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AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This Operational Service and Environment Definition 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 Operational Service and Environment Definition Document provides the description of the following Operational Improvement developed in the solution PJ.02-W2-14.03 Increased Second Glide Slope (ISGS):

- AO – 0320 - Enhanced Arrival procedures using Increased Second Glide Slope (ISGS)

It presents the Safety, Performance and Interoperability requirements for ground based ATC systems and aircraft systems, identified during the validation exercises.

In addition, it explains the methodology used to determine the separations to apply between aircraft, following or not the ISGS procedures.

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1 Executive Summary

This OSED/SPR/INTEROP document has the objective to provide the description of the operational concept for "Increased Second Glide Slope" operations (ISGS).

It is based on and updates the following SESAR PJ02 Wave 1 document:

- PJ02-02 OSED-SPR-Interop Part I, D2.1.01, 24 March 2020 [38]

It is recognised that GBAS technology can easily support several approach paths and therefore may be considered as a valuable enabler. Nevertheless, RNAV guidance will as well be considered because it is anticipated that most aircraft will be able to follow RNAV procedures, whereas only 25% of the fleet is expected to be GBAS-equipped in 2025.

2 Introduction

2.1 Purpose of the document

The OSED/SPR/INTEROP document is used as the basis for assessing and establishing operational, safety, performance and interoperability requirements for the related systems further detailed in the Part II - Safety Assessment Report, Part III – Security Assessment Report, Part IV – HP Assessment Report, Part V – Performance Assessment Report. This document identifies the operational services supported by several entities within the ATM community and includes the operational expectations of the related systems.

2.2 Scope

The OSED/SPR/INTEROP document covers the concept of operation for the Enhanced Arrival Procedures using an Increased Second Glide Slope, AO-0320. This procedure allows reducing the environmental impact (e.g. noise, fuel) by having part of the traffic going to an airport, flying a higher approach slope.

The OI AO-0320 has reached V3 on-going maturity level at the end of PJ02-02 in Wave 1 and the objective of PJ02 W2 14.3 is to bring it to full V3.

This OSED/SPR/INTEROP document develops the use cases for the OI, defines the Operational Requirements and captures expected performance in accordance with the performance framework.

2.3 Intended readership

This document is to support any Airspace Users, ANSPs, Airport Operations and Safety Regulators willing to develop and implement one or more of the proposed approach procedures.

2.4 Background

PJ02 W2 Solution 14.5 complements studies started in the frame of SESAR1 in projects P06.08.08 and continued in SESAR 2020 W1 PJ02-02. The picture below shows the validation activities performed in P06.08.08 on part of the OIs covered by PJ02-02. Details on the outputs of PJ02-02 activities can be found in [39]. It has to be noted that the procedure was called "Increased Glide Slope (IGS)" in P06.08.08 and SESAR 2020 W1 PJ02-02.

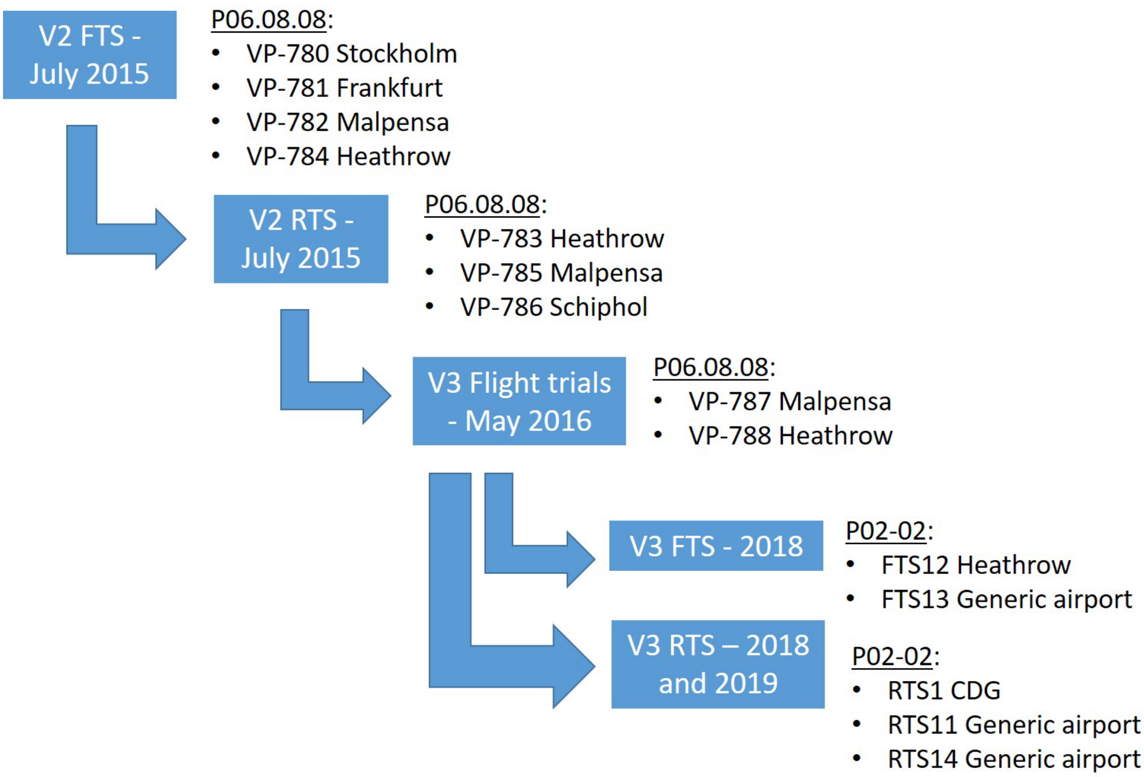

Figure 1: Validations activities performed on ISGS in SESAR1 P06.08.08 and SESAR 2020 W1 PJ02-02

The major recommendations from PJ02-02 [39] were:

- the need to consider the non-nominal situations, and in particular the loss of the ATC tool supporting the controllers in ensuring the needed separations between the aircraft approaching on standard and ISGS procedures.
- the need to consider go-arounds/missed approaches.
- the need to evaluate proposed solutions for PAPI for ISGS approaches.

2.5 Structure of the document

The structure of the document is as follows:

- Chapter 1: This section introduces the document.
- Chapter 2: This section provides the document introduction, its scope, purpose, intended audience, background information as well as the glossary of terms and acronyms.
- Chapter 3: This section gives a description of the detailed operating method and operational environment.
- Chapter 4: This section provides the Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP) that have been validated during validation activities at V3 level.

- Chapter 5: This section lists the references and applicable documents used in producing this document SPR-INTEROP/OSED.
- Chapter 6: This section presents the cost and benefit mechanisms for ISGS procedures
- Chapter 7: This section provides a description of ISGS procedures
- Chapter 8: This section explains the separation design for ISGS
- Chapter 9: This section provides a wake separation minima calculator for ISGS

2.6 Glossary of terms

Term	Definition	Source of the definition
Enhanced arrival operations	Generic term referring in a general manner to all operational concepts developed in SESAR Wave 1 PJ02-02: IGS, A-IGS, SRAP, IGS-to-SRAP, CSPR-ST. The current document concerns only ISGS.	Project definition
Obstacle Clearance Altitude/Height (OCA/H)	In a precision approach procedure, the OCA/H is defined as the lowest altitude/height at which a missed approach must be initiated to ensure compliance with the appropriate obstacle clearance design criteria	ICAO Doc 8168 PANS OPS
Autopilot / Flight Director	AP/FD means that both the Autopilot and the Flight Director are used by the flight crew. They are both driven by the guidance targets coming either from the FMS (FPLN follow up) or the flight crew itself (target selected on Auto Flight system Control Panel). The pilot does not touch the aircraft stick command. FD only means that the Flight Director is displayed and followed manually (using the stick command) by the flight crew on the Primary Flight Display. Without AP/FD means that the flight crew flies a pure manual final approach with the unique aid of lateral and vertical deviations displayed on the Primary Flight Display.	Project proposed definition

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
AIC	Aeronautical Information Circular

A-IGS	Adaptive Increased Glide Slope
AMC	Acceptable Mean of Compliance
ANP AR	Required Navigation Performance Authorization Required
ANSP	Air Navigation Service Provider
AO	Aerodrome Operations
AP	Auto Pilot
AP/FD	Autopilot / Flight Director
APOC	Airport Operations Centre
APP	Approach
ASAS	Airborne Separation Assistance System
ATC	Air Traffic Control
ATCO	Air Traffic Controller Operator
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace Users
CCDF	Complementary Cumulative density Function
CNS	Communication, Navigation & Surveillance
CONOPS	Concept of Operations
CSPR-ST	Closely Space Parallel Runway - Staggered Thresholds
CWP	Controller Working Position
DA(H)	Decision Altitude/Height
DBS	Distance Based Separations
DCB	Demand and Capacity Balancing
DH	Decision Height
DT	Displaced Threshold
EAO	Enhanced Approach Operation
EASA	European Union Aviation Safety Agency

E-ATMS	European Air Traffic Management System
FD	Flight Director
FMS	Flight Management System
FPL	Flight Plan
GBAS	Ground-Based Augmentation System
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
IGE	In Ground Effect
IGS	Increased Glide Slope
IGS-to-SRAP	Increased Glide Slope to Second Runway Aiming Point
ILS	Instrument Landing System
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
ITD	Initial Target Distance indicator
KPA	Key Performance Area
KPI	Key Performance Indicator
LOC	Localizer
MRAP	Multiple Runway Aiming Points
NavDB	Navigation Database
NM	Nautical Mile
OCA/H	Obstacle Clearance Altitude/Height
OFZ	Obstacle Free Zone
OGE	Out-of-Ground Effect
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAN	Precision Approach Navigator

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PANS	Procedures for Air Navigation Service
PAPI	Precision Approach Path Indicator
PBN	Performance Based Navigation
QFU	Runway in use
RECAT-EU	European separation standard for aircraft wake turbulence
RET	Rapid Exit Taxiway
RMC	Rolling Moment Coefficient
RNAV	Area Navigation
RNP	Required Navigation Performance
ROT	Runway Occupancy Time
RTS	Real Time Simulation
RWC	Reasonable Worst Case
SBAS	Satellite-Based Augmentation System
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SOP	Standard Operating Procedure
SPR	Safety and Performance Requirements
SRAP	Second Runway Aiming Point
TBS	Time Based Separations
TMA	Terminal Manoeuvring Area
TS	Technical Specification
TSE	Total System Error
TTOT	Target Take Off Time
TWR	Tower
Vapp	Approach Speed

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VASI	Visual Approach Slope Indicator
WVE	Wake Vortex Encounter

275 **Table 2: List of acronyms**

3 Operational Service and Environment Definition

3.1 SESAR Solution PJ.02-W2-14.3: a summary

This solution introduces an increased second glide slope (ISGS) as a new concept of enhanced approach operations. ISGS helps reduce the environmental impact by the use of two glide slopes active simultaneously.

By doing so, the environmental impact should be reduced as aircraft flying on the higher slope should generate less noise.

<table>
<tr><th colspan="2">The Solution is contributing to</th></tr>
<tr><td>Key feature</td><td>High Performing Airport Operations</td></tr>
<tr><td>Essential Operational Change (EOC)</td><td>Airport and TMA performance</td></tr>
<tr><td>Capability</td><td>Arrival Sequencing
Arrival Traffic Merging
Arrival/Departure Routes Management
Clearance/Instruction Management
Optimised Descent Execution
Optimised Take-Off / Landing Execution
RNP based Operations Execution
Separation Service Provision (airspace)</td></tr>
</table>

<table>
<tr><th colspan="3">SESAR Solution ID</th><th colspan="3">Title</th></tr>
<tr><td colspan="3">PJ.02-W2-14.3</td><td colspan="3">Increased second glide slope (ISGS)</td></tr>
<tr><td></td><td colspan="2">OI code</td><td colspan="2">Title</td><td>Coverage</td></tr>
<tr><td></td><td colspan="2">AO-0320</td><td colspan="2">Enhanced approach operations using an increased second glide slope (ISGS)</td><td></td></tr>
<tr><td></td><td colspan="5">Enhanced approach operations using an Increased Second Glide Slope (ISGS) will allow inbound aircraft to reduce noise footprint (environmental benefit). ISGS procedures are published approaches which feature a glide slope between the "standard" published one (commonly 3 degrees) and 4.49 degrees (limit above which steep approach concept applies), in order to provide a significant reduction in ground noise level (order of magnitude: -3 dBA in approach between 15 NM and 4 NM from runway threshold).</td></tr>
<tr><td colspan="2"></td><td colspan="2">EN code</td><td>Title</td><td>Coverage</td></tr>
<tr><td colspan="2"></td><td colspan="2">A/C-86</td><td>On-board assistance to aircraft energy management</td><td>Optional/Develo p</td></tr>
<tr><td colspan="2"></td><td colspan="4">On-board system that provides energy management cues to the flight crew supporting them in managing appropriately the overall aircraft energy to succeed in</td></tr>
</table>

	reaching energy rendez-vous. The reference one is the stabilization gate, usually at 1000 ft Above airport elevation.		
	A/C-87	On-board assistance to flare	Optional/Develop
	On-board system that provides flare assistance information to the flight crew supporting them in landing appropriately.		
	AERODROME-ATC-102	Aerodrome ATC system to support final approach operations (distinguish approach procedures)	Required/Use
	Aerodrome ATC system upgraded to support final approach operations (distinguish approach procedures) : the ATCO needs to identify without ambiguity which final approach procedure is assigned to each arrival flight.		
	AERODROME-ATC-71	Aerodrome ATC System to support ISGS operations (separation delivery)	Optional/Develop
	Upgrade of the Aerodrome ATC System in order to support increased second glide slope (ISGS) operations' management in terms of final approach airspeed conformance monitoring and separation monitoring: - allowing the Controller to record in the system the final approach procedure flown (expected and/or cleared) - upgrading the Aerodrome ATC system that supports optimised runway delivery on final approach (ORD tool) in order to: a) take this final approach procedure flown (expected and/or cleared) into account b) use the correct separation minima applicable between leader and follower aircraft resulting from the respective final procedure flown c) update the separation minima in case of change of expected final procedure for one aircraft d) take into account the air speed profile of each aircraft according to the final approach procedure flown (expected and/or cleared)		
	AIRPORT-53	PAPI for ISGS approach procedures	Required/Develop
	As procedures with two different glide slopes may be active at the same time for a same threshold, a second PAPI for the increased glideslope is required to be implemented.		
	APP ATC 114	Approach ATC System to support ISGS operations (separation delivery)	Optional/Develop
	Upgrade of the Approach ATC System in order to support increased second glide slope (ISGS) operations' management in terms of approach airspeed conformance monitoring and separation monitoring: - allowing the Controller to record in the system the final approach procedure flown (expected and/or cleared)		

	- upgrading the Approach ATC system that supports optimised runway delivery on final approach (ORD tool) in order to: a) take this final approach procedure flown (expected and/or cleared) into account b) use the correct separation minima applicable between leader and follower aircraft resulting from the respective final procedure flown c) update the separation minima in case of change of expected final procedure for one aircraft d) take into account the air speed profile of each aircraft according to the final approach procedure flown (expected and/or cleared)		
	APP ATC 170	Approach ATC system upgraded to support approach procedure assignment	Required/Use
	Approach ATC system upgraded to provide list of eligible approach procedures for a selected aircraft. The System also allows the ATCO to record the selected expected procedure as well as the further cleared one.		
	HUM-022	Flight Crew new role for handling ISGS approach	Required/Develop
	Flight Crew training relating to enhanced approach procedure using an increased second glide slope (ISGS) will cover the following: - visual references for approaches to runways operating two different glide path angles on the same threshold (i.e. VASI/PAPI and visual assessment of external environment) - energy management and flare for approaches with an increased glide path angle (when no particular assistance is provided by avionics) - assessment of feasibility of ISGS operation considering aircraft capabilities and operational conditions		
	HUM-032	ATC new role for handling ISGS approach	Required/
	ATC training relating to enhanced approach procedure using a increased second glide slope (ISGS) covering all nominal and non-nominal situations.		
	REG-0530	Regulatory provisions for increased second glide slope operations (ISGS)	Required/Develop
	Regulatory provisions (produced by the competent regulatory authority) that relate to wake separation minima when applying Increased Second Glide Slope (ISGS) procedures. These regulatory provisions consist of a minimum arrival separation table expressed in distance or/and time depending on the aircraft type/category and procedure respectively used by leader and follower (ISGS / normal ILS approach). "Regulatory provisions" refers here to advice from the regulatory authorities on the acceptability of a safety case supporting an ATM rule modification.		

	STD-113	Update of EASA/ICAO regulatory frameworks for new visual ground aids (ISGS)	Required/
	While introducing the Increased Second Glide Slope concept for enhancing arrival operations, there is a need to update both: - EASA Aerodrome regulation 139/2014 acceptable mean of compliance (AMC) and - ICAO Annex 14 relating to visual ground aids (second PAPI installation for the same runway threshold).		

Table 3: SESAR Solution PJ.02-W2-14.3 Scope and related OI steps

3.1.1 Deviations with respect to the SESAR Solution(s) definition

N/A

3.2 Detailed Operational Environment

3.2.1 Operational Characteristics

Operational interactions per context (NOV-2)	Operating Environment
[NOV-2] Enhanced Approach Operations	APT-Large APT-Medium APT-Small APT-Very Large TA-High Complexity TA-Low Complexity TA-Medium Complexity TA-Very High Complexity
Comment	
1/ Final Spacing It is assumed that ISGS is compatible with both current and future separation schemes such as Time Based Spacing. It is however worth noting that Enhanced separation minima, based on legacy ICAO wake turbulence categories or on RECAT-EU categories, are specified as a function of which approach the lead and follower aircraft are flying, as a function of ISGS glideslope angle. 2/ Airport layout ISGS is applicable to any airport layout from single to multiple runways with simple or complex taxiway structures. However, the overall airport layout along with airport neighbourhood topography may bring constraints that will be determinant as part of the selection process for the implementation of ISGS. 3/ Runway operating mode	

ISGS is applicable to both dependent and independent runways, mixed and segregated mode operations.

4/ En-Route/TMA Operations

ISGS is applicable to any arrival traffic management operations (radar vectoring, PBN route structure, vertical instructions, Continuous Descent Operations, speed instructions, etc.)

5/ Traffic Mix

ISGS is applicable to airports serving both ISGS capable and non-capable aircraft. Any aircraft wake category mix can be serviced. However, it is worth noting that, as anticipated on the near to medium term horizon, only a part of the traffic will be equipped with advanced satellite-based approach capability (e.g. GBAS or SBAS), some aircraft types from Medium or Light category group will however need to remain on the conventional approach in case ISGS relies on RNP APCH types. In order to apply the adequate separation minima for an arrival pair, the Approach and Tower ATCOs need to know which aircraft type are eligible to fly ISGS.

6/ Weather

Wind has an impact on increased glide slope operations due to more challenging aircraft energy management under tailwind conditions. Thus, a reduced use of ISGS operations can be expected under such conditions.

7/ Runway conditions

ISGS is applicable regardless of the runway conditions.

8/ Airspace consideration

ISGS is compatible with both high traffic density and low traffic density situations. ISGS will be conducted only in controlled airspace where separation is ensured (classes A, B, C, D and E, according to ICAO classification of airspaces).

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294 3.2.2 Roles and Responsibilities

Node	Responsibilities
Aerodrome ATS	Performs all the aerodrome ATS operations. [RELATED ACTORS/ROLES] Runway controller, ground controller, etc.
En-Route/Approach ATS	Performs all the en-route and approach ATS operations. [RELATED ACTORS/ROLES] Executive controller, planning controller, etc.
Flight Deck	Performs all the on-board AU operations including flight execution/monitoring according to agreed trajectory, compliance with ATC clearances/instructions, etc. [RELATED ACTORS/ROLES] Flight Crew

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Operational interactions per context (NOV-2)		Operating Environment
[NOV-2] Enhanced Approach Operations		APT-Large APT-Medium APT-Small APT-Very Large TA-High Complexity TA-Low Complexity TA-Medium Complexity TA-Very High Complexity
Node	**Node instance**	**Node instance description**
En-Route/Approach ATS	Approach Executive Control	Instance of En-Route/Approach ATS for the approach phase.
Flight Deck	Flight Deck	Instance of Flight Deck.
Flight Deck	Following Aircraft	
Aerodrome ATS	Tower Runway Control	Instance of Aerodrome ATS.

3.2.3 CNS/ATS description

Technical constraint	description
Airborne capabilities	1/ Navigation & guidance capabilities for approaches with vertical guidance (precision and APV) - All commercial aircraft are capable of ILS approaches. - Commercial aircraft may also be equipped for GLS (GBAS) or RNP APCH procedures (RNAV APV-Baro or LPV SBAS) approaches. 2/ Deceleration capability - While descending, aircraft are able to maintain speed or decelerate thanks to reduced engine thrust combined when appropriate with airbrakes, slats/flaps and landing gear extension (within corresponding speed limitations). - The higher the descent slope, the more deceleration means are needed to maintain/reduce speed. Beyond a slope value depending on aircraft type and flight conditions, the aircraft may not have enough deceleration capability to maintain/reduce speed.
Ground capabilities	1/ Approach means

	- ISGS may be deployed at airports with any type of approach means supporting vertical guidance: GLS (GBAS) or RNP APCH procedures (RNAV APV-Baro or LPV SBAS), in addition of conventional approaches using the standard ILS. 2/ Glide slope angle of approaches with vertical guidance (precision and APV) - ILS glideslope can be configured to angles different from the standard 3°, but it can only provide a single angle. - GLS (GBAS) or RNP APCH procedures (RNAV APV-Baro or LPV SBAS) allow the provision of different glideslope angles for different approaches on the same runway QFU. 3/ Glideslope anchor point of approaches with vertical guidance (precision and APV) - ILS glideslope anchor point is associated to the physical position of the glideslope station, so it can only define a single anchor point. - GLS (GBAS) or RNP APCH procedures (RNAV APV-Baro or LPV SBAS) allow the provision of different anchor points for different approaches on the same runway QFU.

