (SMI>0.5NM).	
APP ATCO failure to detect infringement during interception in time without indicators & associated alerts	APP_ATCO_x2	Not having the indicators and associated alerts, APP ATCO fails to detect in time the infringement at interception	**SR1.326:** In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point **SR1.327:** In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure **SR1.303:** Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors. **SR1.329:** Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.) **SR1.331:** In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers

			shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off)
APP ATCO failure to timely instruct the adequate separation recovery action before the imminent infringement is evolving to a large under-separation during interception	APP_ATCO_10	APP ATCO does not instruct timely a go around before the imminent infringement due to the missing indicator is evolving to a large under-separation (SMI>5NM) during interception.	All the mitigations from APP_ATCO_x2 apply
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	APP ATCO inadequately communicates the recovery instructions to the crew	All the mitigations from APP_ATCO_x2 apply.
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	The APP ATCO does not detect the inadequate pilot response (to the recovery instruction) through readback and fails to monitor the situation such that to apply a corrective mitigation	No new requirement derived for the ATCO because it is considered that the monitoring of what the crew does after is given an instruction does not change compared to today's operations.

ATC failure to recover separation following imminent infringement due to one separation indicator not displayed or not timely available during the turn-on			
Inadequate separation management due to separation indicator not displayed or not timely available during the turn-on.	See Hz#01a Fault Tree (ref A)	See Hz#01a table. The lack of separation indicator leads to separation minima infringement during the merging of the aircraft onto the final approach, which if not timely managed by ATC evolves into large under-separation (SMI>0.5NM).	
APP ATCO failure to detect the lack of indication affecting one aircraft.	APP_ATCO_8	APP ATCO does not detect the missing separation indicator and merges the aircraft onto the final approach without the required separation (missing indicator affecting one aircraft).	**SR1.093** in “normal conditions” **SR1.313:** If there is insufficient information to calculate a TDI then that TDI shall not be provided, together with a visual warning. **SR1.301:** If the required wind input to calculate a time based wake separation (TBS or WDS) is not available for an interval longer than a specific duration (to be determined based on local wind evolution analysis), then: • The Separation Delivery Tool shall continue displaying TDIs for aircraft that are already established on the final approach path and for which the last available TDIs computation includes a safety buffer managing the acceptable failure rate of the wind measurement; • The Separation Delivery Tool shall display TDIs for non-established aircraft based on conservative wind inputs for TDIs computation
APP ATCO failure to revert timely to DBS minima if lack of indicator is detected.	APP_ATCO_9	APP ATCO does not revert timely to DBS minima when missing indicator is detected.	Same mitigations as for APP_ATCO_x2 apply plus the following: **SR1.123** in “normal conditions”
APP ATCO failure to timely instruct the adequate separation recovery action	APP_ATCO_10	See above.	As for APP_ATCO_10 above

before the imminent infringement is evolving to a large under-separation during interception			
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	See above.	As for ATCO-FCRW_1R above
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	See above.	As for FCRW_1R above
ATC failure to recover separation following imminent infringement during interception despite correctly displayed separation indicator			
Inadequate separation management during interception despite correctly displayed separation indicator.	See Hz#01a Fault Tree (ref B)	See Hz#01a table. The inadequate separation management during interception (despite a correct display of the separation indicator) leads to separation minima infringement, which if not timely managed by ATC evolves into large under-separation (SMI>0.5NM).	
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	See above.	As for ATCO-FCRW_1R above
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	See above.	All mitigations from FCRW_1R above apply, plus the following additional mitigation: **SR1.310:** The Approach Controllers shall be alerted in case the aircraft instructed to turn onto the Target Distance Indicator on the runway extended centreline is not the one planned in the Arrival Sequencing Tool list. **SR1.311:** In case of sequence error alert the Approach Controllers shall perform corrective action to re-establish consistency between the actual sequence order and the Arrival Sequencing Tool list.

APP ATCO failure to timely instruct the adequate separation recovery action before the imminent infringement is evolving to a large under-separation during interception	APP_ATCO_10	ATCO fails to instruct speed adjustment instruction (depending on the triggering event) in order to solve the imminent infringement.	**SR1.080, SR 108, SR1.056, SR1.057, SR1.058** in “normal conditions” **SR1.328:** When spacing ITD is infringed by the aircraft, the ATCOs shall be aware of the next most constraining separation factor ITD and FTD (e.g. Wake or MRS) on the APPROACH and TOWER positions.

Table 14: Derivation of Mitigation/Safety Requirements for Hazard Hz#01b for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.4. Hz#01a (SO 201): Inadequate separation management of a pair of aircraft instructed by ATC to merge on the Final Approach interception

This hazard occurs during the Final approach interception. Basic causes for such failures have been captured in the Hz#01a Fault Tree (See Figure 10).

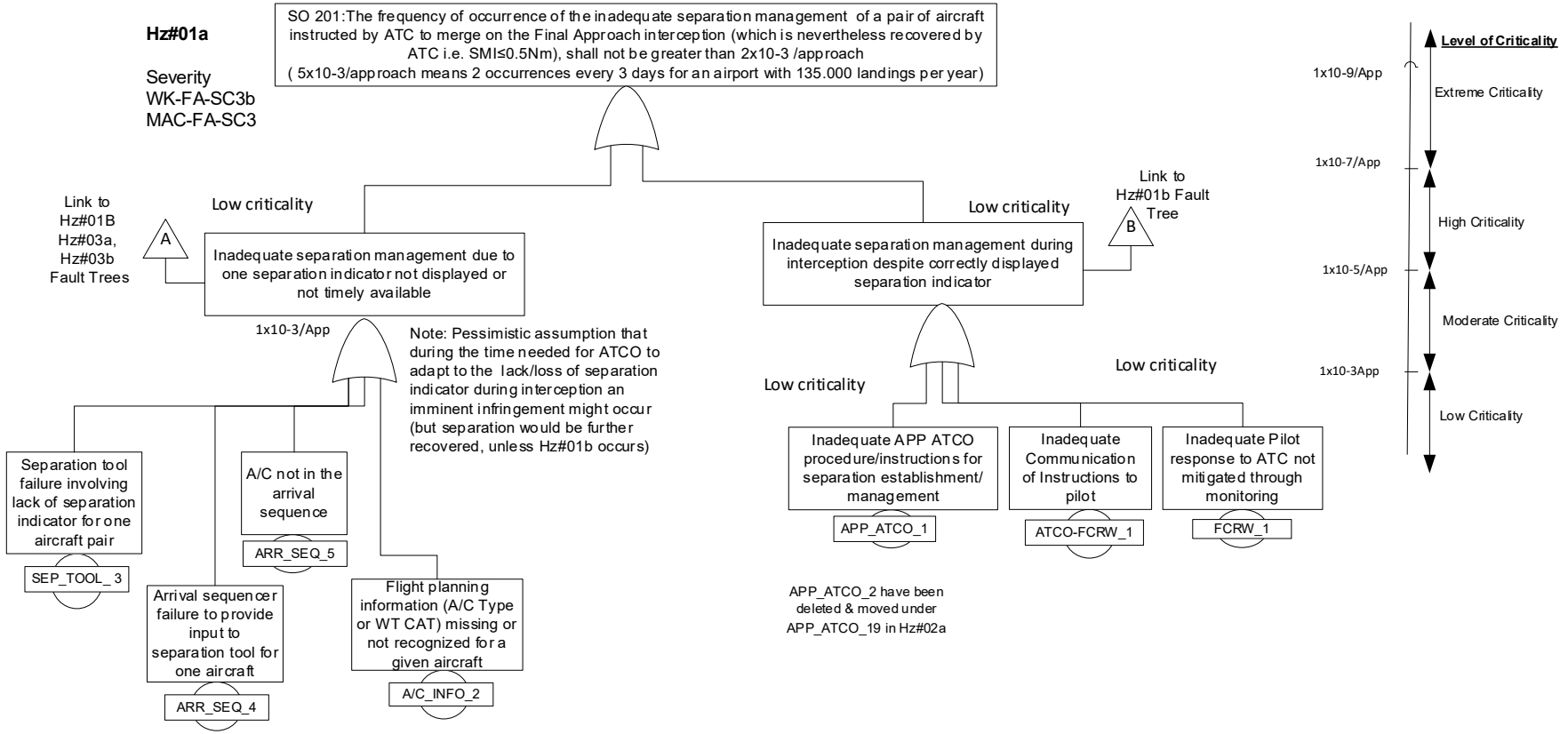


Figure 10: Hz#01a Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#01a Fault Tree and identify the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Inadequate separation management due to one separation indicator not displayed or not timely available during the turn-on			
Separation tool failure involving lack of separation indicator for one aircraft pair.	SEP_TOOL_3	The separation tool fails to display the separation indicator for one aircraft or display it too late for the interception of the final approach.	**SR1.048 and SR1.037** in "normal conditions" **SR1.303:** Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.
Arrival sequencer failure to provide input to separation tool for one aircraft.	ARR_SEQ_4	The arrival sequencer does not provide information to the separation tool for one aircraft despite inputs being correct.	**SR1.028** in "normal operations" **SR1.314**: If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft **SR1.315:** It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust.
A/C not in the arrival sequence.	ARR_SEQ_5	An aircraft not planned for this arrival is authorized to land (e.g. aircraft in emergency).	**SR1.309:** If an aircraft that needs to be inserted in the arrival sequence cannot be input into the Arrival Sequence Service, the Approach Controller shall inhibit the Target Distance Indicator corresponding to the follower aircraft whose position in the actual sequence is taken by the newly inserted aircraft and the Approach Controller shall observe DBS WT Category separation for the impacted pairs of aircraft
Flight planning information (A/C Type or WT CAT)	A/C_INFO_2	The separation tool does not receive or not recognize the aircraft	**SR1.085** in "normal conditions"

missing or not recognized for a given aircraft.		type and/or the Wake Turbulence Category for one aircraft.	**SR1.316:** At the first contact with the Approach, the flight crew shall provide the Aircraft type or alternatively this information could be provided to the Approach Controller via data link and the Approach Controller shall cross check this information with the information displayed on the CWP. **SR1.330:** Approach control shall check the validity of Flight Plan information displayed on the CWP (ICAO aircraft type, wake category). **SR1.321:** When a flight data input error (e.g. missing or wrong ICAO aircraft type or wake category) is detected, it shall be possible to update the corresponding information into the input for the separation delivery tool. **SR1.315:** It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust. **SR1.326:** In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point.
Inadequate separation management during interception despite correctly displayed separation indicator			
Inadequate APP ATCO procedure/instructions for separation establishment/management	APP_ATCO_1	Approach controller is not aware or sufficiently informed on the new WT separation modes.	**SR1.117**, **SR1.050 and SR1.051** in “normal conditions”
Inadequate Communication of Instructions to pilot	ATCO-FCRW_1	As for ATCO-FCRW_1R in Hz#01b	

Inadequate Pilot response to ATC not mitigated through monitoring	FCRW_1		No new requirement derived for the ATCO because it is considered that the monitoring of what the crew does after is given an instruction does not change compared to today's operations.

Table 15: Derivation of Mitigation/Safety Requirements for Hazard Hz#01a for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.5. Hz#02b (SO 204): Separation not being recovered following imminent infringement due to aircraft deviation from Final Approach interception profile without ATC instruction given

This hazard occurs during the Final approach interception and its causes have been captured in the Hz#02b Fault Tree (See Figure 11).

Note: The combination between the occurrences of a Crew/Aircraft induced conflict and its inadequate separation management or separation recovery due to separation indicator not displayed or not timely available during the turn-on, for one or multiple aircraft, is not further analysed. Given that it displays a low probability, it is not dimensioning for the derivation of Safety Requirements

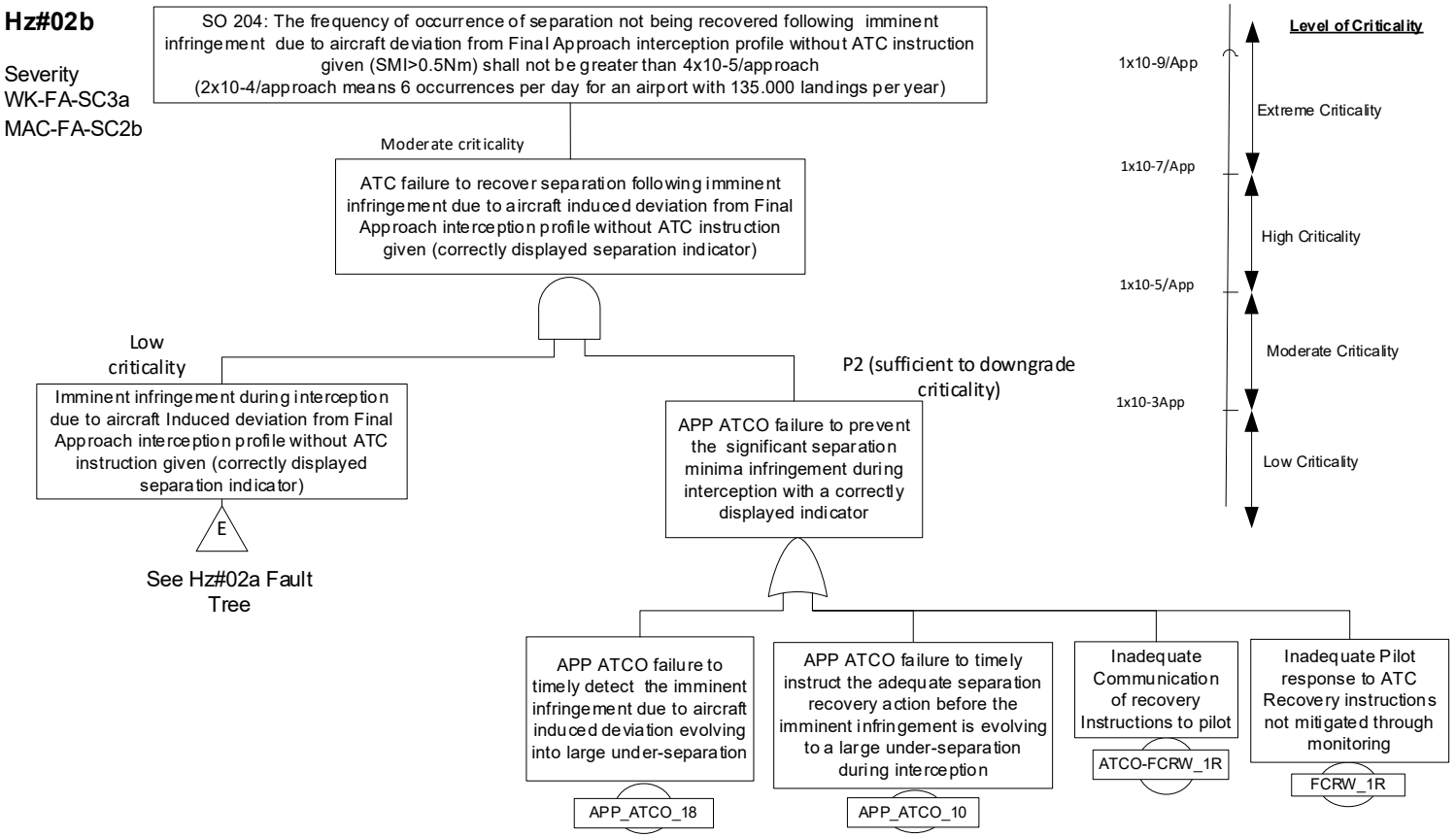


Figure 11: Hz#02b Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#02b Fault Tree and identify the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Imminent infringement during interception due to aircraft Induced deviation from Final Approach interception profile without ATC instruction given (correctly displayed separation indicator)	See Hz#02a Fault Tree (ref E)	See Hz#02a table. The aircraft deviation from the cleared trajectory leads to an imminent infringement (SMI<0.5NM).	
APP ATCO failure to prevent the significant separation minima infringement during interception with a correctly displayed indicator			
APP ATCO failure to timely detect the imminent infringement due to aircraft induced deviation evolving into large under-separation	APP_ATCO_18	APP ATCO failure to timely detect the imminent infringement evolving into large under-separation (A/C deviation from cleared trajectory).	It is assumed that the approach controller verifies the adherence to the radar vectoring instruction, the actual aircraft speed and speed trend during the interception on the radar display (as per Baseline operations). **SR1.063, SR1.056, SR1.057, SR1.058, SR1.052** in "normal conditions" **SR1.328**: When spacing ITD is infringed by the aircraft, the ATCOs shall be aware of the next most constraining separation factor ITD and FTD (e.g. Wake or MRS) on the APPROACH and TOWER positions.
APP ATCO failure to timely instruct the adequate separation recovery action before the imminent	APP_ATCO_10	APP ATCO failure to instruct timely a go around before the imminent infringement is evolving	**SR1.080, SR1.083** in "normal conditions" **SR1.037:** The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that

infringement is evolving to a large under-separation during interception		to a large under-separation during interception.	needs to be delivered after considering all in-trail and if applicable not-in-trail constraints. SR1.038: If the ORD concept is considered, the Separation Delivery tool shall provide to ATCOs a visualisation (ITD indicator) of the required spacing on final approach to be delivered at the deceleration fix in order to deliver the required minimum separation / spacing at the delivery point.
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	As for ATCO-FCRW_1R in Hz#01b when the indicators are correctly displayed	
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	As for FCRW_1R in Hz#01b	

Table 16: Derivation of Mitigation/Safety Requirements for Hazard Hz#02b for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.6. Hz#02a (SO 203): Inadequate separation management of a spacing conflict due to aircraft deviation from final approach interception profile without ATC instruction given

This hazard occurs during the Final approach interception and its causes have been captured in the Hz#02a Fault Tree (See Figure 12).

Note: The combination between the occurrences of a Crew/Aircraft induced conflict and its inadequate separation management due to separation indicator not displayed or not timely available during the turn-on, for one or multiple aircraft, is not further analysed. Given that it displays a low probability, it is not dimensioning for the derivation of Safety Requirements.

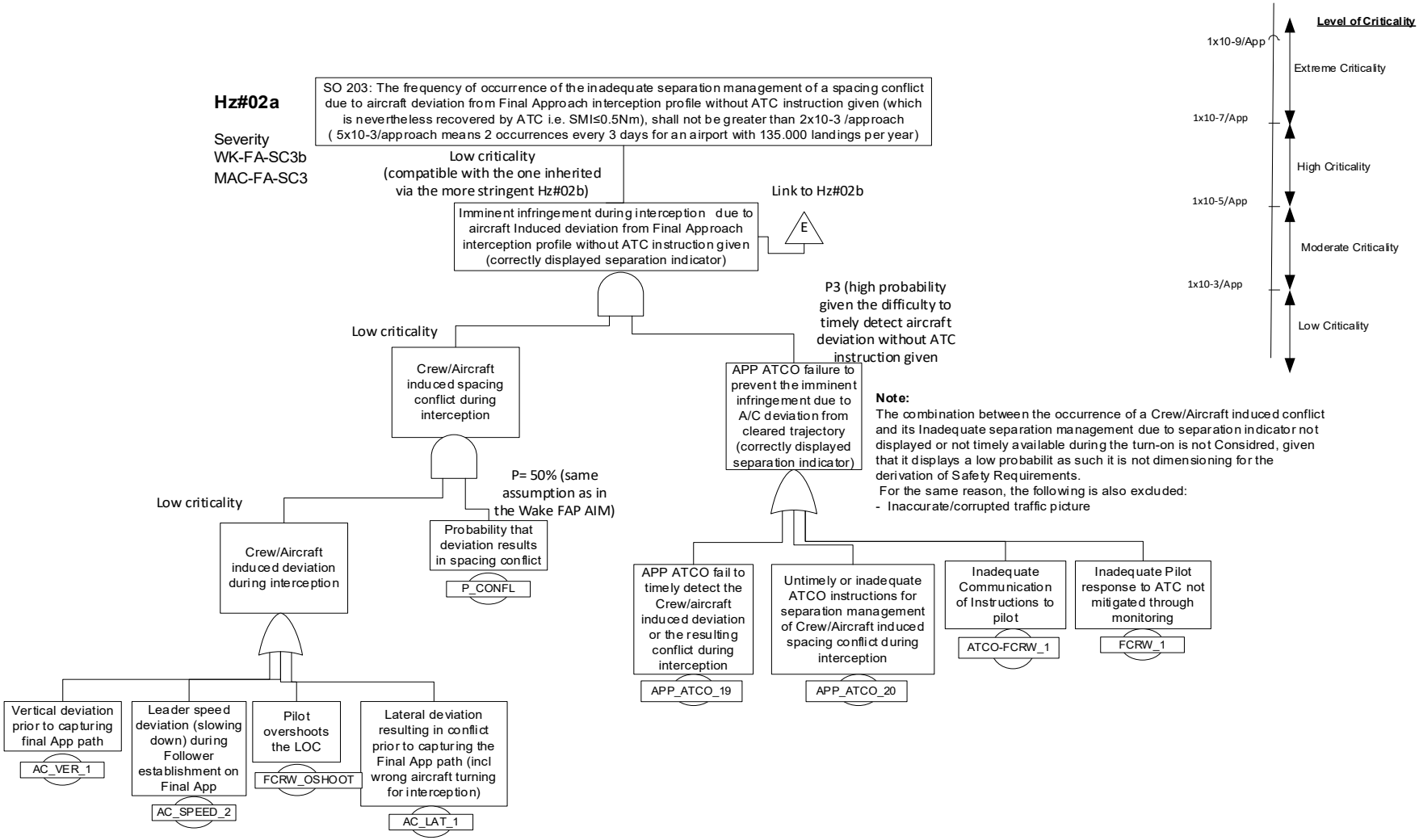


Figure 12: Hz#02a Fault tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#02a Fault Tree and identify the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Crew/Aircraft induced spacing conflict during interception			
Vertical deviation prior to capturing final App path.	AC_VER_1	The vertical deviation from instructed interception altitude might involve capturing final approach path from above or below with impact on the actual speed profile (which will be different from the TAS profile used by the separation tool). As a consequence in TB-modes the FTD computation will be erroneous and the ITD will be erroneous in all modes.	**SR1.110** in “normal conditions”
Leader speed deviation (slowing down) during Follower establishment on Final App	AC_SPEED_2	The leader aircraft slows down when the follower intercepts the final approach path	**SR1.110** in “normal conditions”
Pilot overshoots the LOC.	FCRW_OSHOOT		Same occurrence& effect as per current operations.
Lateral deviation resulting in conflict prior to capturing the Final App path (incl wrong aircraft turning for interception)	AC_LAT_1		**SR1.310:** The Approach Controllers shall be alerted in case the aircraft instructed to turn onto the Target Distance Indicator on the runway extended centreline is not the one planned in the Arrival Sequencing Tool list. **SR1.311:** In case of sequence error alert the Approach Controllers shall perform corrective action to re-establish consistency between the actual sequence order and the Arrival Sequencing Tool list.

APP ATCO failure to prevent the imminent infringement due to A/C deviation from cleared trajectory (correctly displayed separation indicator)			
APP ATCO fail to timely detect the deviation from the cleared trajectory or the resulting conflict during interception.	APP_ATCO_19	APP ATCO does not detect timely the aircraft deviation from the cleared trajectory because she/he is vectoring or adjusting trajectories of other aircraft merging to the final approach.	It is assumed that the Approach Controller monitors all traffic merging to the final approach to detect any deviation from instructed profile. It is assumed that the Approach Controller asks to correct the aircraft trajectory (heading, speed or altitude) during the approach interception if she/he thinks that it will solve the spacing conflict, i.e. avoid imminent infringement. If not she/he takes corrective actions like initiating missed approach. The level of APP ATCO workload and Situation Awareness in the new separation modes (with tool) during interception have been validated as acceptable; thus a reduction of APP ATCO capability to detect Crew/Aircraft induced spacing conflict during interception is not expected.
Untimely or inadequate ATCO instructions for separation management of Crew/Aircraft induced spacing conflict during interception.	APP_ATCO_20	Upon detection, APP ATCO does not instruct timely or adequately for ensuring separation management of Crew/Aircraft induced spacing conflict during interception.	The level of APP ATCO workload and Situation Awareness in the new separation modes (with tool) during interception have been validated as acceptable; thus a reduction of APP ATCO capability to detect Crew/Aircraft induced spacing conflict during interception is not expected.
Inadequate Communication of Instructions to pilot	ATCO-FCRW_1	As for ATCO-FCRW_1R in Hz#01b when the indicators are correctly displayed	
Inadequate Pilot response to ATC not mitigated through monitoring	FCRW_1	As for ATCO-FCRW_1R in Hz#01b	

Table 17: Derivation of Mitigation/Safety Requirements for Hazard Hz#02a for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.7. Hz#03b (SO 206): Separation not being recovered following imminent infringement by an aircraft pair instructed by ATC on the Final Approach

This hazard occurs during the Final approach and its basic causes and combinations thereof have been captured in the Hz#03b Fault Tree (Figure 13).

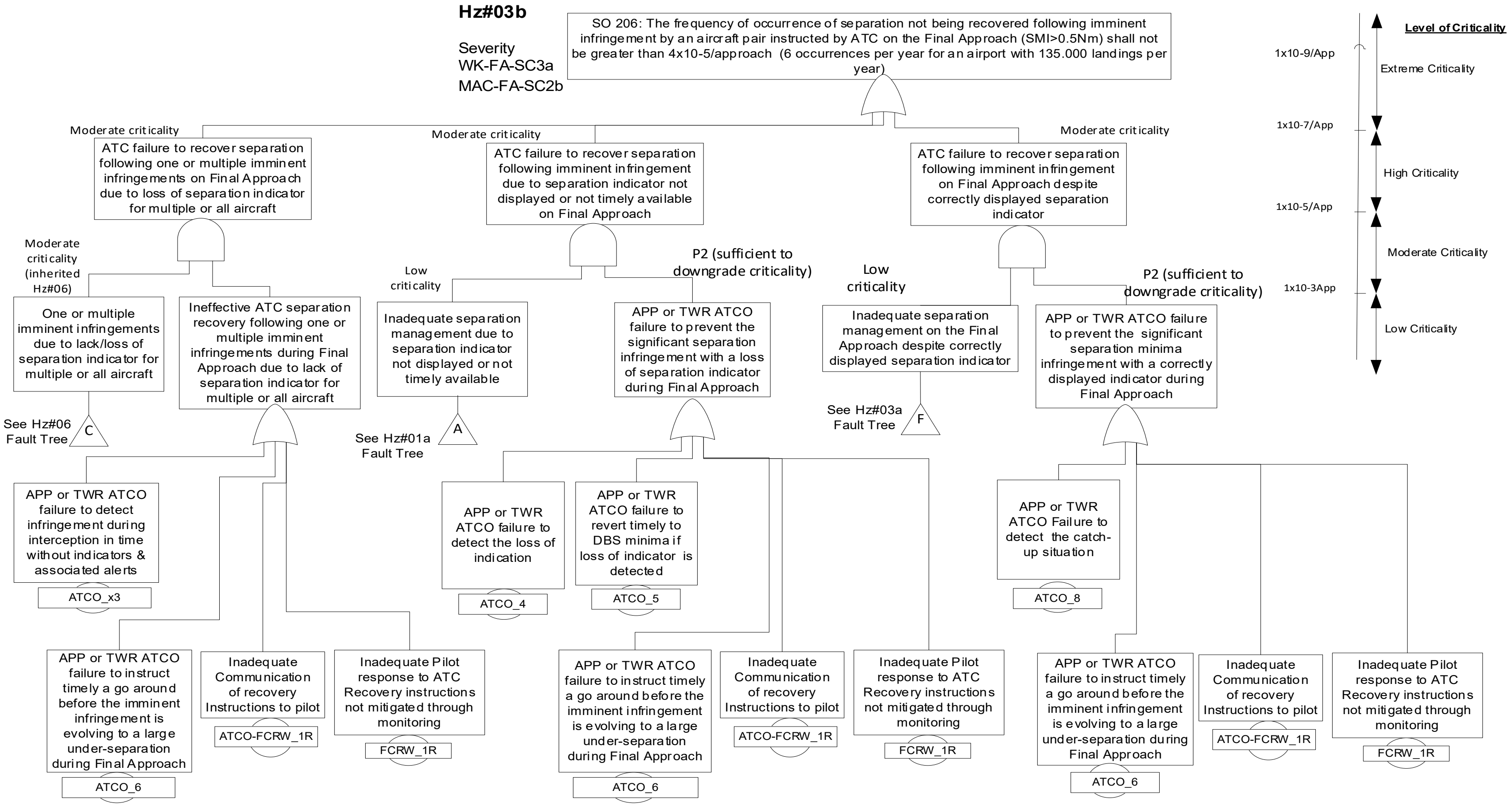


Figure 13: Hz#03b Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#03b Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
ATC failure to recover separation following one or multiple imminent infringements on Final Approach due to loss of separation indicator for multiple or all aircraft			
One or multiple imminent infringements due to lack/loss of separation indicator for multiple or all aircraft.	See Hz#06 Fault Tree (ref C)	See Hz#06 table.	
APP or TWR ATCO failure to instruct timely a go around before the imminent infringement is evolving to a large under-separation during Final Approach.	ATCO_6	APP or TWR ATCO failure to instruct timely a go around before the imminent infringement is evolving to a large under-separation during Final Approach.	**SR1.303:** Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors. **SR1.329:** Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.) **SR1.331:** In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off) **SR1.326:** In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be

			provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point. **SR1.327:** In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure
APP or TWR ATCO failure to detect infringement during interception in time without indicators & associated alerts	ATCO_x3	Not having the indicators and associated alerts, APP or TWR ATCO fails to detect in time the infringement at interception	As for ATCO_6
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	As for ATCO-FCRW_1R in Hz#01b when the indicators are not displayed	
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	As for FCRW_1R in Hz#01b	
ATC failure to recover separation following imminent infringement due to separation indicator not displayed or not timely available on Final Approach			
Inadequate separation management due to separation indicator not displayed or not timely available.	See Hz#01a Fault Tree (ref A)	See Hz#01a table. The detected loss of separation indicator during the final approach may lead to imminent infringement.	
APP or TWR ATCO failure to detect the loss of indication.	ATCO_4	APP or TWR ATCO does not detect the loss of separation indicator in order to prevent the separation infringement.	**SR1.306:** Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.

APP or TWR ATCO failure to revert timely to DBS minima if loss of indicator is detected.	ATCO_5	APP or TWR ATCO does not revert timely to DBS minima when the loss of indicator is detected.	**SR1.123** in "normal conditions" **SR1.329:** Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.)
APP or TWR ATCO failure to instruct timely a go around before the imminent infringement is evolving to a large under-separation during Final Approach.	ATCO_6	As above.	As for ATCO_6 above
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	As for ATCO-FCRW_1R in Hz#01b when the indicators are not displayed	
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	As for FCRW_1R in Hz#01b	
ATC failure to recover separation following imminent infringement on Final Approach despite correctly displayed separation indicator			
Inadequate separation management on the Final Approach despite correctly displayed separation indicator.	See Hz#03a Fault Tree (ref F)	See Hz#03a table. Inadequate separation management on the Final Approach despite correctly displayed separation indicator may lead to imminent infringement.	
APP or TWR ATCO Failure to detect the catch-up situation.	ATCO_8	APP or TWR ATCO does not detect the catch up situation involving imminent infringement despite	**SR1.063** in "normal conditions"

		correct separation indicator is displayed.	
APP or TWR ATCO failure to instruct timely a go around before the imminent infringement is evolving to a large under-separation during Final Approach.	ATCO_6	As per ATCO_6 above	As per ATCO_6 above. The following mitigation also applies, when applying WDS-Xw: **SR1.302:** In case of WDS cross wind, when the leader and follower are established on the glideslope, the Approach and Tower controllers shall be able to give heading instructions (e.g. break-off) to the follower only upwind and not downwind.
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	As for ATCO-FCRW_1R in Hz#01b when the indicators are correctly displayed	
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	As for FCRW_1R in Hz#01b	

Table 18: Derivation of Mitigation/Safety Requirements for Hazard Hz#03b for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.8. Hz#03a (SO 205): Inadequate separation management of an aircraft pair naturally catching-up as instructed by ATC on the Final Approach

This hazard occurs during the Final approach and its basic causes and combinations thereof have been captured in the Hz#03a Fault Tree (See Figure 14).