3.2.4 Applicable standards and regulations

Standard Name	Standard Description	Standard Enabler	Comment
Use Case (NOV-5)	[NOV-5][EAO-01] ISGS Published Approach		
Use Case (NOV-5)	[NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management		
Use Case (NOV-5)	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators		

3.3 Detailed Operating Method

3.3.1 Previous Operating Method

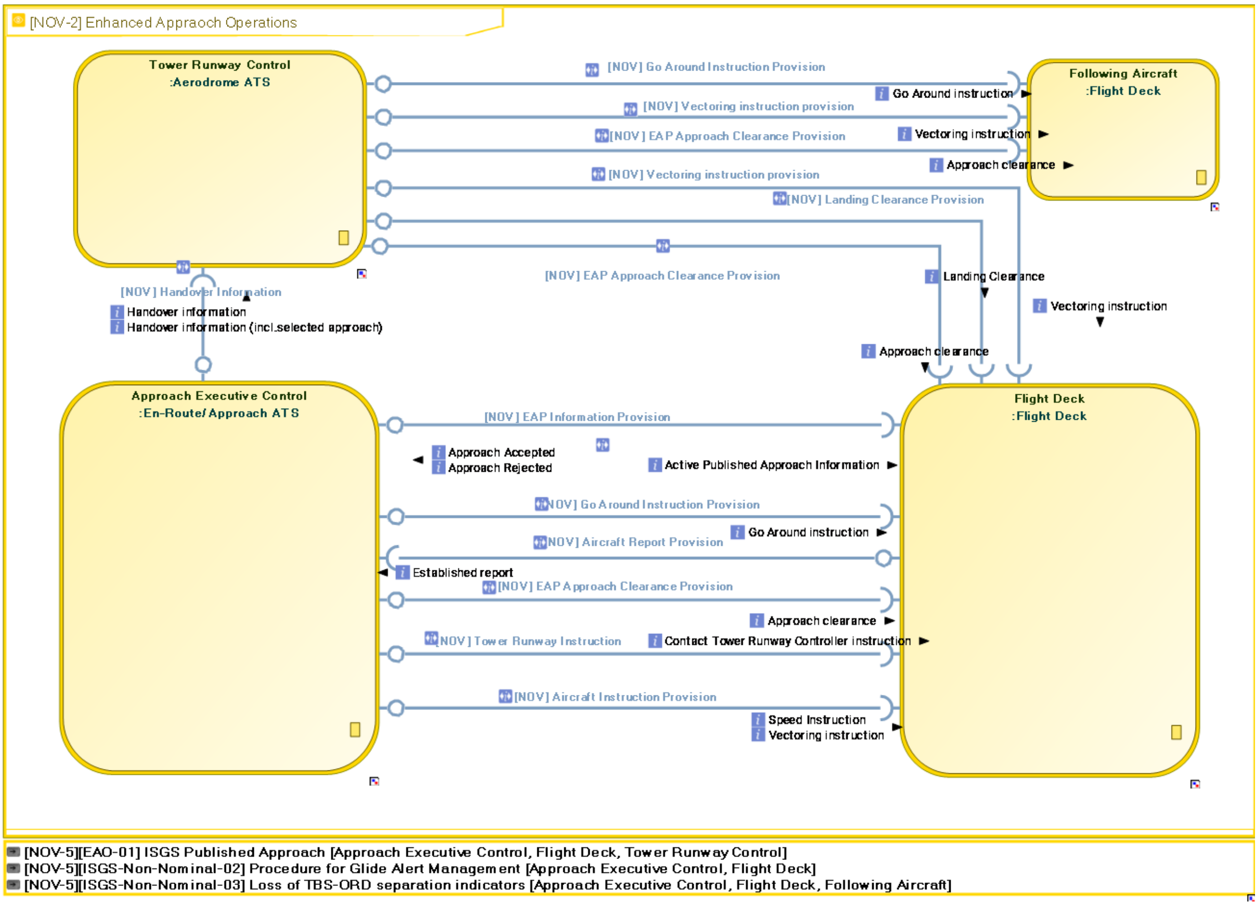
In today's environment, most airports are providing approaches to a single threshold (per QFU) on the arrival runway, at a unique standard final approach slope (usually 3°).
From the Initial Approach Fix, when a precision approach is selected, aircraft fly instrument procedures that terminate with the final approach segment leading to a runway threshold along a glide slope. Whatever their size, their category and their performance, aircraft touch down in a range around the touch down zone, where the glide slope is anchored.
Standard separations during the approach are applied by controllers with no particular aid for separation monitoring. Also, most ATC display systems do not provide easy access to information related to aircraft navigation capabilities (e.g. GBAS, SBAS).

Most popular CAT I precision approach procedures among Europe are based on ILS even if they can be based on other means (e.g. GBAS, SBAS). For this reason, ILS CAT I precision approach procedures are assumed as previous operating method of those enhanced arrival procedures.

3.3.2 New SESAR Operating Method

3.3.2.1 Use Cases for [NOV-2] Enhanced Approach Operations

The operational context view represents the interactions between the main actors involved in the PJ02-W2-14.3 Solution concept of operations.



Use case	[NOV-5][EAO-01] ISGS Published Approach
Use case	[NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management
Use case	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

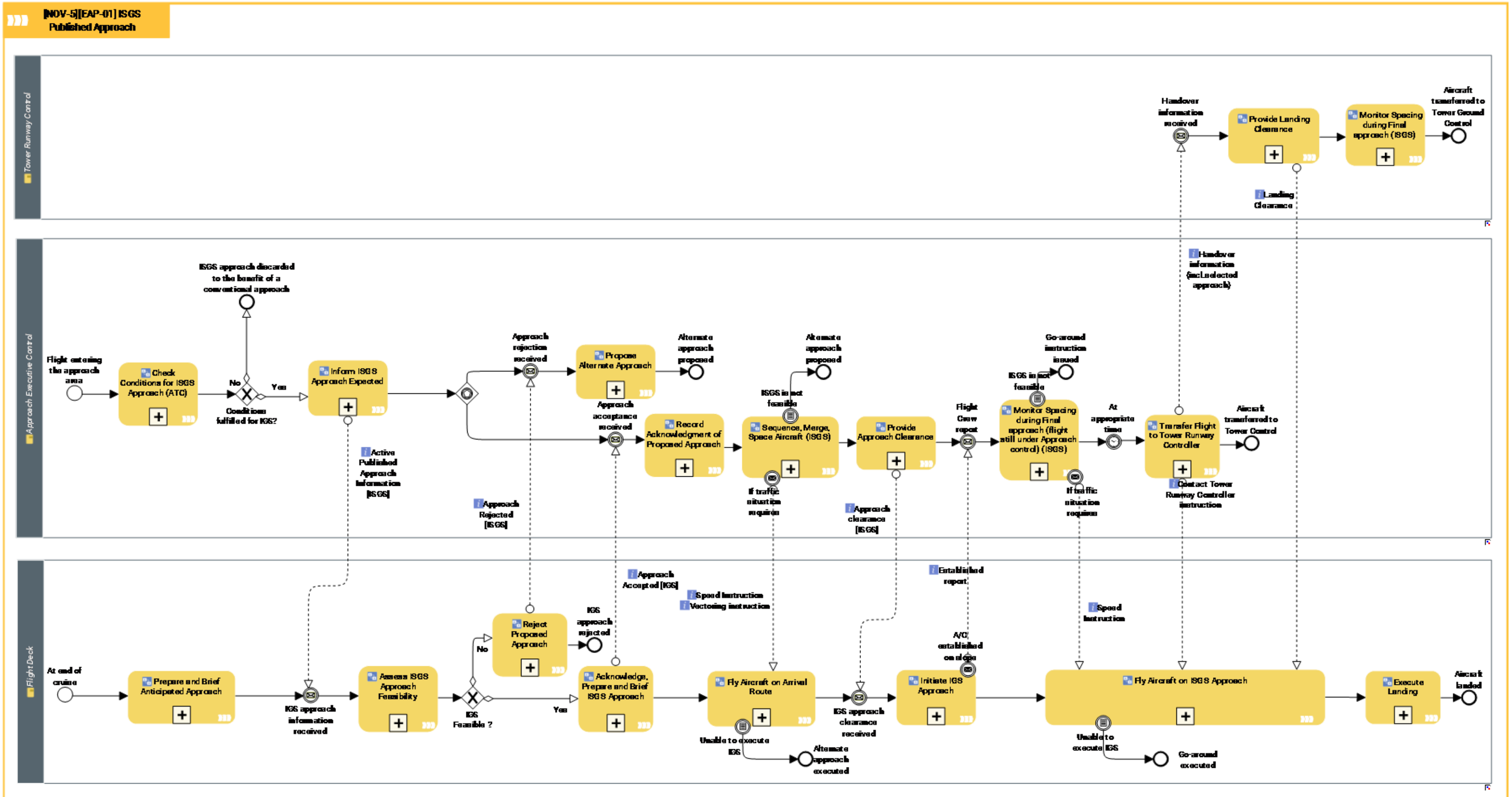
3.3.2.1.1 [NOV-5][EAP-01] ISGS Published Approach

The use case takes place in the execution phase. It describes how one flight performing a published Enhanced Approach Operation (EAO) as an Increased Second Glide Slope (ISGS) approach is integrated in a flow of traffic.

The use case starts when the flight enters the approach control area (taking into account that the Flight Deck has performed a "Prepare & Brief Approach" at the end of cruise), and is initiated following a request from Approach Executive Control and ends when the aircraft has landed.

Pre-conditions:

- The ANSP shall inform Airspace Users (e.g. via AIC) about the availability of ISGS procedure with their differences from the local conventional approaches (including applicable separation minima, location of the second aiming point, landing distance available etc.)
- The need for displaying to the Controllers the interception points respective for each procedure shall be evaluated as part of the local deployment, such that the visual references are operationally relevant and unambiguously presented without e.g. cluttering on the controller air surveillance display.
- ANSPs shall reinforce through a request to Aircraft Operators the need for Flight Plans to be complete and correctly filled with aircraft navigation capabilities.
- A single ISGS procedure type may be supported by different navigation guidance systems and the same ISGS procedure type with different guidance means may be active at the same time.
- The ISGS approach chart shall be specific to one final approach path (i.e. angle) and supporting navigation guidance mean, and shall highlight the glide path angle in case it is significantly increased (e.g. more than 3.5°). The position and color of the associated PAPI shall be indicated on the chart.
- Flight Crew shall be informed about discrepancies from visual aid references when not specifically adapted to increased glideslope procedures.
- ISGS shall be published approach procedures flown based on ILS or GLS or RNP APCH with vertical guidance.
- The design of the GLS or RNAV (LPV, LNAV-VNAV) procedures supporting ISGS shall be compliant with ICAO Doc 8168 and shall be validated in accordance with the Instrument Flight Procedure process specified in ICAO Doc 9906
- Procedure design for ISGS operation shall use a glide path angle limited to 4.49°.
- Contingency procedures shall be revised as appropriate to accommodate non-nominal modes or degraded modes of operations like the navigation guidance supporting an active procedure is no longer serviceable or the ATC separation support function is no longer serviceable (e.g. loss of separation distance indicator).
- Approach Supervision shall decide when a published IGS becomes active/inactive for operations, considering the conditions for application are and remain met:
  1. No operational ATC & weather limitations
  2. Necessary navigation guidance means are serviceable.
- Approach / Tower Supervision shall inform the Approach / Tower Controllers about the list of active approach procedures.
- Information about a published ISGS being active to a given runway QFU shall be available to the Flight Deck in order to prepare expected approach briefing (e.g. via ATIS).
- ISGS Approach separation minima shall be specified for each combination of published approach procedure with different glideslopes, taking into account the associated navigation means and corresponding vertical accuracy around the published profile, for
  - Leader and follower on same glideslope
  - Leader upper glide - follower lower glide
  - Leader lower glide - follower upper glide



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Activity	Description
Acknowledge, Prepare and Brief ISGS Approach	Upon proposal of an ISGS procedure by Approach Executive Control, the Flight Deck acknowledges it and immediately initiates the corresponding briefing to prepare the aircraft to fly the ISGS approach procedure, if not anticipated during approach preparation and briefing at the end of cruise.
Assess ISGS Approach Feasibility	The Flight Deck assesses the feasibility of the ISGS proposed by ATC, i.e.: Aircraft equipment that is necessary for this procedure is available, The proposed published procedure is already available on board, The Flight Deck is able to fly such approach Weather conditions and their impact on energy management are compatible with do not prevent the execution of such a procedure The feasibility assessment is considered when receiving the expected approach information and then until the final approach is being flown.
Check Conditions for ISGS Approach (ATC)	Approach Executive Control determines whether a flight can be given an active ISGS published procedure based on: - aircraft declared navigation capabilities (assuming flight crew ability), - relevance of such a procedure for this flight in current traffic context (density, spacing management, etc.)
Execute Landing	The Flight Deck flies the visual segment after DH (if any) and safely executes landing on the runway.
Fly Aircraft on Arrival Route	The Flight Deck follows arrival procedure or ATC instructions towards the final approach.
Fly Aircraft on ISGS Approach	The Flight Deck flies and monitors the lateral and vertical approach trajectory until reaching the decision height (DH). If distance/altitude information is provided on the chart, it can be used to perform distance/altitude checks. The Flight Deck continues managing aircraft energy and configuration following SOP to prepare aircraft for landing, while respecting potential ATC speed instructions as long as they are compatible with stabilization criteria. Meanwhile, the Flight Deck contacts Tower Runway Control when instructed to do so in order to receive landing clearance. When visual contact is established with the runway (at or before DH), the Flight Deck needs to properly identify visual references.
Inform ISGS Approach Expected	Approach Executive Control initiates the ISGS procedure informing the Flight Deck of the expected enhanced arrival approach.
Initiate IGS Approach	Once the IGS approach clearance has been received, the Flight Deck manages aircraft navigation as appropriate to capture the final approach lateral and vertical path.

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	The Flight Deck also manages aircraft energy and configuration following SOP, while respecting procedure altitude and speed constraints, or ATC speed instructions if any. Once the aircraft is established on the final approach lateral and vertical path, the Flight Deck reports to ATC.
Monitor Spacing during Final approach (flight still under Approach control) (ISGS)	Approach Executive Control monitors the final approach (i.e. aircraft established on the glide slope), especially: the spacing with aircraft ahead, providing speed instructions if traffic situation requires, the adherence to the approach altitude scheme, and compliance to the assigned published final approach profile (i.e. interception of the correct glide and adherence to the glide path). A go-around procedure may be initiated if the conditions for a safe landing are not fulfilled.
Monitor Spacing during Final approach (ISGS)	Tower Runway Control monitors the final approach, especially: the spacing with aircraft ahead, and the adherence to the final approach altitude scheme. A go-around procedure may be initiated if the conditions for a safe landing are not fulfilled. Once the aircraft has landed and vacated the runway, Tower Runway Control transfers the flight to Tower Ground Control.
Prepare and Brief Anticipated Approach	The Flight Deck performs the following sub-tasks: obtain weather and landing information for destination and alternate airports check current aircraft approach and landing capabilities and performance against available airport means and weather conditions insert anticipated arrival and approach procedures into the FMS and check them against published charts insert relevant performance parameters for approach insert landing minimum (DA/DH) check/edit relevant performance parameters for go-around check/perform tuning of relevant NAVAIDs perform approach briefing If the airport operates an EAP approach, the Flight Deck also briefs the most likely EAP procedure.
Propose Alternate Approach	After the Flight Deck has rejected the proposed active EAP, Approach Executive Control takes this refusal into account and clears the arrival flight for another active approach.
Provide Approach Clearance	Approach Executive Control issues, at the appropriate time, and records the approach clearance corresponding to the published chart.
Provide Landing Clearance	At the appropriate time, the tower controller provides the landing clearance as well as the wind information.

	In front of a GBAS arriving aircraft, the runway is considered vacated as soon as the preceding aircraft passes the landing clearance line, which protects the OFZ (Obstacle Free Zone). In front of an ILS arriving aircraft, the runway is considered vacated as soon as the preceding aircraft passes the CAT III holding point, which protects the OFZ and the ILS sensitive area for the next arrival. For GBAS arrival the landing clearance can be provided to pilots at latest 1 NM before touchdown. For ILS arrival aircraft the landing clearance shall be provided at latest 2NM before touchdown [AO-0505-A].
Record Acknowledgment of Proposed Approach	Once the Flight Deck has accepted the proposed approach, Approach Executive Control records the corresponding arrival approach for this particular flight.
Reject Proposed Approach	Once the proposed approach has been assessed as "not feasible", the Flight Deck rejects it (possibly providing the reason why).
Sequence, Merge, Space Aircraft (ISGS)	Approach Executive Control sequences and merges the arrival traffic while respecting all separation and spacing criteria for ISGS procedure using speed and vectoring (altitude and heading) instructions whenever needed.
Transfer Flight to Tower Runway Controller	At the appropriate time, Approach Executive Control: hands over and transfers the control of the flight to Tower Runway Control, mentioning the followed published approach chart, and instructs the Flight Deck to contact Tower Runway Control.

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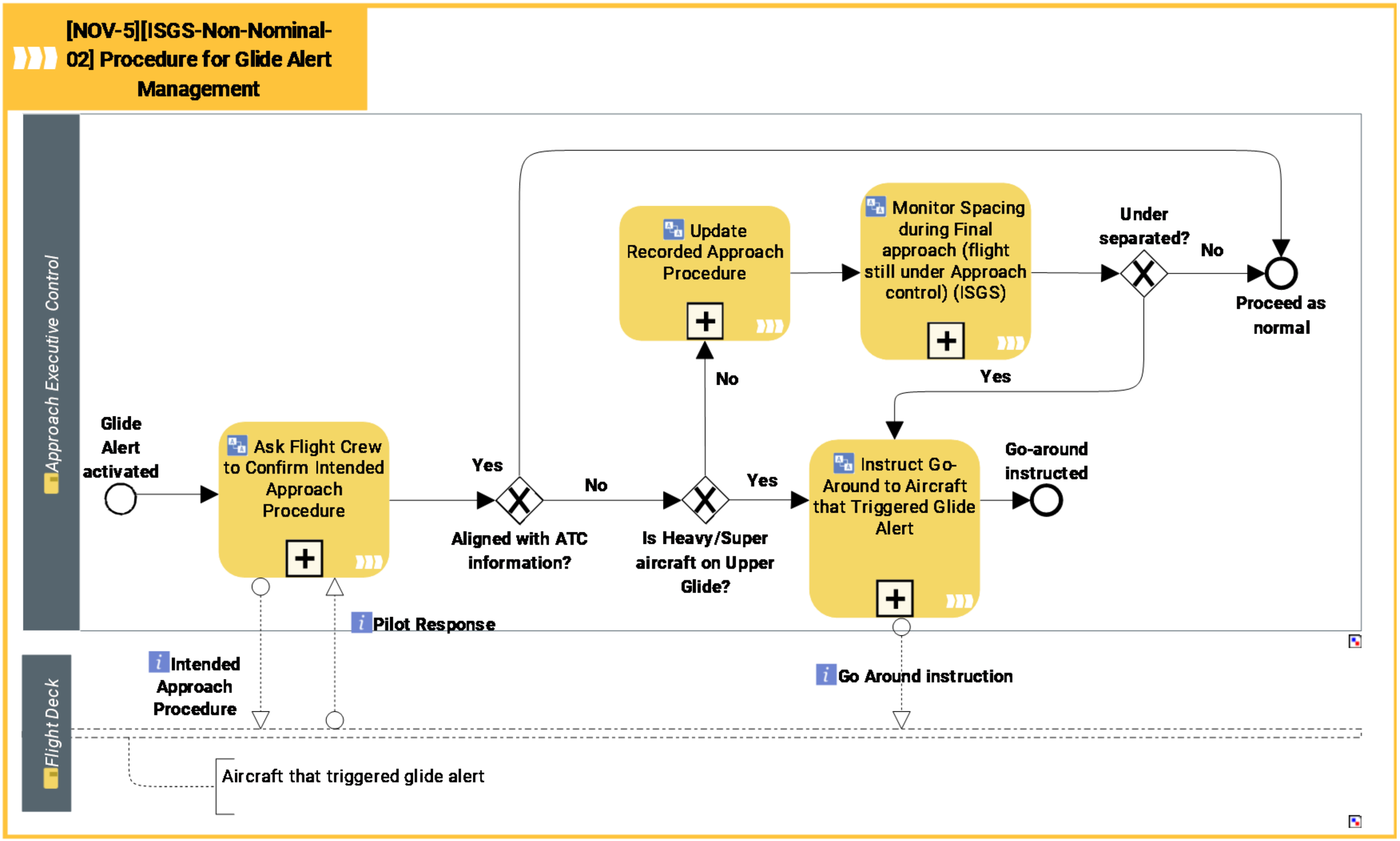
Issuer	Info Flow	Addressee	Info Element	Info Entity
Tower Runway Control	Provide Landing Clearance o--> Fly Aircraft on ISGS Approach	Flight Deck	Landing Clearance	LandingClearance
Approach Executive Control	Inform ISGS Approach Expected o--> IGS approach information received	Flight Deck	Active Published Approach Information	InstrumentApproachProcedure
Flight Deck	Reject Proposed Approach o--> Approach rejection received	Approach Executive Control	Approach Rejected	ApproachClearance

Issuer	Info Flow	Addressee	Info Element	Info Entity
Flight Deck	Acknowledge, Prepare and Brief ISGS Approach o--> Approach acceptance received	Approach Executive Control	Approach Accepted	ApproachClearance
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on Arrival Route	Flight Deck	Vectoring instruction	OpenLoopInstruction
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on Arrival Route	Flight Deck	Speed Instruction	IncreaseSpeedToSpeed
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on Arrival Route	Flight Deck	Speed Instruction	ReduceSpeedToSpeed
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on Arrival Route	Flight Deck	Speed Instruction	SpeedConstraint
Approach Executive Control	Provide Approach Clearance o--> IGS approach clearance received	Flight Deck	Approach clearance	ApproachClearance
Flight Deck	A/C established on slope o--> Flight Crew report	Approach Executive Control	Established report	
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on ISGS Approach	Flight Deck	Speed Instruction	IncreaseSpeedToSpeed
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on ISGS Approach	Flight Deck	Speed Instruction	ReduceSpeedToSpeed
Approach Executive Control	If traffic situation requires o--> Fly Aircraft on ISGS Approach	Flight Deck	Speed Instruction	SpeedConstraint

Issuer	Info Flow	Addressee	Info Element	Info Entity
Approach Executive Control	Transfer Flight to Tower Runway Controller o--> Fly Aircraft on ISGS Approach	Flight Deck	Contact Tower Runway Controller instruction	FrequencyChangeInstruction
Approach Executive Control	Transfer Flight to Tower Runway Controller o--> Handover information received	Tower Runway Control	Handover information (incl.selected approach)	CoordinationAndTransfer

380 #### 3.3.2.1.2 [NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management

381 This Use Case describes a non-nominal scenario in which glide alert is activated during ISGS approach.



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Activity	Description
Ask Flight Crew to Confirm Intended Approach Procedure	Approach Executive Control asks Flight Crew to confirm the approach procedure they have selected on board the aircraft.
Instruct Go-Around to Aircraft that Triggered Glide Alert	ATCO instructs the pilot of an arrival flight that triggered the glide alert to perform a go-around.
Monitor Spacing during Final approach (flight still under Approach control) (ISGS)	Approach Executive Control monitors the final approach (i.e. aircraft established on the glide slope), especially: the spacing with aircraft ahead, providing speed instructions if traffic situation requires, the adherence to the approach altitude scheme, and compliance to the assigned published final approach profile (i.e. interception of the correct glide and adherence to the glide path). A go-around procedure may be initiated if the conditions for a safe landing are not fulfilled.
Update Recorded Approach Procedure	Approach Executive Control updates the approach procedure that was recorded for the flight, with the new one.