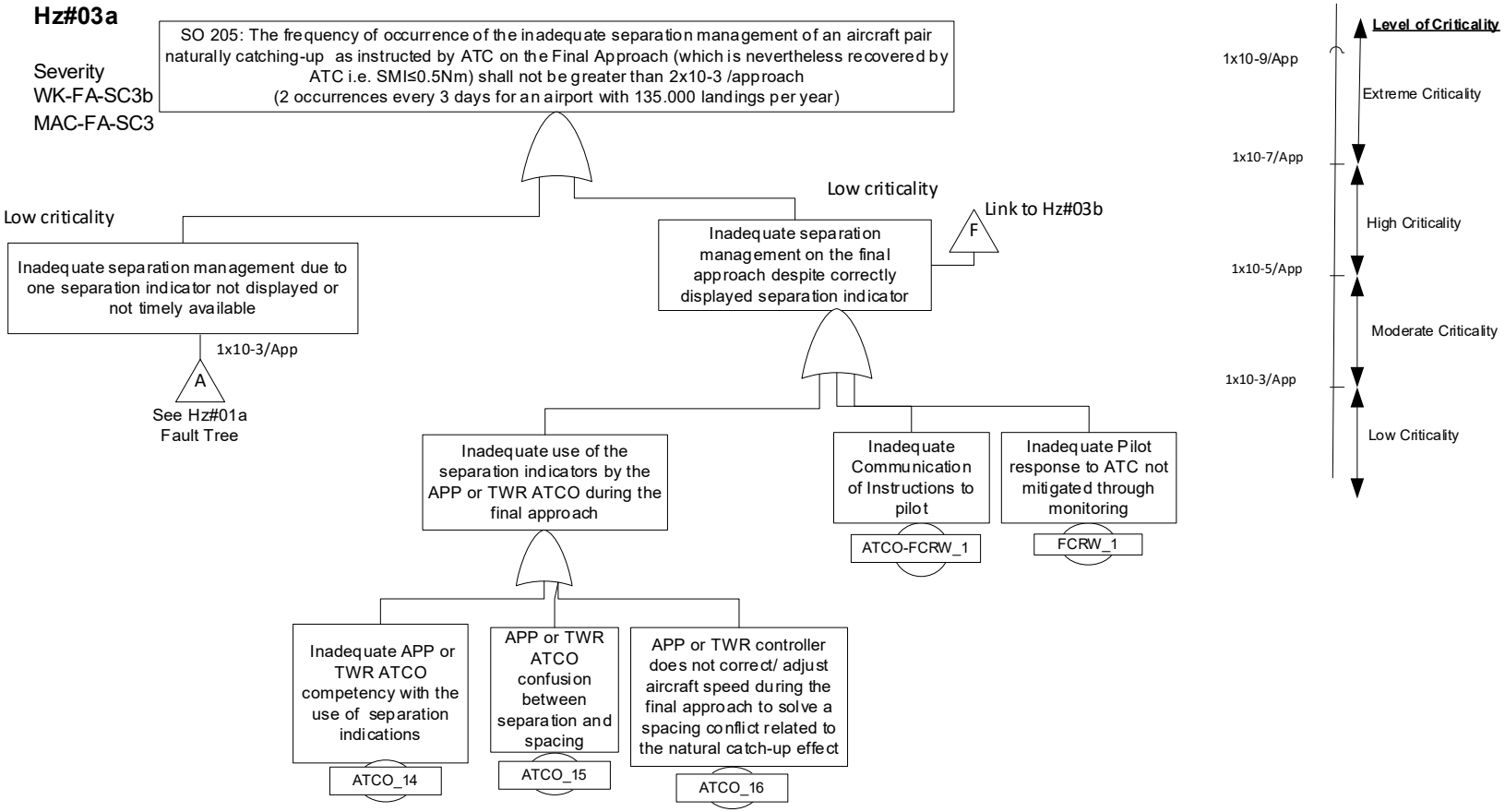


Figure 14: Hz#03a Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#03a Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Inadequate separation management due to separation indicator not displayed or not timely available.	See Hz#01a Fault Tree. (ref A)	See Hz#01a table. The inadequate separation management due to separation indicator not displayed or not timely available leads to an imminent infringement during the final approach considering the aircraft pair (SMI<0.5NM).	
Inadequate separation management on the final approach despite correctly displayed separation indicator			
Inadequate use of the separation indicators by the approach or Tower controller during the Final Approach.	ATCO_14	Inadequate APP or TWR ATCO competency with the use of separation indicators.	**SR1.117, SR1.118 and SR1.124** in "normal conditions"
	ATCO_15	APP or TWR ATCO confusion between separation (e.g. MRS, wake) and spacing indicators (e.g. ROT).	**SR1.090** in "normal conditions"
	ATCO_16	APP or TWR controller does not correct/ adjust aircraft speed during the final approach to solve a spacing conflict related to the natural catch-up effect.	**SR1.063**, **SR1.056, SR1.057, SR1.058, SR1.053, SR1.054, SR1.052 and SR1.103** in "normal conditions" **SR1.214 and SR1.215** in "abnormal conditions"
Inadequate Communication of Instructions to pilot	ATCO-FCRW_1	As for ATCO-FCRW_1R in Hz#01b when the indicators are correctly displayed	
Inadequate Pilot response to ATC not mitigated through monitoring	FCRW_1	As for FCRW_1R in Hz#01b	

Table 19: Derivation of Mitigation/Safety Requirements for Hazard Hz#03a for the PJ.02.01 Arrivals Concepts Solutions

5.5.1.1.9 Hz#04b (SO 208): Separation not being recovered following imminent infringement due to aircraft deviation from Final Approach profile without ATC instruction given

This hazard occurs during the Final approach and its basic causes and combinations thereof have been captured in the Hz#04b Fault Tree (See Figure 15).

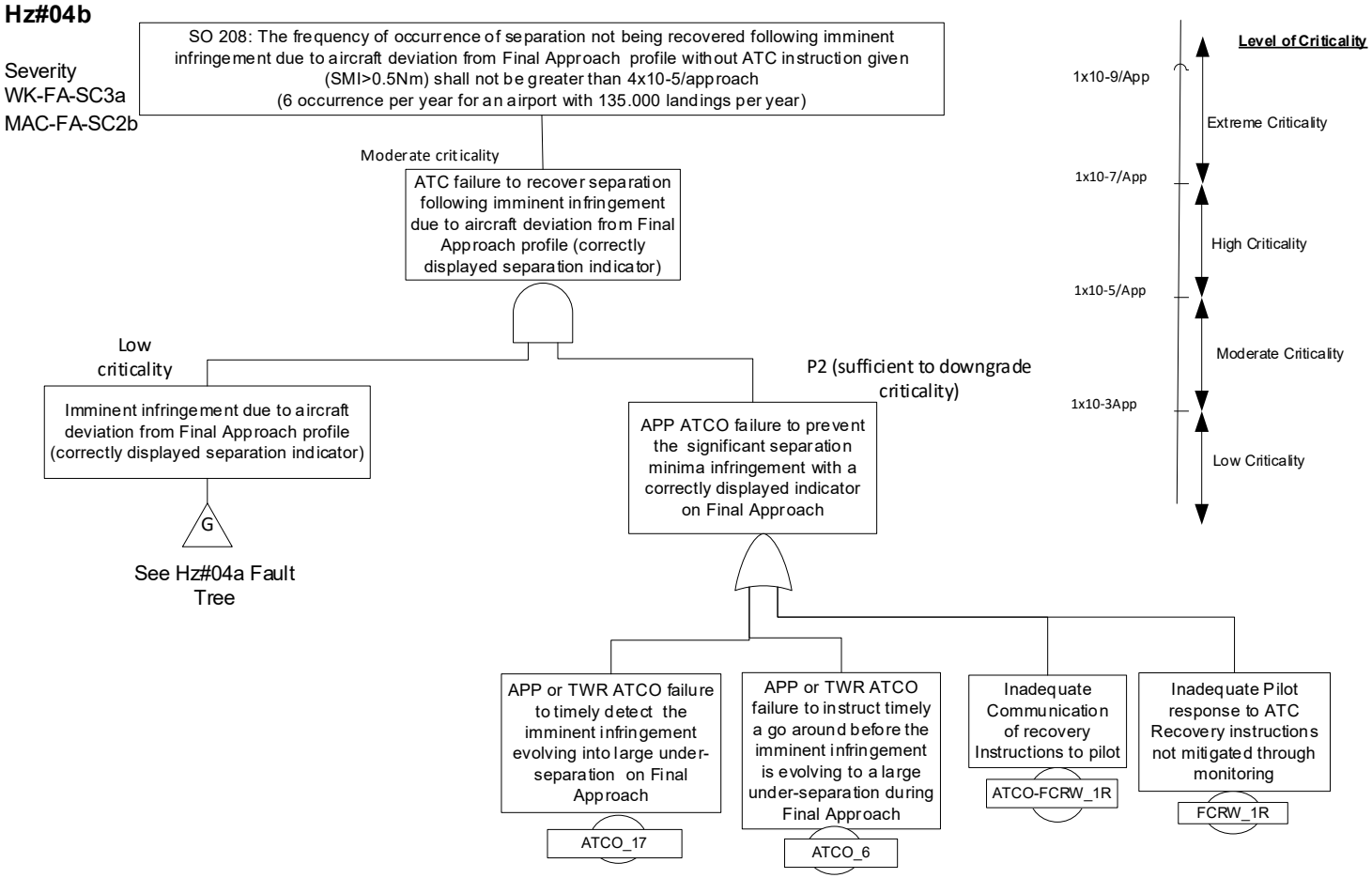


Figure 15: TB Hz#04b Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#04b Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Imminent infringement during interception due to aircraft deviation from Final Approach profile (correctly displayed separation indicator).	See Hz#04a Fault Tree (ref G)	See Hz#02a table.	
APP ATCO failure to prevent the significant separation minima infringement with a correctly displayed indicator			
APP or TWR ATCO failure to timely detect the imminent infringement evolving into large under-separation on Final Approach.	ATCO_17	Aircraft deviates from speed instructions or from the nominal stabilized approach speed and APP or TWR ATCO does not detect the catch up situation with imminent infringement evolving into large under-separation despite correct separation indicator is displayed.	It is assumed that the approach and tower controller verifies the actual speed of the aircraft and the speed trend during the final approach. **SR1.063, SR1.215, SR1.053, SR1.054, SR1.056, SR1.057, SR1.058, SR1.052** in “normal conditions” **SR1.214** in “abnormal conditions”
APP or TWR ATCO failure to instruct timely a go around before the imminent infringement is evolving to a large under-separation during Final Approach.	ATCO_6	APP or TWR ATCO failure to instruct timely a go around before the imminent infringement is evolving to a large under-separation during Final Approach.	As per ATCO_6 in Hz#03b
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	As for ATCO-FCRW_1R in Hz#01b when the indicators are correctly displayed	
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	As for FCRW_1R in Hz#01b	

Table 20: Derivation of Mitigation/Safety Requirements for Hazard Hz#04b for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.10. Hz#04a (SO 208): Inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach profile without ATC instruction given

This hazard occurs during the Final approach and its basic causes and combinations thereof have been captured in the Hz#04a Fault Tree.

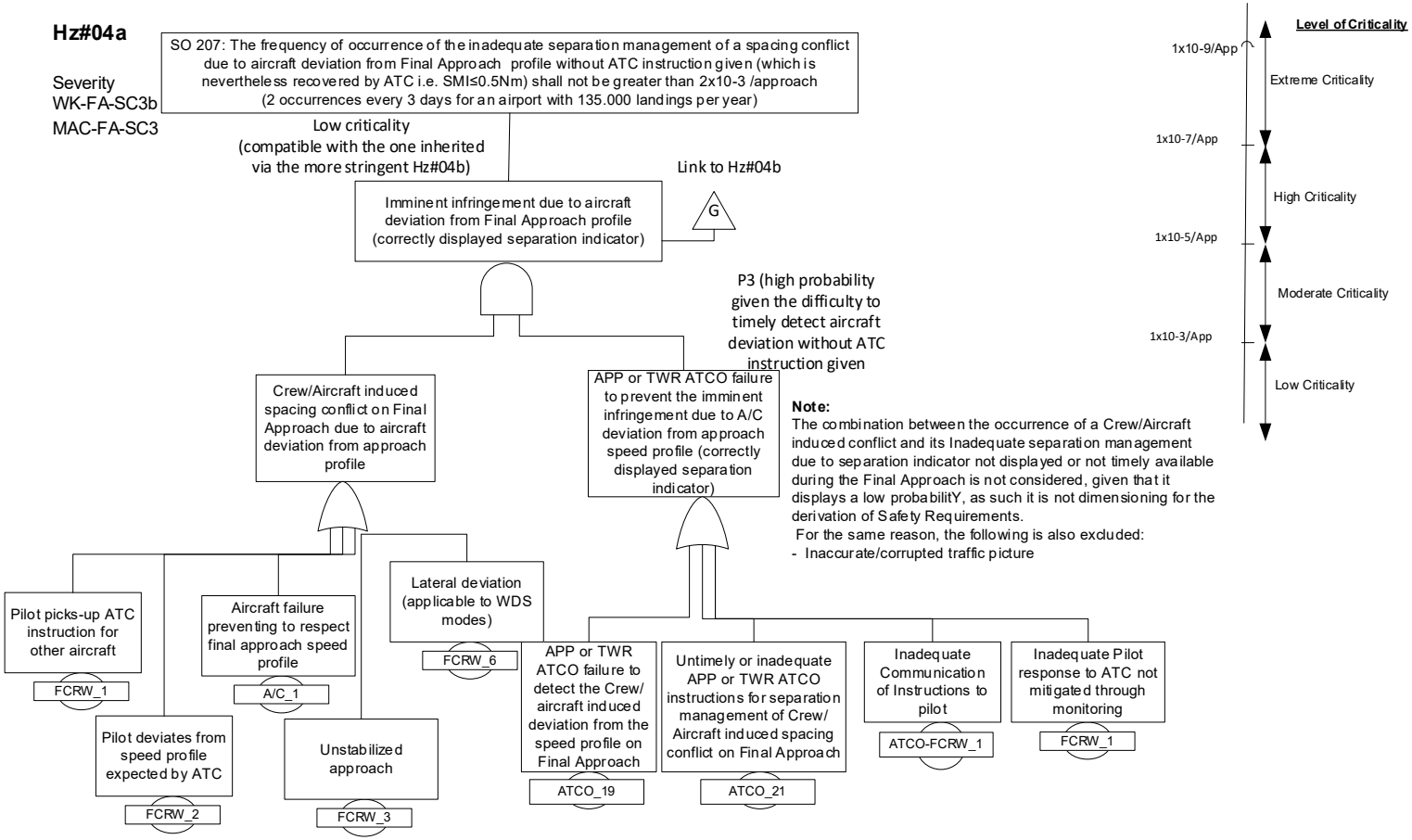


Figure 16: Hz#04a Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#04a Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Crew/Aircraft induced spacing conflict on Final Approach due to aircraft deviation from approach profile			
Pilot picks-up ATC instruction for other aircraft.	FCRW_1	Pilot picks-up ATC instruction for other aircraft.	No specific SR for radio communication. Current read-back/hear-back procedures to be applied.
Pilot deviates from speed profile expected by ATC.	FCRW_2	Pilot deviates from speed profile expected by ATC.	**SR1.110** in “normal conditions”
Aircraft failure preventing to respect final approach speed profile.	AC_1	Aircraft failure (slat, flap, engine,…) led to the impossibility to respect the approach speed profile.	**SR1.110** in “normal conditions”
Un-stabilized approach.	FCRW_3	Failure of the Flight crew to assess or to manage the aircraft's energy during the approach.	**SR1.119** in “normal conditions”
Lateral deviation (applicable to WDS modes)	FCRW_6	While in WDS-Xw, the flight crew deviates laterally down-wind (towards where the wake is transported) from the final approach glide path	**SR1.113** in “normal operations”
APP or TWR ATCO failure to prevent the imminent infringement due to A/C deviation from approach speed profile (correctly displayed separation indicator)			
APP or TWR ATCO failure to detect the Crew/aircraft induced deviation	ATCO_19	APP or TWR ATCO does not detect timely the aircraft deviation from the speed profile.	**SR1.214 and SR1.215** in “abnormal conditions” **SR1.110 and SR1.124** in “normal conditions”

from the speed profile on Final Approach			
Untimely or inadequate APP or TWR ATCO instructions for separation management of Crew/Aircraft induced spacing conflict on Final Approach	ATCO_21	Upon detection, APP or TWR ATCO does not instruct timely or adequately for ensuring separation management of Crew/Aircraft induced spacing conflict during interception.	Level of APP ATCO workload and Situation Awareness in the new separation modes (with tool) during interception have been validated as acceptable; thus a reduction of APP ATCO capability to detect Crew/Aircraft induced spacing conflict during interception is not expected.
Inadequate Communication of recovery Instructions to pilot	ATCO-FCRW_1R	As for ATCO-FCRW_1R in Hz#01b when the indicators are correctly displayed	
Inadequate Pilot response to ATC Recovery instructions not mitigated through monitoring	FCRW_1R	As for FCRW_1R in Hz#01b	

Table 21: Derivation of Mitigation/Safety Requirements for Hazard Hz#04a for the PJ.02.01 Arrivals Concepts Solutions

9.5.1.1.11. Hz#08 (SO 212) runway conflict due to landing clearance in conflict with another landing (ROT not respected) or with cleared line-up/take-off (GAP not respected)

This hazard occurs during mixed mode of operation and its basic causes and combinations thereof have been captured in the Hz#08 Fault Tree.

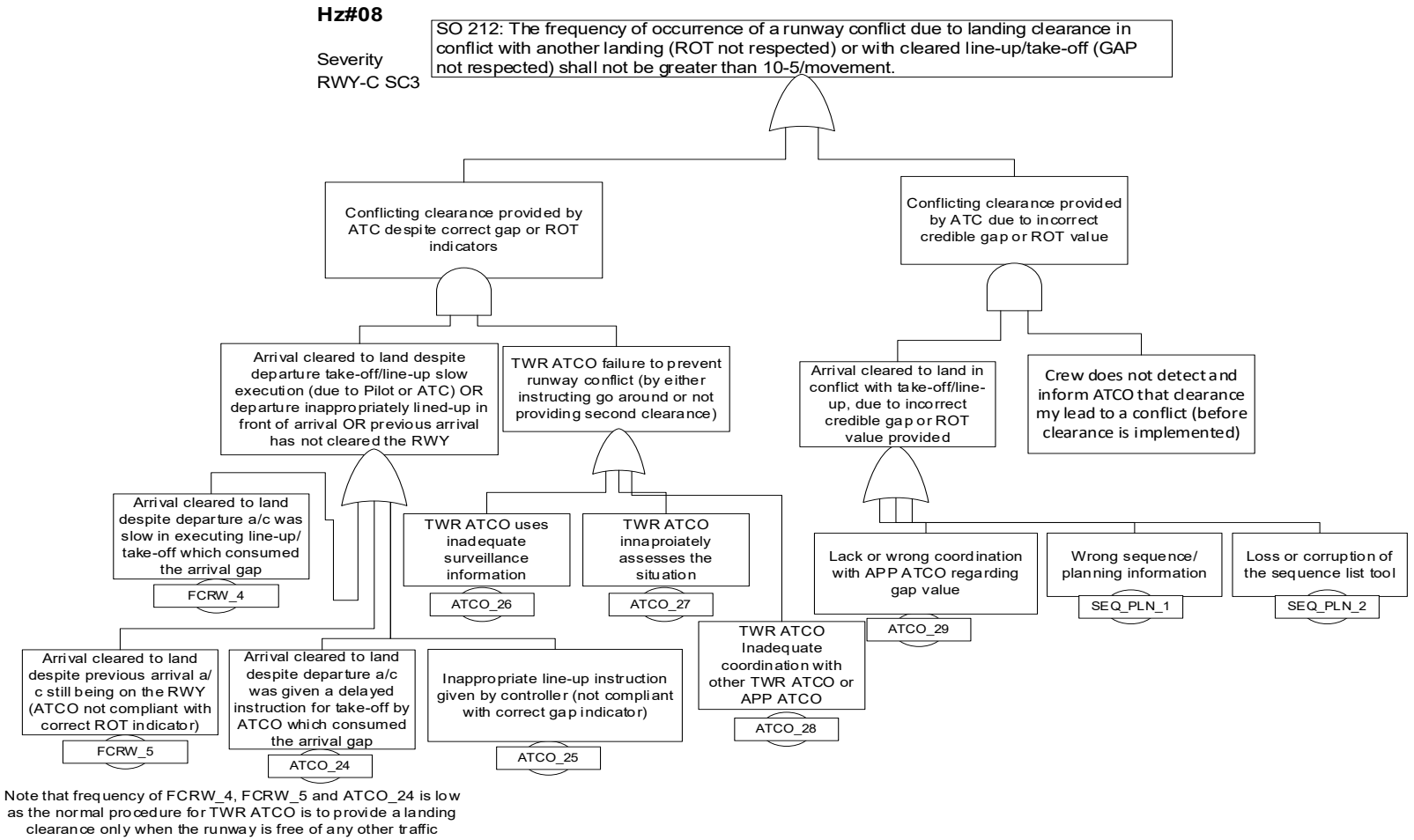


Figure 17 Hz#08 Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Conflicting clearance provided by ATC despite correct gap or ROT indicators			
Arrival cleared to land despite departure a/c was slow in executing line-up/take-off which consumed the arrival gap	FCRW_4	ATCO gives a line-up/take-off clearance, but because the pilot was slow in executing the line-up/take-off, the gap is consumed, ATCO doesn't check and clears the second a/c to land.	**SR1.089** in “normal conditions”
Arrival cleared to land despite previous arrival a/c still being on the RWY (ATCO not compliant with correct ROT indicator)	FCRW_5	ATCO is not compliant with the ROT indicator	As above
Arrival cleared to land despite departure a/c was given a delayed instruction for take-off by ATCO which consumed the arrival gap	ATCO_24	ATCO gives a correct line-up clearance and then is late to give the take-off clearance to the same a/c and by the time he gives the landing clearance he realises the gap is not enough.	As above
Inappropriate line-up instruction given by controller (not compliant with correct gap indicator)	ATCO_25	ATCO misjudges the gap time	As above

Conflicting clearance provided by ATC due to incorrect credible gap or ROT value			
Lack or wrong coordination with APP ATCO regarding gap value	ATCO_29	The arrival gap time is wrongly or not coordinated with the TWR ATCO which results in a runway conflict	This is not changed compared to current operations. Additionally, the following mitigation applies: **SR1.072:** The separation delivery tool shall provide confirmation to ATCO that the gap spacing insertion is successful or not.
Wrong sequence/planning information	SEQ_PLN_1		**SR1.033, SR1.032, SR1.034, SR1.093** "normal conditions" and **SR1.200** "abnormal conditions" **SR1.300:** Controllers shall be trained to check the aircraft landing runway intent and that the aircraft order is correct and coherent with the arrival sequence list. They shall check if and that the aircraft order is displayed in the arrival sequence list and/or if the aircraft sequence number is displayed in the radar label in accordance with their intended sequence.
Loss or corruption of the sequence list tool	SEQ_PLN_2		Corruption of the sequence list: mitigated through the software assurance process which defines the acceptably safe level of confidence in the arrival sequence service prior to implementation. **SR1.317:** The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment As for the loss of the arrival sequence service: **SR1.314:** If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft

Table 22: Derivation of Mitigation/Safety Requirements for Hazard Hz#08 for the PJ.02.01 Arrivals Concepts Solutions

5.5.1.1.12 Hz#07 (SO 211): One or multiple separation minima infringements induced by ATC through inadequate selection & management of a time-based separation mode

This hazard occurs during the execution phase due to an erroneous selection or management of the separation mode, in relation to the conditional activation of the time-based WT separation modes and ATC tools (TBS, TB-S-PWS, TB-WDS or TB-WD-PWS).

Basic causes for such failures have been captured in the Hz#07 Fault Tree (See Figure 18).

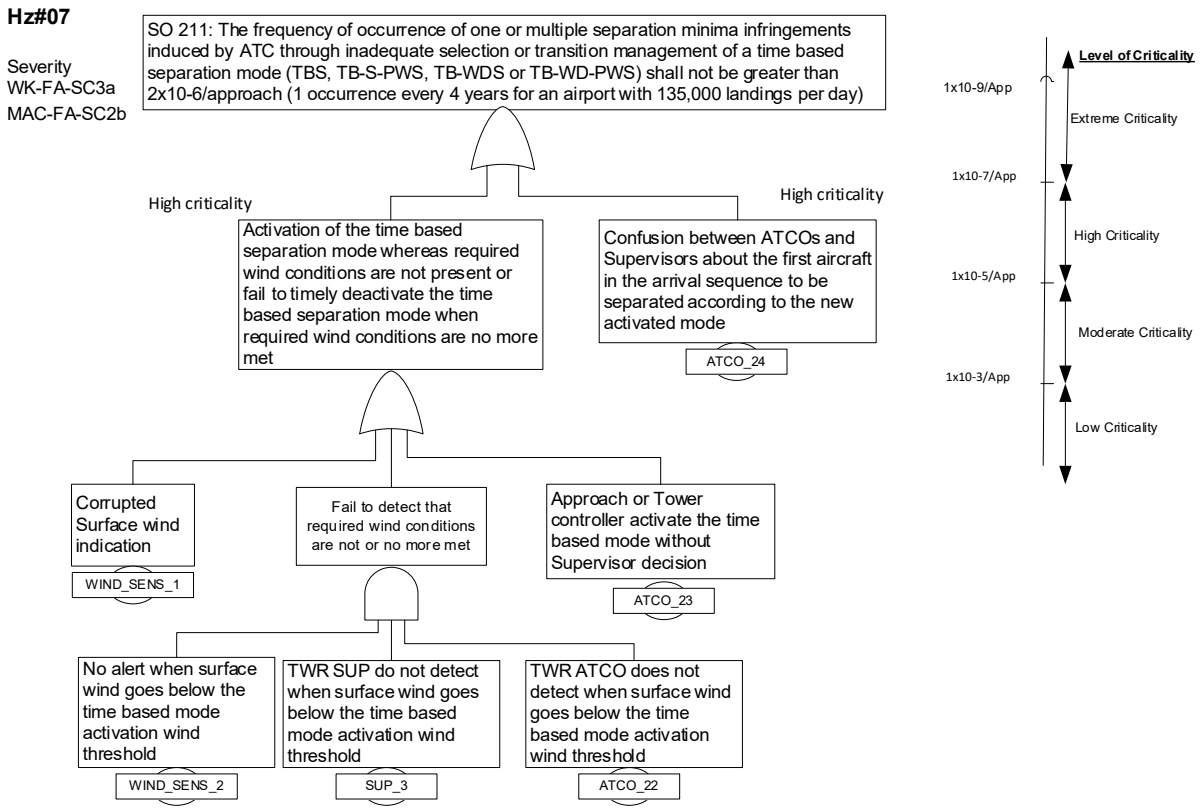


Figure 18: Hz#07 Fault Tree for the PJ.02.01 Arrivals Concepts Solutions

The table below describes the basic causes of the Hazard Hz#07 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Objective.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Corrupted surface wind indication.	WIND_SENS_1	Surface wind sensor provides to ATC wrong surface wind information.	**SR1.315:** It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust.

No alert when surface wind goes below the time based mode activation threshold wind.	WIND_SENS_2	ATC is not automatically informed when surface wind goes below the Time Based PWS activation wind threshold.	**SR1.024 and SR1.025** in “normal conditions” **SR1.207, SR1.208, SR1.209, SR1.210, SR1.211, SR1.212** in “abnormal conditions” **SR1.325**: Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)
Tower Supervisor does not detect that surface wind goes below the time based mode activation wind threshold.	SUP_3	TWR supervisor did not notice that required surface wind conditions are not or no more satisfied.	as above
Tower Controller does not detect that surface wind goes below time based mode activation wind threshold.	ATCO_22	TWR controllers did not notice that required surface wind conditions are no more satisfied.	as above
Approach or Tower controller activate the time based mode without Supervisor decision	ATCO_23	APP or TWR ATCO activates the time based mode in their CWP whereas required wind conditions are not satisfied.	**SR1.312**: The Separation Delivery tool implementation shall forbid the Approach and/or Tower Controller the possibility to activate the TB-WDS-A modes. **SR1.012 and SR1.013 in** “normal conditions”
Confusion between ATCOs and Supervisors about the first aircraft in the arrival sequence to be separated according to the new activated mode	ATCO_24		**SR1.120** from “normal operations”

Table 23: Derivation of Mitigation/Safety Requirements for Hazard Hz#07 for the PJ.02.01 Arrivals Concepts Solutions

5.5.1.2 Common Cause Analysis for the Arrivals Concepts Solutions

The main common causes have been identified through an initial causal analysis of the successive WTA AIM barriers B3, B4, B5, B6 and B3a. They are related to the use of the separation indicators, as a lack of information, or incorrect information would affect all those ATM safety barriers.

To deal with the common causes, two dedicated operational hazards have been defined, and risk appropriately assessed and mitigated:

- **Hz#05**: One or multiple imminent infringements not detected and not recovered due to undetected corruption of separation indicator
- **Hz#06**: One or multiple imminent infringements due to lack of separation indicator for multiple or all aircraft.

5.5.2 Formalisation of Mitigations

This section derives the mitigations to reduce the likelihood that specific failures would propagate up to the Hazard (i.e. operational level) – these mitigations are then captured as additional Safety Requirements (Functional and Performance).

Considering the outcome of the causal analysis (see Section 5.5.1.1) and more particularly the Mitigations identified in each table accompanying the hazard fault trees.

The table below summarizes the safety requirements (functionality & performance) that have been derived in order to mitigate risk associated to the system generated hazards (i.e. mitigation which have not been already captured during the design analysis in Normal operations or in presence of Abnormal conditions).

SO/Hz	SRs	SR Description
SO 201 / Hz#01a	SR1.028 REQ-02.01-SPRINTEROP-ARR0.0300	The approach arrival sequence information shall be provided to the Separation Delivery tool.
	SR1.037 REQ-02.01-SPRINTEROP-ARR0.0110	The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that needs to be delivered after considering all in-trail and if applicable not-in-trail constraints.
	SR1.048 REQ-02.01-SPRINTEROP-ARR0.0630	Criteria to determine the time for displaying indicators for each CWP shall be specified depending upon the local operation's needs.
	SR1.050 REQ-02.01-SPRINTEROP-ARR3.1000	If the ORD concept is implemented, the Final Approach Controller shall maintain the aircraft on or behind the ITD on the final approach and reduce to the final approach procedural airspeed until the transfer to the Tower controller.

	SR1.051 REQ-02.01-SPRINTEROP-ARR3.0170	If the ORD concept is implemented, the Approach controller shall vector the follower aircraft so that it stays on or behind the corresponding ITD.
	SR1.085 REQ-02.01-SPRINTEROP-ARR0.0220	Aircraft identifier, ICAO aircraft type and wake category for all arrival aircraft, including subsequent updates to this information, shall be provided to the Separation Delivery tool.
	SR1.303 REQ-02.01-SPRINTEROP-ARR0.1010	Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.
	SR1.309 REQ-02.01-SPRINTEROP-ARR0.1570	If an aircraft that needs to be inserted in the arrival sequence cannot be input into the Arrival Sequence Service, the Approach Controller shall inhibit the Target Distance Indicator corresponding to the follower aircraft whose position in the actual sequence is taken by the newly inserted aircraft and the Approach Controller shall observe DBS WT Category separation for the impacted pairs of aircraft
	SR1.117 REQ-02.01-SPRINTEROP-ARR0.1250	Approach and Tower Controllers shall be fully trained to apply the procedures for the new separation modes and to use of the Separation Delivery Tool and supporting systems (e.g. alerts) with indicators prior to deployment.
	SR1.314 REQ-02.01-SPRINTEROP-ARR0.1720	If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft
	SR1.315 REQ-02.01-SPRINTEROP-ARR0.0400	It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust.
	SR1.316 REQ-02.01-SPRINTEROP-ARR0.1441	At the first contact with the Approach, the flight crew shall provide the Aircraft type or alternatively this information could be provided to the Approach Controller via data link and the Approach Controller shall cross check this information with the information displayed on the CWP
	SR1.321 REQ-02.01-SPRINTEROP-ARR0.0430	When a flight data input error (e.g. missing or wrong ICAO aircraft type or wake category) is detected, it shall be possible to update the corresponding information into the input for the separation delivery tool
	SR1.326 REQ-02.01-	In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS

	SPRINTEROP-ARR0.1730	without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point
	SR1.327 REQ-02.01-SPRINTEROP-ARR0.1640	In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure
	SR1.329 REQ-02.01-SPRINTEROP-ARR0.1020	Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.)
	SR1.330 REQ-02.01-SPRINTEROP-ARR0.1440	Approach control shall check the validity of Flight Plan information displayed on the CWP (ICAO aircraft type, wake category)
	SR1.331 REQ-02.01-SPRINTEROP-ARR0.1721	In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off)
SO 202 / Hz#01b	SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)
	SR1.057 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a low priority spacing (ROT, gap, other spacing constraints) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner other than the one used for a high priority separation FTD (e.g. yellow colour)
	SR1.058 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed according to the rules defined for the high priority separation and low priority spacing indicators)

SR1.080 REQ-02.01-SPRINTEROP-ARR0.0130	In TB mode, the FTD computed by the tool to indicate the wake separation applicable at the delivery point shall take into consideration: • The time separation from the wake turbulence separation table (for WDS the separation tables might be more than one depending on the total/cross wind values); • The aircraft pair (from the arrival sequence list); • The glideslope headwind profile; • The follower time-to-fly profile obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction
SR1.301 Example of REQ-02.01-SPRINTEROP-ARR0.0142 Example of REQ-02.01-SPRINTEROP-ARR0.0460	If the required wind input to calculate a time based wake separation (TBS or WDS) is not available for an interval longer than a specific duration (to be determined based on local wind evolution analysis), then: • The Separation Delivery Tool shall continue displaying TDIs for aircraft that are already established on the final approach path and for which the last available TDIs computation includes a safety buffer managing the acceptable failure rate of the wind measurement; • The Separation Delivery Tool shall display TDIs for non-established aircraft based on conservative wind inputs for TDIs computation
SR1.093 REQ-02.01-SPRINTEROP-ARR0.0800	The HMI design shall allow Controllers to identify the aircraft associated with each displayed indicator.
SR1.303 REQ-02.01-SPRINTEROP-ARR0.1010	Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.
SR1.310 REQ-02.01-SPRINTEROP-ARR0.1530	The Approach Controllers shall be alerted in case the aircraft instructed to turn onto the Target Distance Indicator on the runway extended centreline is not the one planned in the Arrival Sequencing Tool list.
SR1.311 REQ-02.01-SPRINTEROP-ARR0.1560	In case of sequence error alert the Approach Controllers shall perform corrective action to re-establish consistency between the actual sequence order and the Arrival Sequencing Tool list.

	SR1.313 REQ-02.01-SPRINTEROP-ARR0.0450	If there is insufficient information to calculate a TDI then that TDI shall not be provided, together with a visual warning.
	SR1.123 REQ-02.01-SPRINTEROP-ARR0.1290	Regular trainings shall ensure ATCOs maintain sufficient competency to safely revert to and manage air traffic in DBS operations without Target Distance Indicators (i.e. implementation of the separation tool shall not adversely affect the controller's air traffic- vectoring skills- using DBS WT Category without Target Distance Indicators).
	SR1.326 REQ-02.01-SPRINTEROP-ARR0.1730	In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point
	SR1.327 REQ-02.01-SPRINTEROP-ARR0.1640	In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure
	SR1.328 REQ-02.01-SPRINTEROP-ARR0.0791	When spacing ITD is infringed by the aircraft, the ATCOs shall be aware of the next most constraining separation factor ITD and FTD (e.g. Wake or MRS) on the APPROACH and TOWER positions.
	SR1.329 REQ-02.01-SPRINTEROP-ARR0.1020	Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.)
	SR1.331 REQ-02.01-SPRINTEROP-ARR0.1721	In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off)
SO 203 / Hz#02a	SR1.110 REQ-02.01-SPRINTEROP-ARR0.1420	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), Flight Crew shall be briefed and reminded (e.g. via information campaigns) on the importance to respect on the Final Approach path the ATC speed instructions until the start of the deceleration and/or the published procedural airspeed on final approach and to notify Controller in a timely manner in case of inability to conform to one of those.
	SR1.310 REQ-02.01-	The Approach Controllers shall be alerted in case the aircraft instructed to turn onto the Target Distance Indicator on the runway extended centreline is not the one planned in the Arrival Sequencing Tool list.

	SPRINTEROP-ARR0.1530	
	SR1.311 REQ-02.01-SPRINTEROP-ARR0.1560	In case of sequence error alert the Approach Controllers shall perform corrective action to re-establish consistency between the actual sequence order and the Arrival Sequencing Tool list.
SO 204 / Hz#02b	SR1.037 REQ-02.01-SPRINTEROP-ARR0.0110	The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that needs to be delivered after considering all in-trail and if applicable not-in-trail constraints.
	SR1.038 REQ-02.01-SPRINTEROP-ARR3.0120	If the ORD concept is considered, the Separation Delivery tool shall provide to ATCOs a visualisation (ITD indicator) of the required spacing on final approach to be delivered at the deceleration fix in order to deliver the required minimum separation / spacing at the delivery point.
	SR1.052 REQ-02.01-SPRINTEROP-ARR0.0710	The tool shall automatically display the FTD (if not already displayed) if the aircraft comes within a defined distance of the computed FTD. This distance shall be configurable within the tool.
	SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)
	SR1.057 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a low priority spacing (ROT, gap, other spacing constraints) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner other than the one used for a high priority separation FTD (e.g. yellow colour)
	SR1.058 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed according to the rules defined for the high priority separation and low priority spacing indicators)

	SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.
	SR1.080 REQ-02.01-SPRINTEROP-ARR0.0130	In TB mode, the FTD computed by the tool to indicate the wake separation applicable at the delivery point shall take into consideration: • The time separation from the wake turbulence separation table (for WDS the separation tables might be more than one depending on the total/cross wind values); • The aircraft pair (from the arrival sequence list); • The glideslope headwind profile; • The follower time-to-fly profile obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction
	SR1.083 REQ-02.01-SPRINTEROP-ARR3.0150	The ITD computed by the tool for all separation and spacing constraints (wake separation in DB and TB modes, MRS, ROT and other spacing constraints) shall take in consideration: • The FTD for the considered aircraft pair • The glideslope headwind profile • The leader and follower time-to-fly profiles obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction
	SR1.328 REQ-02.01-SPRINTEROP-ARR0.0791	When spacing ITD is infringed by the aircraft, the ATCOs shall be aware of the next most constraining separation factor ITD and FTD (e.g. Wake or MRS) on the APPROACH and TOWER positions.
SO 205 / Hz#03a	SR1.052 REQ-02.01-SPRINTEROP-ARR0.0710	The tool shall automatically display the FTD (if not already displayed) if the aircraft comes within a defined distance of the computed FTD. This distance shall be configurable within the tool.
	SR1.053 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-	For the TWR HMI, if the first most constraining ITD corresponding to a high priority separation indicator (e.g. WAKE or MRS) is infringed, then its already displayed corresponding FTD shall be accompanied by the distance countdown to the FTD of the corresponding aircraft such that the TWR controller is aware that a high priority ITD has been infringed Note this countdown to the FTD applies only to the high priority

SPRINTEROP-ARR0.0792	separation indicators (WAKE and MRS). The scope of this distance is to show the TWR ATCO when an ITD has been infringed keeping in mind that the ITD is not displayed by default for the TWR controller.
SR1.054 Example of REQ-02.01-SPRINTEROP-ARR0.0792	For the TWR HMI, if the second most constraining ITD corresponding to a high priority separation is infringed, the system shall display the corresponding FTD accompanied by the distance countdown to the FTD, in addition to the already displayed first most constraining FTD such that the TWR controller is aware that a high priority ITD has been infringed (FTD displayed according to the rules defined for the high priority separation indicators)
SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)
SR1.057 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a low priority spacing (ROT, gap, other spacing constraints) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner other than the one used for a high priority separation FTD (e.g. yellow colour)
SR1.058 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed according to the rules defined for the high priority separation and low priority spacing indicators)
SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.
SR1.090 REQ-02.01-SPRINTEROP-ARR0.0691	The Controllers shall be able to visually distinguish (via colour or symbol) if Target Distance Indicators are relative to WT, MRS or ROT (or other spacing constraint).
SR1.103 REQ-02.01-	The Tower Controller shall monitor and ensure that there is no infringement of the FTD.

	SPRINTEROP-ARR0.0165	
	SR1.214 REQ-02.01-SPRINTEROP-ARR0.1500	The Approach and/or Tower controller shall be alerted by the speed conformance alert function when the actual aircraft speed differs by more than a locally-defined threshold from the aircraft speed profile used for the TDIs computation.
	SR1.215 REQ-02.01-SPRINTEROP-ARR0.1700	In TB-modes, in case of speed conformance alert before the stabilisation fix, the Final Approach or Tower Controllers shall check whether the actual spacing behind the leader aircraft is below the distance-based WTC separation minima and if positive shall apply adequate corrective actions: airspeed instructions, path stretching instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary, missed approach instruction, and shall manage the impact on subsequent aircraft in the arrival sequence.
	SR1.303 REQ-02.01-SPRINTEROP-ARR0.1010	Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.
	SR1.117 REQ-02.01-SPRINTEROP-ARR0.1250	Approach and Tower Controllers shall be fully trained to apply the procedures for the new separation modes and to use of the Separation Delivery Tool and supporting systems (e.g. alerts) with indicators prior to deployment.
	SR1.118 REQ-02.01-SPRINTEROP-ARR0.1260	All Approach and Tower controllers and Supervisors shall be fully trained in the operating procedures for the new WT separation modes prior to deployment.
	SR1.124 REQ-02.01-SPRINTEROP-ARR2.0971	The Tower Controller shall ensure that the actual spacing behind the leader aircraft is not infringing the FTD and in case of imminent infringement he shall apply adequate corrective action like delegating visual separation to Flight Crew or instructing go-around.
SO 206 / Hz#03b	SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.
	SR1.302 REQ-02.01-SPRINTEROP-ARR2.1280	In case of WDS cross wind, when the leader and follower are established on the glideslope, the Approach and Tower controllers shall be able to give heading instructions (e.g. break-off) to the follower only upwind and not downwind.

	SR1.303 REQ-02.01-SPRINTEROP-ARR0.1010	Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.
	SR1.306 REQ-02.01-SPRINTEROP-ARR0.0520	Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.
	SR1.123 REQ-02.01-SPRINTEROP-ARR0.1290	Regular trainings shall ensure ATCOs maintain sufficient competency to safely revert to and manage air traffic in DBS operations without Target Distance Indicators (i.e. implementation of the separation tool shall not adversely affect the controller's air traffic- vectoring skills- using DBS WT Category without Target Distance Indicators).
	SR1.326 REQ-02.01-SPRINTEROP-ARR0.1730	In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point
	SR1.327 REQ-02.01-SPRINTEROP-ARR0.1640	In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure
	SR1.329 REQ-02.01-SPRINTEROP-ARR0.1020	Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.)
	SR1.331 REQ-02.01-SPRINTEROP-ARR0.1721	In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off)
SO 207 / Hz#04a	SR1.110 REQ-02.01-SPRINTEROP-ARR0.1420	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), Flight Crew shall be briefed and reminded (e.g. via information campaigns) on the importance to respect on the Final Approach path the ATC speed instructions until the start of the deceleration and/or the published procedural airspeed on final approach and to notify Controller in a timely manner in case of inability to conform to one of those.
	SR1.113 REQ-02.01-	With regards to WDS modes (total wind or cross wind) Flight Crew shall be briefed and reminded on the importance to respect the Final

	SPRINTEROP-ARR0.1430	Approach path in terms of lateral deviation from the glide path and to notify Controller in a timely manner in case of inability to conform to it.
	SR1.214 REQ-02.01-SPRINTEROP-ARR0.1500	The Approach and/or Tower controller shall be alerted by the speed conformance alert function when the actual aircraft speed differs by more than a locally-defined threshold from the aircraft speed profile used for the TDIs computation.
	SR1.215 REQ-02.01-SPRINTEROP-ARR0.1700	In TB-modes, in case of speed conformance alert before the stabilisation fix, the Final Approach or Tower Controllers shall check whether the actual spacing behind the leader aircraft is below the distance-based WTC separation minima and if positive shall apply adequate corrective actions: airspeed instructions, path stretching instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary, missed approach instruction, and shall manage the impact on subsequent aircraft in the arrival sequence.
	SR1.119 REQ-02.01-SPRINTEROP-ARR0.1270	ATCO training shall ensure that the operation in new WT separation modes will not lead to more un-stabilized approaches due to late/rush aircraft stabilisation as a result of tighter spacing and more frequent speed adjustments. However, a greater number of instructions might temporarily occur during the introduction of the new concept.
	SR1.124 REQ-02.01-SPRINTEROP-ARR2.0971	The Tower Controller shall ensure that the actual spacing behind the leader aircraft is not infringing the FTD and in case of imminent infringement he shall apply adequate corrective action like delegating visual separation to Flight Crew or instructing go-around.
SO 208 / Hz#04b	SR1.052 REQ-02.01-SPRINTEROP-ARR0.0710	The tool shall automatically display the FTD (if not already displayed) if the aircraft comes within a defined distance of the computed FTD. This distance shall be configurable within the tool.
	SR1.053 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0792	For the TWR HMI, if the first most constraining ITD corresponding to a high priority separation indicator (e.g. WAKE or MRS) is infringed, then its already displayed corresponding FTD shall be accompanied by the distance countdown to the FTD of the corresponding aircraft such that the TWR controller is aware that a high priority ITD has been infringed Note this countdown to the FTD applies only to the high priority separation indicators (WAKE and MRS). The scope of this distance is to show the TWR ATCO when an ITD has been infringed keeping in mind that the ITD is not displayed by default for the TWR controller.
	SR1.054 Example of REQ-02.01-	For the TWR HMI, if the second most constraining ITD corresponding to a high priority separation is infringed, the system shall display the corresponding FTD accompanied by the distance countdown to the FTD, in addition to the already displayed first most constraining FTD

SPRINTEROP-ARR0.0792	such that the TWR controller is aware that a high priority ITD has been infringed (FTD displayed according to the rules defined for the high priority separation indicators)
SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)
SR1.057 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a low priority spacing (ROT, gap, other spacing constraints) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner other than the one used for a high priority separation FTD (e.g. yellow colour)
SR1.058 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed according to the rules defined for the high priority separation and low priority spacing indicators)
SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.
SR1.214 REQ-02.01-SPRINTEROP-ARR0.1500	The Approach and/or Tower controller shall be alerted by the speed conformance alert function when the actual aircraft speed differs by more than a locally-defined threshold from the aircraft speed profile used for the TDIs computation.
SR1.215 REQ-02.01-SPRINTEROP-ARR0.1700	In TB-modes, in case of speed conformance alert before the stabilisation fix, the Final Approach or Tower Controllers shall check whether the actual spacing behind the leader aircraft is below the distance-based WTC separation minima and if positive shall apply adequate corrective actions: airspeed instructions, path stretching instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary, missed approach instruction, and shall manage the impact on subsequent aircraft in the arrival sequence.

SO 209 / Hz#05	SR1.028 REQ-02.01-SPRINTEROP-ARR0.0300	The approach arrival sequence information shall be provided to the Separation Delivery tool.
	SR1.300 REQ-02.01-SPRINTEROP-ARR0.0540	Controllers shall be trained to check the aircraft landing runway intent and that the aircraft order is correct and coherent with the arrival sequence list. They shall check if and that the aircraft order is displayed in the arrival sequence list and/or if the aircraft sequence number is displayed in the radar label in accordance with their intended sequence.
	SR1.200 Example of REQ-02.01-SPRINTEROP-ARR0.0852	The Intermediate and Final Approach controllers shall be the masters of the Final Approach arrival sequence and shall be able in a simple and timely way to update the sequence, insert or remove an aircraft and amend the sequence when there is a go-around in accordance with their strategy for the interception with no adverse impact on workload.
	SR1.201 REQ-02.01-SPRINTEROP-ARR0.0560	For every change in the arrival sequence (aircraft swapping positions, aircraft removed or missed approach, late change of the runway intent, etc.) the tool shall immediately re-compute all affected TDIs and reflect the change on the HMI accordingly.
	SR1.032 REQ-02.01-SPRINTEROP-ARR0.0550	If there is a change to the sequence order or runway intent, the Approach Controller should check that each indicator for each affected aircraft pair has been updated.
	SR1.033 REQ-02.01-SPRINTEROP-ARR0.0940	In case of a change of the arrival sequence order position of an aircraft, the Approach controller shall check that the arrival sequence order has been updated to reflect the change
	SR1.034 REQ-02.01-SPRINTEROP-ARR0.0941	The sequence manager shall ensure that for the change of the sequence order there is no overlap (or lack of awareness) between the actions taken by the Intermediate Approach Controller and the Final Approach Controller, by allowing only one change at a time.
	SR1.077 REQ-02.01-SPRINTEROP-ARR0.0060	In TBS mode, the separation delivery tool shall be provided with time separation rules.
	SR1.078 REQ-02.01-SPRINTEROP-ARR1.0070	S-PWS wake separation rules shall be provided to the Separation Delivery tool.
	SR1.079 Example of	In TB-modes where WDS is applied (WDS-Xw and WDS-Tw) the separation delivery tool shall be provided with time separation tables

REQ-02.01-SPRINTEROP-ARR2.0030	(for each cross-wind and respectively total wind value and each aircraft pair category) derived from: • the time required for a sufficient vortex decay • the time required for the vortex to be transported away from the path of the follower aircraft • the reference speed profile for the leader and follower aircraft
SR1.080 REQ-02.01-SPRINTEROP-ARR0.0130	In TB mode, the FTD computed by the tool to indicate the wake separation applicable at the delivery point shall take into consideration: • The time separation from the wake turbulence separation table (for WDS the separation tables might be more than one depending on the total/cross wind values); • The aircraft pair (from the arrival sequence list); • The glideslope headwind profile; • The follower time-to-fly profile obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction
SR1.085 REQ-02.01-SPRINTEROP-ARR0.0220	Aircraft identifier, ICAO aircraft type and wake category for all arrival aircraft, including subsequent updates to this information, shall be provided to the Separation Delivery tool.
SR1.086 REQ-02.01-SPRINTEROP-ARR0.0280	The Separation Delivery tool shall be provided with the predicted headwind profile on the glideslope (ideally from ground to the published localiser interception altitude) to compute the ITD in all modes and the FTD in TB-modes. The used profiles shall ensure smooth temporal evolution of the ITD on the final approach.
SR1.088 REQ-02.01-SPRINTEROP-ARR2.0141	In WDS modes (total wind/cross wind) the Separation Delivery tool shall use the relevant separation table for the FTD computation based on the measured total/cross wind
SR1.093 REQ-02.01-SPRINTEROP-ARR0.0800	The HMI design shall allow Controllers to identify the aircraft associated with each displayed indicator.
SR1.109	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), the APP and TWR Controllers shall be made aware with respect to the impact on the TDIs correctness when actual aircraft speed profile is different from the pre-defined TAS profile used by the separation delivery tool.

SR1.110 REQ-02.01-SPRINTEROP-ARR0.1420	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), Flight Crew shall be briefed and reminded (e.g. via information campaigns) on the importance to respect on the Final Approach path the ATC speed instructions until the start of the deceleration and/or the published procedural airspeed on final approach and to notify Controller in a timely manner in case of inability to conform to one of those.
SR1.208	In WDS total wind modes (A-TB-WDS-Tw), the Approach and Tower Controllers and Supervisors shall be alerted by the total wind monitoring function about a significant difference between actual reference total wind and the reference total wind used for the TB computation, i.e. when the predicted allowed time separation (based on the total wind prediction used for Target Distance Indicator computation) compared to the actual allowed time separation (based on the actual total wind measurement) exceeds a threshold to be determined locally.
SR1.209	In WDS cross wind modes (A-TB-WDS-Xw), the Approach and Tower Controllers and Supervisors shall be alerted by the cross wind monitoring function about a significant difference between actual reference cross wind and the reference cross wind used for the TB computation, i.e. when the predicted allowed time separation (based on the cross wind prediction used for Target Distance Indicator computation) compared to the actual allowed time- separation (based on the actual cross wind measurement) exceeds a threshold to be determined locally.
SR1.210	In WDS total wind modes (A-TB-WDS-Tw), in case of total wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.
SR1.211 REQ-02.01-SPRINTEROP-ARR2.1680	In WDS crosswind modes (WDS-Xw), in case of cross wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode, using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.
SR1.212	In TBS and TB-PWS-A modes, in case there is a significant difference between actual glideslope headwind profile and the glideslope headwind profile used for the TDI computation, the Separation Delivery Tool shall re-compute the TDIs based on the correct headwind value and inform the ATCO about the re-computation.

	SR1.213 REQ-02.01-SPRINTEROP-ARR2.1690	The triggering values of the headwind, total wind and cross wind monitoring alerts shall be determined on the basis of the used buffers in the TDI computation
	SR1.214 REQ-02.01-SPRINTEROP-ARR0.1500	The Approach and/or Tower controller shall be alerted by the speed conformance alert function when the actual aircraft speed differs by more than a locally-defined threshold from the aircraft speed profile used for the TDIs computation.
	SR1.215 REQ-02.01-SPRINTEROP-ARR0.1700	In TB-modes, in case of speed conformance alert before the stabilisation fix, the Final Approach or Tower Controllers shall check whether the actual spacing behind the leader aircraft is below the distance-based WTC separation minima and if positive shall apply adequate corrective actions: airspeed instructions, path stretching instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary, missed approach instruction, and shall manage the impact on subsequent aircraft in the arrival sequence.
	SR1.217 REQ-02.01-SPRINTEROP-ARR0.1710	For all modes, in case of speed conformance alert the Final Approach and Tower Controllers shall be aware that ITD indicators are no longer accurate if the same speed is kept until the deceleration fix (ITD computation impacted by pre-defined glideslope airspeed profile of both follower and leader) thus shall manage compression without indicators as per today operations.
	SR1.218 REQ-02.01-SPRINTEROP-ARR0.1510	The triggering value used for the speed conformance alert shall be determined on the basis of the used buffers in the TDI computation. The region on the glideslope where the alert is active shall be defined locally (e.g. 8 NM from RWY threshold).
	SR1.304 REQ-02.01-SPRINTEROP-ARR0.0510	Wake category and aircraft type information shall be always available in the aircraft labels so that this information remains visible for Controllers
	SR1.306 REQ-02.01-SPRINTEROP-ARR0.0520	Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.
	SR1.315 REQ-02.01-SPRINTEROP-ARR0.0400	It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust.
	SR1.316 REQ-02.01-	At the first contact with the Approach, the flight crew shall provide the Aircraft type or alternatively this information could be provided to the

SPRINTEROP-ARR0.1441	Approach Controller via data link and the Approach Controller shall cross check this information with the information displayed on the CWP
SR1.317 REQ-02.01-SPRINTEROP-ARR0.0410	The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment
SR1.318 REQ-02.01-SPRINTEROP-ARR0.0390	Separation delivery tool verification shall be carried-out after modification of the separation time table configuration file (in TB-modes) or the distance separation table configuration file before the system returns in operational service
SR1.319 REQ-02.01-SPRINTEROP-ARR0.0380	A quality assurance process shall be put in place to validate the separation time table configuration file (in TB- modes) or the distance separation table configuration file of the separation delivery tool
SR1.320 REQ-02.01-SPRINTEROP-ARR0.0420	Separation delivery tool verification shall be carried-out after modification of the time-to-fly/airspeed profile configuration file (new A/C types or modification of existing A/C speed profiles) before the system returns in operational service
SR1.321 REQ-02.01-SPRINTEROP-ARR0.0430	When a flight data input error (e.g. missing or wrong ICAO aircraft type or wake category) is detected, it shall be possible to update the corresponding information into the input for the separation delivery tool
SR1.322 REQ-02.01-SPRINTEROP-ARR0.1330	In TB modes, relevant wind information shall be displayed on Approach / Tower Controller working positions for awareness purposes (e.g. to enable significant discrepancy check with the displayed TDI). Note the following assumption is conservatively taken: A015: Controllers cannot have detailed knowledge of separations for each pair of aircraft in all modes except for DBS therefore checking that Target Distance indications are consistent with the associated aircraft types and WT category is not realistic
SR1.123 REQ-02.01-SPRINTEROP-ARR0.1290	Regular trainings shall ensure ATCOs maintain sufficient competency to safely revert to and manage air traffic in DBS operations without Target Distance Indicators (i.e. implementation of the separation tool shall not adversely affect the controller's air traffic- vectoring skills- using DBS WT Category without Target Distance Indicators).
SR1.323 REQ-02.01-SPRINTEROP-ARR0.1310	Approach and Tower Controllers shall be provided with look-up tables for DBS minima to support DBS operations with no TDIs when necessary.

	SR1.324 REQ-02.01-SPRINTEROP-ARR0.0860	ATCOs shall continue to have a 'click and drag' distance measuring tool so they can accurately measure inter a/c spacing when required (e.g. for building confidence in the tool or during degraded modes)
	SR1.325 REQ-02.01-SPRINTEROP-ARR0.1770	Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)
	SR1.124 REQ-02.01-SPRINTEROP-ARR2.0971	The Tower Controller shall ensure that the actual spacing behind the leader aircraft is not infringing the FTD and in case of imminent infringement he shall apply adequate corrective action like delegating visual separation to Flight Crew or instructing go-around.
	SR1.330 REQ-02.01-SPRINTEROP-ARR0.1440	Approach control shall check the validity of Flight Plan information displayed on the CWP (ICAO aircraft type, wake category)
SO 210 / Hz#06	SR1.028 REQ-02.01-SPRINTEROP-ARR0.0300	The approach arrival sequence information shall be provided to the Separation Delivery tool.
	SR1.300 REQ-02.01-SPRINTEROP-ARR0.0540	Controllers shall be trained to check the aircraft landing runway intent and that the aircraft order is correct and coherent with the arrival sequence list. They shall check if and that the aircraft order is displayed in the arrival sequence list and/or if the aircraft sequence number is displayed in the radar label in accordance with their intended sequence.
	SR1.037 REQ-02.01-SPRINTEROP-ARR0.0110	The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that needs to be delivered after considering all in-trail and if applicable not-in-trail constraints.
	SR1.048 REQ-02.01-SPRINTEROP-ARR0.0630	Criteria to determine the time for displaying indicators for each CWP shall be specified depending upon the local operation's needs.
	SR1.303 REQ-02.01-SPRINTEROP-ARR0.1010	Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.

SR1.304 REQ-02.01-SPRINTEROP-ARR0.0510	Wake category and aircraft type information shall be always available in the aircraft labels so that this information remains visible for Controllers
SR1.305 REQ-02.01-SPRINTEROP-ARR0.1600	For all modes, in case of loss of glideslope headwind profile input to the separation tool, the alert for loss of glideslope headwind profile service shall be displayed to the Controllers and Supervisors.
SR1.306 REQ-02.01-SPRINTEROP-ARR0.0520	Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.
SR1.307 REQ-02.01-SPRINTEROP-ARR0.1650	In TB-modes, in the degraded situation where glideslope headwind profile input is missing: • The Controllers shall revert to the correspondent DB- mode (DBS or S-PWS) with use of FTDs only whilst ITDs shall no more be displayed (manual management of compression) or shall revert to an acceptably safe TB-mode with ITD and FTD computed using a conservative wind profile (until the glideslope headwind profile is available again); OR • The Separation Delivery Tool shall automatically revert to the correspondent DB-mode or to an acceptably safe TB-mode (FTD and ITD computed using a conservative wind profile). A notification of the automatic switch shall be provided to the ATCOs and Supervisors.
SR1.308 REQ-02.01-SPRINTEROP-ARR0.1660	In DB- modes, in the degraded situation where glideslope headwind profile input is missing, the Approach Controller shall use only the FTD for the turn-on decision for merging on to final approach (whilst ITDs shall no more be displayed), vectoring the follower aircraft to intercept the final approach and further spacing management during interception whilst adding extra buffer to the FTD to manually account for compression or shall revert to an acceptably safe DB-mode with ITD and FTD computed using a conservative wind profile (until the glideslope headwind profile is available again)
SR1.313 REQ-02.01-SPRINTEROP-ARR0.0450	If there is insufficient information to calculate a TDI then that TDI shall not be provided, together with a visual warning.
SR1.314 REQ-02.01-	If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft

	SPRINTEROP-ARR0.1720	
	SR1.123 REQ-02.01-SPRINTEROP-ARR0.1290	Regular trainings shall ensure ATCOs maintain sufficient competency to safely revert to and manage air traffic in DBS operations without Target Distance Indicators (i.e. implementation of the separation tool shall not adversely affect the controller's air traffic- vectoring skills- using DBS WT Category without Target Distance Indicators).
	SR1.323 REQ-02.01-SPRINTEROP-ARR0.1310	Approach and Tower Controllers shall be provided with look-up tables for DBS minima to support DBS operations with no TDIs when necessary.
	SR1.324 REQ-02.01-SPRINTEROP-ARR0.0860	ATCOs shall continue to have a 'click and drag' distance measuring tool so they can accurately measure inter a/c spacing when required (e.g. for building confidence in the tool or during degraded modes)
	SR1.325 REQ-02.01-SPRINTEROP-ARR0.1770	Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)
	SR1.326 REQ-02.01-SPRINTEROP-ARR0.1730	In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point
	SR1.327 REQ-02.01-SPRINTEROP-ARR0.1640	In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure
	SR1.329 REQ-02.01-SPRINTEROP-ARR0.1020	Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.)
	SR1.331 REQ-02.01-SPRINTEROP-ARR0.1721	In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off)
SO 211 / Hz#07	SR1.012 REQ-02.01-	For TB- modes the Approach and Tower Supervisors shall collaboratively decide when the conditional (TB) mode should be activated or de activated based on meteorological data information and predefined activation criteria and on prior coordination with

SPRINTEROP-ARR2.1060	Controllers. Note: Activation of a WT separation mode encompasses both starting operations at the beginning of the day and transition to a different WT separation mode during the day.
SR1.013 REQ-02.01-SPRINTEROP-ARR0.0980	The Tower Supervisor in coordination with the Approach Supervisor (and occasionally the Tower and Approach Controllers - in line with defined local procedures) shall determine the final approach separation mode and runway spacing constraints that are to be applied at any time by the separation delivery tool.
SR1.024 REQ-02.01-SPRINTEROP-ARR0.1760	In case of conditional application in TB-modes, the Supervisors (Tower and Approach) and Controllers (Tower and Approach) shall be alerted automatically in advance when the predefined activation criteria will not be met anymore hence the imminent need to transition from one separation mode to another, in order to temporarily limit or regulate the flow of inbound traffic (e.g. through metering) prior to the switch of separation mode in order to manage the change and controllers workload
SR1.208	In WDS total wind modes (A-TB-WDS-Tw), the Approach and Tower Controllers and Supervisors shall be alerted by the total wind monitoring function about a significant difference between actual reference total wind and the reference total wind used for the TB computation, i.e. when the predicted allowed time separation (based on the total wind prediction used for Target Distance Indicator computation) compared to the actual allowed time separation (based on the actual total wind measurement) exceeds a threshold to be determined locally.
SR1.209	In WDS cross wind modes (A-TB-WDS-Xw), the Approach and Tower Controllers and Supervisors shall be alerted by the cross wind monitoring function about a significant difference between actual reference cross wind and the reference cross wind used for the TB computation, i.e. when the predicted allowed time separation (based on the cross wind prediction used for Target Distance Indicator computation) compared to the actual allowed time- separation (based on the actual cross wind measurement) exceeds a threshold to be determined locally.
SR1.210	In WDS total wind modes (A-TB-WDS-Tw), in case of total wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.
SR1.211 REQ-02.01-	In WDS crosswind modes (WDS-Xw), in case of cross wind monitoring alert, the Approach and Tower Controllers shall revert to the

	SPRINTEROP-ARR2.1680	correspondent distance based or time based (e.g. TB-PWS) separation mode, using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.
	SR1.212	In TBS and TB-PWS-A modes, in case there is a significant difference between actual glideslope headwind profile and the glideslope headwind profile used for the TDI computation, the Separation Delivery Tool shall re-compute the TDIs based on the correct headwind value and inform the ATCO about the re-computation.
	SR1.120 REQ-02.01-SPRINTEROP-ARR0.1040	All licenced Approach and Tower controllers (and Supervisors) shall be fully trained to switch between the time based and distance based modes of operation.
	SR1.312 REQ-02.01-SPRINTEROP-ARR2.1050	The Separation Delivery tool implementation shall forbid the Approach and/or Tower Controller the possibility to activate the TB-WDS-A modes.
	SR1.325 REQ-02.01-SPRINTEROP-ARR0.1770	Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)
SO 212 / Hz#08	SR1.025 REQ-02.01-SPRINTEROP-ARR2.1190	If the Wind Forecast service detects WDS-A concept suspension, the information shall be transmitted to the Separation Delivery tool and a corresponding alert shall be displayed to the CWPs of the Controllers and Supervisors.
	SR1.300 REQ-02.01-SPRINTEROP-ARR0.0540	Controllers shall be trained to check the aircraft landing runway intent and that the aircraft order is correct and coherent with the arrival sequence list. They shall check if and that the aircraft order is displayed in the arrival sequence list and/or if the aircraft sequence number is displayed in the radar label in accordance with their intended sequence.
	SR1.200 Example of REQ-02.01-SPRINTEROP-ARR0.0852	The Intermediate and Final Approach controllers shall be the masters of the Final Approach arrival sequence and shall be able in a simple and timely way to update the sequence, insert or remove an aircraft and amend the sequence when there is a go-around in accordance with their strategy for the interception with no adverse impact on workload.
	SR1.032 REQ-02.01-SPRINTEROP-ARR0.0550	If there is a change to the sequence order or runway intent, the Approach Controller should check that each indicator for each affected aircraft pair has been updated.