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Issuer	Info Flow	Addressee	Info Element	Info Entity
Flight Deck	Flight Deck o--> Ask Flight Crew to Confirm Intended Approach Procedure	Approach Executive Control	Pilot Response	AIRM_Change_Request
Approach Executive Control	Instruct Go-Around to Aircraft that Triggered Glide Alert o--> Flight Deck	Flight Deck	Go Around instruction	ATCInstruction
Approach Executive Control	Ask Flight Crew to Confirm Intended Approach Procedure o--> Flight Deck	Flight Deck	Intended Approach Procedure	

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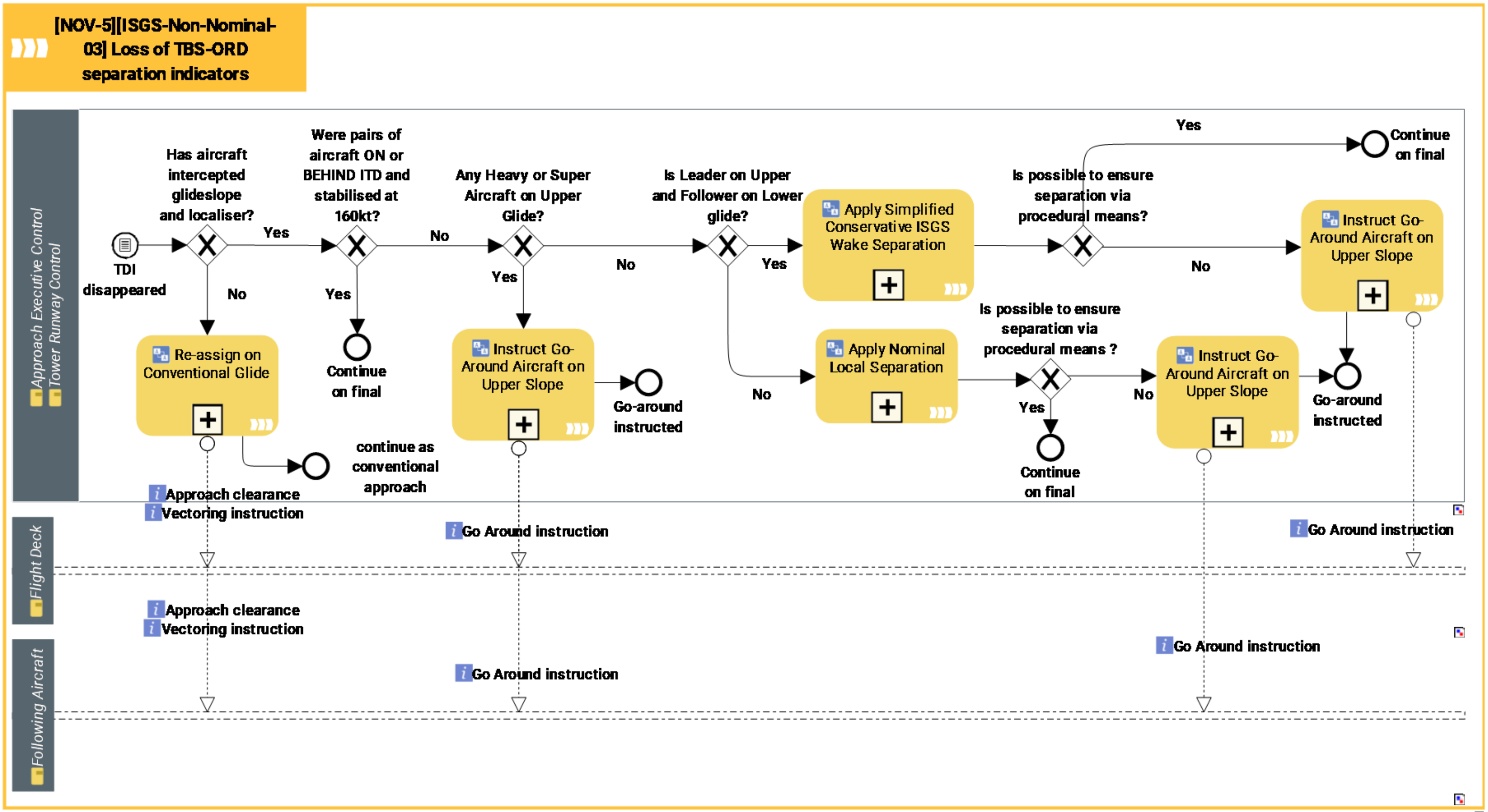
388 **3.3.2.1.3 [NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators**

389 This Use Case describes a non-nominal scenario for the loss of TBS/ORD separation indicators during ISGS approach.



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Activity	Description
Apply Nominal Local Separation	In case leader and follower are flying on the same glide, the ATCO applies the standard separation used on the airport.
Apply Simplified Conservative ISGS Wake Separation	In case of leader on upper glide and follower on lower glide, the separation has to be increased. To simplify the rule as the assistance tool is lost, a simplified conservative wake separation compliant with ISGS is applied by the ATCO, determined at each airport level, according to the separation used locally.
Instruct Go-Around Aircraft on Upper Slope	ATCO instructs a go around to the aircraft flying on the upper slope.
Re-assign on Conventional Glide	For aircraft that were cleared to the upper glide, ATCO changes the approach procedure that was cleared to Flight Crew and issue a new clearance to the lower glide.

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Issuer	Info Flow	Addressee	Info Element	Info Entity
Approach Executive Control	Instruct Go-Around Aircraft on Upper Slope o--> Flight Deck	Flight Deck	Go Around instruction	ATCInstruction
Approach Executive Control	Re-assign on Conventional Glide o--> Following Aircraft	Following Aircraft	Vectoring instruction	OpenLoopInstruction
Approach Executive Control	Re-assign on Conventional Glide o--> Following Aircraft	Following Aircraft	Approach clearance	ApproachClearance
Approach Executive Control	Re-assign on Conventional Glide o--> Flight Deck	Flight Deck	Vectoring instruction	OpenLoopInstruction
Approach Executive Control	Re-assign on Conventional Glide o--> Flight Deck	Flight Deck	Approach clearance	ApproachClearance
Approach Executive Control	Instruct Go-Around Aircraft on Upper Slope o--> Following Aircraft	Following Aircraft	Go Around instruction	ATCInstruction
Approach Executive Control	Instruct Go-Around Aircraft on Upper Slope o--> Flight Deck	Flight Deck	Go Around instruction	ATCInstruction

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Issuer	Info Flow	Addressee	Info Element	Info Entity
Approach Executive Control	Instruct Go-Around Aircraft on Upper Slope o-> Following Aircraft	Following Aircraft	Go Around instruction	ATCInstruction

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395 ### 3.3.3 Differences between new and previous Operating Methods

OI Step code - title		
AO-0320 - Enhanced approach operations using an increased second glide slope (ISGS)		
Acknowledge, Prepare and Brief ISGS Approach	Introduce	Once the IGS approach has been assessed as feasible, the Flight Deck needs to take into account the increased glide slope when preparing the approach strategy (e.g. selection of landing configuration, decelerated vs early-stabilized approach, etc).
Apply Simplified Conservative ISGS Wake Separation	Introduce	
Ask Flight Crew to Confirm Intended Approach Procedure	Introduce	
Assess ISGS Approach Feasibility	Introduce	Once Approach Executive Control has proposed an IGS approach, the Flight Deck needs to particularly assess the feasibility of properly managing aircraft energy taking into account the increased glide slope.
Check Conditions for ISGS Approach (ATC)	Introduce	This task is required to Approach Executive Control in order to check and confirm that all conditions are met at tactical level for such an enhanced approach (assuming the strategic conditions are already met).
Execute Landing	Update	During the visual segment, the Flight Deck needs to properly identify runway visual references without confusion with respect to 3° approaches. In addition, the Flight Deck needs to particularly manage the flare manoeuvre taking into account the increased glide slope and the potentially higher vertical speed.
Fly Aircraft on ISGS Approach	Introduce	The Flight Deck needs to particularly manage aircraft energy and configuration taking into account the increased glide slope. When visual contact is established with the runway (at or before DH), confusion due to visual differences with respect to 3° approaches needs to be avoided.

Inform ISGS Approach Expected	Introduce	Approach Executive Control needs to be able to propose an IGS published procedure to a given flight in order to improve noise impact.
Initiate IGS Approach	Introduce	The Flight Deck needs to particularly manage aircraft energy and configuration taking into account the increased final approach glide slope.
Instruct Go-Around Aircraft on Upper Slope	Introduce	
Monitor Spacing during Final approach (flight still under Approach control) (ISGS)	Update	IGS approach procedure does not allow any separation reduction compared to standard ones (ICAO or RECAT-EU). However, the separation might even be increased, depending on the external conditions, aircraft pair and on the IGS setup (potentially an aircraft flying IGS followed by a lighter aircraft). Thus, the separation monitoring task will evolve to consider the separation modification induced by IGS approach procedure local implementation. IGS approach procedure also requires full compliance to the assigned final approach profile (interception of the correct glide and adherence to the glide path).
Monitor Spacing during Final approach (ISGS)	Update	Tower Runway Control has to use an adapted separation scheme for spacing between pairs of arrival aircraft when one of them is flying an IGS procedure while the other aircraft is flying a standard approach.
Provide Approach Clearance	Update	When Approach Executive Control clears an aircraft for an approach procedure, he/she shall be able to associate and record the cleared approach procedure for this arrival aircraft, including the IGS.
Re-assign on Conventional Glide	Introduce	
Record Acknowledgment of Proposed Approach	Update	Because of Flight Deck acceptance of the IGS approach, Executive Approach Control needs to confirm and record the IGS procedure.
Sequence, Merge, Space Aircraft (ISGS)	Update	Sequencing: In the context of the IGS procedure, Executive Approach Control might have to consider the traffic mix characteristics (pair wise separation or ICAO wake category) to achieve the best possible throughput. In fact, the IGS procedure may increase the wake separation compared to RECAT-EU ICAO scenario, in a situation where an aircraft on an conventional 3° glideslope approach procedure follows a heavier aircraft (leader) flying the IGS approach. Spacing:

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		With a separation tool, the following parameters are considered in the computation of separation and alerts. For IGS, the reduction allowed depends on the following parameters: 1. Glide slope of the conventional approach procedure 2. Glide slope of the IGS approach procedure 3. Traffic mix 4. Type of guidance (GBAS, SBAS, RNAV) and subsequent uncertainty on position (Total System error -TSE-). 5. Aircraft types Without a separation tool, Increased Distance Based Separations (DBS with margins) relying on worst-case scenario for separation for IGS/ILS separation minima should be used. Merging: Depending on local context and IGS implementation, the interception altitude might differ between IGS and conventional approach altitude in order to be able to reduce the separation at the delivery point.
Update Recorded Approach Procedure	Introduce	

Table 4: Differences between new and previous Operating Methods

4 Safety, Performance and Interoperability Requirements (SPR-INTEROP)

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1001
Title	Activation/De-activation of ISGS approach procedure
Requirement	Approach Supervision shall decide when a published ISGS becomes active/inactive for operations, considering the conditions for application are and remain met: 1. No operational ATC & weather limitations 2. Necessary navigation guidance means are serviceable
Status	<validated>
Rationale	Self-explanatory
Category	<Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1002
Title	Information of ISGS procedure availability
Requirement	The ANSP shall inform Airspace Users (e.g. via AIC) about the availability of ISGS procedure with their differences from the local conventional approaches (including applicable separation minima, location of the second aiming point, landing distance available etc.)
Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Safety> , <Operational>

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406 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

407

408 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1003
Title	ISGS - Request for Flight Plans completely and correctly filled
Requirement	ANSPs shall reinforce through a request to Aircraft Operators the need for Flight Plans to be complete and correctly filled with aircraft navigation capabilities.
Status	<validated>
Rationale	This is important so that ATCO can propose the optimum procedure for minimizing wake separation and maximising runway throughput
Category	<Safety> , <Performance> , <Operational>

409

410 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

411

412 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1004
Title	Information to Approach / Tower Control about active ISGS procedures
Requirement	Approach / Tower Supervision shall inform the Approach / Tower Control about the list of active approach procedures
Status	<validated>

Rationale	Self explanatory
Category	<Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1006
Title	ISGS - First contact of aircraft with approach
Requirement	At first call from an incoming traffic to approach, Approach Executive Control shall provide an information to the arrival aircraft about the expected approach procedure, taking in account the traffic eligibility to ISGS, local working methods for traffic assignment (e.g. Heavies left on conventional approach), and using related standard phraseology (e.g. BLUEBIRD 123, Expect GLS Z approach runway 28L).
Status	<validated>
Rationale	Then, later on, the approach clearance will be provided as usual
Category	<Human Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Inform IGS Approach Expected
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1007

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Title	ISGS - Recording of expected approach
Requirement	After Flight Deck acknowledgment, Approach Executive Control shall record the expected approach associated to a given arrival aircraft
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Record Acknowledgment of Proposed Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1008
Title	Go-around when ISGS approach no longer possible after clearance
Requirement	After an aircraft has been cleared to intercept the final approach, if Flight Deck informs ATC that they are no longer able to fly the expected approach (ISGS), Approach Executive Control shall instruct a go-around
Status	<validated>
Rationale	Self-explanatory
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)

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<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

427

428 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1009
Title	ISGS - ATC change of expected approach
Requirement	After Flight Deck has been informed of an expected approach procedure, if a change is needed from ATC, after considering the time needed for the Flight Deck to re-configure for the new approach procedure, Approach Executive Control shall inform Flight Deck at the earliest opportunity and with sufficient time before instructing final approach axis interception (special consideration should be given to the transition from ILS/GLS to RNP APCH which is demanding and time consuming for the pilot).
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Human Performance> , <Operational>

429

430 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Sequence, Merge, Space Aircraft (IGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

431

432 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1010
Title	Availability to ATC of contingency ISGS separation minima - Separation tool in use
Requirement	Applicable Contingency approach separation minima shall be available to Approach Executive Control and Tower Runway Control, when controllers are supported by a separation tool.
Status	<in progress>

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Rationale	In case of loss of the separation tool, the applicable standard baseline separation table (for same slope pairs) and a simplified mixed slope pairs table (e.g. leader on the higher and follower on the lower slope) shall be available to the ATCOs. These tables are to be used only when the tool is off. As an example, if RECAT-EU is the standard baseline separation to be applied for same slope pairs, the RECAT-EU table shall be available to the controllers. An additional table to cover mixed slope pairs when the separation tool is off, be could be RECAT-EU + 3NM.
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Sequence, Merge, Space Aircraft (IGS) Apply Simplified Conservative ISGS Wake Separation Monitor Spacing during Final approach (flight still under Approach control) (ISGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1011
Title	Availability of applicable standard and contingency ISGS separation minima to ATC - No separation tool
Requirement	Applicable Standard approach separation minima when ISGS is active and no separation tool in use shall be available to Approach Executive Control and Tower Runway Control.
Status	<in progress>

Rationale	For nominal operations, ATCO can easily check applicable separation minima For degraded mode / contingency, a simplified table shall be available
Category	<Operational> , <Human Performance> , <Safety>

437

438 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS) Sequence, Merge, Space Aircraft (IGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

439

440 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1012
Title	ISGS - ATC update of recorded cleared approach
Requirement	Approach Executive Control shall be able to update the procedure that was recorded after the clearance in order to record the procedure flown when different from the one initially cleared.
Status	<in progress>
Rationale	
Category	

441

442 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

443

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[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1013
Title	ISGS - Expected or cleared approach procedure reminder at each transfer on frequency
Requirement	At each transfer on frequency, when contacting the next ATC unit, the Flight Deck shall indicate the expected or cleared approach procedure
Status	<in progress>
Rationale	Self-explanatory
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Fly Aircraft on IGS Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1014
Title	Limitation in speed instruction respect possibility when flying ISGS
Requirement	Approach Executive Controll shall consider, when establishing and maintaining separation, that aircraft ability to respect ATC speed instructions may be limited during ISGS operations, especially for slope angles above 3.5 degrees, and aircraft's speed might need to be reduced earlier compared to standard approach.
Status	<validated>
Rationale	Note: the higher the slope angle the longer it takes for the aircraft to decelerate. However, this should not be a problem with slopes under 3.5 degrees.
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1015
Title	ISGS - Final approach interception from above to be avoided
Requirement	Approach Executive Control shall vector the aircraft onto ISGS approach such as to avoid final approach interception from above
Status	<validated>
Rationale	Capture from above has increased potential for unstable approach in case of ISGS
Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Sequence, Merge, Space Aircraft (IGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1016
Title	ISGS- ATC recording of cleared approach procedure
Requirement	When Approach Executive Control clears an aircraft for an approach procedure, he/she shall be able to record the cleared approach procedure for this arrival aircraft.
Status	<validated>

Rationale	Self-explanatory
Category	<Interoperability> , <Operational> , <Safety> , <IER> , <Human Performance> , <Security> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Provide Approach Clearance
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1017
Title	ISGS- ATC update of expected recorded approach procedure
Requirement	In case Approach Executive Control changes the expected approach procedure, he/she shall be able to update the expected approach procedure recorded for this arrival aircraft
Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Record Acknowledgment of Proposed Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1101
Title	Information about activation of published ISGS

Requirement	Information about a published ISGS being active to a given runway QFU shall be available to the Flight Deck in order to prepare expected approach briefing (e.g. via ATIS)
Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1104
Title	ISGS - Approach support for aircraft separation in complex separation scheme (separation minima)
Requirement	For ISGS operations with complex separation minima scheme, Approach Executive Control shall be supported by a Separation Delivery function providing indications about applicable separation minima between arrival aircraft pairs onto final approach segment (FTD),using electronically recorded expected and cleared approach procedures.
Status	<validated>
Rationale	The Separation delivery is necessary to facilitate the management of complex separation schemes, that are function of the approach procedure used flown by aircraft, and to maintain Controller situational awareness.
Category	<Human Performance> , <Operational> , <Performance> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1105
Title	ISGS - Arrival sequencing optimisation or role support
Requirement	For ISGS operations, Approach Executive Control should be supported by arrival sequencing optimisation or role in assigning aircraft to an active approach procedure.
Status	<in progress>
Rationale	Self-explanatory
Category	<Safety> , <Performance> , <Human Performance> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Check Conditions for IGS Approach (ATC)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1106
Title	ISGS - Approach support for aircraft separation in complex separation scheme (required spacing)
Requirement	For ISGS operations with complex separation minima scheme in high traffic environment, Approach Executive Control shall be supported by a Separation Delivery function providing indications about spacing required to account for compression (ITD) to be applied for achieving the separation minima at the separation delivery point

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Status	<validated>
Rationale	The indication taking into account for compression is needed due to difference in speed profiles of Leader and Follower after the Deceleration Fix.
Category	<Performance> , <Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1107
Title	ISGS - Tower support for aircraft separation in complex separation scheme (separation minima)
Requirement	For ISGS operations with complex separation minima scheme the Tower Runway Control shall be supported by a Separation Delivery function providing indications about applicable separation minima between arrival aircraft pairs onto final approach segment (FTD)
Status	<validated>
Rationale	Self-explanatory
Category	<Performance> , <Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (ISGS)

<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1108
Title	ISGS - Warning when catching-up occurs
Requirement	For ISGS operations with complex separation minima scheme in high traffic environment, Approach Executive Control shall be warned when an aircraft is significantly catching-up the preceding traffic with an anticipated risk of loss of separation minima.
Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1109
Title	ISGS - Alert to Approach when deviation / non compliance to vertical profile
Requirement	Approach Executive Control shall be alerted when an aircraft is not complying / is deviating from the assigned published final approach profile.
Status	<in progress>
Rationale	Self-explanatory
Category	<Safety> , <Operational> , <Human Performance>

489

490 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

491

492 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1110
Title	ISGS - Interception points display
Requirement	The need for displaying to the Controllers the interception points respective for each procedure shall be evaluated as part of the local deployment, such that the visual references are operationally relevant and unambiguously presented without e.g. cluttering on the controller air surveillance display
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Human Performance> , <Operational>

493

494 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

495

496 [REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1111
Title	ISGS - Arrival sequencing optimisation or role support not available

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Requirement	In case the support from arrival sequencing optimisation or role is not available and when the traffic pressure is sufficiently high such that the runway throughput is penalised due to the increased separation minima introduced by ISGS procedures, Approach Executive Control shall assign Heavy and Super Heavy aircraft types to the lower glide path.
Status	<validated>
Rationale	Self-explanatory
Category	<Operational> , <Performance> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Check Conditions for IGS Approach (ATC)
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1112
Title	ISGS - Deviation alert reliability
Requirement	The alert shall be sufficiently reliable, the level of reliability being defined locally at each airport.
Status	<validated>
Rationale	This increases the workload and communication load of the Controller.
Category	<Human Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)

<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1201
Title	ISGS - Information to crew about visual aids particularities
Requirement	Flight Crew shall be informed about discrepancies from visual aid references when not specifically adapted to increased glideslope procedures.
Status	<in progress>
Rationale	Self-explanatory
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1202
Title	ISGS chart indications
Requirement	The ISGS approach chart shall follow the following elements: 0. be specific to one final approach path (i.e. angle) and supporting navigation guidance mean, 1. highlight the glide path angle in case it is significantly increased (e.g. more than 3.5), 2. indicate the position and color of the associated PAPI.
Status	<in progress>
Rationale	Self-explanatory
Category	<Operational> , <Safety>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1203
Title	ISGS procedures publication
Requirement	ISGS shall be published approach procedures flown based on ILS or GLS or RNP APCH with vertical guidance
Status	<validated>
Rationale	Self-explanatory
Category	<Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1204
Title	ISGS procedures navigation support and activation
Requirement	ISGS operations for a given slope angle may be simultaneously supported by different navigation guidance systems.
Status	<validated>
Rationale	This may allow to increase the usage of ISGS, since the level of aircraft equipage may be limited for given navigation technologies, and a limited ISGS use may be detrimental to capacity. For example, a GLS and a RNP APCH 3.6o could be active and operated at the same time.

Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1205
Title	ISGS wake turbulence minima to be applied
Requirement	Approach Executive Control shall apply longitudinal wake turbulence distance-based separation minima for the following combinations: 0. Leader and follower on same glideslope 1. Leader upper glide - follower lower glide 2. Leader lower glide - follower upper glide when both aircraft are descending on their respective glide slope.
Status	<validated>
Rationale	The exposure to wake turbulence is affected when an aircraft is flying above or below the preceding one, compared when both fly the same glideslope
Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Monitor Spacing during Final approach (flight still under Approach control) (ISGS)

<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1207
Title	ISGS maximum glide path angle
Requirement	Procedure design for ISGS operation shall use a glide path angle limited to 4.49°.
Status	<validated>
Rationale	Beyond 4.49°, special aircraft and aircrew approval for "steep approach" is required and is not in scope of PJ02-02 solution.
Category	<Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-CTL.1208
Title	ISGS separation minima to be specified
Requirement	ISGS Approach separation minima shall be specified for each combination of published approach procedure with different glideslopes, taking into account the associated navigation means and correponding vertical accuracy around the published profile, for 0. Leader and follower on same glideslope 1. Leader upper glide - follower lower glide 2. Leader lower glide - follower upper glide.
Status	<validated>
Rationale	Self-explanatory

Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-APT-1301
Title	ISGS- approach and landing visual aids
Requirement	Flight Deck shall be supported by appropriate landing visual aids to allow them check they follow the correct approach slope.
Status	<in progress>
Rationale	Self-explanatory
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Fly Aircraft on IGS Approach Execute Landing
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2101
Title	ISGS specific approach briefing on visual references
Requirement	Flight Crew shall recall during approach briefing the possible differences in visual references (VASI/PAPI, runway aspect, etc) that are expected in ISGS operation

Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Acknowledge, Prepare and Brief IGS Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2102
Title	Deceleration needs when flying ISGS
Requirement	Flight Deck shall be able to decelerate the aircraft during final approach, even under flight conditions that reduce deceleration capability (e.g. anti-ice system ON)
Status	<validated>
Rationale	1) Occurrence of unstabilized approach leading to hard landing, long landing and/or landing too fast shall not increase with respect to approaches with standard slope (e.g. 3°). See SAR SO 206a and SO 206b associated with Hz#6a and Hz#6b. 2) Occurrence of unstabilized approach leading to Go Around shall not increase with respect to approaches with standard slope (e.g. 3°).
Category	<Operational> , <Safety> , <Human Performance> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3

<ALLOCATED_TO>	<Activity>	Fly Aircraft on IGS Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

543

544 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2103
Title	Flare when flying ISGS
Requirement	Flight Deck shall be able to execute flare during ISGS operations without increasing the risk of hard landing or long landing
Status	<validated>
Rationale	Occurrence of hard landing or long landing shall not increase with respect to approaches with standard slope (e.g. 3°). See SAR SO 206a and SO 206b associated with Hz#6a and Hz#6b
Category	<Operational> , <Human Performance> , <Safety>

545

546 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Execute Landing
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

547

548 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2104
Title	ISGS initial feasibility assessment
Requirement	Upon initiating the approach briefing, in case the aircraft is eligible for the ISGS approach (possible from ATC point of view and taking into account aircraft capabilities) and the ATIS informs that the ISGS approach is active, the Flight Deck shall assess the feasibility of the ISGS operation under the expected flight and weather conditions.
Status	<validated>
Rationale	Self-explanatory

Category	<Operational> , <Human Performance> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Assess IGS Approach Feasibility
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2105
Title	ISGS feasibility confirmation
Requirement	Upon cleared for ISGS Approach, Flight Deck shall confirm the feasibility of the instructed ISGS operation under the actual flight and weather conditions
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Initiate IGS Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2106
Title	ISGS flying modes
Requirement	Flight Deck shall be able to fly an ISGS operation in both manual and AP/FD modes

Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Fly Aircraft on IGS Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2107
Title	ISGS operation vs SOP
Requirement	Flight Deck shall be able to fly an ISGS operation in a similar way (IHM, SOP, etc) as when an approach with standard slope is flown
Status	<validated>
Rationale	Self-explanatory
Category	<Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Fly Aircraft on IGS Approach
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ACFT.2108
Title	ISGS - Change of frequency between APP and TWR

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Requirement	Flight Deck shall pay particular attention to the transition of frequencies from APP to TWR and shall not delay it.
Status	<validated>
Rationale	To avoid an aircraft being in between two frequencies where they are unable to communicate a missed approach or, conversely, the ATCO to not be able to communicate a go-around.
Category	<Operational> , <Human Performance> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][EAP-01] IGS Published Approach