	SR1.033 REQ-02.01-SPRINTEROP-ARR0.0940	In case of a change of the arrival sequence order position of an aircraft, the Approach controller shall check that the arrival sequence order has been updated to reflect the change
	SR1.034 REQ-02.01-SPRINTEROP-ARR0.0941	The sequence manager shall ensure that for the change of the sequence order there is no overlap (or lack of awareness) between the actions taken by the Intermediate Approach Controller and the Final Approach Controller, by allowing only one change at a time.
	SR1.072 REQ-02.01-SPRINTEROP-ARR0.0253	The separation delivery tool shall provide confirmation to ATCO that the gap spacing insertion is successful or not.
	SR1.089 REQ-02.01-SPRINTEROP-ARR0.0162	The tool in any mode shall display TDIs representing the greatest constraint out of all applicable in-trail or not in-trail separation constraints. The constraints can be the high priority separation (e.g. Wake and MRS) and the low priority runway spacing (ROT) and other spacing constraints (e.g. departure GAP, runway inspections, etc.).
	SR1.093 REQ-02.01-SPRINTEROP-ARR0.0800	The HMI design shall allow Controllers to identify the aircraft associated with each displayed indicator.
	SR1.314 REQ-02.01-SPRINTEROP-ARR0.1720	If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft
	SR1.317 REQ-02.01-SPRINTEROP-ARR0.0410	The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment

Table 24: Additional functionality & performance safety requirements and assumptions to mitigate System generated Hazards for the PJ.02.01 Arrivals Concepts Solutions

5.6 Realism of the safe design

The development and safety analysis of the design would be seriously undermined if it were found in the subsequent Implementation phase that the Safety Requirements were either not 'testable' or impossible to satisfy (i.e. not achievable), and / or that some of the assumptions were in fact incorrect.

5.6.1.1 Achievability of Safety Requirements / Assumptions for the Arrivals Concepts Solutions

All the requirements in this SAR have been developed in different workshops at project level, involving the different partners interested in the arrival concepts solutions. The requirements have also been coordinated at project level such that to avoid duplications and/or contradictions with the OSED, HP and TS requirements.

The vast majority of the Safety Requirements have been demonstrated as capable of being satisfied in a typical implementation because they have been / will be exercised during validation exercises or because their achievability has been confirmed with Controllers, pilots and ground manufacturer during meetings, SAF/HP workshop or debriefing sessions. The information regarding the coverage and /or validation of the requirements in validation exercises is not provided in the current SAR. However, this is taken care of in the VALP[25] (which shows the link between the requirements and the validation objectives for each validation exercise), VALR[28] (which shows the detailed results of the exercises) and the OSED[21] (which shows for each requirement if it has been validated or not).

5.6.1.2 "Testability" of Safety Requirements for the Arrivals Concepts Solutions

Most of the safety requirements are verifiable by direct means which could be by equipment and/or integrated system verification report, training certificate, published procedures, AIP information, etc.

For some safety requirements, verification should rely on appropriate assurance process to be implemented. This is particularly true for the development of the separation delivery and arrival sequencing tools (e.g. based on Software and/or hardware assurance level) but also for the data quality and assurance process of the separation tool configuration files.

5.7 Process assurance for a Safe Design

A safety team encompassing controllers, pilots, ground suppliers, engineers, Safety and Human Performance specialists have supported this safety assessment of the Arrivals Concepts Solutions.

In addition to the activities conducted at Service level, the first step was the validation of the Design level model, then safety requirements have been derived in normal, abnormal and failure conditions to satisfy the Safety Objectives derived at Service level which are identified in Section 4 of this document. In addition to the SAF/HP workshops, several meetings were organised to consolidate the list of safety requirements in particular to obtain consistent Safety and HP requirements.

Appendix A provides the consolidated list of Safety Objectives.

Appendix B provides the consolidated list of Safety Requirements.

Appendix C provides the consolidated list of Safety Assumptions, Issues, Recommendations and Assessment Limitations.

6 SAfety Criteria achievability

The safety-relevant validation objectives for each Safety Criteria have been defined for the safety assurance activities to be conducted according to the safety demonstration strategy.

With regards to the SAC addressing separation design, the following pieces of evidence have been produced based on the modelling, data collection and analysis dedicated to the risk of Wake Vortex Encounter:

- For **RECAT-EU-PWS-SAC#1:** Wake Turbulence Re-categorisation and Pair-Wise Separation Minima on Approach and Departure (RECAT-EU-PWS) Safety Case [7] (updated version including the extension of PWS distance minima matrix with new aircraft types – from 96 to 103 types)

- For **A-TB-WDS-Tw-SAC#1** and **A-TB-WDS-Xw-SAC#1**: PJ02-D2.f: WDS - Data mining, modelling, big data/ machine learning analysis – final report [10] and associated appendix [11].

With regards to the SAC addressing separation delivery, this section outlines the results of the safety assurance activities in response to the validation objectives. These are results of the validation exercises or outcomes of the safety-dedicated workshops (making use of operational experts' judgment). Such results may confirm that the validation objectives are satisfied (thus proving that the correspondent SAC is met) or may allow to validate Safety Requirements or to derive new ones.

It is recalled that at SPR-design level, Safety Objectives have been mapped to Safety Requirements for normal conditions (section 5.3), for abnormal conditions (section 5.4) and for failure aspects (section 5.5). It was shown in these sections (using a combination of safety engineering techniques, safety assessment and results from validation exercises) that these Safety Requirements satisfy the Safety Objectives which in turn have been already shown to satisfy the Safety Criteria.

The information regarding the safety requirements that have been derived within the safety assessment is provided in the Appendix B (providing the consolidated list of the functionality & performance safety requirements).

The next table summarizes the results for the Safety KPA dedicated to each of the SESAR solution success criteria identified in the VAL PLN[25] for the relevant validation exercises. For detailed results please see the corresponding VALR[28].

Note with regard to all the success criteria about the quantification of the under-separations and go-arounds:

- Based on the data collected in the RTS and due to the limited number of scenarios and conditions that can be tested in an RTS, only a limited statistical analysis could be performed for these success criteria, as the data is insufficient to derive a significant statistical conclusion. However, these results do give an indication of trends. Thus, this quantitative data in combination with the qualitative safety data/results obtained from the RTS and other safety related activities (e.g. workshops, HAZIDs) enables us to conclude that safety is not negatively impacted.

Exercise ID, Name, Objective	Exercise Validation objective	Success criterion	Safety Criteria coverage	Validation results & Level of safety evidence
RTS01 - Conducted by EUROCONTROL to assess the application of time based Weather Dependent Separations (WDS - AO-0310) with Optimised Runway Delivery (ORD - AO-0328) for arriving aircraft using the Paris CDG airport and approach environment	**OBJ-PJ.02.01-V3-VALP-SA1:** To assess the impact of weather dependent separations on the final approach on operational safety compared to current wake vortex separation scheme	**CRT-PJ.02.01-V3-VALP-SA1-001:** There is evidence that the level of operational safety is maintained and not negatively impacted under weather dependent separations on the final approach compared to the current operations applying wake vortex separation scheme without ORD tool.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#F5, A-SAC#R1, A-SAC#R2, A-SAC#R3	The controllers were seen to apply the safe standard practices when using the WDS with ORD tool in the simulation. Controllers reported that thanks to the reduced workload, stress levels, increased situation awareness compared to RECAT EU without ORD tool, they were able to allocate spare resources to other tasks, such as preventing runway incursions or detecting possible separation infringements. More specifically, controllers reported that when working in the Tower, the ORD/separation delivery tool increases their awareness of potential separation infringements enabling an easier and earlier identification. The above evidence suggests that the potential for human error with safety implication will as a minimum, not increase compared to using RECAT with no tool. Meanwhile a **Safety issue** subsists: the ITM ATCO situation awareness might be altered in the dual arrival environment (CDG North and South arrivals) because by focusing on the ITDs, the ITM position does not systematically check the

				altitude of the a/c corresponding to the other ITM, as they would in RECAT EU, with potential for separation loss. The impact of the sudden loss of one or multiple/all indicators (i.e. during degraded mode of operations) has been assessed in debriefings. Conclusion: - Multiple indicators: safety risk could be mitigated through an adaptation of the working methods, applying a higher separation than in RECAT EU and accepting a temporary increase in workload (situation judged as similar to manage as switching to LVP procedures in normal operations); - One indicator: applying RECAT-EU to the affected aircraft (making use of the distance vector) or instructing a go-around solves the issue.
		CRT-PJ.02.01-V3-VALP-SA1-002: There is evidence that WDS with ORD tool for arrivals does not increase the number of minor under-separations and decreases the number of	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#R1	The number of minor under-separated aircraft (less than or equal to 0.5 NM but more than 0.1NM) on the final approach is lower with Solution compared to Reference scenario. Moreover, the under separation was at most 0.25NM with Solution, whilst several pairs were

		large under-separations (i.e. those with potential for severe wake encounters) compared to the current operations wake vortex separation scheme without ORD tool.		under-separated more than 0.25NM with Reference. No pairs were observed to be delivered with a major under-separation (more than 0.5NM) when applying WDS with ORD (note that in Reference 5% of the pairs were delivered with major under-separation for South operations and none for North, that being related to the fact that no TWR ATCO was involved on the South position (as such, very few Go-arounds have been initiated in order to prevent major under-separation). Additionally, the number of go-arounds related to separation was larger with Reference than with Solution. The analysis of the separation infringements before alignment did not reveal any cause imputable to the use of the ORD tool, neither related to transitioning between separation rules on the Base leg nor related to the Dual approach operations (conflicts North vs South). ATC can safely handle the mode switch provided they are notified in advance about the change in wind conditions and the imminent need to transition from one separation scheme to another. An advanced warning of the mode transition is required in order to temporarily limit or regulate the flow of inbound traffic (e.g.

				through metering) during the switch of separation scheme in order to manage the change and the controllers workload.
		CRT-PJ.02.01-V3-VALP-SA1-003: The probability of Go around due to inadequate consideration of ROT constraint is not increased	A-SAC#R1	Only two Go-Arounds due to ROT constraint have been recorded in Reference, and none with the Solution – that complies with the success criteria, but is not a statistically representative evidence
RTS2 - Conducted by EUROCONTROL to assess the application of wake turbulence separations based on static aircraft characteristics for arriving aircraft (static PairWise Separations - PWS-A -AO-0310) with ORD (AO-0328)	**OBJ-PJ2.02-V3-VALP-SA2:** To assess the impact of static pairwise separations for arrivals with ORD on operational safety compared to current wake vortex separation scheme	**CRT-PJ2.01-V3-VALP-SA2-001:** To assess the impact of time based Static Pair Wise separations for arrivals PWS-A with ORD on operational safety compared to current operations applying wake vortex separation scheme without ORD tool in single runway mixed mode operations under nominal conditions.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#F5, A-SAC#R1, A-SAC#R2, A-SAC#R3	The controllers were seen to apply the safe standard practices when applying TB-PWS MRS 2.5NM with ORD tool in the simulation. No increase of potential human error was observed during the exercises.

		CRT-PJ2.01-V3-VALP-SA2-002: To collect partial supporting evidence that S-PWS with ORD tool for arrivals does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the current operations wake vortex separation scheme without ORD tool.	A-SAC#F1, A-SAC#F2, A-SAC#F3, A-SAC#F4	No under spacings were observed in RTS02 for either the solution scenario TB PWS with the ORD or the reference scenario. There was no increase in separation non-conformances before alignment or on the base leg due to the use of TB PWS with ORD tool. Therefore no increase in separation infringements were observed in RTS02 with TB PWS and the ORD tool compared to the reference scenario. However, the validity of this conclusion is limited by the low relevance of the statistics involved due to the limited number of runs.
		CRT-PJ2.01-V3-VALP-SA2-003: that time based Static Pair Wise separations for arrivals PWS-A with ORD maintains the same probability of Go around due to inadequate consideration of ROT constraint as per the reference scenario	A-SAC#R1	The number of ROT related Go-arounds is of same order of magnitude in TB PWS-A 2.5NM MRS ORD solution compared to the ICAO DBS reference.

RTS03a - Conducted by EUROCONTROL to assess the application of wake turbulence separations based on static aircraft characteristics for arriving aircraft (static PairWise Separations - PWS-A -AO-0310) and wake turbulence separations based on static aircraft characteristics for departures (static PairWise Separations - PWS-D -AO-0323)	**OBJ-PJ2.02-V3-VALP-SA3:** To assess the impact of the ORD on operational safety compared to current operations applying wake vortex separation scheme without ORD tool in single runway mixed mode operations under nominal conditions.	**CRT-PJ2.01-V3-VALP-SA2-001:** To assess the impact of time based Static Pair Wise separations for arrivals PWS-A with ORD on operational safety compared to current operations applying wake vortex separation scheme without ORD tool in single runway mixed mode operations under nominal conditions. **CRT-PJ2.01-V3-VALP-SA3-001 :** To assess the impact of the ORD on operational safety compared to current operations applying wake vortex separation scheme without ORD tool in single runway mixed mode operations under nominal conditions.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#F5, A-SAC#R1, A-SAC#R2, A-SAC#R3	Safe standard controller working practices were observed with the tool in the 2A-2D-2A mixed mode runway procedures. No new potential causes for human error and no increase in the potential severity of existing human errors were observed or reported to be introduced by the ORD tool or PWS procedures under nominal conditions. No new observations/remarks compared to previous simulations (e.g. RTS1) regarding the loss of separation indicators (ITD/FTD). Safe standard controller working practices were observed with the ORD tool in the alternating arrival departure sequence mixed mode runway procedures assessed. No new potential causes for human error and no increase in the potential severity of existing human errors were observed or reported to be introduced by the ORD tool under nominal conditions.
		CRT-PJ2.01-V3-VALP-SA2-002: To collect partial supporting evidence that S-PWS with	A-SAC#F1, A-SAC#F2, A-SAC#F3, A-SAC#F4	The number of minor under-separated aircraft (less than or equal to 0.5NM) on the final approach in single runway mixed mode operations was not higher and was even reduced

		ORD tool for arrivals does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the current operations wake vortex separation scheme without ORD tool. **CRT-PJ2.01-V3-VALP-SA3-003 :** To collect partial supporting evidence that the ORD maintains the same probability of Go around due to inadequate consideration of ROT constraint as per the reference scenario		under Time Based PWS-A with ORD tool compared to the reference scenario. The number of major under-separated aircraft (more than 0.5NM) on the final approach in single runway mixed mode operations was reduced under Time Based PWS-A with ORD tool compared to the reference scenario. No separation infringements have occurred before alignment to runway centreline and when the aircraft are within 25 NM from the runway threshold (i.e. including base leg). However, more analysis is needed as the number of exercise runs and scenarios assessed was limited.
		CRT-PJ2.01-V3-VALP-SA2-003: that time based Static Pair Wise separations for arrivals PWS-A with ORD maintains the same	A-SAC#R1	*For RTS03a:* There was one go-around instructed by TWR controller in total in the TB PWS-A with ORD tool exercises compared to the no go-arounds in the reference scenario.

		probability of Go around due to inadequate consideration of ROT constraint as per the reference scenario		However, more analysis is needed as the number of exercise runs and scenarios assessed was limited. Number of go-arounds was not higher in the TB spacing with ORD tool exercises compared to DB spacings with no tool. In fact there were more go-rounds with in the DB spacings with no tool: 3 go-arounds were observed for the runs without the ORD tool, as opposed to no go-arounds being observed during the runs with the ORD tool. However, more analysis is needed to validate this finding due to the limited statistical analysis that can be performed based on the collected real time simulation data and to the limited number of scenarios and conditions tested
RTS03b - Conducted by EUROCONTROL to assess the application the operational feasibility of time based separations with the Optimised Runway Delivery (ORD - AO-0328)	**OBJ-PJ2.02-V3-VALP-SA3:** To assess the impact of the ORD tool with separation requirements based on the current wake vortex categories compared to no ORD on operational safety.	**CRT-PJ2.01-V3-VALP-SA3-001:** To assess the impact of TBS with the ORD tool on operational safety compared to distance based separation in segregated runways mode operations under nominal conditions.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#F5, A-SAC#R1, A-SAC#R2, A-SAC#R3	Safe controller working practice was observed during the simulation runs and no specific increase of the risk of potential for human error was observed. However, in the final debriefing controllers reported that while working with the ORD tool, a controller might become less aware about the aircraft distances on the final approach and consequently have a lower level of situational awareness. That issue could further lead to

tool in a Performance Based Navigation environment				human error in degraded modes when no tool is present.
		CRT-PJ2.01-V3-VALP-SA3-002: To collect partial supporting evidence that TBS with ORD tool for arrivals does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the current operations wake vortex separation scheme without ORD tool.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#R1	Regarding under-spacing, for ATCO1, the reference run presents 4 under-spaced aircraft pairs, while none were observed during the corresponding solution runs. For ATCO2 and ATCO3, no under-spaced aircraft pairs were observed during the reference runs whereas one case of a small under-spacing is observed for one of the two solution runs (run #7 for ATCO2 and run #3 for ATCO3). For separation before alignment on the centre line no infringements were observed for ATCO2 and ATCo3 whereas for ATCO 1, 1 and 2 separation infringements were observed for the solution runs 5 and 11 respectively
		CRT-PJ2.01-V3-VALP-SA3-003: To collect partial supporting evidence that TBS with ORD maintains the same probability of Go around due to inadequate consideration of ROT	A-SAC#R1	More go-arounds have been observed for the reference run compared to the solution runs: for the three ATCOs, between 2 and 3 go-arounds were performed during the reference run while none were observed for the corresponding solution runs except for one exercise where 2 were observed.

		constraint as per the reference scenario		In post exercise debriefings controllers reported that the go arounds were mainly due to the fact that the compression after the DF was not the same as in Copenhagen and this effect had a stronger impact in Reference with PBN than in the Solution scenario.
RTS04a – Please see Departures section				
RTS04b - Conducted by EUROCONTROL The first aim is to assess the operational feasibility of time based static Pair-Wise Separation (S-PWS-A - AO-0310) with Optimised Runway Delivery (ORD - AO-0328) for arriving aircraft in a closely spaced parallel runway environment; The second aim is to assess the operational feasibility of the	**OBJ-PJ2.02-V3-VALP-SA2:** To assess the impact of static pairwise separations for arrivals with ORD on operational safety compared to current wake vortex separation scheme	**CRT-PJ2.01-V3-VALP-SA2-001:** To assess the impact of arrivals PWS-A with the ORD in CSPR environment on operational safety compared to current operations applying wake vortex separation scheme without ORD tool in a non CSPR environment under nominal conditions.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#F5, A-SAC#R1, A-SAC#R2, A-SAC#R3	Both ININ and ITMN approach controllers were observed to apply safe standard practices during TB-PWS-A with ORD in CSPR for Arrivals operations. However, at CDG, the TWR ATCOs is already complex and the tower runway controller is already working at high capacity in the peak periods, having to manage crossings, departures on RWY27L and arrivals on RWY27R. Adding, to this environment, an un-steady flow of arrivals on RWY28L due to CSPR (partially segregated operations), was considered to be unacceptable from a safety point of view for the CDG TWR ATCOs.
		CRT-PJ2.01-V3-VALP-SA2-002: To collect partial supporting evidence that S-PWS	A-SAC#F1, A-SAC#F2, A-SAC#F3, A-SAC#F4	The number of under-separations (small and large) being at least not higher in the solution arrivals runs (TB PWS with the ORD tool under CSPR/DT) compared to the reference runs (RECAT

Static PairWise Separations departure concept (S-PWS) - wake turbulence separations for departing aircraft based on static aircraft characteristics (AO-0323).under partially segregated runway departure operations. RTS4b will us conducted using g the Paris CDG airport and approach environment.		with ORD tool for arrivals in a CSPR environment does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the current operations wake vortex separation scheme without ORD tool.		EU with no tool support and no CSPR i.e. segregated runway operations). Additionally there was no increase observed in separation non-conformances before alignment or on the base leg due to the PWS-A with ORD in CSPR/DT.
		CRT-PJ2.01-V3-VALP-SA2-003: To collect partial supporting evidence that time based Static Pair Wise separations for arrivals PWS-A with ORD under CSPR maintains the same probability of Go around due to inadequate consideration of ROT constraint as per the reference scenario.	A-SAC#R1	No increase of ROT related go around was observed in Solution scenario (TB PWS with ORD in CSPR/DT environment) compared to Reference.
RTS5 – Please see Departures section				

RTS06 – Conducted by CRIDA/ENAIRE to assess OI Steps AO-0310 and AO-0328 for arrivals, AO-0323 and AO-0329 for departures, which address weather dependent separations for arrivals (WDS-A) and Wake Turbulence Separations (for Departures) based on Static Aircraft Characteristics (S-PWS-D)	**OBJ-PJ2.02-V3-VALP-SA1:** To assess the impact of weather dependent separations on the final approach on operational safety compared to current wake vortex separation scheme	**CRT-PJ2.01-V3-VALP-SA1-001:** There is evidence that the level of operational safety is maintained and not negatively impacted under weather dependent separations on the final approach compared to the current operations applying wake vortex separation scheme without ORD tool.	A-SAC#F2, A-SAC#F3, A-SAC#F4, A-SAC#F5, A-SAC#R1, A-SAC#R2, A-SAC#R3	Compared to ICAO DBS the results could be summarized as follows: • The percentage of infringements increased a 4% in solution scenarios. Due to several technical problems only two scenarios could be compared hence these results are not conclusive. More runs should be performed to guarantee that the level of infringements does not increase. • The number of go-around is higher in reference scenarios • The data of experienced workload obtained from the questionnaires show that the workload was very similar comparing solution and reference scenarios. Taking into account these results, safety did not get worse in solution scenarios, however more runs should be executed in future steps to guarantee it.
FTS09 – conducted by EUROCONTROL to support the CBA for the wake separation concepts. To assess	No Safety Validation Objective needed to be set for this FTS			

the performance impact of the different wake separation solutions on arrivals of the different concepts both when solutions are deployed in combination (e.g. PWS-A with ORD tool) and/or when solutions are deployed individually. The FTS takes as input the expected traffic sequence at IAF and different parameters (WV separation, MRS, ROT, etc.) to provide an estimate of the expected throughput and spacing between landing aircraft.	

Table 25 Safety Validation Results for the arrivals concepts

7 Acronyms and Terminology

Term	Definition
150k	150,000
ACAS	Airborne Collision Avoidance System
ATC/M/S	Air Traffic Control / Management / System
ATCO	Air Traffic Controller
A-CDM	Airport Collaborative Decision Making
A-SMGCS	Advanced Surface Movement Guidance and Control System
AIM	Accident Incident model
A/C	Aircraft
ANS	Air Navigation Services
APP	Approach
ATIS	Automatic Terminal Information Service
AISP	Aeronautical Information Service Provider
AIP	Aeronautical Information Publication
ARR	Arrival
CSPR	Closely Spaced Parallel Runway Operations
CREDOS	Crosswind Reduced Separations for Departure Operations
CWP	Controller Working Position
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V. / German Aerospace Centre (formerly the German Aerospace Research Institute)
DBS	Distanced Based Separation
DEP	Departure
D-ATIS	Data link / Digital - Automatic Terminal Information Service
EARTH	The project acronym for SESAR 2020 PJ.02 incr**EA**sed **R**unway and Airport **TH**roughput
EUROCONTROL	European Organisation for the Safety of Air Navigation
ENAIRE	Spanish Air Navigation Service Provider
EASA	European Aviation Safety Agency
EC	European Commission
ELS	Elementary Mode-S Surveillance
EGLL	Heathrow Airport
EHS	Enhanced Mode-S Surveillance
FT	Feet
FMS	Flight Management System
FCF	Facilitate Capture of the Final approach
FLD	Facilitate Landing & Deceleration
FAP	Final Approach
FTD	Final Target Distance indicator
FCRW	Flight Crew
FP	Framework Programme
FA	Final Approach
GBAS	Ground Based Augmentation System

GS	Ground Speed
GWCS	Glideslope Wind Conditions Service
HP	Human Performance
HP#X	Pre-existing Hazard
HMI	Human Machine Interface
Hz#X	Hazard
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
ITD	Initial Target Distance indicator
IAS	Indicated Air Speed
IM	Impact Modifier
IA	Interception of the Final Approach
INTEROP	Interoperability
IRS	Interface Requirement Specification
KTS	Knots
LiDAR	Light Detection and Ranging
MRS	Monitoring and Ranging Stations
MLS	Microwave Landing System
MODE A/C	Secondary radar reply message giving aircraft identity
MAC	Mid Air Collision
MET	Meteorology
MSAW	Minimum Safe Altitude Warning
NATS	UK Air Navigation Service Provider
NM	Nautical Miles
NOTAM	Notice to Airmen
OSED	Operational Service and Environment Definition
ORD	Optimal Runway Delivery
OFA	Operational Focus Area
PJ.02.01	Project 02.01
PANS	Procedures for Air Navigation Services
RWY	Runway
RECAT-EU	European separation standard for aircraft wake turbulence
RSVA	Reduced Separation in the Vicinity of an Aerodrome
ROT	Runway Occupancy Time
RPA	Runway Protected Area
RIMCAS	Runway Incursion Monitoring and Conflict Alert System
RC	Runway Collision
SAR	Safety Assessment Report
SPR	Safety and Performance Requirements
SESAR	Single European Sky ATM Research
S-PWS-A/D	Static Pair-Wise Separation Arrivals/Departures
SRM	Safety Reference Material
SAC	SAfety Criteria
SO	Safety Objective
SR	Safety Requirement
SAP	Safety Assessment Plan

SAF	Safety
SMI	Separation Minima Infringement
SUP	Supervisor
SURV	Surveillance
SAD	Separate Arrival Departure
SP	SeParate aircraft with other aircraft
SPT	SeParate aircraft with Terrain
SID	Standard Instrument Departure
SC	Severity Criteria
STCA	Short Term Conflict Alert
TS	Technical Specifications
TBS	Time-based Separation
TMA	Terminal Manoeuvring Area
TWR	Tower
TAS	True Air Speed
TDI	Target Distance Indicator
TAWS	Terrain Avoidance Warning System
UK6	UK Wake Turbulence Separation Category
V1-V3	Validation Maturity Level 1 to Level 3
VCS	Voice Communication System
VAPP	Final Approach Speed
WDS-A/D	Weather Dependant Separation for Arrivals / Departures
WT/E	Wake Turbulence / Encounter
WIDAO	Wake Independent Departure & Arrival Operations
WTC	Wake Turbulence Category

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[22]D1.1.01 – PJ.02-01 OSED-SPR-INTEROP (Final) Part IV – 01.00.00

[23]D1.1.01 – PJ.02-01 OSED-SPR-INTEROP (Final) Part V – 01.00.00

[24]D1.1.02 – PJ.02-01 TS/IRS (Final) – 01.00.00

[25]D1.1.03 – PJ.02-01 VALP (Final) Part I – 00.01.00

[26]D1.1.03 – PJ.02-01 VALP (Final) Part II – 00.01.00

[27]D1.1.03 – PJ.02-01 VALP (Final) Part IV – 00.01.00

[28]D1.1.04 – PJ.02-01 VALR (Final) – 01.00.00

[29]D1.1.01 – PJ.02-01 OSED-SPR-INTEROP (Final) Part II – 02.01.00

Appendix A Consolidated List of Safety Objectives

Appendix A covers the following Concepts Solutions:

- Consolidated Lists of Safety Objectives for Arrivals Concepts Solution in Section A.1
- Consolidated Lists of Safety Objectives for Departures Concepts Solutions in Section A.2

A.1 Arrivals Concepts Solutions

A.1.1 Safety Objectives (Functionality and Performance) for the Arrivals Concepts Solutions

Consolidated list of Safety Objectives – Success Case for the Arrivals Concepts Solutions:

ID	Safety Objective (success approach)
SO 001	ATC shall be able to apply consistent and accurate DBS, TBS, PWS-A or WDS-A wake turbulence separation rules on final approach (encompassing interception) and landing, through operating under Distance Based modes (DBS, DB-PWS-A) and Time Based modes (TBS, T-PWS-A, A-WDS-Tw and A-WDS-Xw), with the possibility to safely switch between a TB-mode and the corresponding DB-mode.
SO 002	In case of conditional application of Time Based (TB) modes, ATC shall apply the correspondent WT separation minima only when the predefined activation criteria for the considered TB-mode are met i.e. specified wind parameter(s) measured against pre-determined wind threshold(s).
SO 003	In case of conditional application of TB-modes the wind threshold(s) for the activation criteria specific to each TB-mode shall be determined to mitigate the risk of wake vortex encounter due to the uncertainties on the wind profile prediction data and on the aircraft adherence to the generic airspeed profile
SO 004	In case of conditional application of TB- modes, ATC shall apply the corresponding distance-based WT separation mode (DBS or respectively DB-PWS-A) when the activation criteria for TBS, TB-WDS-A modes or respectively TB-PWS-A and A-TB-WD-PWS modes are not met anymore
SO 005	In a given WT separation mode, ATC shall sequence and instruct aircraft to intercept the final approach path such as to establish and maintain applicable separation minima on final approach segment based on the displayed Target Distance Indicators corresponding to that separation mode
SO 006	The Target Distance Indicators shall be calculated and displayed to correctly and accurately represent the greatest constraint out of wake separation minima of the mode under consideration (for all traffic pairs and in the full range of weather and operating conditions pertinent for that mode), the MRS, the runway spacing or other spacing constraint (e.g. departure gaps)

SO 007	The design of the Separation Delivery Tool and associated operating procedures and practises shall not negatively impact Flight Crew/Aircraft who shall be able to follow ATC instructions in order to correctly intercept the final approach path in the mode under consideration
SO 008	In a given WT separation mode, ATC shall provide correct spacing minima delivery from final approach path acquisition until landing based on separation indicators correctly computed for that separation mode.
SO 009	ATC and Flight Crew/Aircraft shall ensure that the final approach path is flown whilst respecting the aircraft speed profile (unless instructed otherwise by ATC or airborne conditions require to initiate go around) in order to ensure correctness of the separation indicators
SO 010	ATC (and potentially Flight Crew/Aircraft) shall consider the potential for WDS separation infringement due to lateral deviation from final approach path (e.g. dog leg when WDS crosswind is operated)
SO 011	The runway spacing or other spacing constraint (e.g. departure gaps) shall be input to and accounted for the Separation Delivery Tool (in support of SO 006)
SO 012	TWR ATC shall request the insertion of departure gaps from APP ATC, and shall coordinate with APP the modification and cancellation of these gaps as operationally needed

A.1.2 Consolidated List of Safety Objectives for the Arrivals Concepts Solutions – Abnormal Operations

ID	Description	Abnormal Scenario
SO 101	ATC shall be alerted when the actual wind conditions differ significantly from the wind conditions used for the TDIs computation (wind conditions monitoring alert): for the FTD -glideslope wind in TB-modes only; for the ITD – glideslope wind in all modes (TB and DB).	5
SO 102	ATC shall be alerted when the aircraft speed varies significantly from the procedural airspeed and/or the stabilized approach speed used for the TDIs computation (speed conformance alert) in order to manage compression manually	2
SO 103	ATC shall maintain an updated arrival sequence order following a late change of aircraft runway intent or a go-around	1 and 3
SO 104	ATC shall take into account, for the merging on to final approach, the 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 ITD indication	6
SO 105	The Target Distance Indicators shall be correctly updated in case of late (not planned) change of landing runway	8

SO 106	ATC shall be able to handle scenario specific spacing requests while using the separation delivery tool	9

A.1.3 Consolidated List of Safety Objectives (Integrity) for the Arrivals Concepts Solutions

Consolidated list of Safety Objectives – Failure Case for the Arrivals Concepts Solutions:

ID	Safety Objective
SO 201 **Hz#01a** **(WK-FA SC-3b** **MAC-FA-SC3)**	The frequency of occurrence of the inadequate separation management of a pair of aircraft instructed by ATC to merge on the Final Approach interception (which is nevertheless recovered by ATC i.e. SMI[6]≤0.5NM), shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)* ***Explanation:*** *Computation of the Safety Objective:* *SO =* $\frac{MTFoO}{N*IM}$ *=* $\frac{1E-02}{5*1}$ *= 2E-03 occurrences per approach* *Computation of the no of occurrences per day: 2E-03*135000/365 = 0.74* *Which comes to 2 occurrences every 3 days*
SO 202 **Hz#01b** **(WK-FA-SC3a** **MAC-FA-SC2b)**	The frequency of occurrence of separation not being recovered following imminent infringement of A/C pair instructed by ATC to merge on the Final Approach interception (SMI>0.5NM) shall not be greater than 4x10-5/ approach *(4x10-5/approach means 6 occurrence per year for an airport with 135,000 landings per year)*
SO 203 **Hz#02a** **(WK-FA SC-3b** **MAC-FA-SC3)**	The frequency of occurrence of the inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach interception profile without ATC instruction given (which is nevertheless recovered by ATC i.e. SMI≤0.5NM), shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)*

[6] SMI stands for Separation Minima Infringement (WT or MRS)

SO 204 Hz#02b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement due to aircraft deviation from Final Approach interception profile without ATC instruction given (SMI>0.5NM) shall not be greater than 4x10-5/approach *(4x10-5/approach means 6 occurrence per year for an airport with 135,000 landings per year)*
SO 205 Hz#03a (WK-FA SC-3b MAC-FA-SC3)	The frequency of occurrence of the inadequate separation management of an aircraft pair naturally catching-up as instructed by ATC on the Final Approach (which is nevertheless recovered by ATC i.e. SMI≤0.5NM) shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)*
SO 206 Hz#03b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement by an aircraft pair instructed by ATC on the Final Approach (SMI>0.5NM) shall not be greater than 4x10-5/approach *(4x10-5/approach means 6 occurrences per year for an airport with 135,000 landings per year)*
SO 207 Hz#04a (WK-FA SC-3b MAC-FA-SC3)	The frequency of occurrence of the inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach profile without ATC instruction given (which is nevertheless recovered by ATC i.e. SMI≤0.5NM) shall not be greater than 2x10-3 /approach *(2x10-3/approach means 2 occurrences every 3 days for an airport with 135,000 landings per year)*
SO 208 Hz#04b (WK-FA-SC3a MAC-FA-SC2b)	The frequency of occurrence of separation not being recovered following imminent infringement due to aircraft deviation from Final Approach profile without ATC instruction given (SMI>0.5NM) shall not be greater than 4x10-5/approach *(4x10-5/approach means 6 occurrences per year for an airport with 135,000 landings per year)*
SO 209 Hz#05 (WK-FA-SC3a MAC-FA-SC2b; IM=20)	The frequency of occurrence of one or multiple separation minima infringements due to undetected corruption of separation indicator (SMI>0.5NM) shall not be greater than 2x10-6/approach *(2x10-6/approach means 1 occurrences every 4 years for an airport with 135,000 landings per year)* *Explanation:* *Computation of the no of occurrences per year: 2E-6*135000/365 = 7.4E-04* *Which comes to 1 occurrence every 1350 days which represents 1 occurrence every 3.7 years (rounded to 1 occurrence every 4 years)*

SO 210 **Hz#06** **(WK-FA-SC3a** **MAC-FA-SC2b; IM=10)**	The frequency of occurrence of one or multiple imminent infringements due to lack/loss of separation indicator for multiple or all aircraft (which are nevertheless recovered by ATC i.e. SMI≤0.5NM) shall not be greater than 2x10-4 /approach *(2x10-4/approach means 1 occurrence every 15 days for an airport with 135,000 landings per year)*
SO 211 **Hz#07** **(WK-FA-SC3a** **MAC-FA-SC2b; IM=20)**	The frequency of occurrence of one or multiple separation minima infringements induced by ATC through inadequate selection or management of a separation mode shall not be greater than 2x10-6/approach *(2x10-6/approach means 1 occurrences every 4 years for an airport with 135,000 landings per year)*
SO 212 **Hz#08** **(RWY-C SC3)**	The frequency of occurrence of a runway conflict due to conflicting ATC clearances shall not be greater than 10-7/movement. (10-7/movement means 2,6x10-4/day) It should be noted that **2,6x10-4/day** is **too stringent** for this type of operational hazard. This value will be updated once the Severity Classification Scheme for the Runway Collision Model is updated.

Appendix B Consolidated Lists of Safety Requirements

Appendix B covers the following Concepts Solutions:

- Consolidated Lists of Requirements for Arrivals Concepts Solution in Section B.1
- Consolidated Lists of Requirements for Departures Concepts Solutions in Section B.2

B.1 Arrivals Concepts Solutions

B.1.1 Safety Requirements (Functionality and Performance) for the Arrivals Concepts Solutions

In the next tables the traceability of the Safety Requirements (functionality & performance) is ensured versus the Safety Objectives for the Arrivals Concepts Solutions.

B.1.1.1 Safety Requirements in Normal Operational Conditions for the Arrivals Concepts Solutions

SRs	General Description	Derived from
SR1.001 REQ-02.01-SPRINTEROP-ARR0.0050	The Intermediate Approach, Final Approach and Tower Controllers shall be provided with a Separation Delivery Tool displaying Target Distance Indicators (TDI) to enable consistent and accurate application of TBS, PWS-A, DBS and/or WDS-A wake turbulence separation rules on final approach and landing.	SO 005 SO 008
SR1.002 REQ-02.01-SPRINTEROP-ARR0.0100	The tool shall operate under Distance Based modes (DB- modes: DBS, S-PWS) and Time Based modes (TB- modes:TB S-PWS, TB-WDS-Tw, TB-WDS-Xw, TB-WD-PWS-TW, TB-WD-PWS-XW), with the possibility to switch between DB- modes and corresponding TB- modes.	SO 001
SR1.003 REQ-02.01-SPRINTEROP-ARR0.0131	For the time based separation modes (TB-modes i.e. TBS, TB-PWS-A, TB-WDS-A or A-TB-WD-PWS), for which FTD (Final Target Distance standing for the separation indication) is computed based on a time separation, the risk of under-separation induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated.	SO 003
SR1.004 REQ-02.01-SPRINTEROP-ARR0.0132	For the Time based separation modes the risk of under-separation induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated by one or a combination of the following means: • Adding a time separation buffer in the design of the FTD indicators displayed to Controllers. These buffers may vary depending on the considered applicable separation minima and wind conditions • The conditional application of any TB- mode (e.g. WDS shall be locally pre-determined and used as a wind-based criterion for the activation of that mode • For the TB- mode, taking a buffer in the design of TBS minima (e.g. higher headwind conditions when selecting reference baseline minima)	SO 003

	• The selection of most appropriate mean(s) shall be based on the local operational conditions, local wind behaviour, wind profile and aircraft speed profile prediction system accuracy	
SR1.005 REQ-02.01-SPRINTEROP-ARR3.0151	For all separation modes, for which an ITD (Initial Target Distance standing for the compression indication) is used, the risk of under-separation after Deceleration Fix induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated.	SO 003
SR1.006 REQ-02.01-SPRINTEROP-ARR3.0152	For all separation modes, for which an ITD is used, the risk of under-separation after Deceleration Fix induced by the uncertainty in glideslope headwind prediction and in the actual final approach speed profile shall be mitigated by adding a time separation buffer in the design of the ITD indicators displayed to Controllers. These buffers may vary depending on the considered applicable separation minima and wind conditions.	SO 003
SR1.007 REQ-02.01-SPRINTEROP-ARR0.1030	The Approach or Tower Controller shall be able to safely perform their separation duties during transition between separation modes.	SO 001 SO 004
SR1.008 REQ-02.01-SPRINTEROP-ARR0.1080	The frequency of separation mode switches shall be done in a way that would avoid controller confusion and unnecessary workload.	SO 001 SO 004
SR1.009 REQ-02.01-SPRINTEROP-ARR0.1120	The mode of operation shall be clearly displayed to the controllers (Tower and Approach) and Supervisors (Tower and Approach) at all times.	SO 001 SO 004
SR1.010 REQ-02.01-SPRINTEROP-ARR0.1390	Consideration shall be given to the impact of mode changes on external systems and processes such as AMAN and flow management.	SO 001
SR1.011 REQ-02.01-SPRINTEROP-ARR0.0530	The system architecture shall ensure all applicable Controller Working Positions (e.g. per runway) operate in the same mode(s).	SO 001
SR1.012 REQ-02.01-SPRINTEROP-ARR2.1060	For TB- modes the Approach and Tower Supervisors shall collaboratively decide when the conditional (TB) mode should be activated or de activated based on meteorological data information and predefined activation criteria and on prior coordination with Controllers. Note: Activation of a WT separation mode encompasses both starting operations at the beginning of the day and transition to a different WT separation mode during the day.	SO 002 SO 211

SR1.013 REQ-02.01-SPRINTEROP-ARR0.0980	The Tower Supervisor in coordination with the Approach Supervisor (and occasionally the Tower and Approach Controllers - in line with defined local procedures) shall determine the final approach separation mode and runway spacing constraints that are to be applied at any time by the separation delivery tool.	SO 002 SO 011 SO 211
SR1.014 REQ-02.01-SPRINTEROP-ARR0.1070	Supervisor must reconsider the mode of operation if they receive WTE reports from Pilots over a short period of time via Controllers. Rationale: Several WTE reports in a short space of time may mean the incorrect mode of operation is activated hence Supervisors should reassess the decision.	SO 004
SR1.015 REQ-02.01-SPRINTEROP-ARR0.1222	The Approach and Tower Supervisors shall inform the respective Controller when the conditional (TB) mode will be activated or de activated by indicating the first aircraft in the arrival sequence to be separated according to the new mode. (e.g. at least 2 min before interception- to be locally defined)	SO 002
SR1.016 REQ-02.01-SPRINTEROP-ARR0.1090	In case the reversion from a TB mode is triggered automatically by the Separation Delivery Tool (e.g. due to the wind falling below the applicable minima), the Separation Delivery Tool shall indicate to the ATCO the aircraft to be separated according to the new separation mode. A notification shall indicate to the Controller and the Supervisor the change and preferably the reason behind it.	SO 004
SR1.017 REQ-02.01-SPRINTEROP-ARR0.1223	The ATCOs and the Supervisors shall always have a clear indication in the CWP from which aircraft in the sequence the new mode of operations or the reversion to standard mode are applied.	SO 002 SO 004
SR1.018 REQ-02.01-SPRINTEROP-ARR2.1130	The WDS-TW mode shall be activated only when the runway surface and glide-slope reference total wind (as used in the separation minima design) is equal or greater than the WDS-Tw threshold	SO 003
SR1.019 REQ-02.01-SPRINTEROP-ARR2.1140	The WDS-Xw mode shall be activated only when the runway surface and glide-slope reference cross wind (as used in the separation minima design) is equal or greater than the WDS-Xw threshold	SO 003
SR1.020 REQ-02.01-SPRINTEROP-ARR2.1170	The Wind Forecast Service shall be provided to the users to plan or execute WDS-A (Xw or Tw) concept operations. The service shall include standard meteorological information and WDS-A (Xw or respectively Tw) concept specific information with respect to wind nowcast and forecast, wind speed, direction and trends, in particular the crosswind component (glide-slope and surface cross winds) or respectively the total wind (glide-slope and surface total winds) with respect to each runway direction.	SO 002 SO 004

SR1.021 REQ-02.01-SPRINTEROP-ARR2.1150	The WDS-Tw and WDS-Xw activation thresholds shall be determined to mitigate the risk of wake vortex encounter due to the uncertainties on the wind prediction data and on the lateral aircraft deviation from RWY extended centreline.	SO 003
SR1.022 REQ-02.01-SPRINTEROP-ARR0.0670	Local implementation shall define the latest time that a stable TDI is required by the Controller for spacing, so that the FTD and ITD indicators may be re-calculated due to changing glideslope wind conditions	SO 005
SR1.023 REQ-02.01-SPRINTEROP-ARR2.1160	In order to enable the modes activation/deactivation, the Tower Supervisor and the Approach supervisor shall be provided with a meteorological situation picture that includes the nowcast and forecast data regarding the wind speed and direction at different locations and altitudes covering the area encompassing the final approach phase of arrival flights. Such information shall in particular display the relevant wind component for the application of WDS-A concept reduced wake separations.	SO 002 SO 004
SR1.024 REQ-02.01-SPRINTEROP-ARR0.1760	In case of conditional application in TB-modes, the Supervisors (Tower and Approach) and Controllers (Tower and Approach) shall be alerted automatically in advance when the predefined activation criteria will not be met anymore hence the imminent need to transition from one separation mode to another, in order to temporarily limit or regulate the flow of inbound traffic (e.g. through metering) prior to the switch of separation mode in order to manage the change and controllers workload	SO 004 SO 211
SR1.025 REQ-02.01-SPRINTEROP-ARR2.1190	If the Wind Forecast service detects WDS-A concept suspension, the information shall be transmitted to the Separation Delivery tool and a corresponding alert shall be displayed to the CWPs of the Controllers and Supervisors.	SO 004 SO 212
SR1.026 REQ-02.01-SPRINTEROP-ARR0.1100	Upon reversion to (activation of) a new separation mode, the separation delivery tool shall display the adequate FTD (separation indication) and ITD (compression indications) to the Approach ATCO for all aircraft starting with the first aircraft in the arrival sequence to be separated according to the new mode.	SO 004
SR1.027 REQ-02.01-SPRINTEROP-ARR0.1110	The Approach and Tower Runway ATCO shall continue to use the TDIs that are already displayed (as per the previous separation mode) for the aircraft in the arrival sequence preceding the first one to be separated according to the new mode.	SO 002 SO 004
SR1.028 REQ-02.01-SPRINTEROP-ARR0.0300	The approach arrival sequence information shall be provided to the Separation Delivery tool.	SO 005 SO 201 SO 209 SO 210

SR1.029 REQ-02.01-SPRINTEROP-ARR0.0910	The separation delivery tool shall be given the arrival runway intent including eventual updates for each aircraft such that it is considered for the computation of the Target Distance Indicators	SO 005
SR1.030 REQ-02.01-SPRINTEROP-ARR0.0920	The runway final approach sequence order shall be displayed on the HMI so that it is visible to the Approach, Tower and Supervisor positions.	SO 005
SR1.031 REQ-02.01-SPRINTEROP-ARR0.0570	If there is a change to the separation / spacing constraint (e.g. Gap) the TDI for the affected aircraft pair shall be re-computed.	SO 006 SO 012
SR1.032 REQ-02.01-SPRINTEROP-ARR0.0550	If there is a change to the sequence order or runway intent, the Approach Controller should check that each indicator for each affected aircraft pair has been updated.	SO 005 SO 209 SO 212
SR1.033 REQ-02.01-SPRINTEROP-ARR0.0940	In case of a change of the arrival sequence order position of an aircraft, the Approach controller shall check that the arrival sequence order has been updated to reflect the change	SO 005 SO 209 SO 212
SR1.034 REQ-02.01-SPRINTEROP-ARR0.0941	The sequence manager shall ensure that for the change of the sequence order there is no overlap (or lack of awareness) between the actions taken by the Intermediate Approach Controller and the Final Approach Controller, by allowing only one change at a time.	SO 005 SO 209 SO 212
SR1.035 REQ-02.01-SPRINTEROP-ARR0.0139	TDIs shall be displayed on the extended runway centreline behind each lead aircraft established on final approach and shall be linked to the actual lead aircraft position along the runway axis.	SO 006
SR1.036 REQ-02.01-SPRINTEROP-ARR0.0133	TDI position shall provide the accurate information about the required separation/spacing for each aircraft pair	SO 006
SR1.037 REQ-02.01-SPRINTEROP-ARR0.0110	The Separation Delivery tool shall provide to ATCOs a visualisation (FTD indicator) of the required minimum separation or spacing on final approach that needs to be delivered after considering all in-trail and if applicable not-in-trail constraints.	SO 005 SO 008 SO 201 SO 204 SO 210
SR1.038 REQ-02.01-SPRINTEROP-ARR3.0120	If the ORD concept is considered, the Separation Delivery tool shall provide to ATCOs a visualisation (ITD indicator) of the required spacing on final approach to be delivered at the deceleration fix in order to deliver the required minimum separation / spacing at the delivery point.	SO 005 SO 008 SO 204

SR1.039 REQ-02.01-SPRINTEROP-ARR0.0890	The separation delivery tool shall support ATCOs in the delivery of wake separations that are allowed only when leader and follower aircraft are aligned on the centreline.	SO 005 SO 008
SR1.040 REQ-02.01-SPRINTEROP-ARR0.0190	There shall be surveillance coverage down to the separation delivery point to allow the separation tool to display Target Distance Indicators on the runway extended centreline including the last part of the final approach.	SO 005 SO 008
SR1.041 REQ-02.01-SPRINTEROP-ARR0.0730	The TDIs corresponding to the high priority MRS separation constraint shall remain visible on the radar display until the leader aircraft reaches the separation delivery point.	SO 008
SR1.042 REQ-02.01-SPRINTEROP-ARR0.0740	The TDIs corresponding to the high priority Wake separation constraint shall remain visible on the radar display until the leader aircraft reaches the separation delivery point.	SO 008
SR1.043 REQ-02.01-SPRINTEROP-ARR0.0750	The TDIs corresponding to the low priority Runway Occupancy Time constraint shall remain visible on the radar display until the leader aircraft reaches the separation delivery point.	SO 008
SR1.044 REQ-02.01-SPRINTEROP-ARR0.0760	The TDIs corresponding to the low priority Gap spacing constraint shall remain visible on the radar display until the follower aircraft reaches the separation delivery point.	SO 008 SO 012
SR1.045 REQ-02.01-SPRINTEROP-ARR0.0690	TDI display shall be robust to ensure they do not keep switching on and off as aircraft perform normal manoeuvres	SO 005 SO 008
SR1.046 REQ-02.01-SPRINTEROP-ARR0.0490	The follower TDI shall be linked to the actual aircraft position of the leader: - If the leader is aligned with the runway axis, then the follower TDIs are to be displayed behind the actual leader position; - If the leader is not yet aligned with the runway axis and the perpendicular projected position on the runway extended centreline is behind its own ITD then the follower TDIs are to be displayed behind the perpendicular projected position on the runway extended centreline; - If the leader is not yet aligned with the runway axis and the perpendicular projected position on the runway extended centreline is ahead its own ITD, then the follower TDIs are to be displayed behind the position of ITD ahead. In case several aircraft have not yet intercepted the glide, this leads to a train of ITDs, each one being attached to the previous one and all	SO 005

	moving at the speed of the last aircraft on the extended runway centreline.	
SR1.047 REQ-02.01-SPRINTEROP-ARR0.0480	The TDIs shall be displayed to the Intermediate and Final Approach Controllers sufficiently early in order to allow correct interception	SO 005
SR1.048 REQ-02.01-SPRINTEROP-ARR0.0630	Criteria to determine the time for displaying indicators for each CWP shall be specified depending upon the local operation's needs.	SO 005 SO 201 SO 210
SR1.049 REQ-02.01-SPRINTEROP-ARR0.0470	The Separation Delivery tool and associated procedures shall support the Controller decision to turn onto final approach.	SO 005
SR1.050 REQ-02.01-SPRINTEROP-ARR3.1000	If the ORD concept is implemented, the Final Approach Controller shall maintain the aircraft on or behind the ITD on the final approach and reduce to the final approach procedural airspeed until the transfer to the Tower controller.	SO 005 SO 008 SO 201
SR1.051 REQ-02.01-SPRINTEROP-ARR3.0170	If the ORD concept is implemented, the Approach controller shall vector the follower aircraft so that it stays on or behind the corresponding ITD.	SO 005 SO 008 SO 201
SR1.052 REQ-02.01-SPRINTEROP-ARR0.0710	The tool shall automatically display the FTD (if not already displayed) if the aircraft comes within a defined distance of the computed FTD. This distance shall be configurable within the tool.	SO 005 SO 008 SO 204 SO 205 SO 208
SR1.053 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0792	For the TWR HMI, if the first most constraining ITD corresponding to a high priority separation indicator (e.g. WAKE or MRS) is infringed, then its already displayed corresponding FTD shall be accompanied by the distance countdown to the FTD of the corresponding aircraft such that the TWR controller is aware that a high priority ITD has been infringed Note this countdown to the FTD applies only to the high priority separation indicators (WAKE and MRS). The scope of this distance is to show the TWR ATCO when an ITD has been infringed keeping in mind that the ITD is not displayed by default for the TWR controller.	SO 008 SO 205 SO 208
SR1.054 Example of REQ-02.01-	For the TWR HMI, if the second most constraining ITD corresponding to a high priority separation is infringed, the system shall display the corresponding FTD accompanied by the distance countdown to the FTD, in addition to the already displayed first most constraining FTD	SO 008 SO 205 SO 208

SPRINTEROP-ARR0.0792	such that the TWR controller is aware that a high priority ITD has been infringed (FTD displayed according to the rules defined for the high priority separation indicators)	
SR1.055 Example of REQ-02.01-SPRINTEROP-ARR0.0793	For the TWR HMI, if the high priority ITD is no longer infringed: - In case the FTD corresponding to this high priority ITD is the first most constraining FTD the corresponding countdown distance to the FTD shall be hidden by the system and - In case the FTD corresponding to this high priority ITD is the second most constraining FTD, the FTD shall be hidden together with the countdown to the FTD	SO 008
SR1.056 Example of REQ-02.01-SPRINTEROP-ARR3.1520 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a high priority separation (WAKE, MRS) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner adequate to an alert (e.g. red colour)	SO 005 SO 008 SO 202 SO 205 SO 204 SO 208
SR1.057 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the most constraining ITD corresponding to a low priority spacing (ROT, gap, other spacing constraints) indicator is infringed or the aircraft comes within a defined distance of the computed FTD, then its corresponding FTD shall be displayed in a manner other than the one used for a high priority separation FTD (e.g. yellow colour)	SO 202 SO 205 SO 204 SO 208
SR1.058 Example of REQ-02.01-SPRINTEROP-ARR0.0795	For the APP HMI, if the second and/or third most constraining ITD corresponding to a low/high priority spacing/separation is infringed the system shall display the corresponding FTDs in addition to the already displayed first most constraining FTD (FTD displayed according to the rules defined for the high priority separation and low priority spacing indicators)	SO 005 SO 008 SO 202 SO 205 SO 204 SO 208
SR1.059 Example of REQ-02.01-SPRINTEROP-ARR0.0796	For the APP HMI, if the second and/or third most constraining ITD is no longer infringed, the corresponding FTDs shall be hidden by the system	SO 005 SO 008
SR1.060 REQ-02.01-SPRINTEROP-ARR0.0850	The HMI design shall allow ATCO to hide/unhide indicators for a specific aircraft pair, and current and forthcoming alerts/warnings for that aircraft as a follower (e.g. infringement, catch-up, speed,..)	SO 005 SO 008

SR1.061 REQ-02.01-SPRINTEROP-ARR0.0900	Following the ATCO action to suppress the TDIs for specific aircraft the tool shall • remove any information on the spacing/separation (ITD and FTD) • remove its ongoing or not display the forthcoming Separation Delivery Tool alerts (e.g. Catchup/Speed/SeqNumber/Infringement)	SO 005 SO 008
SR1.062 REQ-02.01-SPRINTEROP-ARR0.0720	The Approach controller shall be able to remove the FTD from the radar display, but not when the FTD has been automatically displayed by the System.	SO 005 SO 008
SR1.063 REQ-02.01-SPRINTEROP-ARR0.1350	Procedures shall be defined regarding required actions if catching up or infringing the ITD or FTD.	SO 005 SO 008 SO 204 SO 205 SO 206 SO 208
SR1.064 REQ-02.01-SPRINTEROP-ARR0.0870	The Approach controller shall maintain applicable surveillance separation minima at any point during approach. This includes the case of a leader aircraft established on the final approach axis and a follower not yet established	SO 005 SO 008
SR1.065 REQ-02.01-SPRINTEROP-ARR0.1340	The current operational procedures for transitioning from intermediate separations (3NM) to final approach separations (e.g. 2.5NM MRS) shall continue to apply.	SO 005
SR1.066 REQ-02.01-SPRINTEROP-ARR3.0500	Once the follower aircraft has been positioned w.r.t ITD and before the leader reaches its deceleration point, the Controller shall apply speed instructions in accordance to the reference glide slope air speed used for ITD calculation.	SO 005 SO 008
SR1.067 REQ-02.01-SPRINTEROP-ARR0.0080	In DB- modes the separation delivery tool shall be provided with a range of wake turbulence distance-based separation rules based on ICAO Aircraft Type (e.g. ICAO, RECAT-EU, RECAT-EU-PWS) depending upon the airport needs.	SO 006
SR1.068 REQ-02.01-SPRINTEROP-ARR0.0230	All applicable Minimum Radar Separation (MRS) rules shall be provided to the Separation Delivery tool.	SO 006
SR1.069 REQ-02.01-SPRINTEROP-ARR0.0251	The separation delivery tool shall provide ATCOs the possibility to manage gap spacing between consecutive arrival flights.	SO 006

SR1.070 REQ-02.01-SPRINTEROP-ARR0.0240	All applicable runway-related spacing rules other than those related to runway configuration shall be provided to the Separation Delivery tool.	SO 006
SR1.072 REQ-02.01-SPRINTEROP-ARR0.0253	The separation delivery tool shall provide confirmation to ATCO that the gap spacing insertion is successful or not.	SO 006 SO 012 SO 212
SR1.073 REQ-02.01-SPRINTEROP-ARR0.0254	The ATCOs shall be able to insert automatic gap spacing based on pre-defined scenarios in the sequence manager	SO 006 SO 012
SR1.074 REQ-02.01-SPRINTEROP-ARR0.0255	The tool shall provide ATCOs the ability to update and cancel any gap spacing previously inserted.	SO 006 SO 012
SR1.075 REQ-02.01-SPRINTEROP-ARR0.0310	An expected aircraft speed or time-to-fly profile model on the final approach glide-slope shall be provided to the Separation Delivery tool for the FTD calculation.	SO 006
SR1.076 REQ-02.01-SPRINTEROP-ARR1.0320	An expected aircraft speed or time-to-fly profile model on the final approach glide-slope shall be provided to the Separation Delivery tool for the ITD calculation.	SO 006
SR1.077 REQ-02.01-SPRINTEROP-ARR0.0060	In TBS mode, the separation delivery tool shall be provided with time separation rules.	SO 006 SO 209
SR1.078 REQ-02.01-SPRINTEROP-ARR1.0070	S-PWS wake separation rules shall be provided to the Separation Delivery tool.	SO 006 SO 209
SR1.079 Example of REQ-02.01-SPRINTEROP-ARR2.0030	In TB-modes where WDS is applied (WDS-Xw and WDS-Tw) the separation delivery tool shall be provided with time separation tables (for each cross-wind and respectively total wind value and each aircraft pair category) derived from: - the time required for a sufficient vortex decay - the time required for the vortex to be transported away from the path of the follower aircraft - the reference speed profile for the leader and follower aircraft	SO 006 SO 209

SR1.080 REQ-02.01-SPRINTEROP-ARR0.0130	In TB mode, the FTD computed by the tool to indicate the wake separation applicable at the delivery point shall take into consideration: • The time separation from the wake turbulence separation table (for WDS the separation tables might be more than one depending on the total/cross wind values); • The aircraft pair (from the arrival sequence list); • The glideslope headwind profile; • The follower time-to-fly profile obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction	SO 006 SO 202 SO 204 SO 209
SR1.081 REQ-02.01-SPRINTEROP-ARR0.0161	The spacing constraint computation shall take into consideration the same inputs as for the ITD and FTD plus: • The time separation value representing the spacing constraint (ROT, GAP, scenario specific spacing, etc.)	SO 006
SR1.082 REQ-02.01-SPRINTEROP-ARR0.0321	Aircraft time-to-fly profiles used in the FTD and ITD calculations shall be based on a time-to-fly model representative of nominal aircraft speed behaviour on final approach, in the local environment.	SO 006
SR1.083 REQ-02.01-SPRINTEROP-ARR3.0150	The ITD computed by the tool for all separation and spacing constraints (wake separation in DB and TB modes, MRS, ROT and other spacing constraints) shall take in consideration: • The FTD for the considered aircraft pair • The glideslope headwind profile • The leader and follower time-to-fly profiles obtained either from modelled time-to-fly profile in the considered headwind conditions • The time separation buffer considering uncertainties of final approach speed profiles of the a/c pair and of the glide slope wind prediction	SO 006 SO 204
SR1.084 REQ-02.01-SPRINTEROP-ARR3.0163	If the ITD calculation is smaller than the FTD (e.g. pull away scenario) then it shall be changed to the same value as the FTD.	SO 006
SR1.085 REQ-02.01-SPRINTEROP-ARR0.0220	Aircraft identifier, ICAO aircraft type and wake category for all arrival aircraft, including subsequent updates to this information, shall be provided to the Separation Delivery tool.	SO 006 SO 201 SO 209
SR1.086 REQ-02.01-SPRINTEROP-ARR0.0280	The Separation Delivery tool shall be provided with the predicted headwind profile on the glideslope (ideally from ground to the published localiser interception altitude) to compute the ITD in all modes and the FTD in TB-modes. The used profiles shall ensure smooth temporal evolution of the ITD on the final approach.	SO 006 SO 209