[REQ]

Identifier	REQ-14.3-SPRINTEROP-GALT.0001
Title	ISGS Glide alert - Check of approach flown
Requirement	When a wrong glide alert is activated, Approach Executive Control shall ask Flight Crew to confirm the flown approach procedure.
Status	<validated>
Rationale	In case of glide alert, Approach executive shall confirm the aircraft that triggered the alert is indeed not flying the expected glide slope.
Category	<Human Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Ask Flight Crew to Confirm Intended Approach Procedure

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<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management

[REQ]

Identifier	REQ-14.3-SPRINTEROP-GALT.0002
Title	ISGS Glide alert - Instruct go around to aircraft mistakenly on ISGS if Heavy
Requirement	When a wrong glide alert is activated by a Heavy aircraft wrongly on the ISGS procedure, and Flight Crew confirms flying a different approach procedure than the instructed one, Approach Executive Control shall instruct a go around to that aircraft.
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Instruct Go-Around to Aircraft that Triggered Glide Alert
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management

[REQ]

Identifier	REQ-14.3-SPRINTEROP-GALT.0003
Title	ISGS Glide alert - Coordination between controllers
Requirement	After a glide alert procedure, Approach Executive Control shall coordinate with Tower Runway Control about the aircraft that triggered the glide alert when ISGS is active.
Status	<validated>

Rationale	To maintain the situational awareness of Tower Runway Control. This is particularly important when an aircraft is finally not flying the procedure it would normally fly (for example if a Heavy aircraft is flying the ISGS Approach).
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management

[REQ]

Identifier	REQ-14.3-SPRINTEROP-GALT.0004
Title	ISGS Glide alert - Aircraft other than Heavy
Requirement	When a wrong glide alert is activated by an aircraft other than Heavy and Flight Crew confirms flying a different approach procedure than the instructed one, the Approach Executive Control shall: 0. Update the CWP HMI with the actually flown approach procedure 1. Check the position of the concerned aircraft, leading aircraft and following aircraft against their indicators 2. If any under separated, instruct go-around to the flight which triggered the glide alert.
Status	<validated>
Rationale	
Category	<Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3

<ALLOCATED_TO>	<Activity>	Instruct Go-Around to Aircraft that Triggered Glide Alert Update Recorded Approach Procedure
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-02] Procedure for Glide Alert Management

583

584 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0001
Title	ISGS Loss of separation tool - Application of conservative ISGS wake separations
Requirement	In case of loss of separation tool, for all upper-lower slope pairs without Heavy which are not stabilised at 160kts or not on (or behind) the ITD, Approach Executive Control or Tower Runway Control shall apply the addtional simplified mixed slope pairs table. It that is not possible, Approach Executive Control or Tower Runway Control shall instruct a go around to the aircraft flying the ISGS procedure.
Status	<validated>
Rationale	Self-explanatory As an example, if RECAT-EU is the standard baseline separation to be applied for same slope pairs, the RECAT-EU table shall be available to the controllers. An additional table to cover mixed slope pairs when the separation tool is off, be could be RECAT-EU + 3NM.
Category	<Human Performance> , <Operational> , <Safety>

585

586 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Instruct Go-Around to Aircraft on Upper Slope Apply Simplified Conservative ISGS Wake Separation

<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

587

588 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0002
Title	ISGS Loss of separation tool - Go around to ISGS aircraft when necessary separation cannot be ensured
Requirement	In case of loss of separation tool, for all lower-upper and same slope pairs which are not stabilised at 160kts or not on (or behind) the ITD, Approach Executive Control or Tower Runway Control shall apply reference separation minima. It that is not possible, Approach Executive Control or Tower Runway Control shall instruct a go around to the aircraft flying the ISGS procedure.
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Operational> , <Human Performance>

589

590 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Instruct Go-Around to Aircraft on Upper Slope Apply Nominal Local Separation
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

591

592 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0003
Title	ISGS Loss of separation tool - reassignment to conventional approach procedure
Requirement	In case of loss of separation tool, Approach Executive Control shall re-assign all the aircraft that have not yet intercepted the glide slope and localiser, to conventional approach procedure.

Status	<validated>
Rationale	Self-explanatory
Category	<Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Re-assign on Conventional Glide
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0004
Title	ISGS Loss of separation tool - assistance to Approach Executive Control
Requirement	In peak traffic, in case of loss of separation tool, the coordinator/assistant shall aid the Approach Executive Control for checking the separations between aircraft and suggesting which aircraft should be sent around.
Status	<validated>
Rationale	Self-explanatory
Category	<Safety> , <Human Performance> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0005

Title	ISGS Loss of separation tool - coordination between Approach Executive Control and Tower Runway Control
Requirement	In case of loss of separation tool, Approach Executive Control should inform Tower Runway Control about the last aircraft flying the ISGS procedure until the tool is running again and the situation back to nominal.
Status	<validated>
Rationale	That would improve Tower Runway Control situational awareness and avoid Tower Runway Control to be surprised if an aircraft flying on ISGS arrives after a number of aircraft on standard approach.
Category	<Safety> , <Human Performance> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

[REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0006
Title	ISGS Loss of separation tool - Pairs of aircraft stabilised and on (or behind) ITD
Requirement	In case of loss of separation tool, Approach Executive Control or Tower Runway Control should let all aircraft from pairs which are stabilised at 160kts and on (or behind) the ITD, continue on final.
Status	<validated>
Rationale	Self-explanatory
Category	<Human Performance> , <Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

607

608 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0007
Title	ISGS Loss of separation tool - Pairs of aircraft not stabilised or not on (or behind) ITD
Requirement	In case of loss of separation tool, for all mixed slope pairs which are not stabilised at 160kts or not on (or behind) the ITD, and for which a heavy aircraft is on the upper glide, Approach Executive Control or Tower Runway Control shall instruct a go-around to the heavy aircraft.
Status	<validated>
Rationale	Self-explanatory
Category	<Operational> , <Safety> , <Human Performance>

609

610 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<Activity>	Instruct Go-Around to Aircraft on Upper Slope
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

611

612 [REQ]

Identifier	REQ-14.3-SPRINTEROP-ORDF.0008
Title	SRAP Loss of separation tool - Return to operations
Requirement	When the separation delivery tool returns to operations, the Approach Executive Control shall communicate to the Tower Runway Control the first aircraft in the sequence that is performing ISGS arrival procedure.
Status	<validated>

Rationale	This is important for the Tower Runway Control to know that the SRAP is back in operation.
Category	<Human Performance> , <Safety> , <Operational>

613

614 [REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ02-PJ.02-W2-14.3
<ALLOCATED_TO>	<ActivityView>	[NOV-5][ISGS-Non-Nominal-03] Loss of TBS-ORD separation indicators

5 References and Applicable Documents

5.1 Applicable Documents

Content Integration

3. B.04.01 D138 EATMA Guidance Material
4. EATMA Community pages
5. SESAR ATM Lexicon

Content Development

3. B4.2 D106 Transition Concept of Operations SESAR 2020

System and Service Development

3. 08.01.01 D52: SWIM Foundation v2
4. 08.01.01 D49: SWIM Compliance Criteria
5. 08.01.03 D47: AIRM v4.1.0
6. 08.03.10 D45: ISRM Foundation v00.08.00
7. B.04.03 D102 SESAR Working Method on Services
8. B.04.03 D128 ADD SESAR1
9. B.04.05 Common Service Foundation Method

Performance Management

3. B.04.01 D108 SESAR 2020 Transition Performance Framework
4. B.04.01 D42 SESAR2020 Transition Validation
5. B.05 D86 Guidance on KPIs and Data Collection support to SESAR 2020 transition.
6. 16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model
7. 16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA
8. Method to assess cost of European ATM improvements and technologies, EUROCONTROL (2014)
9. ATM Cost Breakdown Structure_ed02_2014
10. Standard Inputs for EUROCONTROL Cost Benefit Analyses
11. 16.06.06_D26-08 ATM CBA Quality Checklist
12. 16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

Validation

22. 03.00 D16 WP3 Engineering methodology
23. Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects
24. European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

System Engineering

25. SESAR 2020 Requirements and Validation Guidelines

Safety

26. SESAR, Safety Reference Material, Edition 4.0, April 2016
27. SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016
28. SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015
29. SESAR, Resilience Engineering Guidance, May 2016

Human Performance

30. 16.06.05 D 27 HP Reference Material D27
31. 16.04.02 D04 e-HP Repository - Release note

Environment Assessment

32. SESAR, Environment Reference Material, alias, "Environmental impact assessment as part of the global SESAR validation", Project 16.06.03, Deliverable D26, 2014.
33. ICAO CAEP – "Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes" document, Doc 10031.

Security

34. 16.06.02 D103 SESAR Security Ref Material Level
35. 16.06.02 D137 Minimum Set of Security Controls (MSSCs).
36. 16.06.02 D131 Security Database Application (CTRL_S)

5.2 Reference Documents

37. ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.
38. PJ02-02 D2.1.01 PJ02-02 OSED-SPR-Interop Part I, Edition 00.01.00
39. PJ02-02 D2.1.04 SESAR PJ02-02 VALR, Edition 00.01.00

40. P06.08.05 D05 Enhanced Arrival Procedures Enabled by GBAS - INTEROP – Consolidation, Edition 00.01.02

41. P06.08.08 D07 Enhanced Arrival Procedures enabled by GBAS – OSED Consolidation, Edition 00.01.01

42. D4.2.006 - PJ.02-W2-14.3 VALR Final, Edition 00.01.00

6 Cost and Benefit Mechanisms

6.1 Stakeholders identification and Expectations

The table below presents the stakeholders expectations as identified by the solution.

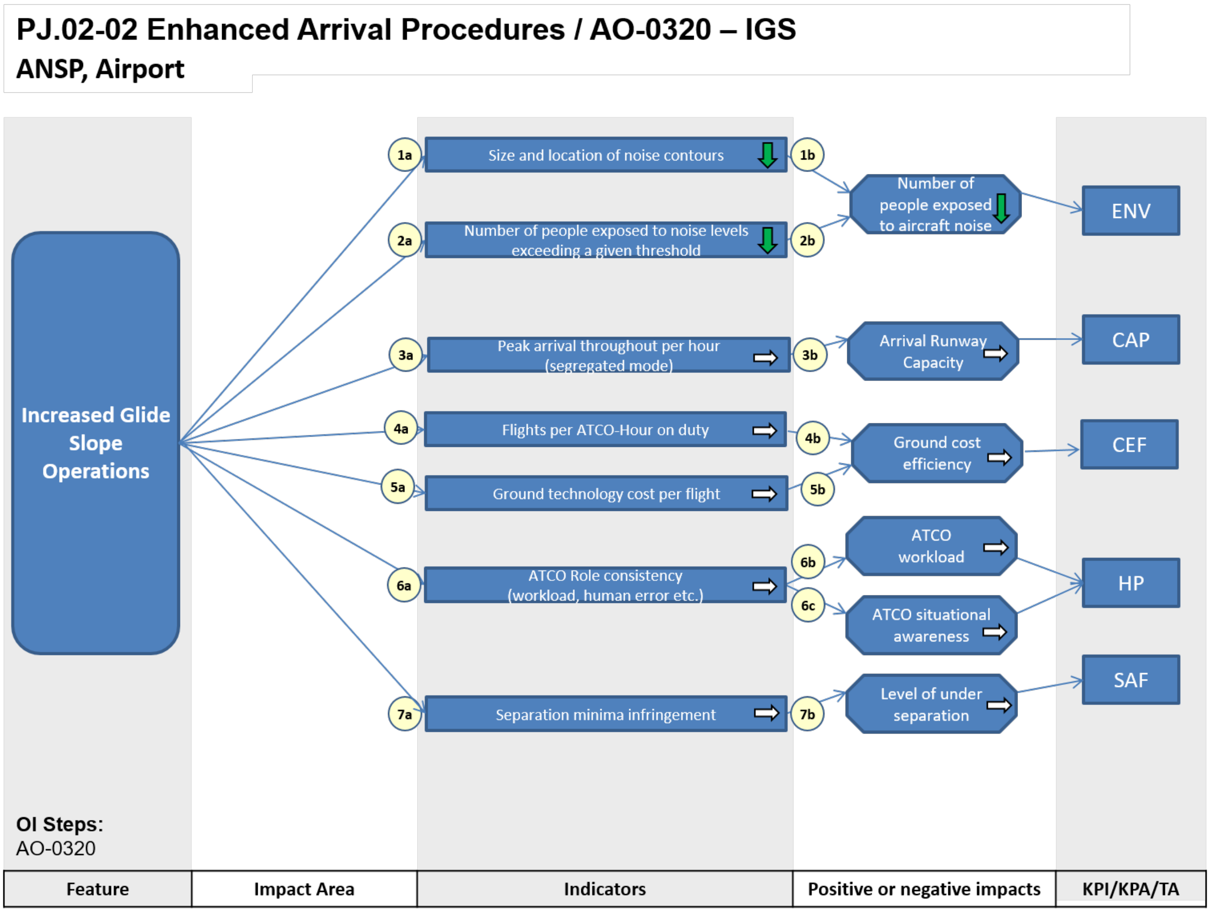
Stakeholder	Involvement	Why it matters to stakeholder
Airspace Users	No involvement in the validations. Interested in the results.	Capacity, Cost Efficiency and Environmental Sustainability are key KPA for Airspace users. Increase in airport capacity means possible increase in demand for Airspace Users. Reduction in environmental impact affects both fuel consumption and operating restrictions coming from noise limits. Airspace Users are interested as well in assessing the impact on crew on safety and HP point of view.
ANSPs	ANSPs are running the exercises, providing operational expertise for the validations too. ATCOs will provide feedback on PJ02-02 solution via real-time simulations	Better cost efficiency, capacity increase and safety assurance are targets for ANSP. This solution should meet these ANSP target.
Airport Operators	Airport Operators support to operational scenario(s) definition and review of validations results.	Some Airport Operators operating large hub airports are looking into the business model of contracting ANSP services for their main airport and surrounding small airports based on this solution expecting economies of scale. Airport Operators are interested in this solution for two main reasons: • Noise reduction in the areas close to the airport. Supporting then that capacity restrictions due to noise are mitigated and then improving quality of service to AUs • ROT reduction, leading to potential increase in RWY capacity.

Passengers	No involvement in the validations. Interested in the results.	Passengers will indirectly benefit from PJ02-02 as this solution will provide capacity increase and could generate an increase in the destinations' availability
Communities around airports	No involvement in the validations. Interested in the results.	Communities around airports are interested into environmental benefits, especially noise, coming from the implementations of PJ02-02 solution
Airborne industry	Manufacturing Industry is running the exercises, providing operational expertise for the validations too	Manufacturing Industries are interested in assessing the impact on the crew on safety and HP point of view.
European Commission	Direct participation through SJU	EC is interested into improving the main KPA related the ATM. Regarding PJ02-02 EC is interested in Capacity and Environment KPA possible benefits coming from solution implementation.

682 **Table 5: Stakeholder's expectations**

683 6.2 Benefits mechanisms

684 6.2.1 Ground benefits mechanisms



(1a) Once established on the glide path, at a given distance from the threshold, a flight following the ISGS procedure flies higher than a flight on the conventional approach procedure which would reduce the size of noise contours on final approach, and related various noise levels, around the airport area.
(1b) This means the number of people in the airport vicinity exposed to aircraft noise below the final approach segment should decrease thanks to ISGS operations, which links to Environment KPA.
(2a) As described in (1a), ISGS operations would reduce the size of noise contours around the airport area which would lead to reduce the number of people exposed to noise levels exceeding a given threshold.
(2b) This means the number of people in the airport vicinity exposed to aircraft noise below final approach, and related various noise levels, will decrease thanks to ISGS operations, which links to Environment KPA.
(3a) Depending on the aircraft types, if the lead aircraft is flying a higher approach glideslope angle than the succeeding traffic, the wake turbulence separation between aircraft might need to be increased, in particular behind large aircraft leader. The impact of the increased wake minima will be depending on the relative increase compared to local standard (surveillance) separation minima applied at an airport, or compared to the prevailing average traffic spacing for that pair (e.g. under low traffic pressure). The introduction of ISGS operations may therefore be:

- close to neutral on applied separations, having no or little impact on peak arrival runway throughput (typically this can be during the night conditions or off-peak period, or when surveillance minima are set to 5NM or more or the pressure is low)

- or may tend to increase the applied separations, thus degrading the peak arrival runway throughput.

(3b) In this case, ISGS operations will have a neutral or negative impact on hourly Arrival Runway Capacity which links to Capacity.

(4a) Linked to the impact of ISGS operations on the peak arrival runway throughput, the flights per ATCO-Hour on duty would as well be unchanged or degraded when activating ISGS operations.

(4b) That would not affect or affect negatively the ground cost efficiency, and so the Cost Efficiency.

(5a) The wake separation tables to be used when ISGS operations are active, are complex because depending on aircraft pairs and applicable wake scheme (i.e. RECAT-EU with 6 aircraft wake categories, RECAT-EU-PWS with pair-wise separation minima), and on types of approaches (ILS, GLS, RNP LPV or Baro-VNAV, and respective vertical accuracy) flown by leader and following aircraft

Some operational conditions are identified when these separation tables can possibly remain simple and manageable by controllers without support. Such conditions are to be determined at each airport level but encompass the following cases:

– When there are few wake turbulence categories operated at an airport (e.g. ICAO legacy), the complexity induced by the introduction of ISGS approaches may be low and still manageable without controller separation support tool, only with the support of a new simple separation matrix.

- When the local separation minima (or spacing for example during night) applied at the considered airport are higher than the separations needed due to the introduction of ISGS approaches.

When these conditions cannot be met, a separation delivery support tool will be necessary to help controllers manage the separations.

Nevertheless, it has to be noted that such a tool may be already in use due to the complexity of the separation applied even without ISGS operations (e.g. RECAT-EU-PWS or Time-Based Separation - TBS). Thus, only an adaptation of the tool may be needed in order to take into account the particularities linked to ISGS operations.

In addition, ISGS operations increase the number of published approach procedures active at a time, which may increase the complexity of some of the ATCO's tasks (For instance, optimisation of the sequence to reduce as much as possible the average spacing, monitor conformance to various glide paths). ATCO's task performance (workload, Taskload) and situational awareness might be therefore negatively impacted necessitating new ATC support tools.

Regarding visual aid, there would be a need to provide a PAPI calibrated for the increased glideslope. The PAPI set-up could be based on a second static PAPI display, or a dynamic (switching) evolution of the existing PAPI. In case the need of a PAPI adaptation for ISGS is confirmed, there will be a ground technology cost impact.

In conclusion, according to each local case, the impact of ISGS introduction on the ground technology cost per flight may be neutral or may be negative, increasing the ground technology cost per flight, but the impact would be lower in case a separation assistance tool is already used by controllers because of the complexity of the separation scheme of the airport.

(5b) That would not affect or affect negatively the ground cost efficiency, and so the Cost Efficiency.

(6a) As explained in (5a), either the separation tables to be applied can be locally simplified or a controller separation support tool will be deployed to support controllers.

Therefore, it is expected that the workload and the human error are maintained at the same level as today.

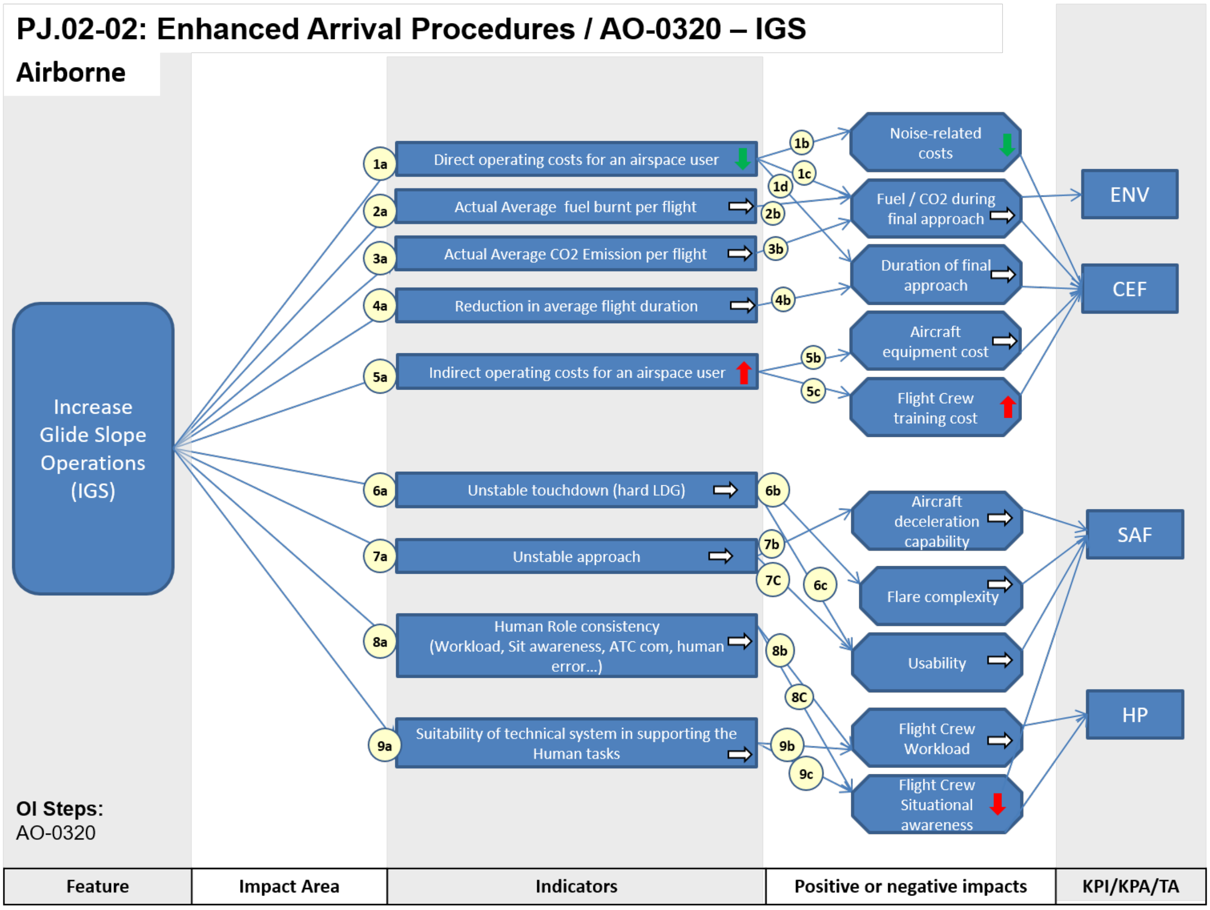
(6b) The ATCO workload would be maintained. Finally, no impact on Human performance KPA are expected.

(6c) The ATCO situational awareness would be maintained. Finally, no impact on Human performance KPA are expected.

(7a) As explained in (5a), either the separation tables to be applied can be locally simplified or a controller separation support tool will be deployed to support controllers. So, either the situation in terms of separation minima infringement will be as today or it will be improved when a tool will be used.

(7b) The number of under separation situations is thus expected to be as of today or reduced, and Safety maintained.

6.2.2 Airside Benefits Mechanisms



(1a) Noise benefits introduced by IGS operations might be an enabler for direct operating cost reduction for airspace users.

(1b) This could be enabled through noise charges/fines reduction and alleviation of operational restrictions (curfew, early arrivals …). This is dependent on local noise scheme (if defined by Airport and Local Authority), and how operational noise is considered as a key driver to contribute to the reduction of the airport environmental impact.

(1c) Final approach slope has an influence on Fuel burnt during final approach, but such impact greatly depends on other aspects such as aircraft type, flight and weather conditions. As a result, the overall impact of IGS on fuel-related direct operating costs is negligible.

(1d) In some cases (e.g. significant slope, heavy aircraft, tailwind conditions), it may be necessary to anticipate deceleration to ensure approach stabilization. In such cases, final approach duration would be slightly increased, but the impact on total flight duration and thus on time-related direct operating costs is negligible.