SR1.087 REQ-02.01-SPRINTEROP-ARR0.0290	If in a local implementation the tool is required to consider the actual runway surface wind conditions, then the runway surface wind conditions shall be provided to the Separation Delivery tool.	SO 006
SR1.088 REQ-02.01-SPRINTEROP-ARR2.0141	In WDS modes (total wind/cross wind) the Separation Delivery tool shall use the relevant separation table for the FTD computation based on the measured total/cross wind	SO 006 SO 209
SR1.089 REQ-02.01-SPRINTEROP-ARR0.0162	The tool in any mode shall display TDIs representing the greatest constraint out of all applicable in-trail or not in-trail separation constraints. The constraints can be the high priority separation (e.g. Wake and MRS) and the low priority runway spacing (ROT) and other spacing constraints (e.g. departure GAP, runway inspections, etc.).	SO 006 SO 011 SO 212
SR1.090 REQ-02.01-SPRINTEROP-ARR0.0691	The Controllers shall be able to visually distinguish (via colour or symbol) if Target Distance Indicators are relative to WT, MRS or ROT (or other spacing constraint).	SO 006 SO 205
SR1.091 REQ-02.01-SPRINTEROP-ARR0.0580	The display option for the indicator shall be configurable depending on the type of separation / spacing.	SO 006
SR1.092 REQ-02.01-SPRINTEROP-ARR0.0681	The design of the TDIs shall be made in order to ensure they are easy to read and interpret, being in line with the design philosophy (shape, colour etc.) of the other ATC tools used in the local environment.	SO 006
SR1.093 REQ-02.01-SPRINTEROP-ARR0.0800	The HMI design shall allow Controllers to identify the aircraft associated with each displayed indicator.	SO 006 SO 202 SO 209 SO 212
SR1.094 REQ-02.01-SPRINTEROP-ARR0.1410	The Flight Crew shall be made aware of the locally applied separation mode and minima via appropriate means (e.g. from ATIS, AIP, NOTAM, information campaigns).	SO 007
SR1.095 REQ-02.01-SPRINTEROP-ARR0.1421	Information campaigns shall familiarise the flight crew/ airspace users with all novel concepts associated to the implementation of reduced separations.	SO 007
SR1.096 REQ-02.01-SPRINTEROP-ARR0.1400	An overview of the key principles of the TBS, S-PWS, WDS and / or ORD concept of operations (ConOps) shall be published in AIP.	SO 007

SR1.097 REQ-02.01-SPRINTEROP-ARR0.0970	If ORD is not implemented, the Final Approach Controller shall maintain the aircraft behind the FTD with sufficient buffer due to the effect of compression caused by different leader and follower groundspeed profiles, and shall reduce aircraft's speed to the final approach procedural airspeed.	SO 005 SO 008
SR1.098 REQ-02.01-SPRINTEROP-ARR0.0167	If both the FTD and ITD are available, the ITD indication ("compressions indicator") shall be the main indicator to be used by the final approach controller.	SO 005 SO 006 SO 008
SR1.099 REQ-02.01-SPRINTEROP-ARR0.0651	In case the ITD is the main display on the final approach, the ATCOs shall be able to display the FTD , depending upon the local operation's needs.	SO 005 SO 006 SO 008
SR1.100 REQ-02.01-SPRINTEROP-ARR0.0590	TDIs shall be displayed on all applicable ATCO and SUP CWPs (Tower Runway, Final Approach and Intermediate Approach), according to the local implementation rules.	SO 006
SR1.101 REQ-02.01-SPRINTEROP-ARR0.0700	Approach and Tower shall have access to consistent information (on their CWP HMI) relating to separation delivery to be able to communicate effectively with each other.	SO 006
SR1.102 REQ-02.01-SPRINTEROP-ARR0.0770	The displayed indicator distance and shape shall be consistent between all applicable CWPs.	SO 006
SR1.103 REQ-02.01-SPRINTEROP-ARR0.0165	The Tower Controller shall monitor and ensure that there is no infringement of the FTD.	SO 008 SO 205
SR1.104 REQ-02.01-SPRINTEROP-ARR0.0650	The Approach controller shall have the possibility to globally select the display of the FTD, however the FTD shall automatically be displayed when some alerts are active (e.g. risk of imminent FTD infringement).	SO 006
SR1.105 REQ-02.01-SPRINTEROP-ARR0.0164	The FTD indicator shall be the main TDI to be used by the Tower Controller.	SO 006 SO 008
SR1.106 REQ-02.01-SPRINTEROP-ARR3.0660	The Tower controller shall have the possibility to globally select the display of the ITD (in addition to FTD which shall always be displayed).	SO 006

SR1.107 REQ-02.01-SPRINTEROP-ARR3.0160	Before the Leader reaches its Deceleration Fix (DF), the ITD shall be "static" (i.e. the separation distance between the Leader position and the displayed ITD shall be static, the ITD shall hence move at the leader speed). It shall be computed accounting for the compression/ pull-away effect for the aircraft pair expected from the leader DF until the separation delivery point. After the Leader passes the DF, the ITD shall move towards the FTD, accurately account for compression/pull-away effect for the aircraft pair expected from the actual leader position until the separation delivery point.	SO 006
SR1.108 REQ-02.01-SPRINTEROP-ARR0.0140	Before the Leader reaches the separation delivery point, the FTD shall be "static" (i.e. the separation distance between the Leader position and the displayed FTD shall be static, the FTD shall hence move at the Leader speed). It shall be computed accounting for the expected time-to-fly of the Follower aircraft until the separation delivery point. After the Leader passes the separation delivery point and until the Follower reaches the separation delivery point, the FTD shall be disconnected from the Leader (e.g. move at the expected Follower speed to reach zero when the Follower is expected to reach the delivery point).	SO 006
SR1.109	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), the APP and TWR Controllers shall be made aware with respect to the impact on the TDIs correctness when actual aircraft speed profile is different from the pre-defined TAS profile used by the separation delivery tool.	SO 009 SO 209
SR1.110 REQ-02.01-SPRINTEROP-ARR0.1420	For all modes (where FTD and/or ITD are based on a pre-defined aircraft speed profile of the follower), Flight Crew shall be briefed and reminded (e.g. via information campaigns) on the importance to respect on the Final Approach path the ATC speed instructions until the start of the deceleration and/or the published procedural airspeed on final approach and to notify Controller in a timely manner in case of inability to conform to one of those.	SO 009 SO 209 SO 203 SO 207
SR1.111 REQ-02.01-SPRINTEROP-ARR0.0200	All applicable runway configuration spacing rules shall be provided to the Separation Delivery tool.	SO 006
SR1.112 REQ-02.01-SPRINTEROP-ARR0.0270	The tool shall allow the runway occupancy time (ROT) constraints to be configurable for each aircraft based on multiple parameters.	SO 006
SR1.113 REQ-02.01-SPRINTEROP-ARR0.1430	With regards to WDS modes (total wind or cross wind) Flight Crew shall be briefed and reminded on the importance to respect the Final Approach path in terms of lateral deviation from the glide path and to notify Controller in a timely manner in case of inability to conform to it.	SO 010 SO 207

SR1.114 REQ-02.01-SPRINTEROP-ARR0.0166	Clear guidelines with regard to the list of possible actions to be made in the case of an FTD infringement (in the APP and in the TWR) shall be described per position for the local implementation.	SO 005 SO 008
SR1.115 REQ-02.01-SPRINTEROP-ARR0.0441	In case of a change of runway configuration, the Approach and/or Tower supervisors shall coordinate prior to inserting the new arrival runway into the tool.	SO 006
SR1.116 REQ-02.01-SPRINTEROP-ARR0.0440	In case of a change of runway configuration, the Approach and/or Tower supervisors shall be able to input to the separation tool the new arrival runway to be considered for Target Distance Indicators computation. ISSUE 2: In case of a late landing runway change, it should be verified if the arrival sequencing tool can be timely reconfigured in order to display the Approach Arrival Sequence for the switched runway and update the TDIs accordingly.	SO 006
SR1.117 REQ-02.01-SPRINTEROP-ARR0.1250	Approach and Tower Controllers shall be fully trained to apply the procedures for the new separation modes and to use of the Separation Delivery Tool and supporting systems (e.g. alerts) with indicators prior to deployment.	SO 005 SO 008 SO 201 SO 205
SR1.118 REQ-02.01-SPRINTEROP-ARR0.1260	All Approach and Tower controllers and Supervisors shall be fully trained in the operating procedures for the new WT separation modes prior to deployment.	SO 005 SO 008 SO 205
SR1.119 REQ-02.01-SPRINTEROP-ARR0.1270	ATCO training shall ensure that the operation in new WT separation modes will not lead to more un-stabilized approaches due to late/rush aircraft stabilisation as a result of tighter spacing and more frequent speed adjustments. However, a greater number of instructions might temporarily occur during the introduction of the new concept.	SO 207
SR1.120 REQ-02.01-SPRINTEROP-ARR0.1040	All licenced Approach and Tower controllers (and Supervisors) shall be fully trained to switch between the time based and distance based modes of operation.	SO 001 SO 211
SR1.121 REQ-02.01-SPRINTEROP-ARR0.0370	Local implementation shall ensure that roles and responsibilities are clearly defined regarding the management of data inputs into the Separation Delivery tool including runway policy, runway spacing constraints, visibility conditions and runway conditions.	SO 006 SO 011
SR1.122 REQ-02.01-SPRINTEROP-ARR0.0180	The Surveillance system shall provide the Separation Delivery Tool with aircraft position and altitude for all arrival aircraft.	SO 006

SR1.123 REQ-02.01-SPRINTEROP-ARR0.1290	Regular trainings shall ensure ATCOs maintain sufficient competency to safely revert to and manage air traffic in DBS operations without Target Distance Indicators (i.e. implementation of the separation tool shall not adversely affect the controller's air traffic- vectoring skills-using DBS WT Category without Target Distance Indicators).	SO 001 SO 209 SO 210 SO 202 SO 206
SR1.124 REQ-02.01-SPRINTEROP-ARR2.0971	The Tower Controller shall ensure that the actual spacing behind the leader aircraft is not infringing the FTD and in case of imminent infringement he shall apply adequate corrective action like delegating visual separation to Flight Crew or instructing go-around.	SO 008 SO 209 SO 205 SO 207
SR1.125 REQ-02.01-SPRINTEROP-ARR0.0990	The Approach and Tower Runway Controllers shall remain responsible for monitoring for separation infringements and for timely intervention actions to resolve or prevent them.	SO 008
SR1.126 REQ-02.01-SPRINTEROP-ARR0.1021	The transition tasks (activation and deactivation of TB modes) shall be defined for all actors involved, for both a spontaneous transition (e.g. sudden change of wind conditions, etc.) as well as for a planned transition, where a collaborative approach for the ATCO and SUPs in APP and TWR shall apply.	SO 001
SR1.127 REQ-02.01-SPRINTEROP-ARR0.1031	Mode transitions (planned) should take place outside peak hours.	SO 001
SR1.128 REQ-02.01-SPRINTEROP-ARR2.1222	Timely reversion from conditional mode to standard mode of operations shall be triggered by the Supervisor or automatically by the system depending on the local implementation. The possibility for the ATCOs spontaneous reversal (e.g. in case of sudden loss of indicators) shall be locally defined.	SO 001
SR1.129 REQ-02.01-SPRINTEROP-ARR0.1351	In a dual approach arrival environment, ATCOs shall have supporting alert, for identifying vertical and horizontal infringements for the crossing aircraft (e.g. North runways to South runways)	SO 005 SO 008

B.1.1.2 Safety Requirements in Abnormal Operational Conditions for the Arrivals Concepts Solutions

SRs	General Description	Derived from
SR1.200 Example of REQ-02.01-SPRINTEROP-ARR0.0852	The Intermediate and Final Approach controllers shall be the masters of the Final Approach arrival sequence and shall be able in a simple and timely way to update the sequence, insert or remove an aircraft and amend the sequence when there is a go-around in accordance with their strategy for the interception with no adverse impact on workload.	SO 103 SO 209 SO 212
SR1.201 REQ-02.01-SPRINTEROP-ARR0.0560	For every change in the arrival sequence (aircraft swapping positions, aircraft removed or missed approach, late change of the runway intent, etc.) the tool shall immediately re-compute all affected TDIs and reflect the change on the HMI accordingly.	SO 103 SO 209
SR1.202 REQ-02.01-SPRINTEROP-ARR0.0561	For a late change of the runway intent, the tool shall immediately re-compute all affected TDIs and reflect the change on the HMI accordingly (i.e. the TDIs corresponding to the affected aircraft disappear from the extended runway centreline of the old runway and is displayed on the extended runway centreline of the new runway).	SO 105
SR1.203 REQ-02.01-SPRINTEROP-ARR0.0950	When the aircraft is already inserted into the sequence with a runway intent and there is a change of aircraft landing runway intent, the Approach controller shall check that Target Distance Indicators reflect the change of aircraft landing runway intent	SO 105
SR1.204 REQ-02.01-SPRINTEROP-ARR0.0851	Local procedures shall define the procedures related to the use of the TDIs and the specific instances in which they can be removed.	SO 103
SR1.205 REQ-02.01-SPRINTEROP-ARR0.0960	The Target Distance Indicators associated to a leader aircraft executing a go-around shall be removed from the sequence and new Target Distance Indicators shall be computed for the following a/c, considering the new arrival pairs created due to this go-around. The aircraft could be removed from the sequence manually by the ATCO or automatically.	SO 103
SR1.206 REQ-02.01-SPRINTEROP-ARR0.0250	Scenario specific spacing gaps between aircraft pairs shall be provided to the Separation Delivery tool.	SO 106
SR1.208	In WDS total wind modes (A-TB-WDS-Tw), the Approach and Tower Controllers and Supervisors shall be alerted by the total wind monitoring function about a significant difference between actual reference total wind and the reference total wind used for the TB computation, i.e. when the predicted allowed time separation	SO 101 SO 209 SO 211

	(based on the total wind prediction used for Target Distance Indicator computation) compared to the actual allowed time separation (based on the actual total wind measurement) exceeds a threshold to be determined locally.	
SR1.209	In WDS cross wind modes (A-TB-WDS-Xw), the Approach and Tower Controllers and Supervisors shall be alerted by the cross wind monitoring function about a significant difference between actual reference cross wind and the reference cross wind used for the TB computation, i.e. when the predicted allowed time separation (based on the cross wind prediction used for Target Distance Indicator computation) compared to the actual allowed time-separation (based on the actual cross wind measurement) exceeds a threshold to be determined locally.	SO 101 SO 209 SO 211
SR1.210	In WDS total wind modes (A-TB-WDS-Tw), in case of total wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.	SO 101 SO 209 SO 211
SR1.211 REQ-02.01-SPRINTEROP-ARR2.1680	In WDS crosswind modes (WDS-Xw), in case of cross wind monitoring alert, the Approach and Tower Controllers shall revert to the correspondent distance based or time based (e.g. TB-PWS) separation mode, using the FTD and ITD indicators and when needed take corrective actions during the transition phase like instructing go-around.	SO 101 SO 209 SO 211
SR1.212	In TBS and TB-PWS-A modes, in case there is a significant difference between actual glideslope headwind profile and the glideslope headwind profile used for the TDI computation, the Separation Delivery Tool shall re-compute the TDIs based on the correct headwind value and inform the ATCO about the re-computation.	SO 101 SO 209 SO 211
SR1.213 REQ-02.01-SPRINTEROP-ARR2.1690	The triggering values of the headwind, total wind and cross wind monitoring alerts shall be determined on the basis of the used buffers in the TDI computation	SO 101 SO 209
SR1.214 REQ-02.01-SPRINTEROP-ARR0.1500	The Approach and/or Tower controller shall be alerted by the speed conformance alert function when the actual aircraft speed differs by more than a locally-defined threshold from the aircraft speed profile used for the TDIs computation.	SO 102 SO 209 SO 205 SO 208 SO 207
SR1.215 REQ-02.01-SPRINTEROP-ARR0.1700	In TB-modes, in case of speed conformance alert before the stabilisation fix, the Final Approach or Tower Controllers shall check whether the actual spacing behind the leader aircraft is below the distance-based WTC separation minima and if positive shall apply adequate corrective actions: airspeed instructions, path stretching	SO 102 SO 209 SO 205 SO 208 SO 207

	instructions (if allowed after localiser interception), delegation of visual separation to Flight Crew and, if necessary, missed approach instruction, and shall manage the impact on subsequent aircraft in the arrival sequence.	
SR1.216 REQ-02.01-SPRINTEROP-ARR0.1370	Pilots shall notify ATC of an inability to fly the standard approach procedure, and of any non-conformant final approach procedural airspeed issues, in a timely manner.	SO 104
SR1.217 REQ-02.01-SPRINTEROP-ARR0.1710	For all modes, in case of speed conformance alert the Final Approach and Tower Controllers shall be aware that ITD indicators are no longer accurate if the same speed is kept until the deceleration fix (ITD computation impacted by pre-defined glideslope airspeed profile of both follower and leader) thus shall manage compression without indicators as per today operations.	SO 102 SO 209
SR1.218 REQ-02.01-SPRINTEROP-ARR0.1510	The triggering value used for the speed conformance alert shall be determined on the basis of the used buffers in the TDI computation. The region on the glideslope where the alert is active shall be defined locally (e.g. 8 NM from RWY threshold).	SO 102 SO 209
SR1.219 REQ-02.01-SPRINTEROP-ARR0.1360	The Approach Controller shall take into account any notified inability to fly the standard approach procedure and any non-conformant final approach procedural airspeed issues when setting up the spacing on final approach.	SO 104
SR1.220 REQ-02.01-SPRINTEROP-ARR0.1380	Procedures shall be locally defined for the handling of scenario specific spacing requests and runway changes.	SO 106

B.1.1.3 Safety Requirements Mitigation to System Generated Hazards for the Arrivals Concepts Solutions

SRs	General Description	Derived from
SR1.300 REQ-02.01-SPRINTEROP-ARR0.0540	Controllers shall be trained to check the aircraft landing runway intent and that the aircraft order is correct and coherent with the arrival sequence list. They shall check if and that the aircraft order is displayed in the arrival sequence list and/or if the aircraft sequence number is displayed in the radar label in accordance with their intended sequence.	SO 209 SO 210 SO 212
SR1.301 Example of REQ-02.01-SPRINTEROP-ARR0.0142 Example of REQ-02.01-SPRINTEROP-ARR0.0460	If the required wind input to calculate a time based wake separation (TBS or WDS) is not available for an interval longer than a specific duration (to be determined based on local wind evolution analysis), then: • The Separation Delivery Tool shall continue displaying TDIs for aircraft that are already established on the final approach path and for which the last available TDIs computation includes a safety buffer managing the acceptable failure rate of the wind measurement; • The Separation Delivery Tool shall display TDIs for non-established aircraft based on conservative wind inputs for TDIs computation	SO 202
SR1.302 REQ-02.01-SPRINTEROP-ARR2.1280	In case of WDS cross wind, when the leader and follower are established on the glideslope, the Approach and Tower controllers shall be able to give heading instructions (e.g. break-off) to the follower only upwind and not downwind.	SO 206
SR1.303 REQ-02.01-SPRINTEROP-ARR0.1010	Local operational procedures shall be developed for handling traffic situations with missing Target Distance Indicators in different WT separation modes for both controllers and supervisors.	SO 210 SO 206 SO 205 SO 201 SO 202
SR1.304 REQ-02.01-SPRINTEROP-ARR0.0510	Wake category and aircraft type information shall be always available in the aircraft labels so that this information remains visible for Controllers	SO 209 SO 210
SR1.305 REQ-02.01-SPRINTEROP-ARR0.1600	For all modes, in case of loss of glideslope headwind profile input to the separation tool, the alert for loss of glideslope headwind profile service shall be displayed to the Controllers and Supervisors.	SO 210

SR1.306 REQ-02.01-SPRINTEROP-ARR0.0520	Approach and Tower Supervisors shall be made aware if any tool / monitoring / alerting features are lost or inoperative.	SO 210 SO 206 SO 209
SR1.307 REQ-02.01-SPRINTEROP-ARR0.1650	In TB-modes, in the degraded situation where glideslope headwind profile input is missing: - The Controllers shall revert to the correspondent DB- mode (DBS or S-PWS) with use of FTDs only whilst ITDs shall no more be displayed (manual management of compression) or shall revert to an acceptably safe TB-mode with ITD and FTD computed using a conservative wind profile (until the glideslope headwind profile is available again); OR - The Separation Delivery Tool shall automatically revert to the correspondent DB-mode or to an acceptably safe TB-mode (FTD and ITD computed using a conservative wind profile). A notification of the automatic switch shall be provided to the ATCOs and Supervisors.	SO 210
SR1.308 REQ-02.01-SPRINTEROP-ARR0.1660	In DB- modes, in the degraded situation where glideslope headwind profile input is missing, the Approach Controller shall use only the FTD for the turn-on decision for merging on to final approach (whilst ITDs shall no more be displayed), vectoring the follower aircraft to intercept the final approach and further spacing management during interception whilst adding extra buffer to the FTD to manually account for compression or shall revert to an acceptably safe DB-mode with ITD and FTD computed using a conservative wind profile (until the glideslope headwind profile is available again)	SO 210
SR1.309 REQ-02.01-SPRINTEROP-ARR0.1570	If an aircraft that needs to be inserted in the arrival sequence cannot be input into the Arrival Sequence Service, the Approach Controller shall inhibit the Target Distance Indicator corresponding to the follower aircraft whose position in the actual sequence is taken by the newly inserted aircraft and the Approach Controller shall observe DBS WT Category separation for the impacted pairs of aircraft	SO 201
SR1.310 REQ-02.01-SPRINTEROP-ARR0.1530	The Approach Controllers shall be alerted in case the aircraft instructed to turn onto the Target Distance Indicator on the runway extended centreline is not the one planned in the Arrival Sequencing Tool list.	SO 202 SO 203
SR1.311 REQ-02.01-SPRINTEROP-ARR0.1560	In case of sequence error alert the Approach Controllers shall perform corrective action to re-establish consistency between the actual sequence order and the Arrival Sequencing Tool list.	SO 202 SO 203

SR1.312 REQ-02.01-SPRINTEROP-ARR2.1050	The Separation Delivery tool implementation shall forbid the Approach and/or Tower Controller the possibility to activate the TB-WDS-A modes.	SO 211
SR1.313 REQ-02.01-SPRINTEROP-ARR0.0450	If there is insufficient information to calculate a TDI then that TDI shall not be provided, together with a visual warning.	SO 202 SO 210
SR1.314 REQ-02.01-SPRINTEROP-ARR0.1720	If the Approach Arrival Sequence Service fails, the Separation Delivery tool shall continue displaying TDIs for aircraft already established and shall stop displaying TDIs for all other aircraft	SO 201 SO 210 SO 212
SR1.315 REQ-02.01-SPRINTEROP-ARR0.0400	It shall be demonstrated that the data inputs including flight data, approach arrival sequence information and glideslope wind conditions to the Separation Delivery are sufficiently robust.	SO 201 SO 209
SR1.316 REQ-02.01-SPRINTEROP-ARR0.1441	At the first contact with the Approach, the flight crew shall provide the Aircraft type or alternatively this information could be provided to the Approach Controller via data link and the Approach Controller shall cross check this information with the information displayed on the CWP	SO 201 SO 209
SR1.317 REQ-02.01-SPRINTEROP-ARR0.0410	The software assurance level of the Separation Delivery tool and supporting tools shall be determined by the V4 safety assessment	SO 209 SO 212
SR1.318 REQ-02.01-SPRINTEROP-ARR0.0390	Separation delivery tool verification shall be carried-out after modification of the separation time table configuration file (in TB-modes) or the distance separation table configuration file before the system returns in operational service	SO 209
SR1.319 REQ-02.01-SPRINTEROP-ARR0.0380	A quality assurance process shall be put in place to validate the separation time table configuration file (in TB- modes) or the distance separation table configuration file of the separation delivery tool	SO 209
SR1.320 REQ-02.01-SPRINTEROP-ARR0.0420	Separation delivery tool verification shall be carried-out after modification of the time-to-fly/airspeed profile configuration file (new A/C types or modification of existing A/C speed profiles) before the system returns in operational service	SO 209
SR1.321 REQ-02.01-	When a flight data input error (e.g. missing or wrong ICAO aircraft type or wake category) is detected, it shall be possible to update	SO 209 SO 201

SPRINTEROP-ARR0.0430	the corresponding information into the input for the separation delivery tool	
SR1.322 REQ-02.01-SPRINTEROP-ARR0.1330	In TB modes, relevant wind information shall be displayed on Approach / Tower Controller working positions for awareness purposes (e.g. to enable significant discrepancy check with the displayed TDI). Note the following assumption is conservatively taken: A015: Controllers cannot have detailed knowledge of separations for each pair of aircraft in all modes except for DBS therefore checking that Target Distance indications are consistent with the associated aircraft types and WT category is not realistic	SO 209
SR1.323 REQ-02.01-SPRINTEROP-ARR0.1310	Approach and Tower Controllers shall be provided with look-up tables for DBS minima to support DBS operations with no TDIs when necessary.	SO 209 SO 210
SR1.324 REQ-02.01-SPRINTEROP-ARR0.0860	ATCOs shall continue to have a 'click and drag' distance measuring tool so they can accurately measure inter a/c spacing when required (e.g. for building confidence in the tool or during degraded modes)	SO 209 SO 210
SR1.325 REQ-02.01-SPRINTEROP-ARR0.1770	Approach and Tower Supervisors shall be alerted when the wind monitoring function for the conditional application of the TB modes (glideslope headwind, total wind, cross wind) are lost or inoperative (encompassing loss of wind input)	SO 209 SO 210 SO 211
SR1.326 REQ-02.01-SPRINTEROP-ARR0.1730	In case of separation tool failure with loss of TDI computation (TDIs preserved for aircraft already established) a specific separation tool failure alert shall be provided and the Controllers shall revert to DBS without indicators for aircraft without TDIs. Only for aircraft already established, TDIs that continue to be displayed can be used up to the separation delivery point	SO 201 SO 202 SO 210 SO 206
SR1.327 REQ-02.01-SPRINTEROP-ARR0.1640	In case of Separation Tool Failure, the Supervisors and Controllers shall receive a message containing the source of the tool failure	SO 201 SO 202 SO 206 SO 210
SR1.328 REQ-02.01-SPRINTEROP-ARR0.0791	When spacing ITD is infringed by the aircraft, the ATCOs shall be aware of the next most constraining separation factor ITD and FTD (e.g. Wake or MRS) on the APPROACH and TOWER positions.	SO 202 SO 204
SR1.329 REQ-02.01-	Controllers and Supervisors shall regularly receive training on reversal procedures (TB to DB modes) and contingency measures in	SO 201 SO 202

SPRINTEROP-ARR0.1020	case of abnormal and degraded modes of operation (e.g. loss of one TDI, loss of all TDIs etc.)	SO 206 SO 210
SR1.330 REQ-02.01-SPRINTEROP-ARR0.1440	Approach control shall check the validity of Flight Plan information displayed on the CWP (ICAO aircraft type, wake category)	SO 201 SO 209
SR1.331 REQ-02.01-SPRINTEROP-ARR0.1721	In case of separation tool failure with loss of all TDIs (aircraft already established and aircraft going to intercept), the Controllers shall revert to DBS without indicators for all aircraft (one or several aircraft might be instructed to break-off)	SO 201 SO 202 SO 206 SO 210

Appendix C Assumptions, Safety Issues & Limitations

Appendix C covers the following Concepts Solutions:

- Assumptions, Safety Issues & Limitations for Arrivals Concepts Solution in Section C.1
- Assumptions, Safety Issues & Limitations for Departures Concepts Solutions in Section C.2

C.1 Arrivals Concepts Solutions

C.1.1 Assumptions Log for the Arrivals Concepts Solutions

The following Assumptions were necessarily raised during the safety assessment of the Arrivals Concepts Solutions:

Assumption ref	Safety Assumption	Validation
A015	Controllers cannot have detailed knowledge of separations for each pair of aircraft in all modes except for DBS, therefore checking that Target Distance indications are consistent with the associated aircraft types and WT category is not realistic.	Validated. Associated to Hz#05.

Table 26: Assumptions Log for the PJ.02.01 Arrivals Concepts Solutions

C.1.2 Safety Issues Log for the Arrivals Concepts Solutions

The following Safety Issues were necessarily raised during the safety assessment of the Arrivals Concepts Solutions:

Issue ref [origin]	Safety Issue	Status
ISSUE 01	The wind used for the WDS concept remains to be defined. The corresponding separation reductions shall be defined accordingly (and will depend on the wind definition). A forecast of that wind shall be available with the time window required for separation computation.	Closed. The A-WDS concept is described in Appendix I
ISSUE 02 SO 105	In case of a late landing runway change, it should be verified if the arrival sequencing tool can be timely reconfigured in order to display the Approach Arrival Sequence for the switched runway and update the TDIs accordingly.	Open.
ISSUE 03 See Hz#01a, ARR_SEQ_5	Whether the Approach or Tower Controllers shall be able to inhibit a Target Distance Indicator for a particular aircraft (both FTD and ITD) remains to be further validated. In case Controllers are allowed to inhibit both FTD and ITD for a particular aircraft, a means to recall the lack of TDI needs to be specified in order to mitigate the risk of a wrong association by ATCO of the aircraft with	Closed. Requirements have been put in place to mitigate this issue.

Issue ref [origin]	Safety Issue	Status
	the FTD/ITD of another aircraft (e.g. change colour (fade) when inhibited).	
ISSUE 04 SAF/HP workshop, (Hz#01a, FCRW_1)	The changes introduced by the new WT separation modes and ATC tools should not negatively impact Flight Crew workload by significantly increasing the number of speed instructions.	Closed. Requirements have been put in place to mitigate this issue.

Table 27: Safety Issues Log for the PJ.02.01 Arrivals Concepts Solutions

C.1.3 Recommendations Log for the Arrivals Concepts Solutions

The following Recommendations were necessarily raised during the safety assessment of the Arrivals Concepts Solutions:

Rec ref [origin]	Safety Recommendation	Status
REC001 See SAC#1 for any mode, in relation to LIM#003	For any local implementation of a specific WT separation concept it is recommended that an analysis be conducted which, for the given local traffic mix and wind conditions, estimates the net effect on the frequency of wake turbulence encounters at each level of severity in comparison to an accepted baseline. This analysis may then be reviewed by local stakeholders and regulatory bodies.	To be addressed in local implementation.
REC002 See SAC#1 for any mode, in relation to LIM#004	For any local implementation and based on the local procedure design and potential encounter geometries, the impact on the wake turbulence encounter probability and severity during the intermediate approach and localiser intercept phases should be considered.	To be addressed in local implementation.

Table 28: Recommendations Log for the PJ.02.01 Arrivals Concepts Solutions

C.1.4 Operational Limitations Log for the Arrivals Concepts Solutions

The following Operational Limitations were necessarily raised during the safety assessment of the Arrivals Concepts Solutions:

Lim ref	Limitation	Status
LIM#001	Dependent Parallel Approach operations are not addressed in this Safety Assessment	In line with OSED

Lim ref	Limitation	Status
LIM#002	Only runway segregated mode is addressed in this Safety Assessment	In line with OSED
LIM#003	The P6.81 WT risk analysis and safety assessment work have not addressed the net effect on the frequency of wake turbulence encounters at each level of severity in comparison to an accepted baseline (focusing only on ensuring that for each aircraft pair the WT encounter severity shall not be higher than the severity of reference aircraft type pair in reasonable worst-case conditions).	To be addressed in local implementation (See REC001)
LIM#004	The design criteria for each specific WT separation scheme consider only the final approach wake turbulence encounter risk	To be addressed in local implementation (See REC002)
LIM#005	Regarding the conditional application of Time-based modes, in line with the OSED, only the activation and deactivation conditions of each WT separation mode and the switching between each TB-mode and the corresponding DB-mode are covered within this specification and related safety assessment, but not other transitions between modes.	To be considered in further steps.
~~LIM#006~~	~~The assessment of whether the Approach Controllers (Intermediate and Final) and the Tower Controller can safely deliver aircraft during and after the transition between WT separation modes has not been covered by the validation exercises (both planned transition and unplanned reversion to correspondent DBS mode with indicators or to DBS mode without indicators need to be validated)~~	To be considered in further steps. Has been considered within THALIN 3.
LIM#007	The assessment of whether the Approach or the Tower Controller can safely revert to DBS separation without indicator for a particular aircraft has not been covered by the validation exercises.	To be considered in further steps.
LIM#008	Further investigation is required into understanding how well separation is maintained as aircraft are intercepting the localiser. This could be studied in a future RTS after separation rule transition procedures have been defined (i.e. ICAO to new WT separation, or 3Nm MRS to 2.5Nm MRS, as aircraft merge onto the final approach); Additionally, specific validation needs to be performed in each local implementation because: the assessment of whether Approach Controllers can maintain radar separation during the intermediate approach and localiser intercept phases is strongly dependant on the local environment &	To be addressed in further steps & in local implementation.