(2a) As explained in (1c), the impact of IGS operations on average fuel burnt per flight is negligible.

(2b) As explained in (1c), this is due to the fact that the increase of final approach slope may have a positive or negative effect depending on each flight, leading to a negligible overall impact.

(3a) Just like fuel, impact of IGS operations on average CO2 emissions per flight is negligible.

(3b) Just like fuel, this is due to the fact that the increase of final approach slope may have a positive or negative effect, leading to a negligible overall impact.

(4a) As explained in (1d), the impact of IGS on average flight duration is negligible.

(4b) As explained in (1d), this is due to the fact that potential final approach duration increase in some cases is negligible when considering the overall flight duration.

(5a) The introduction of IGS operations may lead to a limited increase in indirect operating cost for airspace users mainly due to training costs.

(5b) No specific aircraft equipment or certification is currently required to fly approach slopes in the range considered by IGS (between 3.01° and 4.49°). However, in order to enhance safety when IGS operations get widely deployed, manufacturers might prescribe the use of energy management and flare assisting functions for some aircraft. Since this need is neither confirmed nor generalizable, it can be assumed that impact of IGS on aircraft equipment costs is not applicable.

(5c) No specific flight crew training is currently required to fly approach slopes in the range considered by IGS (between 3.01° and 4.49°). However, in order to ensure an easy-to-use operation on a daily basis when IGS operations get widely deployed, it seems necessary to reinforce pilots training for such operations regarding energy management and flare, as well as potential differences in visual references (runway aspect, VASI/PAPI, etc). Thus, training costs would slightly increase for all aircraft. The increase would be higher for aircraft equipped with new energy management and flare assisting functions since training would also cover the use of such functions.

(6a) & (7a) Steeper (between 3.01° and 4.49°) than standard final approach segment is a factor leading to an additional operational complexity for the pilots. However, the number of unstable approach and unstable touchdown (hard landing) may not be negatively impacted.

(7b) IGS operations are initially expected to potentially negatively impact aircraft deceleration capability, as the aircraft is flying steeper slopes than the conventional ones. However, pilots training and energy management assisting function would help the crew to correctly and timely manage the aircraft energy. For this reason, the aircraft deceleration capability should not be negatively impacted.

(7c) The Flight crew is expected to accomplish the approach tasks until touchdown as usual, with the potential addition of energy and flare assisting functions. So, the usability of the IGS operations is expected to be not negatively impacted.

(8a) The impact of IGS operations on the human role consistency is considered negligible.

(8b) IGS operations may potentially increase the Perceived Subjective Workload, to cope with energy management along the increased glide slope. This feeling is very slope and aircraft dependent. This could be minimized through the introduction of an energy management assisting function. Thanks to this enabler for demanding slope, the crew workload is expected to remain within acceptable limits. This means that flight crew workload is expected to be maintained at the same level of current operations

(8c) This means that the flight crew situational awareness is expected to be negatively impacted.

(9a) The flare assisting and energy management functions are enablers but are not mandatory to fly IGS operations as that is fully aircraft and slope dependent. In some cases these two enablers will facilitate the IGS operations. Besides, the training should allow to counterbalance the difficulty for the flight Crew to manage the IGS operations. Adequate visual Aids (VASI/PAPI) will be provided to the Flight crew when the flying an Increased Glide Slope operation. Several solutions are envisaged: a single PAPI for the standard approach and IGS when slope values are close (e.g. 3° and 3.2°), a single PAPI switching to cope with the slope of the next aircraft to land or two PAPIs, one on each side of the runway, for each slope, with different colours.

This means that flight crew workload and situational awareness are expected to be maintained at the same level of current operations.

(9b) IGS operations are expected to maintain task load (e.g. Number and type of requests, Number of flight crew operations, Number and type of communications etc.) at the same level of current final approach operations as flight crew will be provided with the same kind of clearances as today operations. The phraseology used by ATCO and Flight crew is the standard one and remains the same as today. No additional communication is needed to fly IGS procedures.

(9c) Flight Crew situational awareness is expected to be maintained.

6.3 Costs mechanisms

PJ02 W2 solution 14.3 uses the costs mechanisms developed by PJ02-02. They used the cost categorisation defined by SESAR PJ19 W1, as well as the tables developed by that project. The table below shows where costs have been identified per stakeholder, the detail of the costs is available in the CBA document.

Please note that as no costs have been identified for Military or NM stakeholders, they have been suppressed from all tables.

Category	Sub-category	Cost type	Description	Airspace Users		ANSP	Airports	Other Stakeholder
				Airborne costs (Forward Fit and Retrofit per aircraft)	Ground costs (per AOC - Airline Operation Centre)			
Pre-implementation Costs								
R&D and Pre-Industrialisation costs are already incurred in the SESAR Development Phase and therefore not included in the cost assessment								
Implementation Costs								
	One-Off Costs		costs incurred during the implementation period and that are paid once					
		Initial Training & Staffing	Initial Staffing Initial Training Training Material Training simulator	X		X	X	
		Project Management	Project Definition, Programme management and support, Planning costs, including design costs, planning authority resources and other planning costs Change management Procurement activities Meeting/ travel costs Processes and documentation costs	X		X	X	

Category	Sub-category	Cost type	Description	Airspace Users		ANSP	Airports	Other Stakeholder
				Airborne costs (Forward Fit and Retrofit per aircraft)	Ground costs (per AOC - Airline Operation Centre)			
		Airspace design & Procedures	Changes to airspace design Changes to and design of new ATC and flight procedures LoAs			X	X	
		Administrative costs	New procedures, regulation, processes to put in place Documentation	X		X	X	
		Installation & Commissioning	Installation costs, Initial Test and evaluation (*Test plans, procedures, reports ; Test equipment/tools, including aircraft ; Test staff and training)* Functional integration (*standardisation*) Human/product interface			X	X	
		Validation & Certification costs	Validation Safety assessments / audits			X	X	
		Other One-off Costs	Costs not covered by any of the other categories. Please describe them					
	Capital Costs							

Category	Sub-category	Cost type	Description	Airspace Users		ANSP	Airports	Other Stakeholder
				Airborne costs (Forward Fit and Retrofit per aircraft)	Ground costs (per AOC - Airline Operation Centre)			
		Equipment & System	Hardware and software acquisition, Software development (*development, engineering, knowledge base: adaptation data, production, reviews and audit*) Initial software licensing			X	X	
		Integration costs	Physical integration Software development System integration			X	X	
		Building & Facilities	Architecture, engineering, and construction of special facilities					
		Land & property costs	Land acquisition and land restitution costs (including demolition, land clearance, site preparation, removal of redundant equipment/facilities, etc) Construction costs (incl. professional fees) Contingencies					
		Licences, patent						

Category	Sub-category	Cost type	Description	Airspace Users		ANSP	Airports	Other Stakeholder
				Airborne costs (Forward Fit and Retrofit per aircraft)	Ground costs (per AOC - Airline Operation Centre)			
		Other Capital Costs	Costs not covered by any of the other categories. Please describe them					
	Transition Costs		Costs for maintaining current systems, during transition to a new system					
		Transition Investments costs						
		Transition Operations costs						
		Transition Staff costs						
		Other						
Operating costs (includes **only delta costs**, i.e. changes to the operating costs that this project(s) will bring when deployed)								
	Raw Material							
		Material, supplies, utilities						

Category	Sub-category	Cost type	Description	Airspace Users: Airborne costs (Forward Fit and Retrofit per aircraft)	Airspace Users: Ground costs (per AOC - Airline Operation Centre)	ANSP	Airports	Other Stakeholder
	Personal & Training		Change in costs for staff, training due to operational improvements implemented					
		Personnel cost	Salary & wages and other benefits such as health insurance, conveyance allowance, etc.					
		Training	Training (new staff)	X		X	X	
		Staff support						
	Maintenance & Repair							
		Hardware & Software	Hardware and Software maintenance and repair			X	X	
		Other services	External contract fees to maintain the system					
	Facility costs							
		Rent & Lease	Rent or Lease payments Office space rent					
		Furniture & equipment						
		Communication costs						
		Energy						

Category	Sub-category	Cost type	Description	Airspace Users		ANSP	Airports	Other Stakeholder
				Airborne costs (Forward Fit and Retrofit per aircraft)	Ground costs (per AOC - Airline Operation Centre)			
		Property Taxes	Property taxes and equivalent assessments Operations taxes					
	Administration Costs							
		Standard expenditures related to changes in procedures, regulation, processes		X		X	X	
		Documentation						
		Travel						

7 Description of ISGS procedures

ISGS concept consists in mixing aircraft flying the final segment following an ILS conventional slope (usually 3°) with aircraft following another higher final segment, with a limitation at 4.49°, and landing on the same threshold.

Having two arrival slopes active at the same time, it can be envisaged to have one or two interception altitudes, according to each local case. The figures below show the two cases.

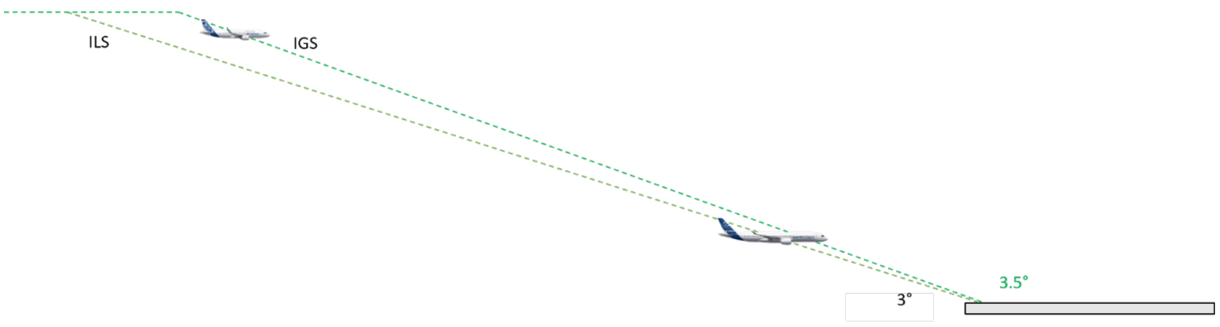


Figure 2: ISGS procedure with one interception altitude

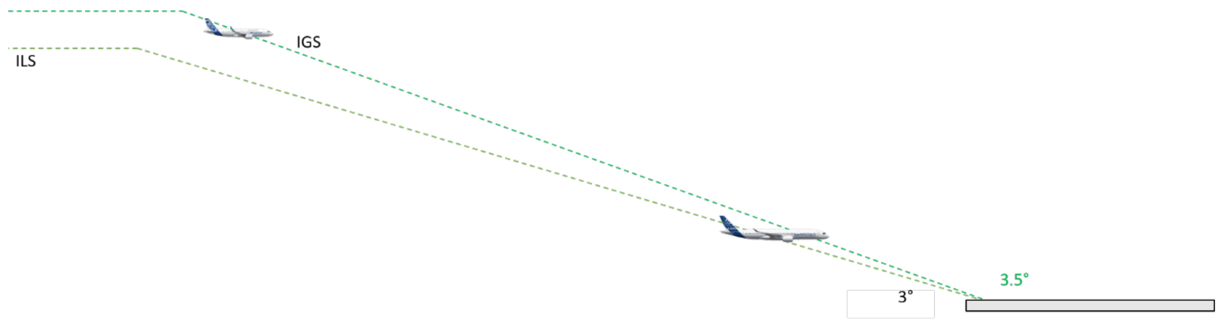


Figure 3: ISGS procedure with two interception altitudes

8 Separation design for ISGS

When using ISGS, the aircraft positioned on the “modified” glide are flying above those flying on the conventional (e.g. ILS) glide, at least foe a part of the glide. Because vortices are sinking (and also rebounding back to about their generation altitude when generated close to the ground), the probability to encounter a wake generated by a preceding aircraft flying on the ILS is lower when flying on the “modified” glide than if both aircraft were flying on the same glide. They are therefore better protected in terms of WVE risk. On the contrary, aircraft flying on the ILS behind a preceding aircraft flying on the modified glide are more exposed.

The wake vortex encounter risk related to ISGS therefore depends on the difference in altitude of the two considered glides. This altitude difference also depends on the uncertainty in aircraft vertical positioning when flying on the ILS or on a modified glide (where ILS, GBAS, SBAS, or RNAV is used for navigation and surveillance).

Based on these arguments and using a relative approach with current operations as baseline, the rules of wake separation design for ISGS is here established. This also allows us to determine whether ISGS procedures are favourable in terms of capacity (in addition to noise benefits) for all types of pairs.

In order to generalize the analysis, all analyses are performed depending on the mean altitude difference between the two considered glides at a certain position. The reasoning behind that glide altitude difference (i.e. the investigated ISGS concept and parameter values) is then no longer required. However, the navigation uncertainty related to the used navigation system (GBAS, SBAS or RNAV) has an impact on the wake risk. The wake separation design will hence be provided by altitude difference and by navigation system.

8.1 Risk assessment methodology

For wake separation design, two altitudes of wake evolution have to be considered, illustrated in Figure 4:

- The Out-of-Ground Effect (OGE) region (typically for wake evolving above 1 generator wingspan)
- The In-Ground Effect (IGE) region (typically for wake evolving below 1 generator wingspan)

In the OGE region, the vortices sink due to their mutual interaction and are transported by the wind. Their decay is slower compared to the IGE region and is influenced by the atmospheric turbulence and stratification.

In the IGE region, due to the interaction with the ground, the vortices first sink and then rebound potentially back to their generation altitude or even above. The decay is stronger compared to the OGE region due to the interaction of the vortices with the ground generated boundary layer. The closer the vortices from the ground, the stronger is their decay.

For wake separation design, it has been agreed at ICAO level that the Reasonable Worst Case corresponds to long lasting wakes generated at one generator wing span. This is valid for two trailing aircraft following the same glide. When using two glides, the OGE region has also to be considered especially when the follower is on a lower glide compared to the leader.

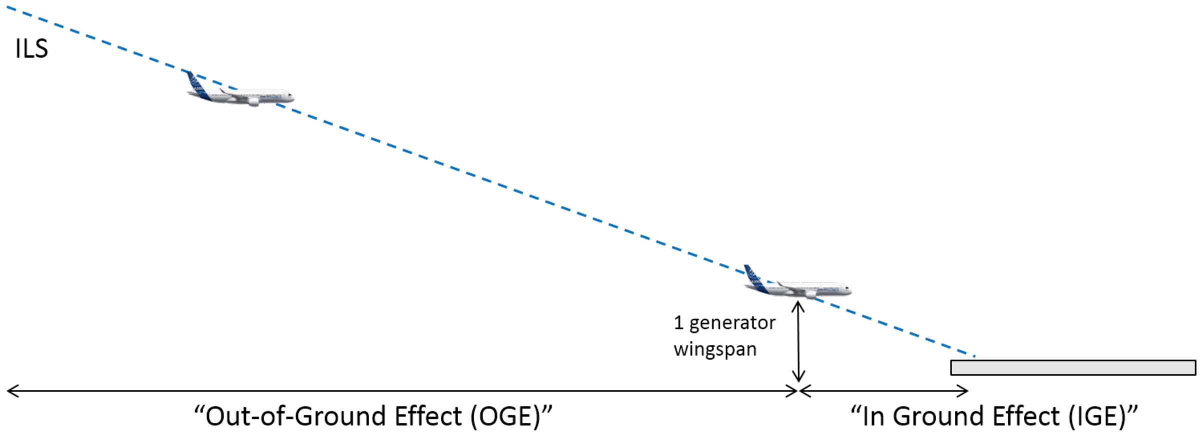


Figure 4: description of the two regions of wake evolution

The wake vortex severity is assessed computing the induced Rolling Moment coefficient (RMC), as formulated in RECAT-EU-PWS (see (De Visscher, Winckelmans, & Treve, 2015)) accounting for the wake strength and for the follower resistance to the encounter (through its speed and wing geometry). Long lasting wake strength is considered.

The wake encounter frequency effect is accounted for IGE region for which the Complementary Cumulative density Function (CCDF) of RMC are compared between the test case (i.e. operation of ISGS IGE) and an acceptable baseline (i.e. current operations);

The wake encounter frequency effect is not taken into account for OGE region since the operation of aircraft on an upper glide significantly increases the exposure of the follower aircraft (on a lower glide) all along the glide. The assessment is thus performed on an absolute basis using an absolute RMC threshold found "acceptable" in the EUROCONTROL WISA Flight simulator campaign.

For IGE assessment, the separations are provided as a function of glide altitude difference for wake generated at 1 generator wing span altitude.

8.2 LiDAR data description and processing

This assessment is performed using three LiDAR databases described in (De Visscher, Stempfel, & Jacques, October 2017):

- EGLL-IGE database for characterisation of Cat-B and Cat-C wake evolution in ground proximity
- EGLL-OGE database for characterisation of Cat-B, Cat-C wake evolution OGE
- CDG LiDAR database for characterisation of Cat-D, Cat-E wake evolution OGE

The LiDAR data were first filtered and processed in order to be able to evaluate the probability to encounter a vortex of a certain strength in a certain position after a certain time.

Because a lot of tracks have only limited measured time and in order to smooth the wake circulation evolution, the 4-parameter decay model, described in (Bourgeois, Choroba, & Winckelmans, 2012), is applied on each measured track. It also allows some filtering of the tracks. Are excluded:

- tracks with lasting time smaller than 30s
- tracks for which the fitting algorithm did not converge
- tracks with circulation increase evolution
- tracks with initial circulation that deviates by more than 40% from the median measured initial circulation when considering all tracks of a specific aircraft type.

For IGE data, the RWC tracks are selected based on their lasting time with a 5 t_0 selection criterion using t_0 values computed in RECAT-EU-PWS. The tracks are also shifted in time so as to be at one generator wing span at time=0. The vortex altitude evolution is extrapolated using linear extrapolation based on the last 4 points of measurements with a conservative capping at the last measured altitude (i.e., if the extrapolation provides a value lower than the last measured altitude, the values are conservatively set to the last measured altitude).

For OGE data, the RWC tracks are selected based on their lasting time with a 5 t_0 selection criterion using t_0 values computed from the measured initial circulation and assuming s=π/4.

8.3 Navigation uncertainty

Based on personal exchange with navigation experts from EUROCONTROL and Airbus, the following navigation uncertainties have been determined and are used in what follows.

When using ILS, GBAS or SBAS, the navigation performances are equivalent. At 1 NM from the runway threshold, typical value of Total System Error (TSE) is 13 m in vertical position and 35 m in lateral position. When using RNAV, those values are larger reaching a TSE vertical of 26 m and a lateral TSE of 148 m.

Note that on lateral precision, the value has to be bounded by the runway half width (typically 45 m).

8.3.1 Wake separation design for leader on ILS

This section describes the methodology for wake separation design for ISGS operations behind a leader on conventional (i.e. ILS) glide.

8.3.1.1 IGE assessment methodology

The first case that is here investigated concerns ILS approach followed by ISGS with a certain altitude difference ΔH and a certain navigation uncertainty providing a certain difference between the two glide altitudes when the leader is at one wing span altitude. This is illustrated in Figure 5. For wake separation design, the reference altitude of wake generation corresponds to one wingspan generator. We thus here consider vortices generated at one wing span altitude potentially impacting aircraft flying in ISGS on a glide located $\Delta H + TSE_{vert}$ above, see illustration in Figure 6.

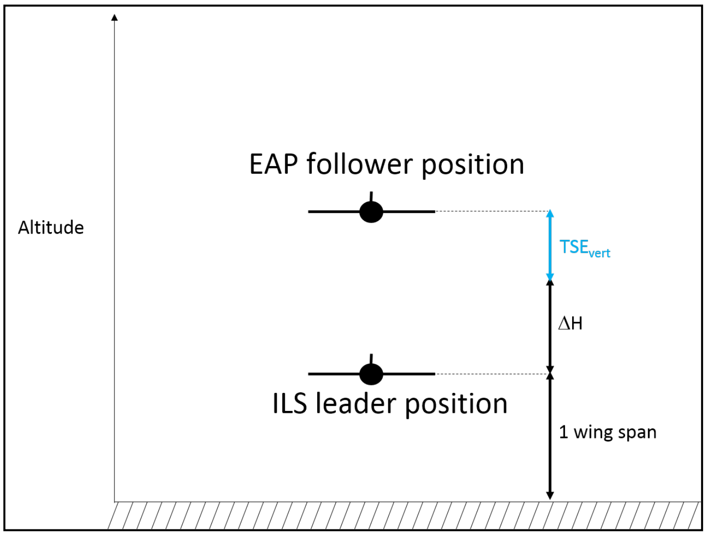


Figure 5: schematic view of ILS and ISGS region of flight

For that situation, vortices generated by the leader on the ILS glide might rebound above the glide in a region where the follower could be (i.e. ΔH above the ILS glide altitude). The wake vortex encounter area hence corresponds to the region located ΔH above the ILS glide altitude, see Figure 6.

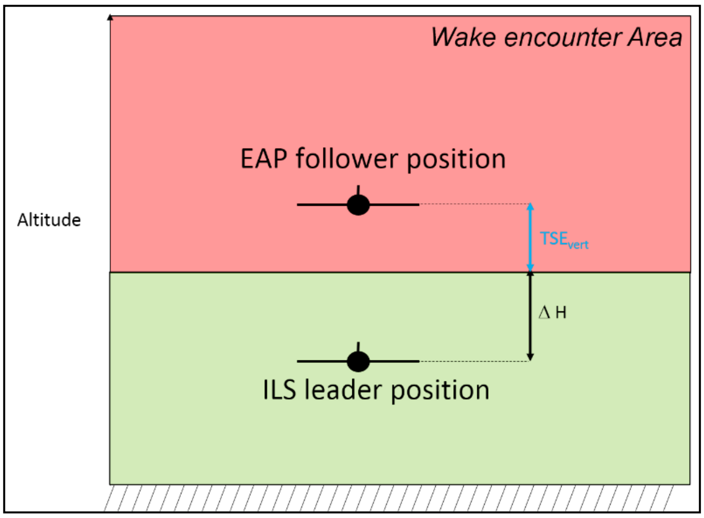


Figure 6: schematic view of ISGS wake analysis for close to ground effect region

In order to perform a relative safety assessment, this situation has to be compared to an acceptable baseline. Here, we chose two aircraft on the same ILS glide. For that situation, the follower can encounter any vortex present above the glide altitude reduced by $TSE_{vert, ILS}$, see Figure 7. This defines the wake vortex encounter area for the baseline case.

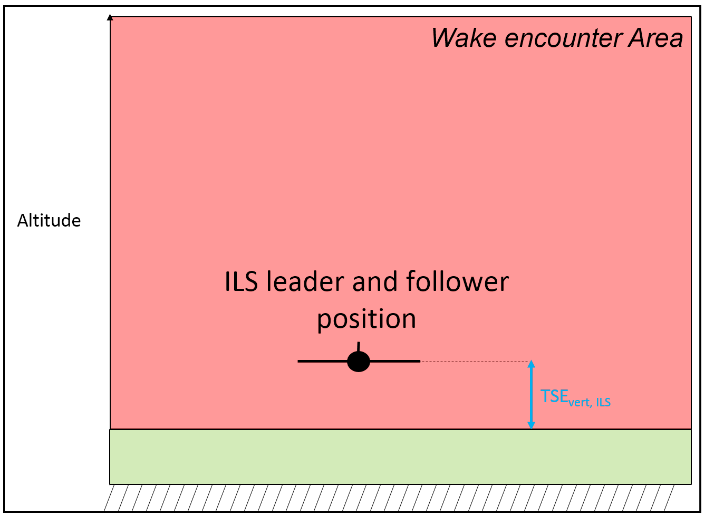


Figure 7: schematic view of baseline for ISGS wake analysis for close to ground effect region

The wake encounter risk associated to the test case and the baseline case is expressed as the CCDF of RMC found in the wake vortex encounter area at a certain time separation.

For each ΔH value, the CCDF of the test case for various time separation reduction values is compared to the baseline CCDF curve defined as the CCDF of RMC computed at the nominal separation time. The allowed time separation reduction then corresponds to that leading to a test CCDF curve below the baseline one at least for RMC values above the RMC threshold. The RMC threshold is set to 0.08 which is the maximum value allowing safe go-around according to WISA campaign in ground proximity (200 ft).

Since we compare the results only depending on the leader for a same follower aircraft type, the RMC is here directly linked to the vortex circulation. The maximum circulation corresponding to the RMC threshold is then computed as the minimum circulation leading to that RMC threshold value per RECAT-EU category pair and based on a sample of the 96 most frequent aircraft types in Europe for which data were collected in the framework of RECAT-EU-PWS. The circulation thresholds values corresponding to RMC=0.08 are provided in Table 6.

Leader/Follower	Cat-A	Cat-B	Cat-C	Cat-D	Cat-E	Cat-F
Cat-A	813	553	414	355	249	217
Cat-B	786	528	386	328	223	183
Cat-C	756	502	356	300	194	143
Cat-D	749	496	349	293	188	134
Cat-E	729	479	330	276	169	113
Cat-F	721	471	322	269	161	104

Table 6: Circulation thresholds corresponding to RMC=0.08 for each RECAT-EU category pair

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Co-funded by the European Union

The analysis is based on the EGLL-IGE LiDAR data analysis. Given the traffic mix of the database, the assessment is only performed for Cat-B and Cat-C leader aircraft types. For the other aircraft types, the obtained results are extended from those results.

For Cat-B and Cat-C aircraft types, the following baseline time separations are considered:

- 70 s for a 3NM separation minimum
- 100 s for a 4 NM separation minimum
- 120 s for a 5 NM separation minimum
- 150 s for a 6 NM separation minimum
- 180 s for a 7 NM separation minimum

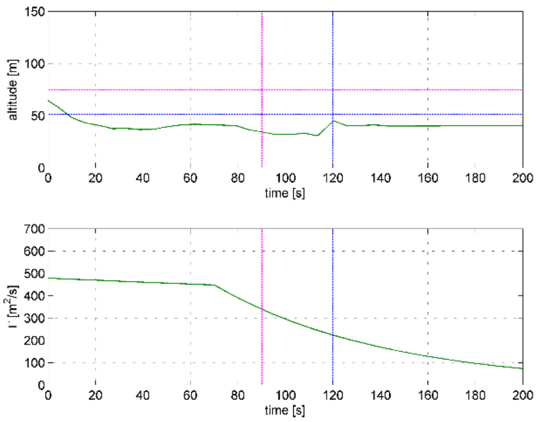
The results are obtained for a time resolution of 5 s and a ΔH resolution of 5 m.

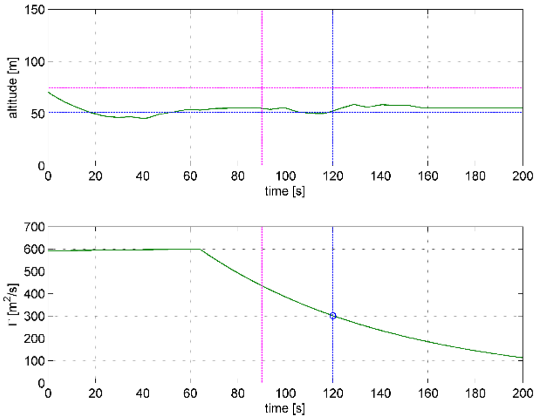
8.3.1.2 IGE Results

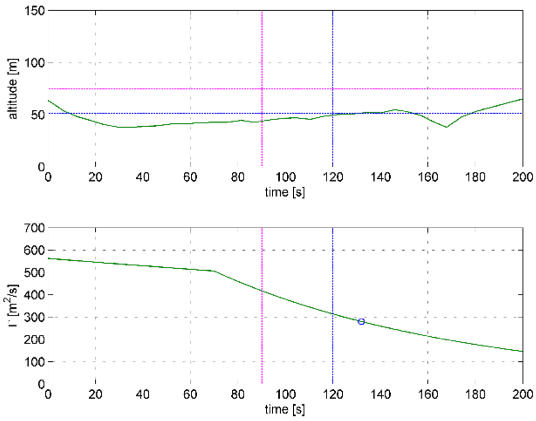
The allowed time separation reduction when operation ISGS behind ILS approach, depending on the glide altitude difference is assessed by comparing for each pair type the distribution of RMC compared to that of the baseline (i.e. two consecutive ILS approaches). The allowed separation reduction is that providing an RMC distribution below the baseline one at least for RMC values below the RMC threshold value (with a tolerance of one data point).

Figure 8 provides an example of track processing allowing the CCDF computation for a baseline time separation of 120s with 65 m generator, ΔH=10 m and a time separation reduction of 30s. In those 5 examples:

- Case 1 (top left): no vortex found neither for baseline or test case
- Case 2 (top right): vortex found at or before time separation minima for baseline but not for test case
- Case 3 (row 2 left): vortex found after time separation minima for baseline but not for test case
- Case 4 (row 2 right): vortex found at or before time separation minima for both baseline and test case
- Case 5 (bottom): vortex found at or before time separation minima for baseline but after time separation minima for test case.




altitude [m]
time [s]
Γ [m²/s]
time [s]


altitude [m]
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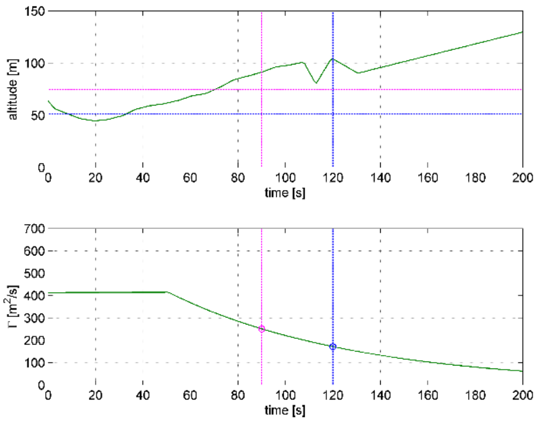
altitude [m]
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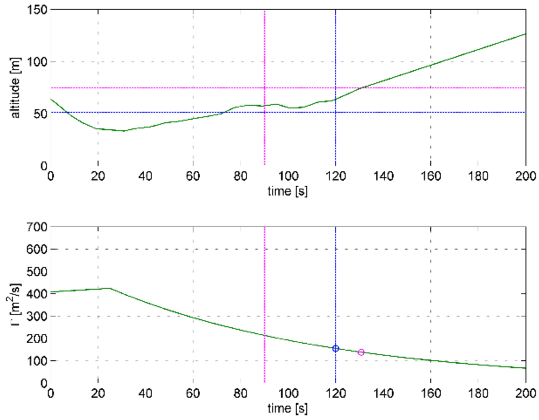


Figure 8: Example of 5 tracks providing altitude (top) and circulation (bottom) evolution. Comparison of test case and baseline for baseline time of 120s, ΔH=10 m and a time separation reduction of 30s. The blue (resp. magenta) circle indicates the circulation value considered for the baseline (resp. test case)

8.3.1.2.1 Cat-B leaders

Figure 9 to Figure 17 provide examples of CCDF(RMC) comparison when operating ISGS behind an ILS approach for various ΔH values and for Cat-B leaders.

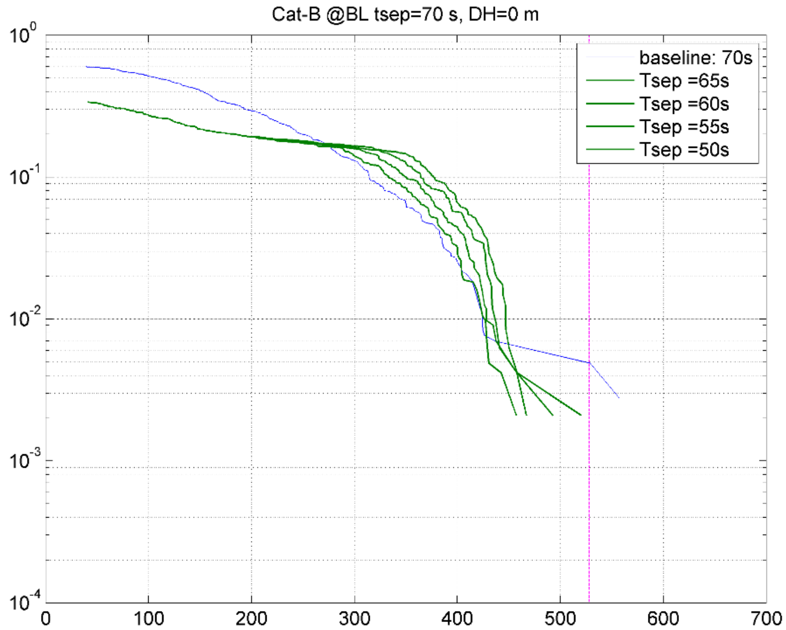


Figure 9: CCDF(RMC) for CAT-B-CAT-B with leader on ILS @ one wind span altitude and follower following an ISGS DH=0 m above the ILS with various separation reductions compared to the baseline time separation (70 s)

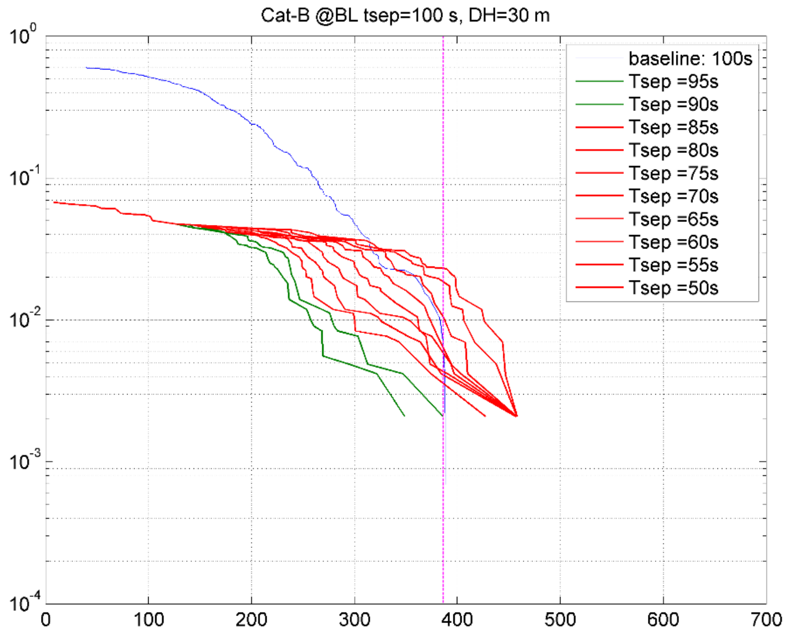


Figure 10: CCDF(RMC) for CAT-B-CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=30 m above the ILS with various separation reductions compared to the baseline time separation (100 s)

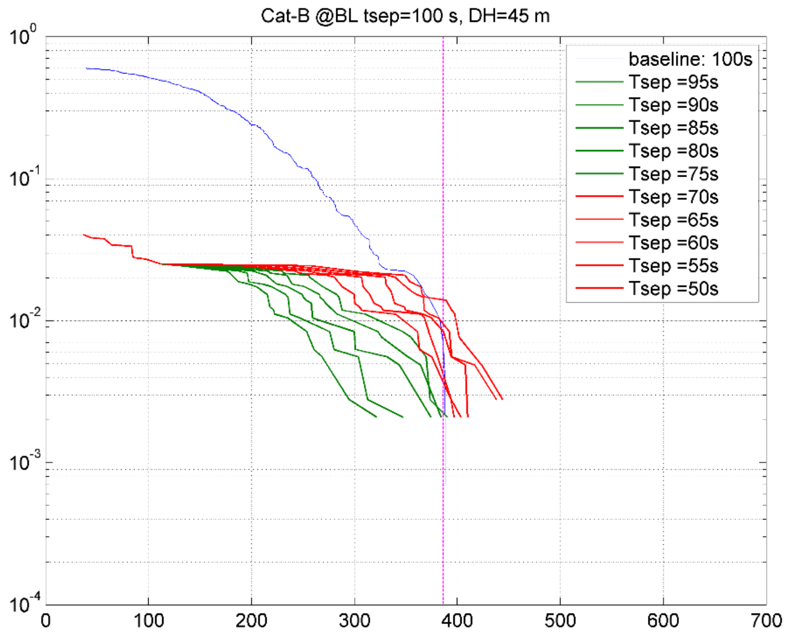


Figure 11: CCDF(RMC) for CAT-B-CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=45 m above the ILS with various separation reductions compared to the baseline time separation (100 s)

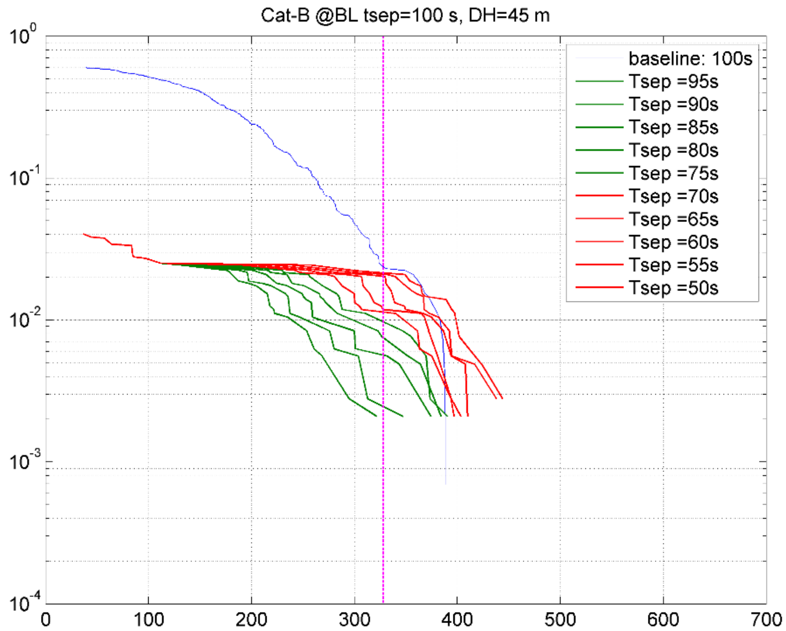


Figure 12: CCDF(RMC) for CAT-B-CAT-D with leader on ILS @ one wind span altitude and follower following an ISGS DH=45 m above the ILS with various separation reductions compared to the baseline time separation (100 s)

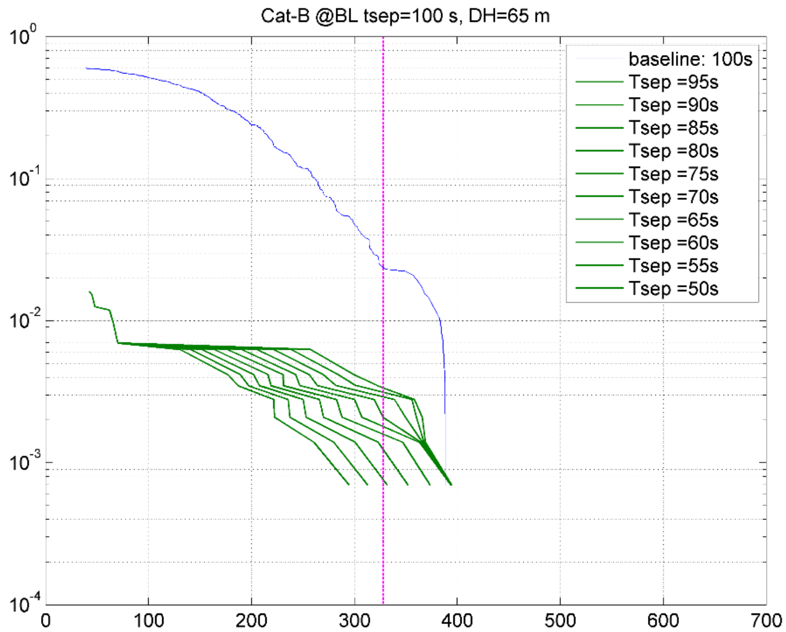


Figure 13: CCDF(RMC) for CAT-B-CAT-D with leader on ILS @ one wind span altitude and follower following an ISGS DH=65 m above the ILS with various separation reductions compared to the baseline time separation (100 s)

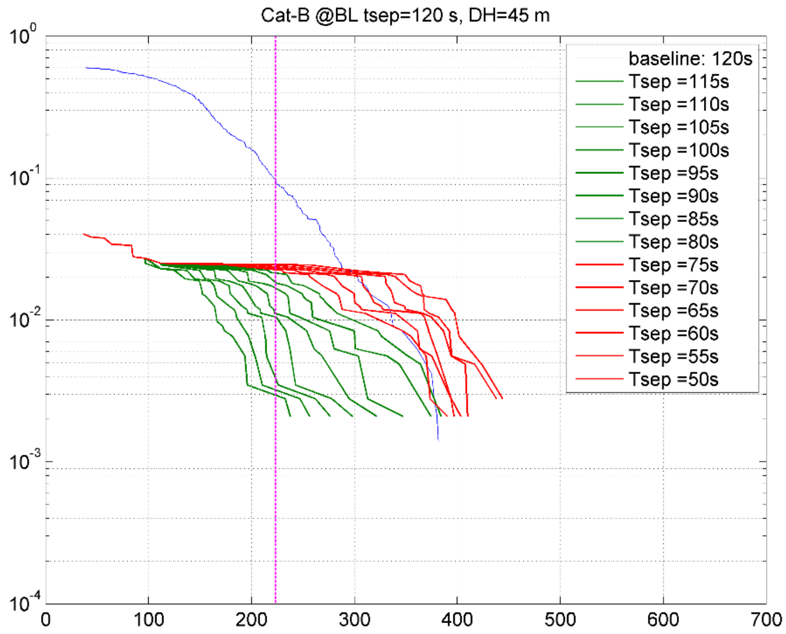


Figure 14: CCDF(RMC) for CAT-B-CAT-E with leader on ILS @ one wind span altitude and follower following an ISGS DH=45 m above the ILS with various separation reductions compared to the baseline time separation (120 s)

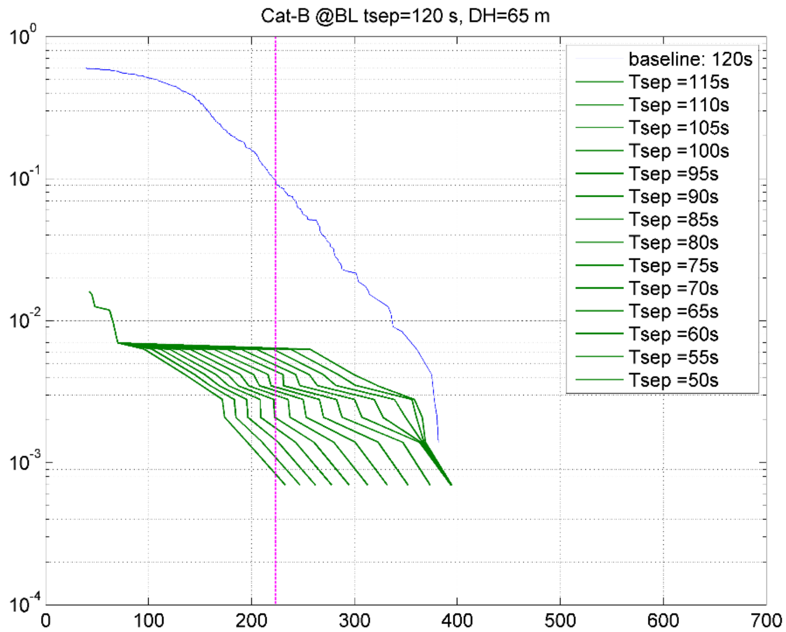


Figure 15: CCDF(RMC) for CAT-B-CAT-D with leader on ILS @ one wind span altitude and follower following an ISGS DH=65 m above the ILS with various separation reductions compared to the baseline time separation (120 s)

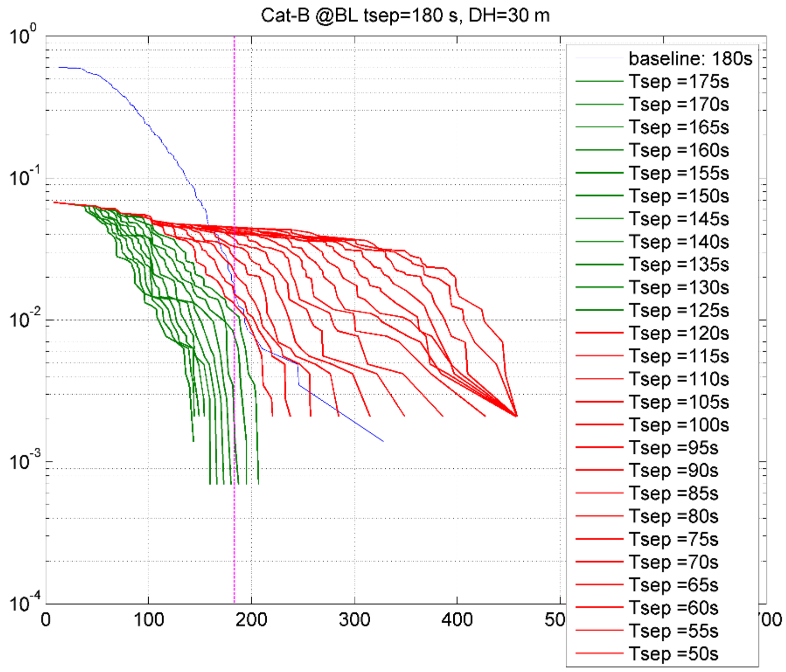


Figure 16: CCDF(RMC) for CAT-B-CAT-F with leader on ILS @ one wind span altitude and follower following an ISGS DH=30 m above the ILS with various separation reductions compared to the baseline time separation (180 s)

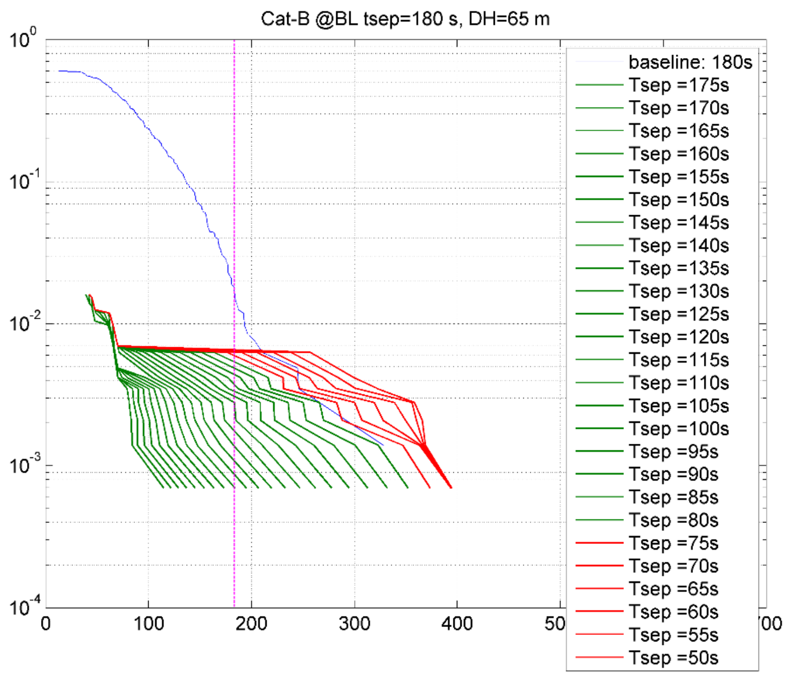


Figure 17: CCDF(RMC) for CAT-B-CAT-F with leader on ILS @ one wind span altitude and follower following an ISGS DH=65 m above the ILS with various separation reductions compared to the baseline time separation (180 s)

Table 7 provides the obtained allowed time separation reductions for CAT-B leaders following the ILS and Cat-B, Cat-C, Cat-D, CAT-E and CAT-F followers following an ISGS procedure.