Lim ref	Limitation	Status
	interception conditions (altitude, distance to threshold, orientation of the arrival flows, wind conditions, etc.).	
LIM#009	The demonstration that the number of go-arounds (ATC initiated) due to the operation in the new WT separation modes and ATC tools does not increase significantly has not been successfully performed. Further refinement of the tool and procedures about when to initiate a go-around are required in order to ensure that the go-around rate (ATC induced) does not significantly increase with the new WT separation modes.	To be addressed in further steps.

Table 29: Operational Limitations Log for the PJ.02.01 Arrivals Concepts Solutions

Appendix D Relevant Accident Incident Models (AIM)

The simplified version of the Accident Incident Models as being relevant for the PJ.02 Solution 1 are presented in the next figures.

Appendix D covers the following Concepts Solutions:

- Relevant Accident Incident Models (AIM) for Arrivals Concepts Solution in Section D.1
- Relevant Accident Incident Models (AIM) for Arrivals and Departures Concepts Solutions in Section D.2
- Relevant Accident Incident Models (AIM) for Departures Concepts Solutions in Section D.3

D.1 Relevant Accident Incident Models (AIM) for the Arrivals Concepts Solutions

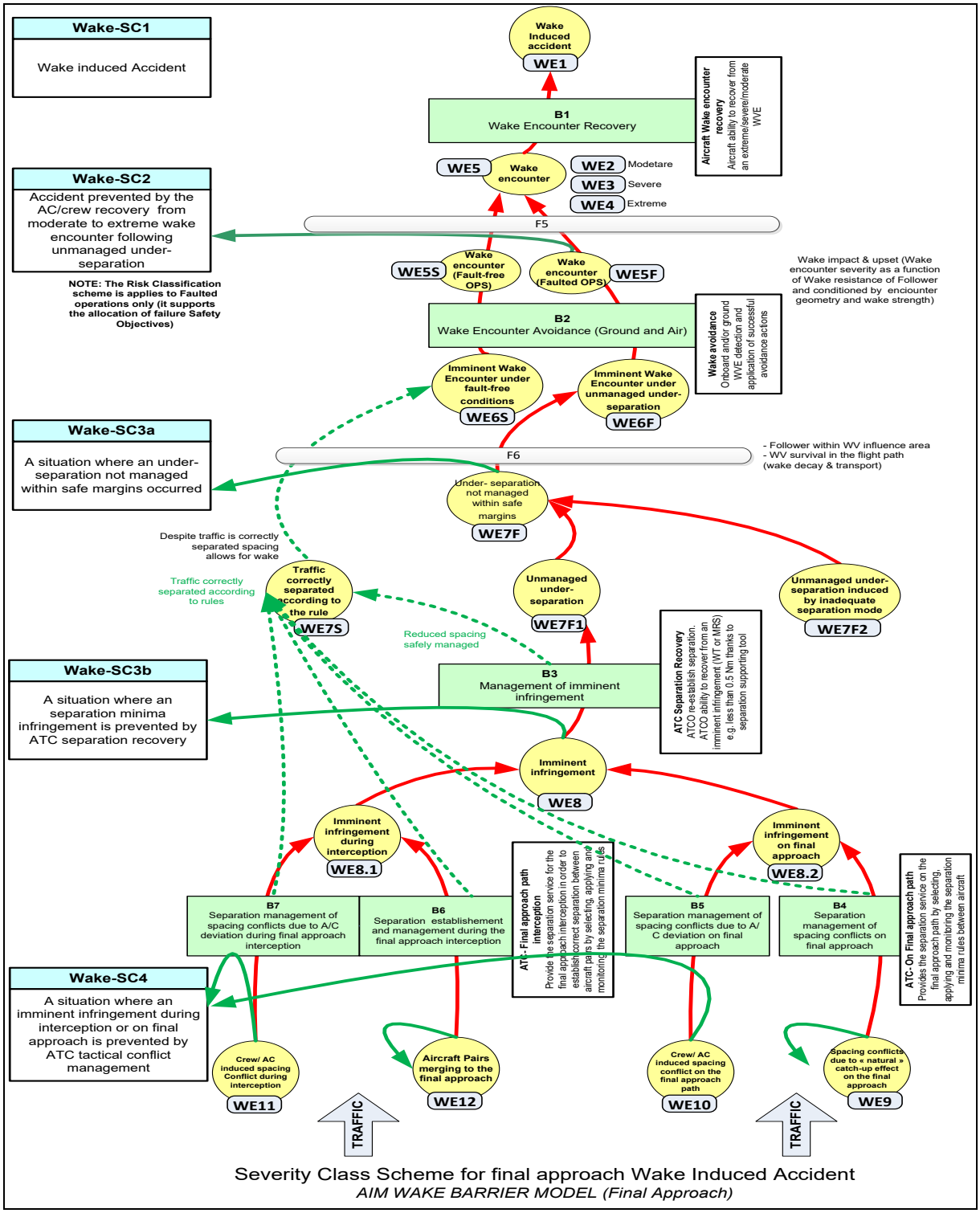

Figure 19: Simplified AIM Model for WT Induced Accident on Final Approach for the PJ.02.01 Arrivals Concepts Solutions

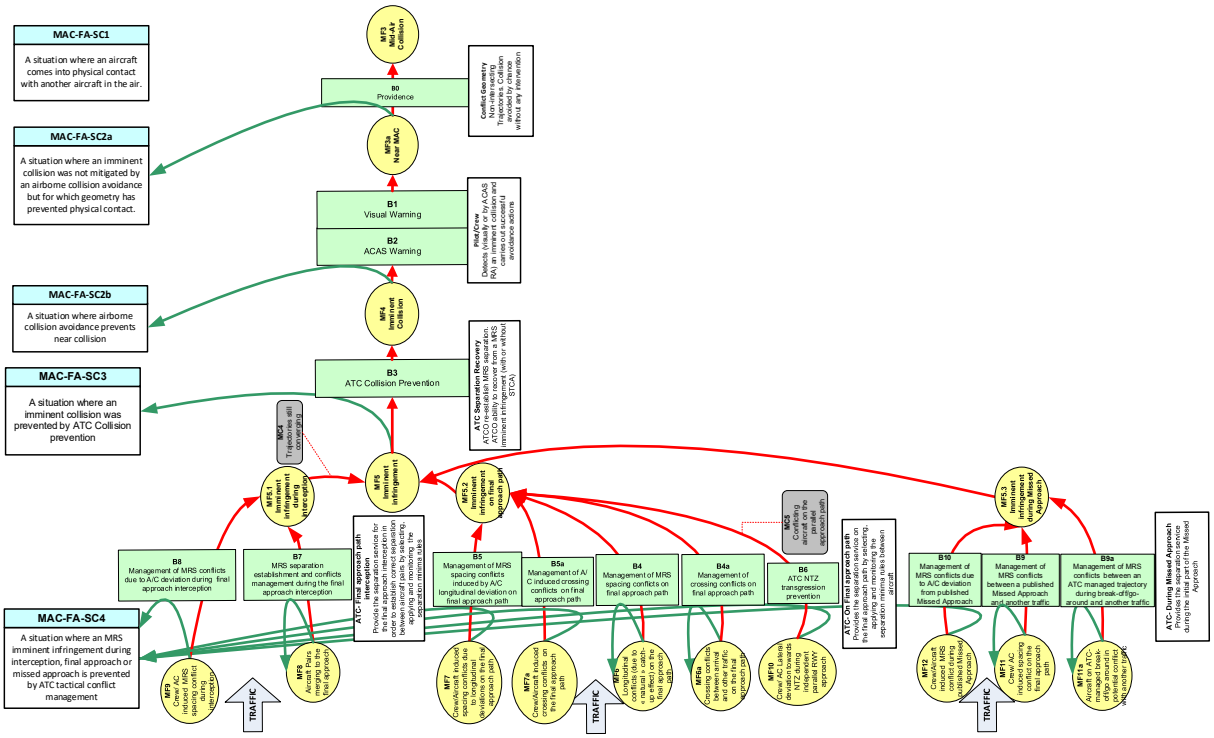

Figure 20: Simplified AIM Model for MAC on Final Approach for the PJ.02.01 Arrivals Concepts Solutions

D.2 Relevant Accident Incident Models (AIM) for the Arrivals and Departures Concepts Solutions

TBD – simplified version not yet available.

Appendix E PJ.02.01 SAF & HP Workshop

A PJ.02.01 SAF & HP workshop took place at EUROCONTROL Bretigny the 30th of October 2018. The list of participants was as follows:

Organisation	Name	Email	Position
Vienna Airport	Haris Usanovic	Haris.Usanovic@austrocontrol.at	TWR & APP ATCO
DGAC/CDG-LB	Guilain Herrmann	guilain.herrmann@aviation-civile.gouv.fr	TWR & APP ATCO
	Louis Lespiac	louis.lespiac@aviation-civile.gouv.fr	TWR & APP ATCO
NATS	Charles Morris	Charles.Morris@nats.co.uk	Concept design expert
	Andrew Belshaw	Andrew.BELSHAW@nats.co.uk	SAF expert
	Pawlee Imafidon	Pawlee.IMAFIDON@nats.co.uk	HP Expert
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	Renée Pelchen-Medwed	renee.pelchen-medwed@eurocontrol.int	HP expert
	Dana Botezan	adriana-dana.botezan@eurocontrol.int	HP expert
	Valerio Cappellazzo	Valerio.Cappellazzo@eurocontrol.int	Concept design expert
	Ivan De Visscher	ivan.devisscher@wapt.be	Wake expert

E.1 Arrivals

E.1.1 Applicable to the Interception Phase

Possible Hz	Causes	Mitigations	Comments
1. Unanticipated pilot/aircraft behaviour during interception (cause for Hz#01a orHz#02a)	(a) Pilot slow in following instruction or inadequate response to ATC (not recovered through monitoring) (b) Overshoot (c) Lateral, vertical or speed deviation initiated by crew/aircraft (e.g. deviation from published speed) (d) Wrong a/c turns on the indicator (pick-up instruction for other aircraft) Note: a) is a cause for Hz#01a: Inadequate separation management during interception b), c) and d) are causes for Hz#02a: Inadequate separation management of a spacing conflict due to aircraft deviation from Final Approach interception profile without ATC instruction given	**Preventive Mitigations:** **Protective Mitigations** (a, b, c, d) Continue with the currently applicable rules for allowance to descend from 3NM to 2.5NM upon turning on to intercept (spacing buffer leaving room for separation recovery during interception) (a) Detect inadequate response to ATC through monitoring of the instruction execution & correct (a, b, c, d) ATC Recovery from imminent infringement by adequate action (vectoring, level instructions or go-around) - see line 11	Heathrow: Pilot compliance with speed instruction has been a problem at the beginning of the TBS implementation. Airlines have been briefed about the safety importance of the speed compliance with the new concept. Current HP REQ: Information campaigns for flight crew. E.g. aircraft instructed 160 kt then transferred to TWR, afterwards leader a/c reduces to 150 kt before DF with risk of separation infringement by the follower. That requires APP ATCO to quickly coordinate with TWR requiring to increase speed back to 160 kt

Possible Hz	Causes	Mitigations	Comments
HUMAN PERFORMANCE	1. TDIs reduce ATCOs overall SAà risk to focus too much on getting the a/c to the target so their focus of attention may become narrower • Not detecting the deviation on time • Not detecting downwind or base leg infringements • Need of having alerts/ alarms at this stage for identifying a, b, c or any other possible causes for this hazard?		

Possible Hz	Causes	Mitigations	Comments
2. Wrong ATC instruction during interception despite correct separation indicator (cause for Hz#01a or Hz#02a)	(a) Inadequate procedures/instructions for separation establishment/management (b) ATCO – pilot misunderstanding	**Preventive Mitigations:** (a) Target distance indicators displayed far enough in advance on RWY extended centreline (a) INI_APP contribution (prepare traffic for ITM_APP) **Protective Mitigations** Resolve situation by vectoring, level instructions or go-around	
HUMAN PERFORMANCE	1. Equitable distribution of work for INI and ITM? • Communication load • a/c on frequency Type/ number of instructions		

Possible Hz	Causes	Mitigations	Comments
3. Separation indicator not displayed or not timely available for	(a) ORD tool failure (one pair affected only) (b) No input from Sequencing tool (one pair)	**Preventive Mitigations** **Protective Mitigations** ATCO detects the missing indicator and: (c) corrects the arrival sequence	

Possible Hz	Causes	Mitigations	Comments
one aircraft pair during turn-on (cause of Hz#01a)	(c) Aircraft not in arrival sequence tool (d) Flight Planning info missing/not recognized (a/c type or WT CAT)	(a), (b), (d) ATCO applies Baseline DBS separation minima (ATCO needs to keep awareness of the aircraft type/WTC)	
HUMAN PERFORMANCE	1. Would it be easy/ enough to identify the a/c pair based on the sequence alert? 2. How would you keep the awareness for this a/c pair with regard to the DBS application?		

Possible Hz	Causes	Mitigations	Comments
4. Lack/loss of indicators for multiple or all aircraft Cause for Hz#06	(a) Loss of ORD Tool (b) Loss of sequencer tool (c) Loss of flight planning information (d) RWY Separation mode not updated (the information about the mode of operation - segregated or mixed mode- is not sent to the arrival sequencer)	**Preventive Mitigations:** **Protective Mitigations** ATCO detects the missing indicators and reverts to Baseline DBS (a supporting DBS table is required, especially in TB PWS with multiple categories) Aircraft established on Final approach stabilized with 160kts IAS and behind ITD are allowed to continue the approach All other aircraft – either not established on Final or not at stabilized IAS 160kts or not behind ITD - Initiate Go-around or break off - Establish ICAO DBS asap	
HUMAN PERFORMANCE	1. What is the role of the supervisor in case this hazard applies? For spontaneous transitions, the ATCO independently reverts to DBS, as the collaboration with the SUP might not be timely enough. 2. Would you trust the TDIs if they suddenly reappear?		

Possible Hz	Causes	Mitigations	Comments
	• E.g. in Vienna there is a Central Control Service that gives permission to proceed after degraded modes. • How is it in CDG? **3.** Are alerts necessary for all these possible causes so that you quickly understand the situation and act accordingly? Where possible, there shall be an indication of the error that has occurred. **HP REQ: To be clearly specified at local level what alerts and alarms are available and what procedures apply in case of such errors.** 4. In this case is the separation table a “must have” ? What other support info you would need handy? What other support info you would need handy? HP REQ: ATCOs shall have the conventional separation table available (on display if required) in case they need to revert from TBS to DBS. 5. In case the possibility to “toggle on and off” the indicators exists and is applicable, what indications would you need to make sure they were intentionally removed or you are actually dealing with a degraded mode. The ATCOs would like to know whether the TDIs disappeared as a result of an error or if they are intentionally removed for DBS reversal.		

E.1.2 Applicable to the Interception and Final Approach Phases

Possible Hz	Causes	Mitigations	Comments
5. Corruption of one or multiple separation indicators Cause for Hz#05	(a) Incorrect a/c type or WT CAT (b) Flight plan info corruption (c) Corruption of separation tool (d) Sep tool config failure (i.e. incorrect airspeed profile, incorrect sep table) (e) Corruption of arr seq or arr seq not (correctly) updated (f) Corrupted RWY operation mode (g) Inadequate/missing surveillance data (h) Missing update or detected loss of the G/S headwind profile	**Preventive Mitigations** Adequate SW assurance **Protective Mitigations** (a, b) Incorrect a/c type might be detected via Pilot reporting **(to derive SAF REQ for systematic a/c type reporting)** (c to g): Only in case of gross error ATCO might detect the corruption of the indicator/s. Upon detection: Discard the corrupted indicator(s) and instruct aircraft such as to enable Baseline DBS separation minima (if not feasible, instruct break-off/go around If undetected, no protective mitigation available **For (h) only:** ATCO reverts to Baseline DBS with no indicators without coordination with SUP due to not enough time to coordinate (a supporting DBS table is required, especially in TB PWS with multiple categories). *SR1.307 "In TB-modes, in the degraded situation where glideslope headwind profile input is missing:* *- The Controllers shall be displayed with the loss of glideslope headwind alert and shall revert to the correspondent DB- mode (DBS or S-PWS) with use of FTD but without ITD*	LHR: in case of loss of wind input, ORD tool reverts to DBS plus conservative conditions for computing compression In case of tool loss, ATCOs apply DBS plus 1NM conservative for compression

Possible Hz	Causes	Mitigations	Comments
		(manual management of compression) or keep using the TB-mode with ITD and FTD computed using a conservative wind profile until the glideslope headwind profile is available again; ***OR*** *- The Separation Delivery Tool shall automatically revert to the correspondent DB-mode or an acceptably safe TB-mode (FTD and ITD computed using a conservative wind profile). A notification of the automatic switch shall be provided to the ATCOs and Supervisors"*	
HUMAN PERFORMANCE			

Possible Hz	Causes	Mitigations	Comments
6. Incorrect G/S wind profile used for computation Cause for Hz#05	(a) Meteo error/incorrect reference wind prediction (b) Incorrect reference wind monitoring	**Preventive Mitigations:** (b) Reference wind monitoring alert Upon detection via this alert, APP/TWR SUP or ATCOs revert from TB-mode to corresponding DB-mode (similar to lack of glideslope wind profile input; see SR688) **Protective Mitigations** Partially for both DB and TB modes: Buffer for ITD and FTD take margins on the wind computation. In DB-mode: ATCO will realise that the tool is using incorrect wind reference because	

Possible Hz	Causes	Mitigations	Comments
		successive aircraft separated correctly using the chevrons will have the tendency to infringe the correct FTD as the leader decelerates, triggering a go-around by the TWR controller. In TB-mode: It is difficult for the ATCO to realise that the tool is using incorrect wind reference. The a/c will be separated according to a wrong FTD, i.e. wake separation infringement. TO DERIVE INTEGRITY/RELIABILITY SO OR SR Mitigation for sudden wind variation: *SR300: "For all DB modes with ORD (i.e. displaying ITDs) and TB modes, the Approach and Tower Controllers and Supervisors shall be alerted by the glideslope headwind monitoring function about a significant difference between actual glideslope headwind profile and the glideslope headwind profile used for the TDI computation, i.e. when the predicted time-to-fly (based on the headwind profile prediction used for Target Distance Indicator computation) compared to the actual time-to-fly (based on the actual headwind measurement) exceeds a threshold to be determined locally"*	

Possible Hz	Causes	Mitigations	Comments
HUMAN PERFORMANCE	1. What additional wind information would you require as compared to today`s operations? What about the supervisor?		

Possible Hz	Causes	Mitigations	Comments
7. Incorrect separation indicator in relation to speed non-conformance of the leader aircraft Cause for Hz#05	(a) ATCO failure to detect a/c abnormal speed (b) Speed conformance alert failure	**Preventive Mitigations:** (a) Speed conformance monitoring alert (10NM to DF) (b) The tool computes some buffer for coping with speed non-conformance **Protective Mitigations** Go-around to Follower (because TDI might be wrong)	
HUMAN PERFORMANCE	1. A failure of LORD related alerts would make you uncomfortable working with the LORD, prompting that other indications might be incorrect?		

E.1.3 Applicable to the Final Approach Phase

Possible Hz	Causes	Mitigations	Comments
8. Inadequate use of separation indicators by the APP ATCO Cause for Hz#03a	(a) ATCO confusion between separation and spacing (b) ATCO does not adjust a/c speed to solve a conflict due to catch-up effect	**Preventive Mitigations:** (a to c) Catch-up alert (a to c) Adequate ATCO training for the use of indicators **Protective Mitigations** Go-around (note that ITD and FTD are computed with buffers, which gives some	

Possible Hz	Causes	Mitigations	Comments
	(c) Inadequate ATCO competency/currency with the use of indicators	room to ATCO to prevent the loss of separation if the problem is detected)	
HUMAN PERFORMANCE			

Possible Hz	Causes	Mitigations	Comments
9. Aircraft deviates from the final approach speed profile expected by ATC Cause of Hz#04a	(a) Pilot picks up instruction for other a/c (b) Pilot deviates from expected/instructed speed profile (c) Aircraft failure (d) Un-stabilized approach	**Preventive Mitigations:** (a, b) Publish procedural air speed on Final Approach (a, b) Add briefing to airlines, provide monthly reports on speed compliance (e.g. as in EGLL), follow-up with WebEx/calls. **Protective Mitigations** Supported by catch-up warning; Re-clear a/c to fly a different speed if possible OR Go-around;	
HUMAN PERFORMANCE			

Possible Hz	Causes	Mitigations	Comments
10. Lack/loss of indicator for one aircraft on Final App Cause of Hz#01a and Hz#03a	(a) ORD tool failure (b) Sequencer tool failure (c) Aircraft not in the arrival sequence tool (d) Flight planning information (A/C Type or WT CAT) missing or not recognized for a given aircraft	**Preventive Mitigations:** **Protective Mitigations** ATCO detects the missing indicator and: Aircraft established on Final approach stabilized with 160kts IAS and behind ITD is allowed to continue the approach, otherwise initiate Go around Proposed saf req: Consider this non-nominal situation in Training and in the procedures (operating manual) Proposed saf req: Consider this non-nominal situation in Training and in the procedures (operating manual) To validate *SRx41 (REQ-02.01-SPRINTEROP-OPS3.0004): "The tool shall provide ATCOs the ability to selectively supress TDIs for specific aircraft (Rationale: For example in case of delegating responsibility for wake separation to flight deck)"*	
HUMAN PERFORMANCE	1. Would you feel comfortable working with the TDIs for the following a/c pairs? 2. Would you just increase separations for this a/c pair (DBS) and then continue with TBS? 3. Would you consult the Supervisor à new procedure?		

Possible Hz	Causes	Mitigations	Comments
Protective mitigation for above hazards			
11. Fail to recover from imminent	(a) ATCO failure to detect need for recovery action (e.g. Go around,	**Preventive Mitigations**	

Possible Hz	Causes	Mitigations	Comments
infringement by adequate action Cause for: Hz#01b, Hz#02b, Hz#03b, Hz#04b	break off etc- depends on the triggering event) (b) ATCO failure to instruct timely the separation recovery action before the imminent infringement is evolving to a large under-separation (c) Pilot failure to timely execute the separation recovery instruction	FTD (in TB concepts) and ITD (in both DB and TB concepts) are computed with buffers to attempt to prevent separation infringement, regardless of the value of the FTD. Outside a pre-defined region (4NM at Heathrow): STCA will trigger. Indication of IAS and GS to APP ATCO (current mitigation). **Protective Mitigations** With respect to WTE risk: Follower within WV influence area, WV survival in the flight path (F6) Wake impact & upset (F5) Wake encounter recovery (B1) The use of ORD is expected to mitigate that risk increase by contributing to the reduction of separation infringements thanks to the increased separation delivery accuracy.	
HUMAN PERFORMANCE			

Possible Hz	Causes	Mitigations	Comments
	Abnormal conditions		
12. Unplanned blocked Runway Abnormal condition	Debris on RWY	**Protective Mitigations** Instruct Go around & break off to all aircraft established or in the process of interception	

Possible Hz	Causes	Mitigations	Comments
		- Instruct go around (alternative left, straight, right – if those alternatives are possible at the airport, for horizontal separation) - Instruct level off at different intermediary altitudes (for vertical separation) - Transfer to Departures.	
HUMAN PERFORMANCE			

Possible Hz	Causes	Mitigations	Comments
Applicable to Mode Management (Selection, Transition)			
13. Incorrect selection or transition management of separation mode when a/c established on final (only with conditional application e.g. in WDS) Hz#07	(a) Corrupted surface wind indication (b) Fail to detect that wind cond are not or no more met (c) ATCO activate TB mode without SUP decision (d) Confusion between ATCO-SUP about first aircraft to be separated according to the new activated mode	**Preventive Mitigations:** SW assurance Reliable wind measurements (double source) **Protective Mitigations**	

Possible Hz	Causes	Mitigations	Comments
HUMAN PERFORMANCE	1. Examples from today`s operations (e.g. when they switch to LVP)? 2. What does the SUP coordination imply? 3. How do the supervisors communicate (more need of silent communication?)? 4. What is the role of the ATCO in the transition? 5. When do the supervisors need to consult ATCOs? 6. How would the tool display this information? (both ATCO and SUP) 7. What type of alerts would they need? (both ATCO and SUP) – wind related/ mode related etc. 8. Any other potential risks remained unidentified? 9. Any additional information needed for ATCOs? (e.g. the first aircraft in the arrival sequence to be separated according to the new mode (e.g. at least 2 min before interception) 10. Unaware whether you operate in DBS or WDS/TBS –PWS: would a simple indication of the mode of operation be enough? 11. Supervisor WKLD? à significant changes? 12. Equitable distribution of work during transition for APP – TWR (ATCO and SUP)/ communication load?		

E.2 Mixed Mode

Possible Hz	Causes	Mitigations	Comments
1. Instruct aircraft line-up in conflict with arrival aircraft	(c)	**Preventive Mitigations:** A wrong Sequence planning information is systematically detected by ATCO (via his situation awareness & own view of the correct sequence and possible use of a gap) **Protective Mitigations** Go around timely instructed & executed (RWY Col AIM Barrier B2)	A failure, loss or corruption of the sequence list tool will have an impact on the ATCO performance, but is safely mitigated by ATCO keeping full awareness of the sequence in the short term. ATCO will apply a more conservative strategy (e.g. instruct 2 departures in a gap instead of the 3 initially planned), will estimate the

Possible Hz	Causes	Mitigations	Comments
			departures fitting in the arrival gaps by himself.
HUMAN PERFORMANCE	1. Current alerts? 2. Sequence toolà coordination changes? (more silent coordination- e.g. manual input of time to be approved?) 3. What if the sequence list has inaccurate values? Would you consider it feasible for you to identify them without an alert? 4. Coordination for the gap- requirement to not make such a coordination after base leg?		

Possible Hz	Causes	Mitigations	Comments
2. Aircraft lines-up without instruction in conflict with arrival aircraft	(a) lines-up without instruction	**Preventive Mitigations:** Stop-bar and A-SGMCS features that might identify such non authorized runway incursions **Protective Mitigations** Go around timely instructed & executed (RWY Col AIM Barrier B2)	As per current ops
HUMAN PERFORMANCE	1. Different than today`s operations?		

Possible Hz	Causes	Mitigations	Comments
3. Delayed take-off brings lined up aircraft in conflict with arrival aircraft	(c)	**Preventive Mitigations:** **Protective Mitigations** Go around timely instructed & executed (RWY Col AIM Barrier B2)	As per current ops
HUMAN PERFORMANCE	1. Different than today`s operations? 2. Slow reaction times under 2nm MRS/ pilot reluctance à any change in phraseology needed?		

Appendix F PJ.02.01 / PJ.02.02 / PJ.02.03 Pilots and ATCOs Workshop

A workshop with pilots from Air France and CDG ATCOs has taken place on the 28th of January 2019 on the Air France premises at CDG airport. The workshop was facilitated by SAF and HP experts from EUROCONTROL and it included APP and TWR ATCOs from DSNA, pilots from Air France, together with safety, human performance and concept experts from EUROCONTROL. The workshop helped clarifying remaining SAF/HP and concept questions for projects PJ.02.01, PJ.02.02 and PJ.02.03. Note only the results from PJ.02.01 and PJ.02.03 were kept in this appendix.

PJ	QUESTION	RATIONALE	COMMENTS:
PJ.02-01 PJ.02-03	1. Pilots do not conform to ATC clearances as they may not be comfortable with the reduced separations, e.g. pilots may reduce speed to ensure they have what they consider to be a safe spacing between themselves and the a/c ahead.	Clarify responsibilities between ATCOs and pilots for conformance to speed instructions. Would information campaigns ensure higher acceptability of procedures/ reduced separations?	Depends on confidence pilot vs ATCO. E.g. ATC London is perceived to be more precise than CdG (note that TBS tool-based is already implemented in London) In London the Pilot feels safer when the landing clearance is given only when RWY is safe (and not landing clearance anticipately instructed as in CdG)- according to the Pilots this seems to be the procedure in most airports but not in CdG. As a result, the pilots consider that information campaigns are paramount in order to gain trust and confidence in new procedures and related ATC instructions. Difficult for Heavy to maintain high speed till 4NM (risk for not able to adequately decelerate) –e.g. case of high headwind Difference between instructed speed (based on ground speed as perceived by ATCO) and the IAS ECTL: Note the ORD tool accounts for variability of speed profile for various a/c type via a computation buffer. The time to fly accounts for the wind conditions Regarding awareness of separation applicable on Final App, Pilots follow the ATC instructions (not possible to be familiar with the different

			separation minima applicable on airports around the world) and they consider that especially because of the complexity/diversity of new procedures it should remain the case (pilots shall trust and follow ATC instructions). The ATCOs present in the meeting agree with this approach.
PJ.02-01	2. What information would you require in case an airport is applying under certain conditions reduced wake separations, in addition to the AIP (no indication about actual WDS or DBS mode of operations)?	Flight crew are unaware of the transition or mode of operations DBS and WDS operation. They may ignore ATCOs instructions if they feel that the spacing is not appropriate given the mode of operation.	Pilots do not need much information on frequency Everything that is static becomes standard and should be published in AIP : MRS 2NM, S- PWS (e.g. RECAT) Need of information on ATIS regarding the differences from standard: reduced separation on Fin App WDS (conditional application) Note in CdG the Pilots may sometimes deviate from instructed speed (e.g. reduce speed below the instructed one) or published altitude restrictions (e.g. on STAR) That highlights the importance of information campaigns and change management with the introduction of new separation minima (in addition to AIP publication) For more awareness, in case the condition is active, this could be “highlighted” in the ATIS. Currently they do not have this info (e.g. London), but Pilots consider it would be an added value.
PJ.02-01 PJ.02-03	3. Do you require additional info. from the ATCOs, as compared to today`s operations, in order to continue to monitor and conform to safe separations? (e.g. a/c type in front etc.).	Identify info. requirements for pilots to allow them to accurately monitor WDS on approach and to request/take appropriate action in the event that they were	Not enough time/resources (e.g. R/T already busy enough) to perform such check, even in case a cockpit tool would be available.

		concerned that wake separation is lost.	
PJ.02-01 PJ.02-03	4. Would you need a cockpit tool that indicates the applicable separation minima?	Pilots might not adhere to speed instructions and procedures on the FIN APP resulting in separation infringements.	No See above (that would increase Pilot workload) ATC would be in a better position to initiate & manage a Go around Meanwhile, such tool might be useful in case of high wind (involving significant difference of IAS vs ground speed)
PJ.02-01 PJ.02-03	5. Do you consider the need to double check separation values with ATCOs would increase, when applying reduced MRS/conditional separations?	Could WDS negatively impact the amount of R/T usage between pilots & ATCOs. à Validation activities show an acceptable level of R/T for ATCOs during hypothetical normal operating conditions (i.e. no questioning by Pilots)	Pilot will not perform such check (see points 1 and 3 above)
PJ.02-01 PJ.02-03	6. Is the responsibility of the pilots remaining unchanged?	In terms of monitoring and task requirements.	No changes identified.
PJ.02-01 PJ.02-03	7. Can the flight crew detect inappropriate ATC instructions?	Only gross WT separation error can be detected by Pilots in WDS; more efficient detection in PWS, as Pilots might be able to roughly appreciate WT separation of the their aircraft type behind the Leaderà **Weak mitigation**	Pilots share the same view as the one described in the ATC workshop, i.e. they confirm that checking applicable separation minima is not their responsibility and they have neither the means nor the workload resources to ensure that

		According to the ATCOs this is not the responsibility of the pilots, therefore they do not consider this as a solid and effective mitigation.	The pilots. They consider ATCOs should have enough information to correctly instruct them, referring again to the importance of trust between the 2 actors. (see points 1 and 3 above)
PJ.02-01 PJ.02-03	8. Is there a possibility for the pilot/aircraft to accelerate at interception or on the final approach path without ATCO instruction? (due to a pilot error or aircraft malfunction)	Wake FAP: WE11.2 MAC FAP: MB9.2	Not relevant. Sometimes the aircraft might increase speed (e.g. increased speed due to the high weight) but Pilot monitors and corrects
PJ.02-01 PJ.02-03	9. Is there a need to revise phraseology?	E.g. the phraseology is clear for communicating between ATCOs and pilots in regard to their position in relation to the a/c ahead on final approach (confirm to follower a/c their position with respect to the a/c ahead on final approach). How to inform the reduced MRS? Slow reaction times for 2nm MRS due to pilot reluctance require any change in phraseology needed for a fast input? RTS results: The ATCOs consider	Again Pilots recall their recommendation for removing the early landing clearance at CdG, in order to improve Pilots confidence. This is a requirement in order to enable the implementation of the reduced separations, in order to increase the Pilots confidence in ATC instructions (that is misleading for the Pilots, they have the wrong feeling that responsibility for RWY separation is somehow delegated to them) Additionally, the early landing clearance is not on the safe side because in case of frequency occupancy or interference or radio failure, the a/c will proceed on landing whilst the RWY is not clear of traffic. In the USA they use as well “clear to land behind” in case the runway was not vacated yet. The current ATC procedures (in CdG) will need to be changed, besides the early landing clearance, also for phraseology: no more need to inform about ahead aircraft type and distance – that is no more feasible and useful with the complex new PWS and WDS separation minima.

		the phraseology is clear. ➔ a/c type to be specified upon first contact with ATC? (as a mitigation to an erroneous a/c type in PLN)	RRSM (RWY Reduced Separation Minima) – require a second TWR ATCO dedicated to monitoring & instructing Go around (in case the 2400 m wrt to the Leader are not met by the time the Follower attempts landing). Pilots need to listen to both TWR frequencies (applies in certain US airports, both single RWY and CSPR) Pilots feel there would not be additional workload if they are required to declare the a/c type at first radio contact (instead of the currently "super" or "Heavy") On ATCO side: to analyse whether at INI or ITM first contact (in order to minimize the length of that message). Nonetheless, both pilots and ATCOs mentioned that the exchange with the INI is already quite heavy. The FPL inconsistency might be 1 – 2 per year at CdG (to check with the CdG Safety manager & data collection) In London the a/c reporting became mandatory with the application of TBS (**Question to NATS**: how is this a/c type provided: full name or not – significant for certain PWS pairs e.g. B777 /200 with 60m wing span and /300ER with 64m wing span – the former called B777/2 , the latter B777/W). Alternatively, the PWS table might be simplified (conservatively group the B777/2 under the B777/W). That would be justified due to the ROT as well. ***ANSWER NATS:*** *The a/c type is provided in detail by Heathrow (e.g. B77W) – beside the fact that different a/c types are separated differently in terms of wake, it is important to state the type because different types also have different stabilisation speeds.* In the US, in certain airports a 2nd frequency with a different ATCO needs to be monitored by pilots on final approach, in case a go-around is required. This applies for very complex environments. Ideally, the introduction of the Mode-S datalink would resolve this issue in the future.