DH [m]/Follower	Cat-B 70s	Cat-C 100 s	Cat-D 100 s	Cat-E 120 s	Cat- F 180 s
0	50	100	100	115	175
5	50	100	100	110	160
10	50	95	95	100	150
15	50	90	90	90	145
20	50	90	90	90	140
25	50	90	90	90	125
30	50	90	90	90	125
35	50	90	90	90	120
40	50	90	90	90	115
45	50	75	75	80	110
50	50	75	75	80	110
55	50	75	75	75	110
60	50	65	65	70	100
65	50	50	50	50	80
70	50	50	50	50	80
75	50	50	50	50	50

Table 7: Allowed time separation minima [s] behind Cat-B depending on ΔH value and for various followers

8.3.1.2.2 Cat-C leaders

Figure 18 to Figure 23 provide examples of CCDF(RMC) comparison when operating ISGS behind an ILS approach for various ΔH values and for Cat-C leaders.

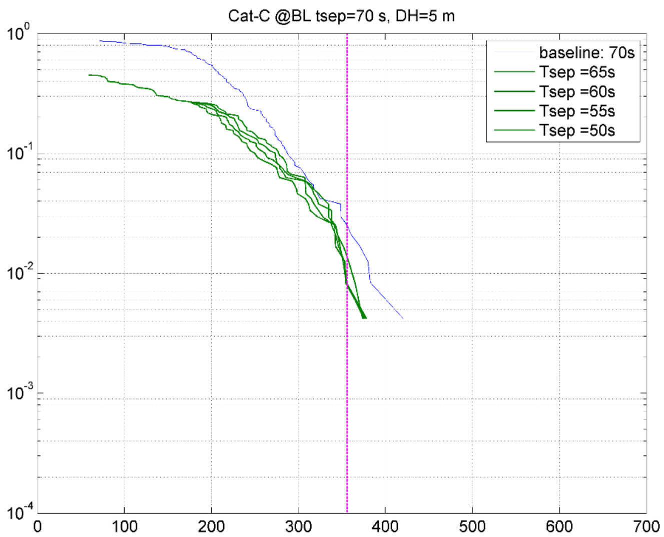


Figure 18: CCDF(RMC) for CAT-C-CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=5 m above the ILS with various separation reductions compared to the baseline time separation (70 s)

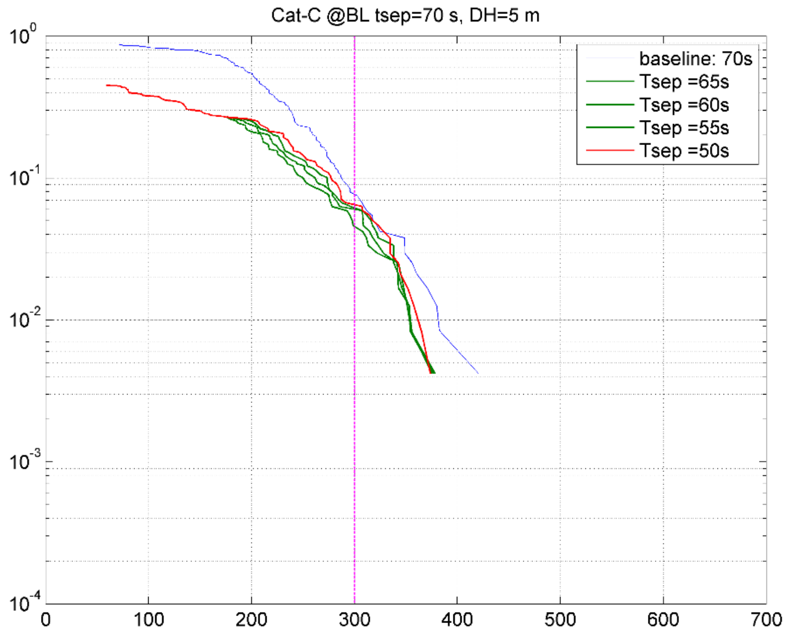


Figure 19: CCDF(RMC) for CAT-C-CAT-D with leader on ILS @ one wind span altitude and follower following an ISGS DH=5 m above the ILS with various separation reductions compared to the baseline time separation (70 s)

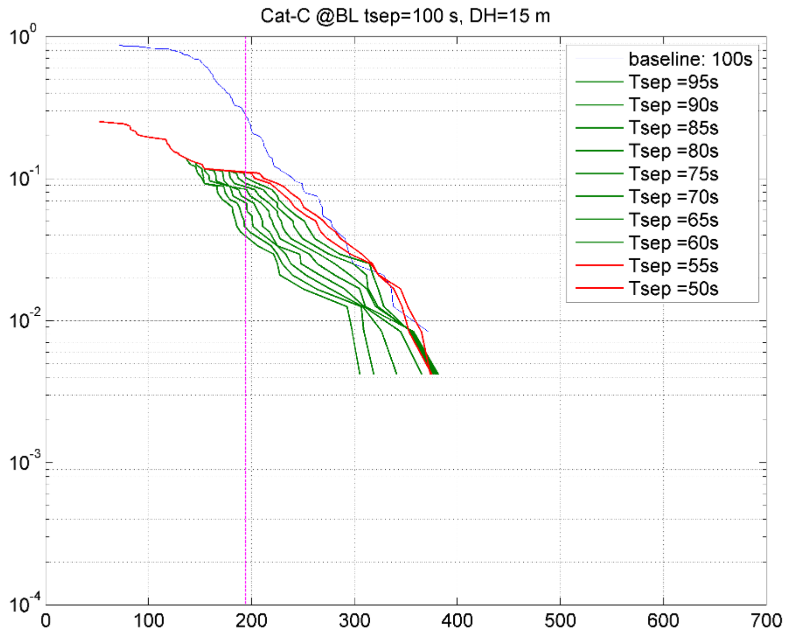


Figure 20: CCDF(RMC) for CAT-C-CAT-E with leader on ILS @ one wind span altitude and follower following an ISGS DH=15 m above the ILS with various separation reductions compared to the baseline time separation (100 s)

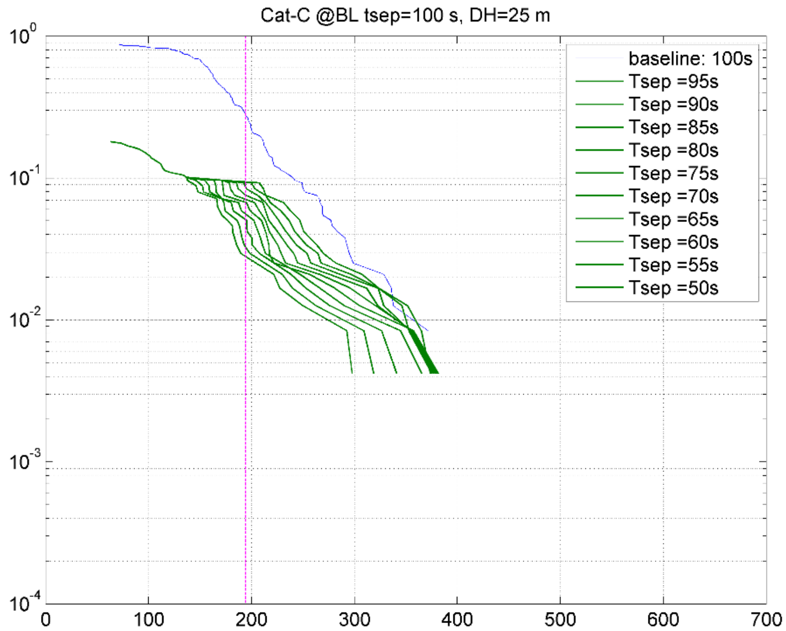


Figure 21: CCDF(RMC) for CAT-C-CAT-E with leader on ILS @ one wind span altitude and follower following an ISGS DH=25 m above the ILS with various separation reductions compared to the baseline time separation (100 s)

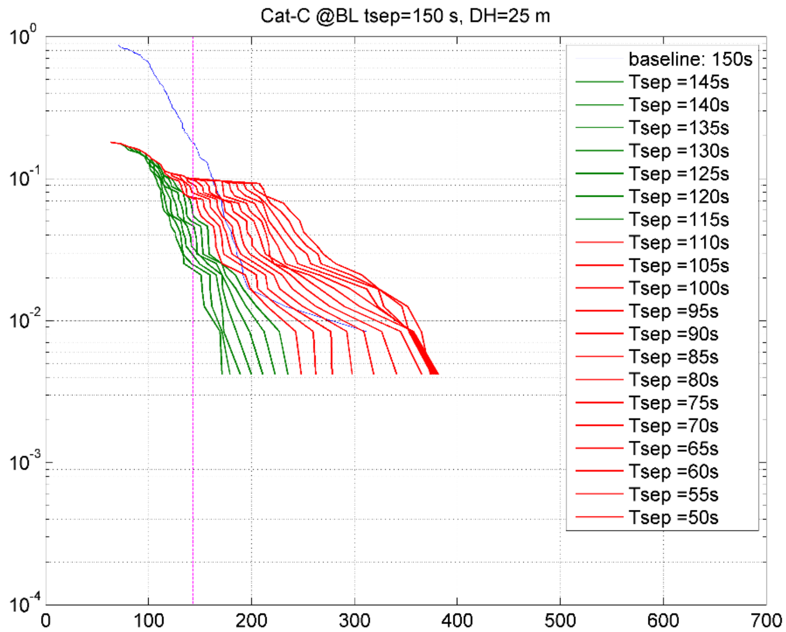
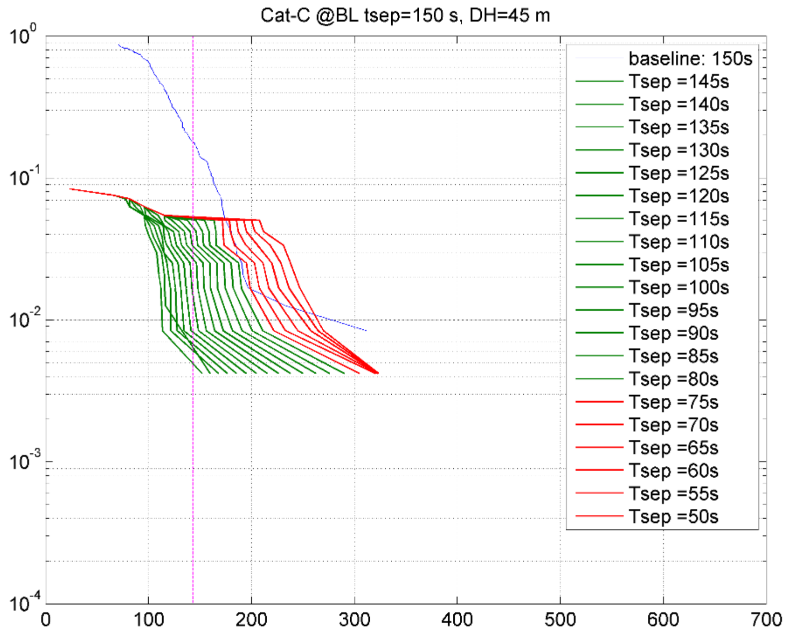


Figure 22: CCDF(RMC) for CAT-C-CAT-F with leader on ILS @ one wind span altitude and follower following an ISGS DH=25 m above the ILS with various separation reductions compared to the baseline time separation (150 s)



1085

1086 **Figure 23: CCDF(RMC) for CAT-C-CAT-F with leader on ILS @ one wind span altitude and follower following an**
1087 **ISGS DH=45 m above the ILS with various separation reductions compared to the baseline time separation**
1088 **(150 s)**

1089 Table 8 provides the obtained allowed time separation reductions for CAT-C leaders following the ILS
1090 and Cat-C, Cat-D, CAT-E and CAT-F followers following an ISGS procedure.

DH [m]/Follower	Cat-C 70 s	Cat-D 70 s	Cat-E 100 s	Cat- F 150 s
0	60	65	100	150
5	50	55	100	150
10	50	50	95	150
15	50	50	60	125
20	50	50	60	120
25	50	50	50	115
30	50	50	50	80
35	50	50	50	80
40	50	50	50	80
45	50	50	50	80
50	50	50	50	70
55	50	50	50	60
60	50	50	50	60
65	50	50	50	50

1091 **Table 8: Allowed time separation minima [s] behind Cat-C depending on ΔH value and for various followers**

1092

8.3.1.2.3 Extension for Cat-A leaders

The time separation minima for Cat-A leader pairs are established applying the same time separation reduction as allowed for Cat-B leaders. The results are provided in Table 9.

DH [m]/Follower	Cat-B	Cat-C	Cat-D	Cat-E	Cat- F
0	20	0	0	5	5
5	20	0	0	10	20
10	20	5	5	20	30
15	20	10	10	30	35
20	20	10	10	30	40
25	20	10	10	30	55
30	20	10	10	30	55
35	20	10	10	30	60
40	20	10	10	30	65
45	20	25	25	40	70
50	20	25	25	40	70
55	20	25	25	45	70
60	20	35	35	50	80
65	20	50	50	70	100
70	20	50	50	70	100
75	20	50	50	70	130

Table 9: Allowed time separation reduction [s] behind Cat-A depending on ΔH value and for various followers

8.3.1.2.4 Extension for Cat-D leaders

The time separation minima for Cat-D-Cat-F pairs are established conservatively using Cat-C LiDAR data at 120 baseline separation but with a RMC threshold computed for a Cat-D leader.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

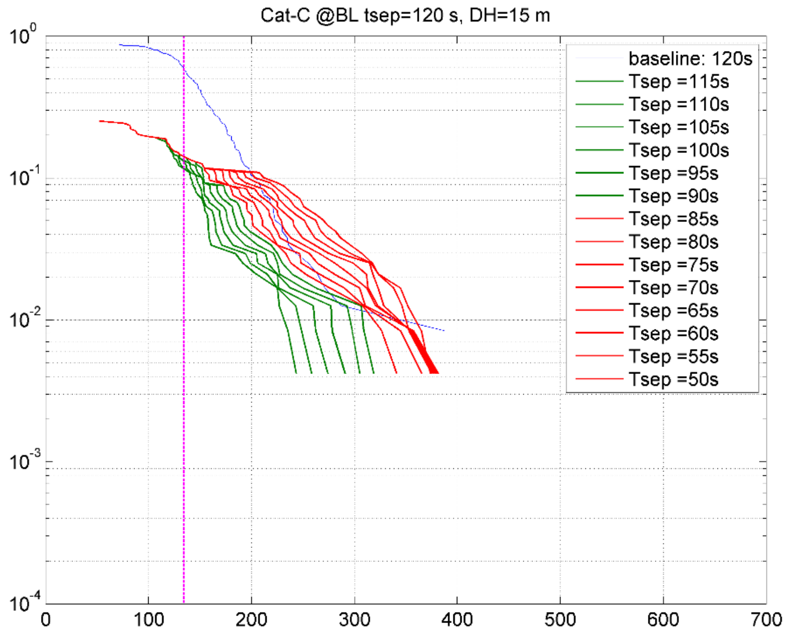


Figure 24: CCDF(RMC) for CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=15 m above the ILS with various separation reductions compared to the baseline time separation (120 s) and RMC threshold for Cat-D-Cat-F

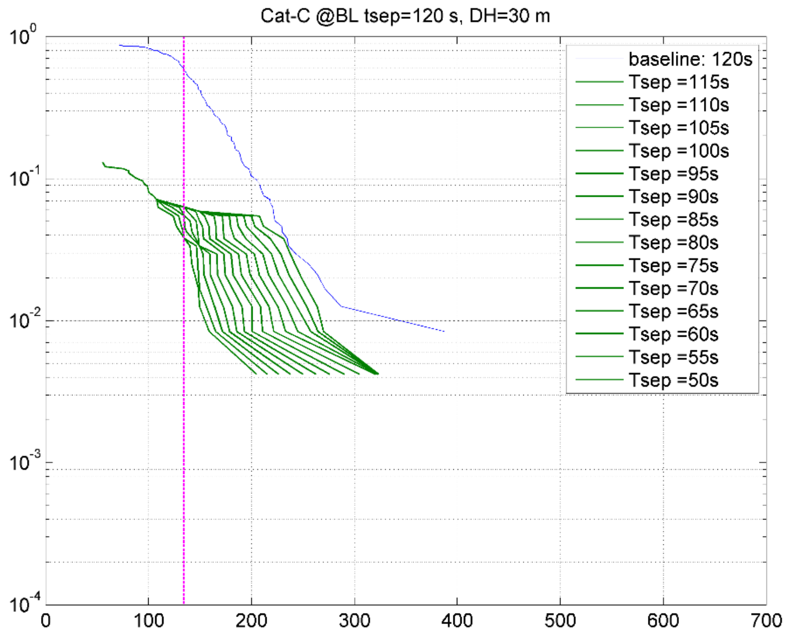


Figure 25: CCDF(RMC) for CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=30 m above the ILS with various separation reductions compared to the baseline time separation (120 s) and RMC threshold for Cat-D-Cat-F

The results are provided in Table 10.

DH [m]/Follower	Cat- F
0	120
5	115
10	110
15	90
20	90
25	80
30	50

Table 10: Allowed time separation minima [s] behind Cat-D depending on ΔH value and for Cat-F followers

8.3.1.2.5 Extension for Cat-E leaders

The time separation minima for Cat-E-Cat-F pairs are established conservatively using Cat-C LiDAR data at 100 baseline separation but with an RMC threshold computed for a Cat-E leader.

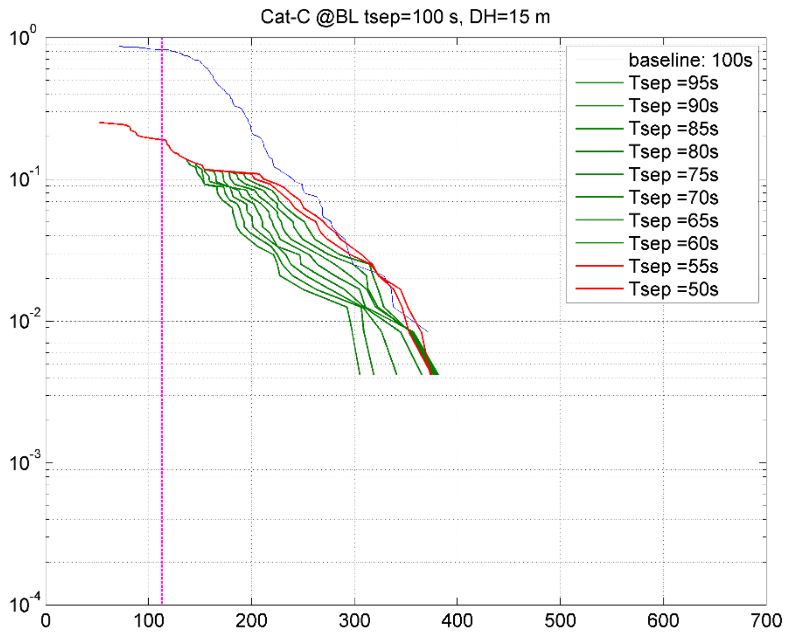


Figure 26: CCDF(RMC) for CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=15 m above the ILS with various separation reductions compared to the baseline time separation (100 s) and RMC threshold for Cat-E-Cat-F

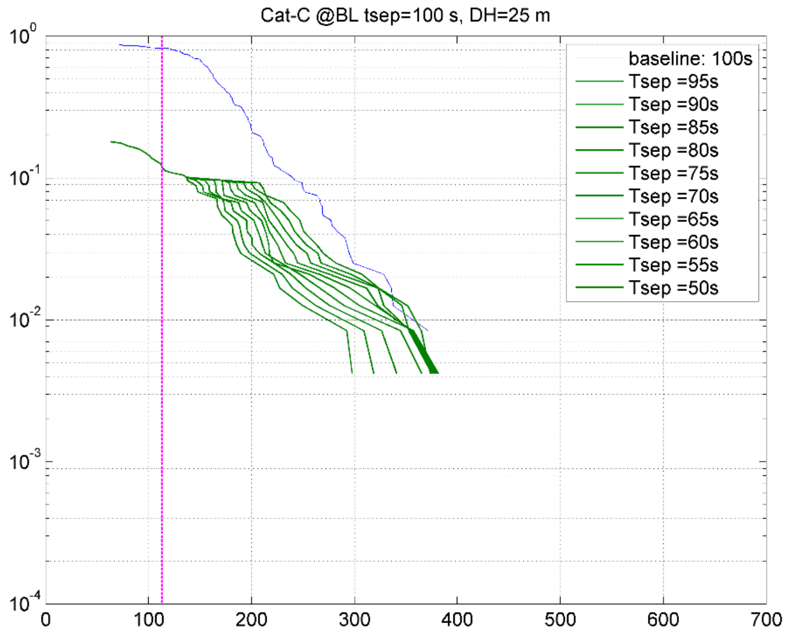


Figure 27: CCDF(RMC) for CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=25 m above the ILS with various separation reductions compared to the baseline time separation (100 s) and RMC threshold for Cat-E-Cat-F

The results are provided in Table 11.

DH [m]/Follower	Cat- F
0	100
5	100
10	95
15	60
20	60
25	50

Table 11: Allowed time separation minima [s] behind Cat-E depending on ΔH value and for Cat-F followers

8.3.1.2.6 Extension for Cat-F leaders

The time separation minima for Cat-F-Cat-F pairs are established conservatively using Cat-C LiDAR data at 70 s baseline separation but with an RMC threshold computed for a Cat-F leader.

The results are provided in Table 12.

DH [m]/Follower	Cat- F
0	60
5	55
10	50

Table 12: Allowed time separation minima [s] behind Cat-F depending on ΔH value and for Cat-F followers

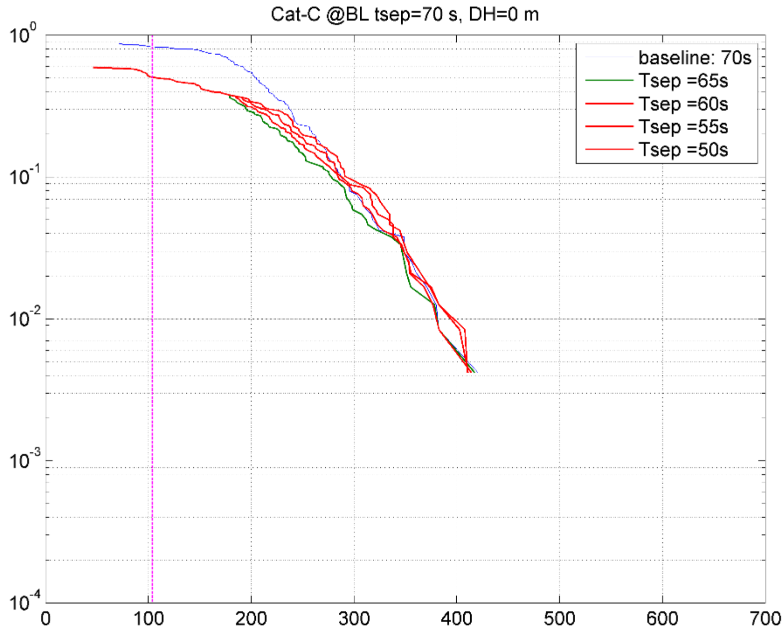


Figure 28: CCDF(RMC) for CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=5 m above the ILS with various separation reductions compared to the baseline time separation (70 s) and RMC threshold for Cat-F-Cat-F

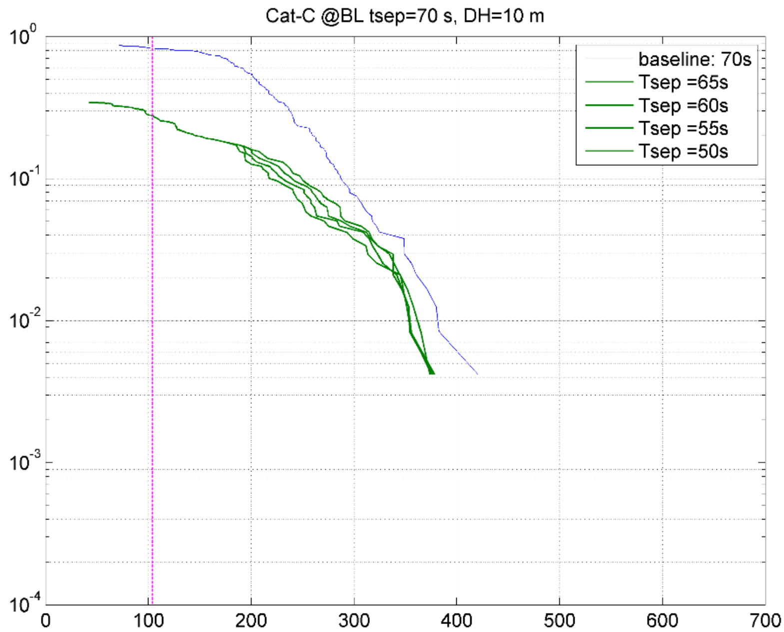


Figure 29: CCDF(RMC) for CAT-C with leader on ILS @ one wind span altitude and follower following an ISGS DH=10 m above the ILS with various separation reductions compared to the baseline time separation (70 s) and RMC threshold for Cat-F-Cat-F

8.3.1.3 OGE assessment methodology

The second case that is here investigated concerns ILS approach followed by ISGS with a certain altitude difference ΔH and a certain navigation uncertainty providing a certain difference between the two glide altitudes when the leader is above one wing span altitude. This is illustrated in Figure 30.

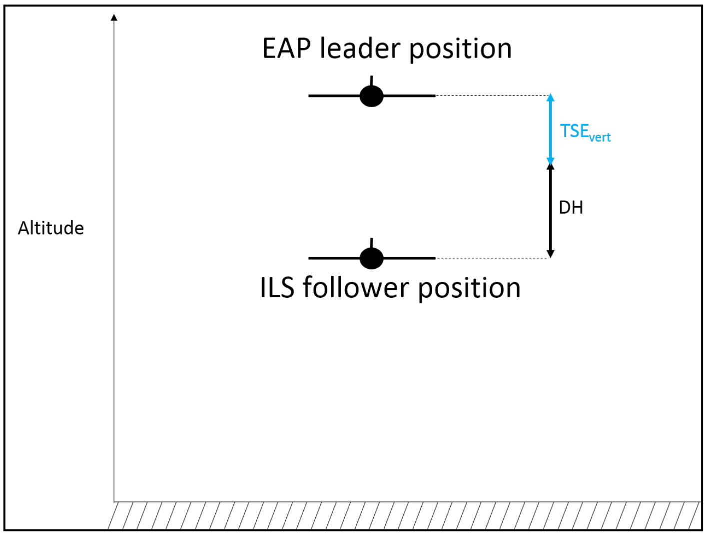


Figure 30: schematic view of ILS and ISGS region of flight for OGE situation

For that situation, vortices generated by the leader on the ILS glide will sink below the glide in a region where the follower could not encounter it, see illustration in Figure 31.

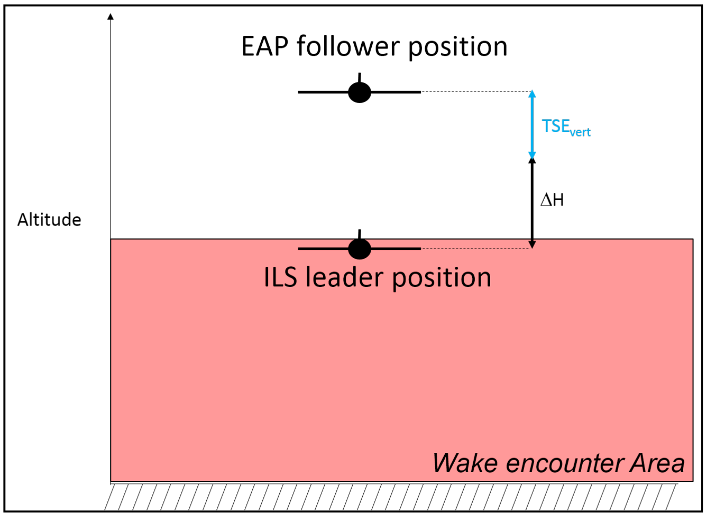


Figure 31: schematic view of the wake vortex encounter area for wake generated on the ILS with a follower on ISGS for OGE situation

The probability to encounter the wake is thus close to zero. This is verified through analysis of the EGLL-OGE database, see Figure 32 and Figure 33.

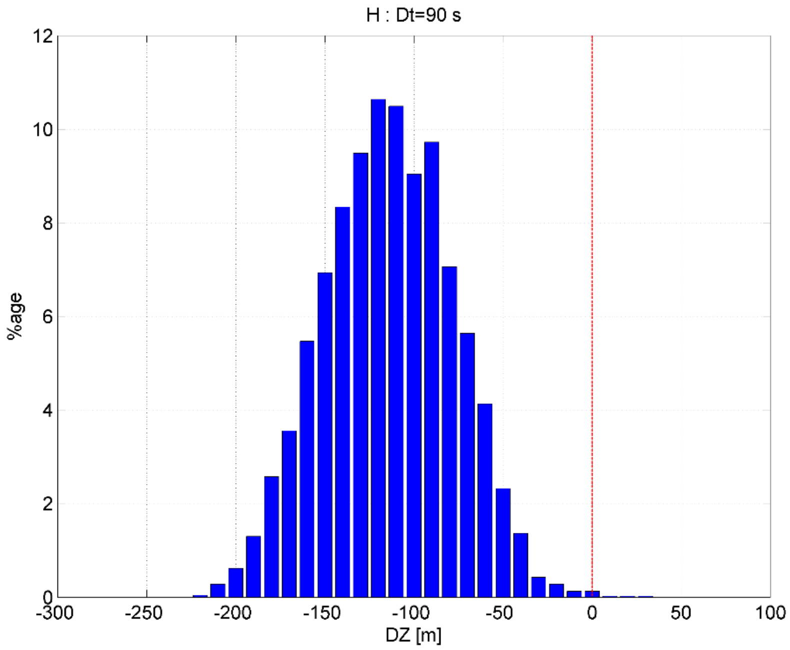


Figure 32: distribution of vortex vertical displacement after 90 s based on EGLL-OGE database

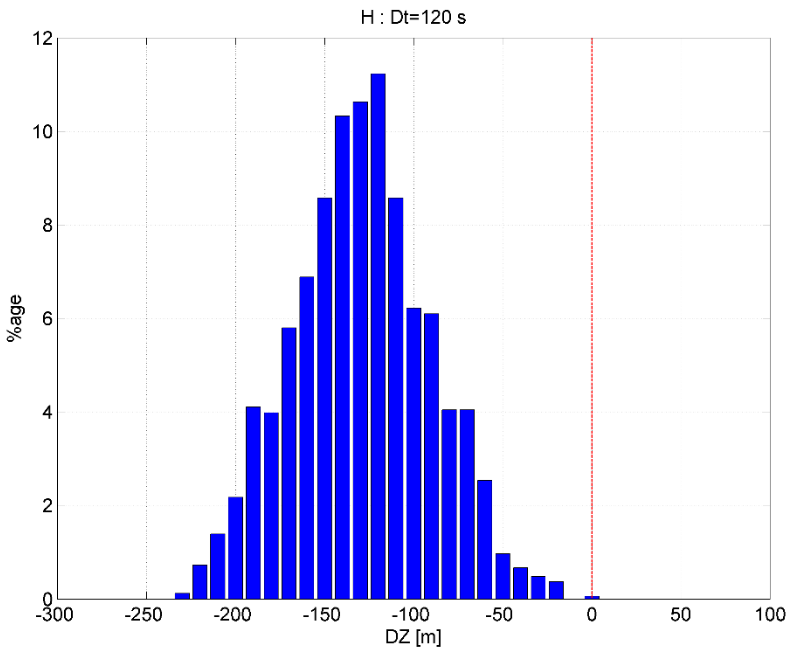


Figure 33: distribution of vortex vertical displacement after 120 s based on EGLL-OGE database

The separation reductions determined in Section 8.3.1.2 are therefore also valid for OGE situation.

8.3.2 Wake separation design methodology with leader on ISGS

8.3.2.1 IGE assessment methodology

The first case that is here investigated concerns ISGS approach followed by ILS with a certain altitude difference ΔH and a certain navigation uncertainty providing a certain difference between the two glide altitudes when the leader is at one wing span altitude. This is illustrated in Figure 34. For wake separation design, the reference altitude of wake generation corresponds to one wingspan generator. We thus here consider vortices generated at one wing span altitude potentially impacting aircraft flying in ILS on a glide located ΔH + TSE_{vert} below, see illustration in Figure 34.

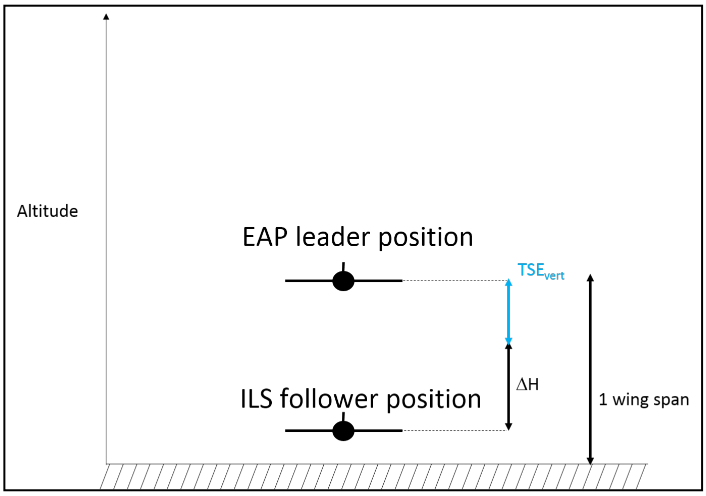


Figure 34: schematic view of ISGS and ILS region of flight

In the plane in which an aircraft is at one wing span altitude when located on the upper glide, an aircraft on the lower conventional glide, is either already on the ground (if the ΔH is sufficient) or at a similar altitude compared to the ISGS if ΔH is small. For that reason, there is no major modification of wake encounter risk for IGE situation when operation an aircraft on the ILS behind a leader on an ISGS upper glide.

8.3.2.2 OGE assessment methodology

On the contrary, for OGE situation, when an aircraft on a lower glide follows an aircraft flying on an upper ISGS glide, the risk of wake encounter significantly. Indeed, due to the slow decay of wake vortices evolving OGE and the increased exposure frequency due to the follower being always below the leader all along the glide with wake tending to sink. This is illustrated in Figure 35. For that reason, and whatever the altitude difference between the two glides, the separation minima are increased in order to reduce the severity of those potential encounters.

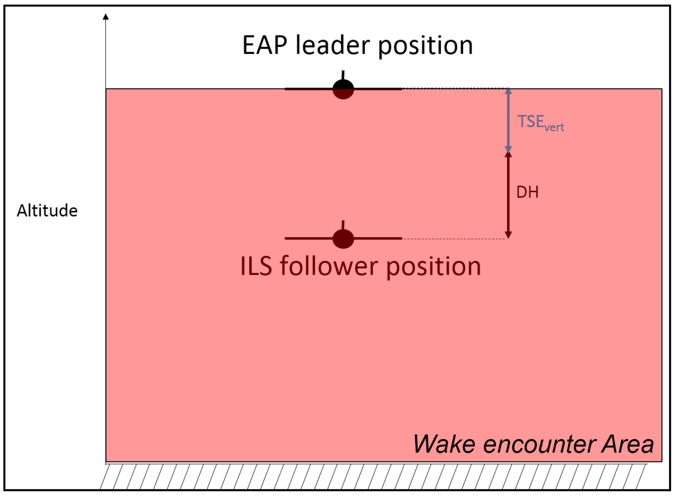


Figure 35: schematic view of ISGS and ILS region of flight

The maximum median severity accepted for wake separation minima is here set to RMC=0.04, which represent the absolute maximum acceptable RMC value OGE based on Flight simulator campaign (WISA).

The maximum vortex strength guaranteeing RMC ≤ 0.04 for any leader and follower at final approach speed is then computed per RECAT-EU category based on RECAT-EU-PWS 96 more frequent aircraft types. The results are provided in Table 13.

Lead/Foll	Cat-A	Cat-B	Cat-C	Cat-D	Cat-E	Cat-F
Cat-A	407	276	207	178	124	109
Cat-B	393	264	193	164	111	91
Cat-C	378	251	178	150	97	71
Cat-D	375	248	175	147	94	67
Cat-E	365	239	165	138	85	56
Cat-F	361	236	161	134	80	52

Table 13: Maximum wake circulation [m^2/s] guaranteeing RMC ≤ 0.04 for any leader-follower pair of the considered category and with the follower at final approach speed.

The RWC decay of each aircraft category is computed by selecting only long lasting wakes, namely tracks with lasting time greater or equal to 5 t_0 (rounded to the next 10 multiple) using t_0 values computed from the median measured initial circulation and assuming a vortex spacing factor $s=\pi/4$ (which is conservative since in approach configuration, aircraft will be more inboard loaded leading to smaller s, and hence t_0, values). The used values are reported in Table 14.

	Γ_0 [m²/s]	b [m]	b_0 [m]	t_0 [s]	5 t_0 criterion [s]
Cat-A	680	80	63	36	180
Cat-B	410	60	47	34	170
Cat-C	325	45	35	24	120
Cat-D	300	34	27	15	80
Cat-E	250	26	20	11	60

Table 14: Vortex initial circulation, spacing and characteristic time per RECAT-EU category

The assessment is performed using EGLL-OGE database for Cat-A, Cat-B and Cat-C leader aircraft types and using CDG database for Cat-D and Cat-E leader aircraft types. The results for Cat-F followers are conservatively copied from Cat-E results.

8.3.2.3 OGE assessment results

Figure 36 to Figure 40 provide the RWC decay evolution for Cat-A to Cat-E leader aircraft types. The circulation level corresponding to RMC=0.04 for each follower category is also showed. The intersection between the median (i.e. p50) decay evolution and the circulation threshold provides the wake separation time minima for each category pair. The results are provided in Table 15.

Leader/Follower	Cat-A	Cat-B	Cat-C	Cat-D	Cat-E	Cat-F
Cat-A	152	198	235	257	308	325
Cat-B		148	190	210	277	305
Cat-C		88	142	168	239	288
Cat-D			74	89	128	157
Cat-E			53	67	109	144
Cat-F			53	67	109	144

Table 15: Wake time separation minima [s] for operation of leader on an upper glide and follower on a lower glide

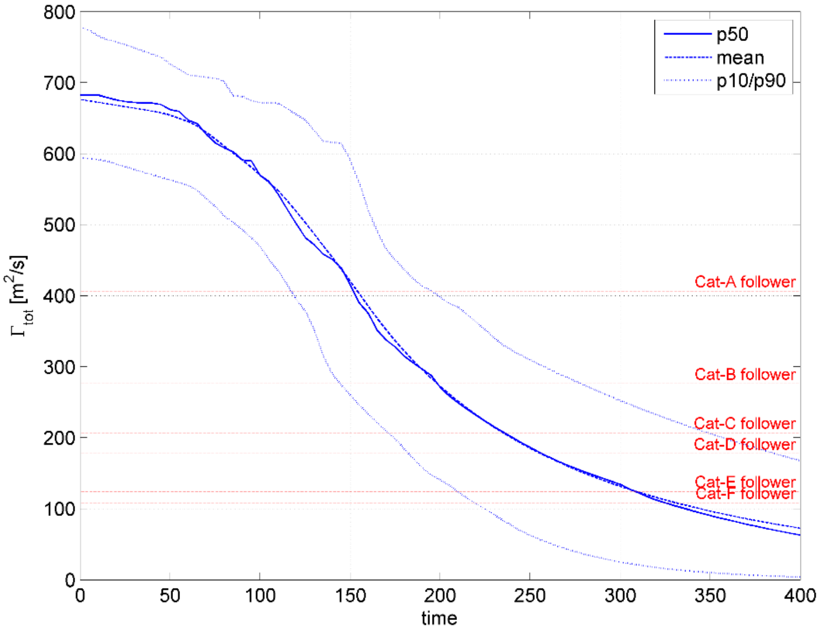


Figure 36: RWC wake decay evolution for Cat-A generated vortices OGE

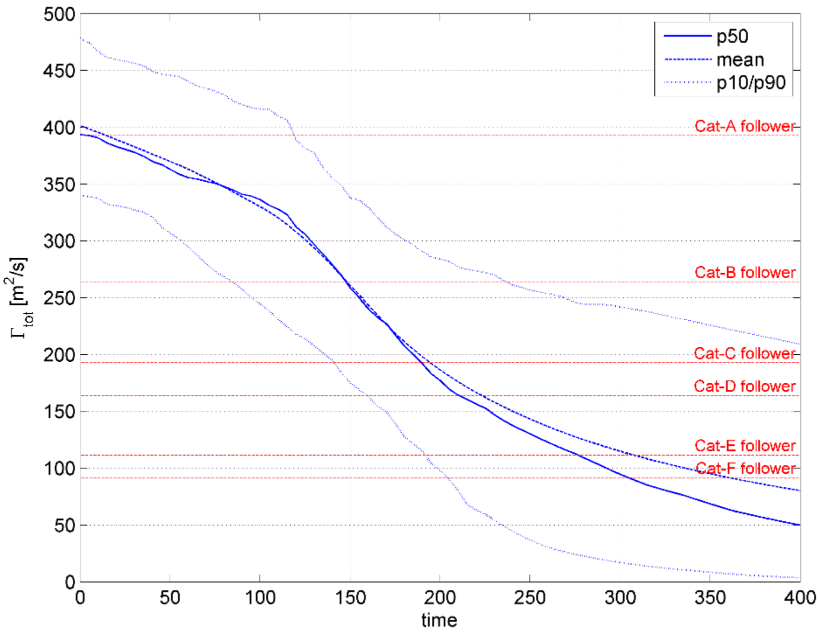


Figure 37: RWC wake decay evolution for Cat-B generated vortices OGE

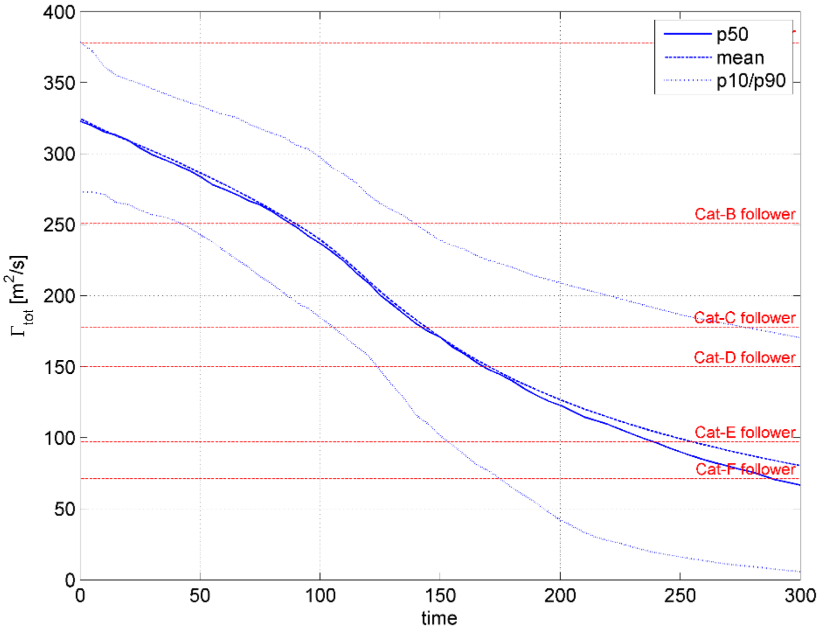


Figure 38: RWC wake decay evolution for Cat-C generated vortices OGE

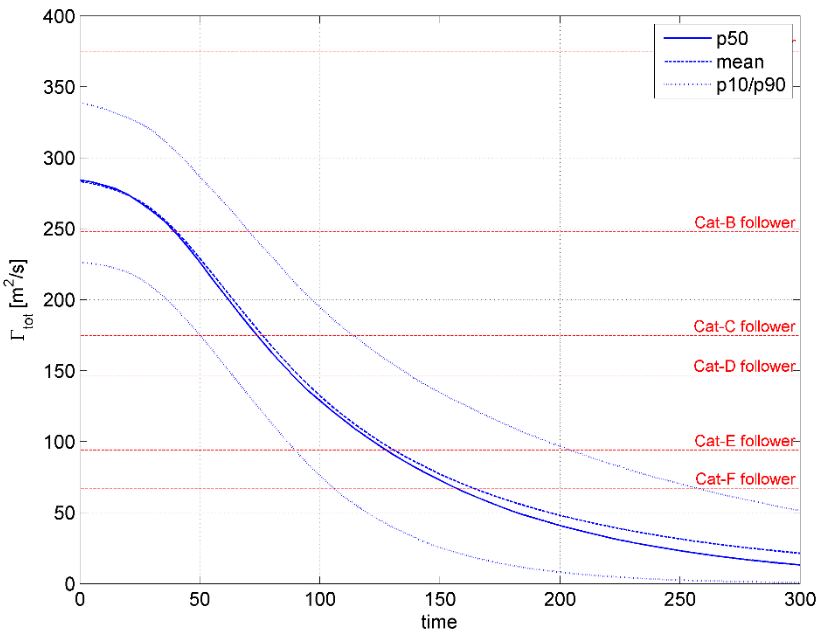
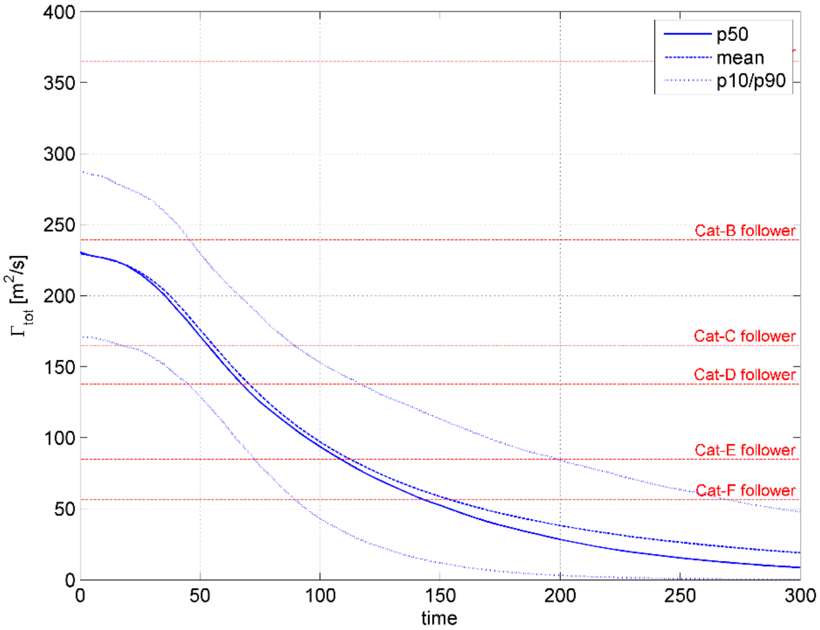


Figure 39: RWC wake decay evolution for Cat-D generated vortices OGE



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1225 **Figure 40: RWC wake decay evolution for Cat-E generated vortices OGE**

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8.3.3 Wake separation summary

The wake separation minima for ISGS operation in combination with a conventional ILS glide are determined based on the following principle:

- For a pair for which both aircraft follow the same glide (either conventional or ISGS), the wake separation minima are not modified compared to the currently applied separation scheme.
- For a pair for which the leader aircraft follows an upper ISGS glide and the follower follows a lower glide, the wake separation minima are increased according to Section 8.3.2.3.
- For a pair for which the leader aircraft follows a conventional glide and the follower follows an upper glide, the wake separation minima are reduced depending on the glide altitude difference at one wingspan altitude of the conventional glide according to Section 8.3.1.2.

A separation computation tool is provided in section 9.

For ISGS operations, given the very low altitude difference between the two glides at low altitude (i.e. in IGE region), the separation minima are unchanged for leader on conventional glide and follower on IGS glide. For leader on IGS followed by follower on conventional glide, the separation minima are increased due to the altitude difference in OGE region. See Table 16.

	Follower on ILS	Follower on IGS
Leader on ILS	Baseline	Same as baseline
Leader on IGS	Separation increase	Same as baseline

Table 16: Wake separation minima modification for operation of IGS in combination with conventional ILS procedure

9 ISGS wake separation minima calculator

EAP_sep_matrix_RECAT_v2.1.xlsx