PJ.02-01 PJ.02-03	10. TCAS TA nuisance?	Identify parameters under which aircrew would become sufficiently concerned at a perceived loss of separation that they take unilateral action?	To check whether the reduced separations would involve TCAS nuisance alerts Pilots will give priority to ATCO on Final Approach Pilot suggestion: To arrange the ORD such as to avoid TCAS nuisance alerts, but not change the current TCAS settings (in order to preserve the Pilot confidence in TCAS; note TCAS is very useful at certain airports in order to e.g. at Nice to secure separation against intruding helicopters. Note TA received till ground. RA inhibited below 1000ft. (PJ.02-03 is currently checking via FTS that RA are not triggered with 2NM MRS; on CSPR there might be a issue)
PJ.02-01	11. In case of strong crosswind the wake separations could be completely removed. This means that MRS or ROT will apply with a final spacing of about 2.5/3.0 NM behind very heavy aircraft. Provided that enough briefing and concept awareness is provided to Pilots, Airlines other AU, would they accept these separations (e.g. fly with an A320 at 3.0 NM behind an A388, with 13knots crosswind)?	Already RECAT-EU had 2NM reductions for A388-Upper Medium and Lower Heavy-Upper Medium pairs compared to ICAO. However, with RECAT-EU A388-A320 the wake separation was still 5 NM. With WDS-XW we could have 3.0 NM for the same pair, so even with no wake risk there is the ''perception'' from the cockpit of being very close to the leader aircraft and with challenging wind conditions due to the strong crosswind.	Covered above (see points 1 and 3)
PJ.02-01 Depart.	12. How often do Pilots question the time of the take-off instruction wrt WT considerations?	Departures	Current Pilot procedure (AF SOPS compliant with ICAO): Pilot shall check the time separation with previous take-off, in complement to the ATC instruction for take-off (prior to that Pilot requests to ATCO the previous

			aircraft type, if necessary). For the time being the regulation requires them to double-check. That needs adaptation when D-PWS and D-WDS will be introduced (safety question: the safety barrier represented by Pilot crosscheck will disappear; note that unlike for Arrivals, the aircraft might face wake encounter as soon as it rotates after take-off i.e. no room for ATCO to monitor/recover WT separation)
PJ.02-01 Depart.	13. Prior to push-back (or at the latest before line up) the pilot is either instructed the SID by Ground ATCO or ask confirmation of Ground ATCO for the SID value that has been automatically entered by AO FPL system à always asking/ crosschecking?	Do pilots always ask confirmation for the automatically entered SID? Is this within the required responsibilities? Are you aware of any occurrences of SID mismatch between the ATC expected and the FMS SID?	Pilots do debriefing and check SID that is input in FMS. If they do not receive any SID info with the clearance, they consider the info in the FMS is correct- they do not double check. Sometimes there is a last minute change of the SID between off-block and take-off time (not frequent, because safety critical and time consuming; new SID involves additional onboard checking & computation). The same for RWY entry point
PJ.02-01 Depart	14. Does the pilot switch on the auto-pilot in the stable climb phase before the first SID turn? (flown manually over the take-off roll, rotation, the unstable climb phase and the transition to the stable climb phase)	Question related to the Departures WDS Crosswind concept concerning the navigation performance (which links to a certain deviation from the initial common departure path).	Switch on the auto-pilot at minimum 100ft and at least 5 sec after lift-off (in general it might be as early as e.g. 400ft or as late as e.g. 10000ft) Lateral deviation is not significantly different between whether on Manual (Flight Director) or Autopilot mode Only some slight pitch deviation The climb profile depends on weight, noise abatement procedures (e.g. NADP1 climb first 1300ft then retract flaps at 3000ft). But same procedure applicable to all aircraft departing from same RWY Lateral deviation might arise due to engine failure, strong crosswind, Pilot experience (young)

PJ.02-01 PJ.02-03	15. What other possible impact of reduced separations is envisaged by pilots in terms regarding workload; situational awareness, task performance and task distribution?	Identify impact of any such changes to flight deck procedures on pilot cognitive and physical demand. e.g. do you envisage an increase in workload due to the decreased buffer (go-around procedures, speed adjustment etc)	TCAS TA might trigger also during initial departure. Risk for reducing too close to the minimum speed (stall). There are three phases, each of them with specific rate of climb In case of separation on level (need to stop the climb to prevent MRS separation infringement- mainly following a take-off clearance given too soon), potential risk for aircraft because that would involve need for thrust reduction. Not more frequent need for stopping the climb in case of the application of reduced WT separation. Instructing lateral deviation to prevent separation infringement is rare. Normally not allowed below MSA, however that rule might be infringed in critical situations, at airports with low terrain/no major obstacles.

Appendix G Risk Classification Schemes for relevant accident-incident types

Appendix G covers the following Concepts Solutions:

- Accident-incident types for Arrivals Concepts Solution in Section G.1
- Accident-incident types for Arrivals and Departures Concepts Solutions in Section G.2

G.1 Accident-Incident Types for Arrivals Concepts Solutions

Severity Class	Hazardous situation	Operational Effect	MTFoO (per approach)
Wake-SC1	Aircraft accident following an encountered wake turbulence which led to a fatal structural failure, a collision with the ground or a collision with other aircraft in the air	Wake Induced Accident (WE1)	2E-08
WK-FA-SC2a	A situation where a wake-induced accident was prevented by the aircraft wake encounter recovery (both correctly and under-separated aircraft)	Wake Encounter (WE5 i.e. WE2/3/4)	1E-05
WK-FA-SC2b	A situation where a wake encounter was prevented by the wake encounter avoidance (both correctly and under-separated aircraft)[7]	Imminent wake encounter (WE6S, WE6F)	1E-05
WK-FA-SC3a	A situation where an under-separation not managed within safe margins occurred	Under- separation not managed within safe margins (WE7F)	2E-04
WK-FA-SC3b	A situation where an unmanaged under separation is prevented by ATC separation recovery	Imminent Infringement (WE 8)	1E-02
WK-FA-SC4	A situation where a Crew/aircraft induced imminent infringement during interception or on the Final Approach path was prevented by ATC spacing conflict management	Crew/Aircraft Induced spacing Conflict during Interception (WE11) or on Final Approach (WE10)	1,00E-01

Table 30: Risk Classification Scheme for WT Accident on Final Approach for the PJ.02.01 Arrivals Concepts Solutions

[7] This barrier is ineffective in current operations (will be supported by SESAR 2020 PJ.02-01 Wake Risk Monitoring & Awareness)

G.2 Accident-Incident Types for Arrivals and Departures Concepts Solutions

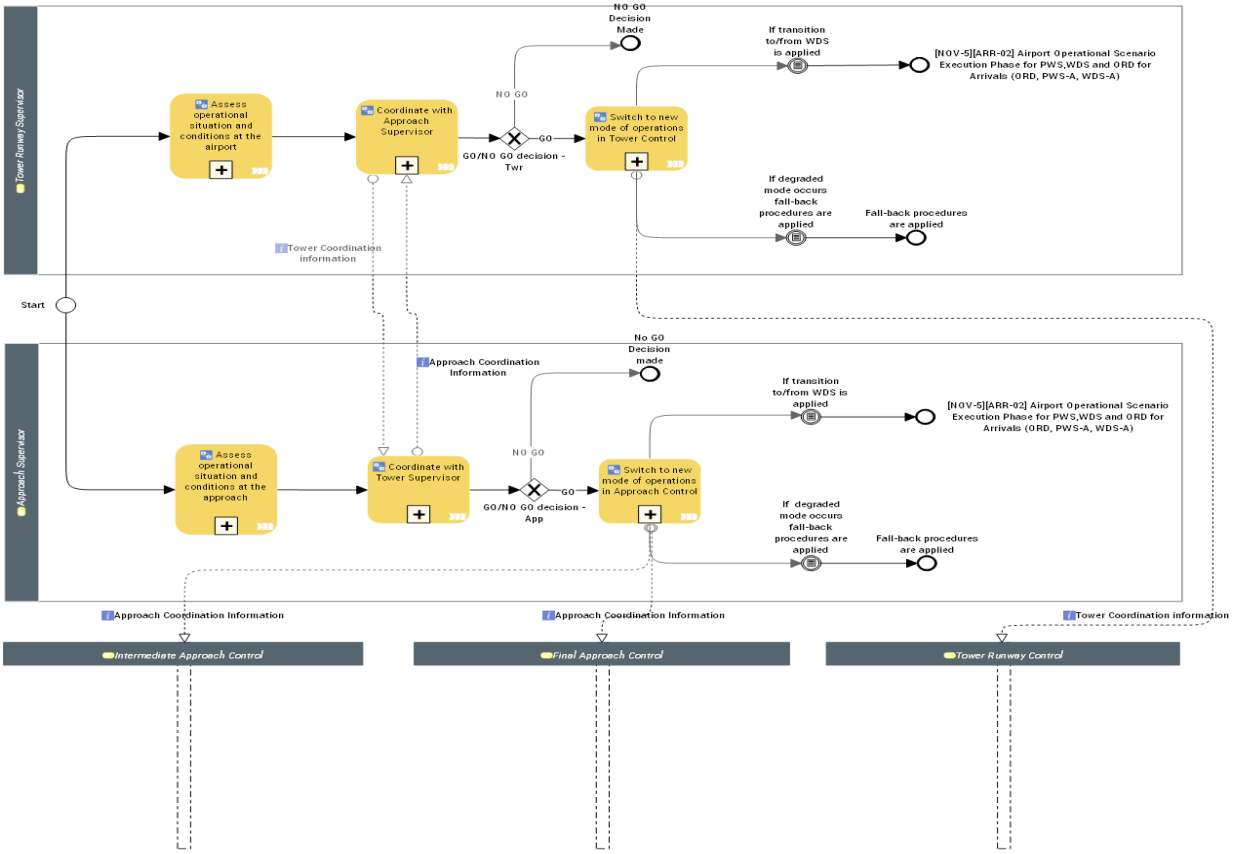
Severity Class	Hazardous situation	Operational Effect	MTFoO [per movt.]
RWY-SC1	A situation where an aircraft has come into physical contact with another object on the runway	Accident - Runway Collision (RF3)	1e-8
RWY-SC2a	A situation where an imminent runway collision was not mitigated by pilot/driver or aircraft system collision avoidance but for which geometry has prevented physical contact.	Near Runway Collision (RF3a)	1e-7
RWY-SC2b	A situation where pilot/driver runway collision avoidance prevents a near runway collision	Imminent runway collision (RP1)	1e-6
RWY-SC3	A situation where an encounter between a/c, vehicle or person on the runway and one a/c approaching occurs but ATC runway Collision avoidance prevents it to become an Imminent Runway Collision.	Runway Conflict (RP2)	1e-5
RWY-SC4	A situation where a runway incursion due to unauthorized entry/exit is concurrent with another aircraft awaiting clearance to use the runway but ATC runway conflict prevention prevents this situation to become a runway conflict	Runway incursion (RP3)	1e-4
RWY-SC5	A situation where runway monitoring prevents a runway incursion	Imminent Runway incursion (RP4)	1e-2

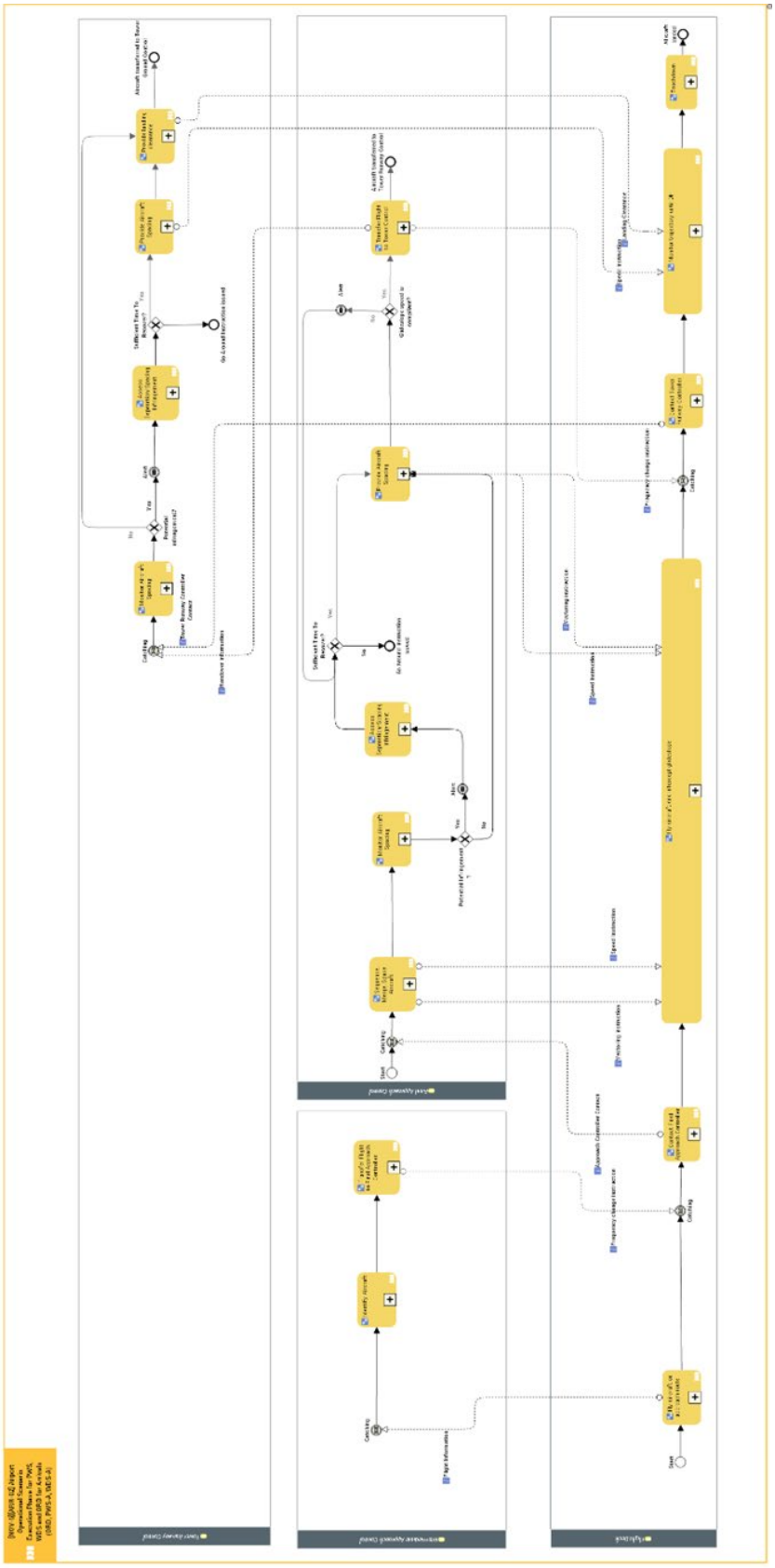
Table 31: Risk Classification Scheme for Runway Collision for the PJ.02.01 Arrivals and Departures Concepts Solutions

Appendix H EATMA Models for arrivals

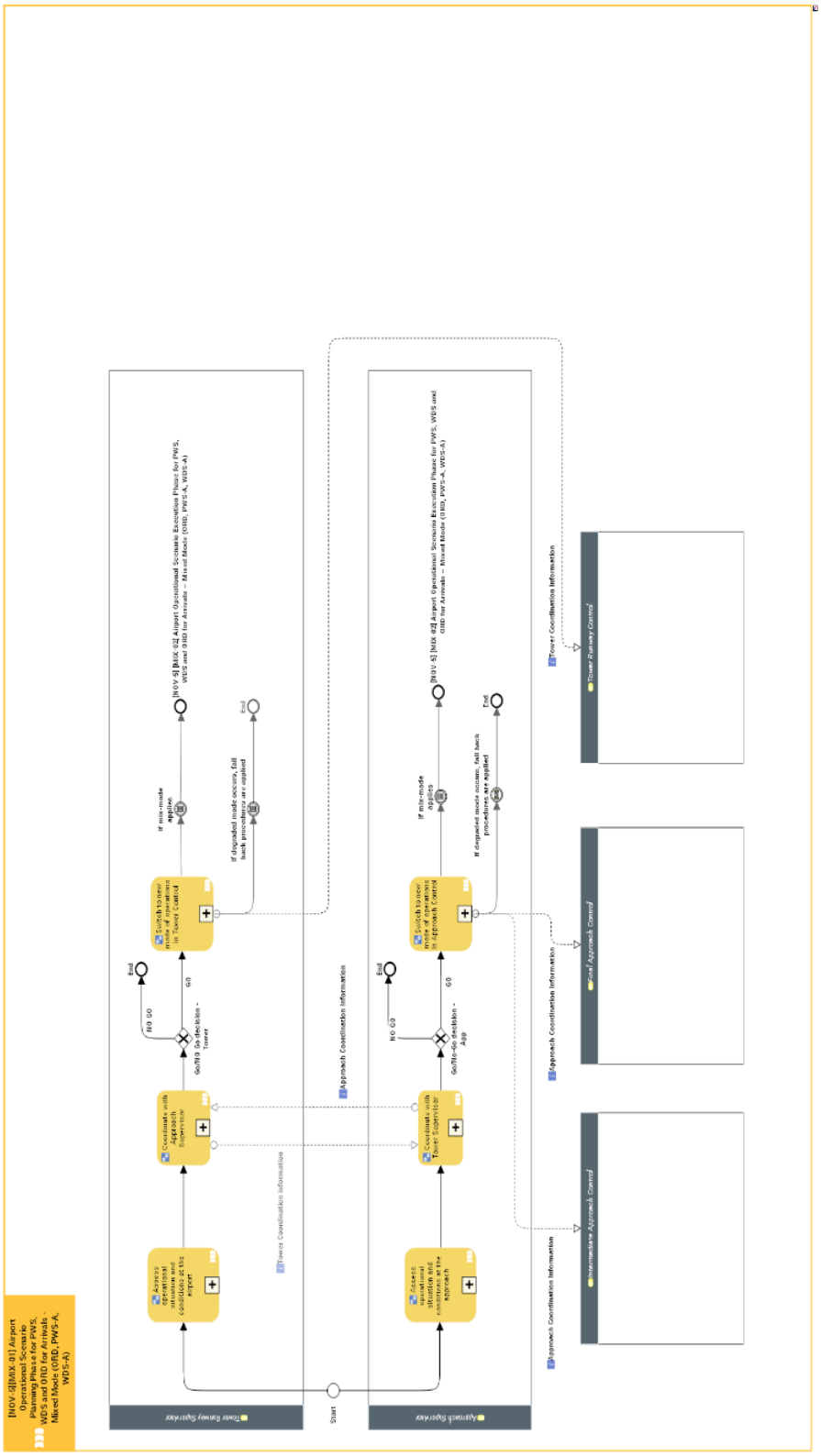
H.1 NOV-5

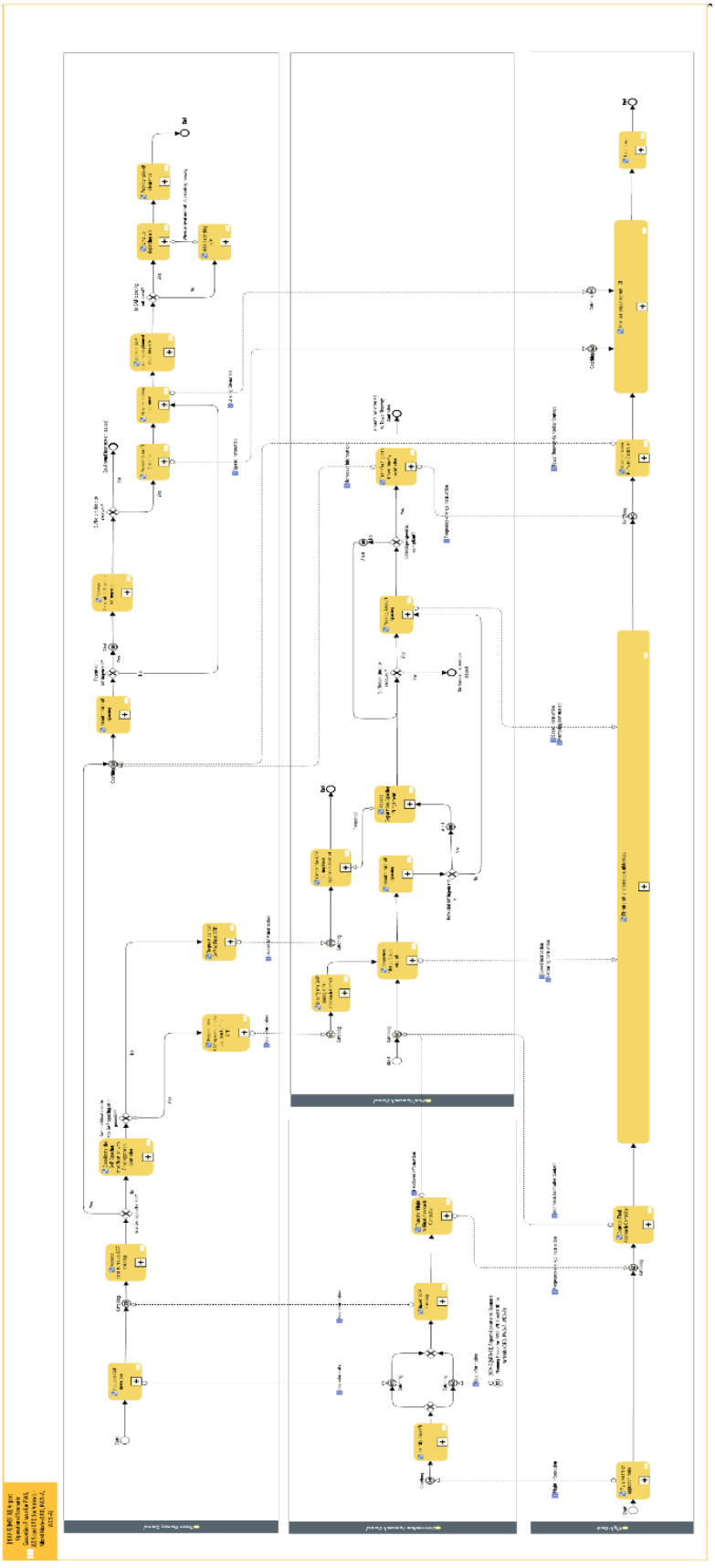
H.1.1 Arrivals





H.1.2 Mixed Mode

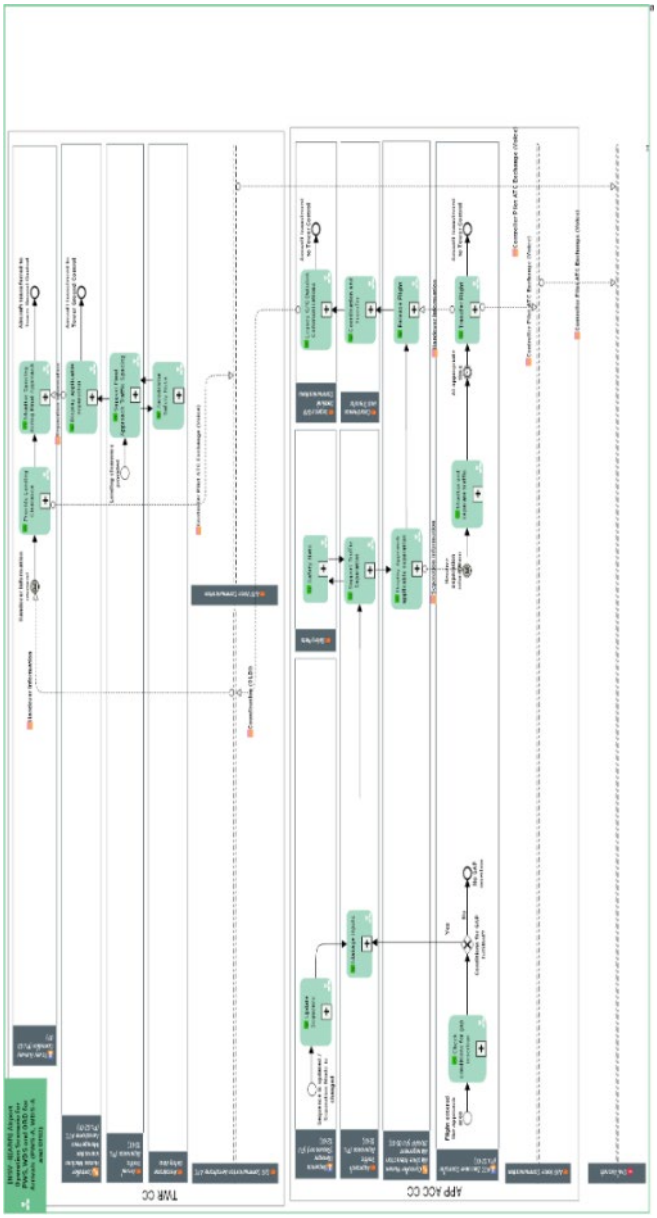




H.2 NSV-4

H.2.1 Arrivals

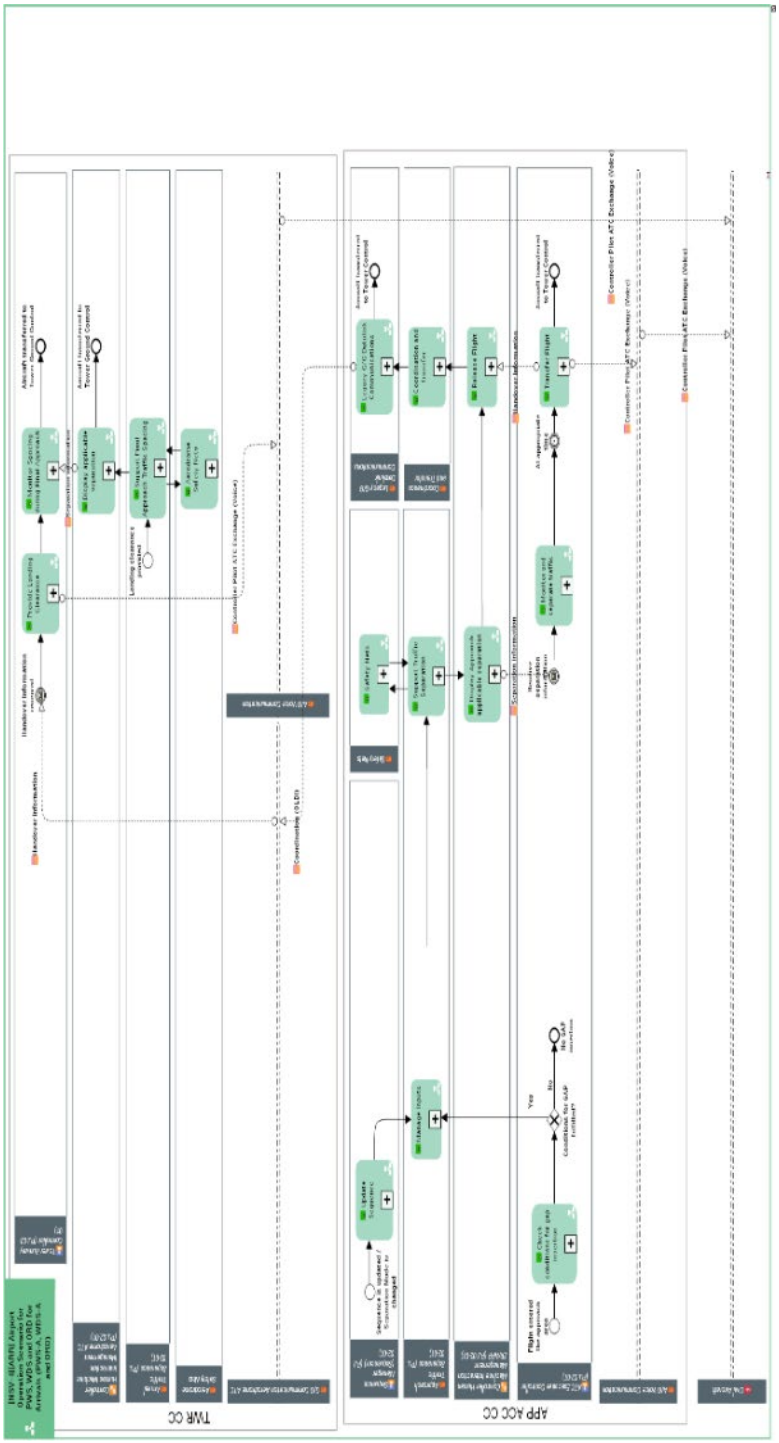
Note that, at the time when this report was written, the EATMA NSV-4 Diagrams for Arrivals were still being updated. Therefore, please refer to the NSV-4 stored in EATMA in the PJ.02.01 Folder for the latest version of the EATMA NSV-4 Use Cases for arrivals.




EUROCONTROL


NATS


SEAC


TWR CC
APP ACC CC